Shire of Chittering

Local Planning Scheme No. 6

Amendment No. 67

Summary of Amendment Details

Rezoning land contained within Precinct 3 of the Muchea Employment Node Structure Plan, being Lots 800-804, 192, 194 and 35 Great Northern Highway, Muchea from 'Agricultural Resource' zone to 'Light Industrial' zone and introducing provisions relating to land use and development requirements

FORM 2A

Planning and Development Act 2005

RESOLUTION TO PREPARE AMENDMENT TO LOCAL PLANNING SCHEME

Shire of Chittering Local Planning Scheme No.6
Amendment No.67

Resolved that the Local Government pursuant to section 75 of the *Planning and Development Act* 2005, amend the above Local Planning Scheme by:

1. ***Rezoning Lots 800-804, 192, 194 and 35 Great Northern Highway, Muchea from 'Agricultural Resource' zone to the 'Light Industrial' zone.***

   And amending the Scheme Maps accordingly.

2. ***Amending clause 5.1.1 Operation of Special Control Areas to include 'Muchea Employment Node' as new dot point 6; and reflecting Precinct 3 of the Muchea Employment Node on the Scheme Maps accordingly.***

3. ***Introducing the following uses into Schedule 1 – Dictionary of Defined Words and Expressions of Local Planning Scheme 1 as follows:***

   'Concrete Batching Plant means premises used for concrete batching, as defined in the Environmental Protection Regulations 1987'

   'Workforce Accommodation means premises, which may include modular or relocatable buildings, used –
   (a) Primarily for the accommodation of workers engaged in construction, resource, agricultural or other industries on a temporary basis; and
   (b) For any associated catering, sporting and recreation facilities for the occupants and authorised visitors'

4. ***Amending Schedule 2 – Zoning Table to identify the uses:***
   i. 'Concrete Batching Plant' as a 'D' use in the Light Industrial and General Industrial zones, and an 'X' use otherwise
   ii. 'Workforce Accommodation' as a 'D' use in the Light Industrial zone, and an 'X' use otherwise
   iii. 'Fast Food Outlet' in the Light Industrial Zone as a 'D' use

5. ***Amending clause 4.9: Requirements for Industrial Zones and Land Uses, of Local Planning Scheme 1 to introduce the following provisions:***

(g) where Workforce Accommodation is a discretionary use-

i. the accommodation is to have a maximum floor area of 250m2

ii. the accommodation is to be incidental to the industrial land use

iii. subdivision of the accommodation from the parent lot will not be permitted

iv. the local government will not consider applications for Workforce Accommodation prior to the primary site activity being either approved or constructed

v. where simultaneous approval has been granted by local government for both Workforce Accommodation and the main activity on the same lot, the main activity must be developed and be operational prior to the occupation of the Workforce Accommodation

vi. Workforce Accommodation must be carefully sited and constructed so the potential site (or estate) impacts from noise, dust, odour, amenity and heavy vehicle access/egress from the site are minimised

And renumber the subsequent clauses accordingly.

6. Amending Schedule 11 – Muchea Employment Node Special Control Area of Local Planning Scheme No.1 to add Precinct 3, by including provisions for Precinct 3 of the Muchea Industrial Precinct No.1 as follows:

NO.	DESCRIPTION OF LAND	CONDITIONS
2.	Precinct 3 (P3) of the Muchea Industrial Park	**1. Hierarchy of Plans** Structure planning, subdivision and development shall be undertaken in accordance with the Scheme. **2. Structure Plan** a. Structure Plan Preparation A Structure Plan shall be prepared in accordance with the provisions of the deemed provisions over the entire area of Precinct 3 of the Muchea Industrial Park. b. Environmental Management Plans The following Environmental Management Plans shall be prepared as part of the Structure Plan process and approved as required by the relevant agency: i. Local Water Management Strategy ii. Environmental Assessment and Management Strategy iii. Transport Impact Assessment Environmental Management Plans shall be implemented to the satisfaction of the local authority. **3. Subdivision** i. An Urban Water Management Plan shall be prepared by the developer, consistent with the Local Water Management Strategy, for approval by the relevant

NO.	DESCRIPTION OF LAND	CONDITIONS
		agency, to satisfy a condition of subdivision approval. ii. A reticulated water supply provided by a licensed operator shall be provided at the first stage of subdivision. iii. Road Reservation and Construction a. An internal Loop Road, constructed to accommodate RAV10 vehicles, shall be constructed in accordance with Austroads and MRWA standards b. When a lot is subdivided, the totality of land required for all road reserves within that lot shall be ceded to the Crown c. The full length of roads within the subdivision area is to be constructed on the creation of all lots. A staging plan and triggers for road construction, to ensure construction of all roads within the subdivided area is to be outlined in an approved Structure Plan. iv. Subdivision applications shall demonstrate that a suitable temporary turning circle for the Loop Road can be provided within the boundaries of the subdivision area until the entire Loop Road is constructed to allow RAV10 vehicles access and egress onto Great Northern Highway. At that time, the temporary turning circle shall be removed and the land suitably remediated. v. Drainage a. The drainage approach for Precinct 3 is set out in the Structure Plan. b. When the first lot in a subdivision is created, any works or ceding of land associated with the drainage network is to be implemented. c. Where staging of drainage infrastructure is determined to be acceptable by the WAPC and relevant agencies including DWER and the local authority, proposals are to make provision for connection to the overall drainage network, and the approach is to be outlined in an UWMP that accompanies the subdivision application.

NO.	DESCRIPTION OF LAND	CONDITIONS
		4. Development **i.** Development of land shall be generally in accordance with the Scheme and approved Structure Plan. ii. Land use permissibility within Precinct 3 shall be in accordance with the Light Industrial Zone of LPS6 (as amended).

The amendment is standard under the provisions of the *Planning and Development (Local Planning Schemes) Regulations* 2015 for the following reason(s):

1. The Amendment is consistent with the approved Muchea Employment Node Structure Plan 2011
2. The Amendment is consistent with the Draft Shire of Chittering Local Planning Strategy

Dated this _____ day of _____ 20___

_____
(Chief Executive Officer)

URBIS

MUCHEA INDUSTRIAL PARK SCHEME AMENDMENT

PRECINCT 3

PREPARED FOR

TOMAHAWK PROPERTY ON BEHALF OF THE MUCHEA EMPLOYMENT NODE PRECINCT 3 LANDOWNER GROUP

OCT 2019

TABLE OF CONTENTS

1. Introduction 1
1.1. Relationship to Planning Regulations 1
2. Site Description 3
2.1. Land Description 3
2.1.1. Location 3
2.1.2. Area and Land Use 4
2.1.3. Site Particulars 4
2.1.4. Site Context 7
3. Planning Framework 11
3.1. Zoning, Reservations and Land Use Permissibility 11
3.1.1. Shire of Chittering Local Planning Scheme No.6 11
4. Regional and Subregional Planning Context 15
4.1. Planning Strategies 15
4.1.1. State Planning Strategy (2014) 15
4.1.2. Perth & Peel @ 3.5 Million (2018) 15
4.1.3. Wheatbelt Regional Planning and Infrastructure Framework (2015) 15
4.1.4. Muchea Employment Node Scheme Amendment (MENSP) (2011) 15
4.1.5. Local Planning Strategy 2001-2015 (2004) 18
4.1.6. Local Planning Strategy 19
4.2. Planning Policies 21
4.2.1. State Planning Policy No.3.7 – Bush Fire Risk Management 21
4.2.2. State Planning Policy No.2.4 – Basic Raw Materials 21
4.2.3. Draft State Planning Policy No.2.4 – Basic Raw Materials (October 2018) 21
4.2.4. State Planning Policy No.3.6 – Development Contributions 21
4.2.5. Other State Policies 21
4.2.6. EPA Guidance for the Assessment of Environmental Factors No.3 23
4.3. Local Planning Policies 23
4.4. Key Outcomes from Review of Strategic and statutory Planning Context 23
5. Site Conditions and Constraints 25
5.1. Landform and Soils 26
5.1.1. Topography 26
5.1.2. Landscape 26
5.1.3. Geology, Landform and Soils 26
5.1.4. Soil Permeability 26
5.1.5. Contaminated Sites 26
5.2. Existing Movement Network 26
5.2.1. PDNH 26
5.2.2. Great Northern Highway 27
5.2.3. Brand Highway 27
5.2.4. Muchea East Road 27
5.2.5. RAV Network 27
5.3. Biodiversity and Natural Assets 27
5.3.1. Vegetation 27
5.3.2. Rare and Significant Flora 28
5.3.3. Fauna 28
5.4. Groundwater and Surface Water 28

5.4.1. Groundwater 28
5.4.2. Surface Water 28
5.4.3. Water Resources 28
5.4.4. Water Quality 29
5.5. Bushfire Hazard 29
5.5.1. Bushfire Assessment Results 31
5.6. Indigenous Heritage 36
5.7. Acoustics 36
5.8. Dust 36
6. Proposed Scheme Amendment 37
6.1. Zoning and Land Use 37
6.1.1. Zoning 37
6.1.2. Land Use and Development 37
6.2. Design Concept 37
7. Movement Network 39
7.1. Proposed Road Network 39
7.2. Changes to External Transport Networks 39
8. Local Water Management 40
8.1. Water Efficiency Measures 40
8.2. Stormwater Management Strategy 40
8.2.1. Principles and Objectives 40
8.2.2. Drainage Management System 40
8.2.3. Through Drainage 40
8.2.4. Internal Drainage 40
8.2.5. Major Storm Drainage 42
8.2.6. Ellen Brook Floodplain 42
8.2.7. Surface Water Quality Management 42
8.2.8. Groundwater Management Strategy 44
9. Servicing and Infrastructure 45
9.1. Stormwater Management 45
9.2. Effluent Disposal 45
9.2.1. Land Capability for On-Site Effluent Disposal 45
9.2.2. System Selection and Location 46
9.2.3. Subsoil Drainage 46
9.3. Water Reticulation 46
9.4. Power 47
9.5. Gas 47
9.6. Earthworks 47
9.7. Telecommunications 48
10. Landscape Masterplan 49
11. Environmental Management 53
11.1. Acoustics 53
11.2. Odour 53
11.3. Dust 53
11.4. Vegetation and Flora 53
11.5. Fauna 53
11.6. Groundwater Monitoring 53
12. Conclusion 54
TECHNICAL APPENDICES 55

Disclaimer 57

Appendix A Certificate of Titles and Sketches
Appendix B Environmental Assessment Management Plan
Appendix C Transport Impact Assessment
Appendix D Engineering Servicing Report
Appendix E Geotechnical Report
Appendix F Ellen Brook Flood Modelling
Appendix G Bush Fire Management Plan
Appendix H Local Water Management Strategy
Appendix I Landscape Masterplan

FIGURES:
Figure 1 – Location Plan 3
Figure 2 – Cadastral Plan 6
Figure 3 – Regional Context Plan 8
Figure 4 – Local Context Plan 10
Figure 5 – Shire of Chittering Local Planning Scheme No.6 11
Figure 6 – Muchea Employment Node Scheme Amendment 17
Figure 7 – LPS Extract (2001 – 2015) 18
Figure 8 – LPS Extract (2019) 20
Figure 9 – Opportunities and Constraints 25
Figure 10 – Bushfire Prone Area 30
Figure 11 – Bushfire Hazard Level 32
Figure 12 – Likely BHL Post Development 33
Figure 13 – Bushfire Management Measures 35
Figure 14 – P3 Concept Plan 38
Figure 15 – Typical Drainage Design Concept 41
Figure 16 – Drainage Concept 43
Figure 17 – Aqua Ferre Water Strategy 47
Figure 18 – Landscape Masterplan 50
Figure 19 – Landscaping of Bio-Retention Swales 51
Figure 20 – Individual Lot Landscaping Concept 51
Figure 21 – Ellen Brook Landscaping 52

Tables:
Table 1 – Certificates of Title: P3 Properties 4
Table 2 – Other State Planning Policy Considerations 22
Table 3 – Local Planning Policy Considerations 23
Table 4 – Bushfire Hazard Level (BHL) Assessment 31

1. INTRODUCTION

This report has been prepared by Urbis for Tomahawk Property on behalf of the Muchea Employment Node Precinct 3 Landowner Group, in support of an application to rezone land (and introduce relevant provisions) within Precinct 3 (P3) of the Muchea Employment Node Structure Plan area (MENSP). This Amendment proposes the land be rezoned from 'Agricultural Resource' to 'Light Industrial', to facilitate its development for a range of industrial purposes.

The MENSP was adopted by the WAPC in August 2011, and provides a 20 year planning framework for industrial development within the Shire of Chittering. P3 forms the eastern portion of the MENSP, to the west of Great Northern Highway (GNH). The MENSP is also more recently referred to the as the Muchea Industrial Park (or MIP).

A Structure Plan has also been prepared and lodged with the Shire of Chittering, to provide the detailed framework to deliver industrial development in a timely and coordinated manner, in a form which will facilitate flexibility in lot size and layout, and enable access and manoeuvrability within the Estate for Restricted Access Vehicles, or RAV10 and RAV7 industrial vehicles.

The Amendment (and associated Structure Plan) have been prepared in consultation with all landowners within the Structure Plan area.

This report has been informed by a variety of technical investigations which are appended to this report.

This Amendment report addresses the relevant considerations of the *Planning and Development (Local Planning Scheme) Regulations 2015*, and the requirements of the Shire of Chittering Local Planning Scheme No.6 (LPS6).

1.1. RELATIONSHIP TO PLANNING REGULATIONS

This report has been prepared in accordance with the principles of the Western Australian Planning Commission's (WAPC) key State Planning Policies which guide industrial subdivision and development.

Under Clause 35 of the *Planning and Development (Local Planning Schemes) Regulations 2015 ('the Regulations')* when undertaking a scheme amendment, a local government must specify and justify whether the proposed amendment is basic, standard or complex.

The proposed amendment is considered to be a 'standard amendment', which is described under Clause 34 of the Regulations as follows:

Standard amendment means any of the following amendments to a local planning scheme:

(a) an amendment relating to a zone or reserve that is consistent with the objectives identified in the scheme for that zone or reserve;

(b an amendment that is consistent with a local planning strategy for the scheme that has been endorsed by the Commission;

(c) an amendment to the scheme so that it is consistent with a region planning scheme that applies to the scheme area, other than an amendment that is a basic amendment;

(d) an amendment to the scheme map that is consistent with a structure plan, activity centre plan or local development plan that has been approved under the scheme for the land to which the amendment relates if the scheme does not currently include zones of all the types that are outlined in the plan; (emphasis added)

(e) an amendment that would have minimal impact on land in the scheme area that is not the subject of the amendment;

(f) an amendment that does not result in any significant environmental, social, economic or governance impacts on land in the scheme area;

(g) any other amendment that is not a complex or basic amendment.

The amendment is standard under the provisions of the Planning and Development (Local Planning Schemes) Regulations 2015 for the following reason(s):

1. The Amendment is consistent with the approved Muchea Employment Node Structure Plan 2011
2. The Amendment is consistent with the Draft Shire of Chittering Local Planning Strategy

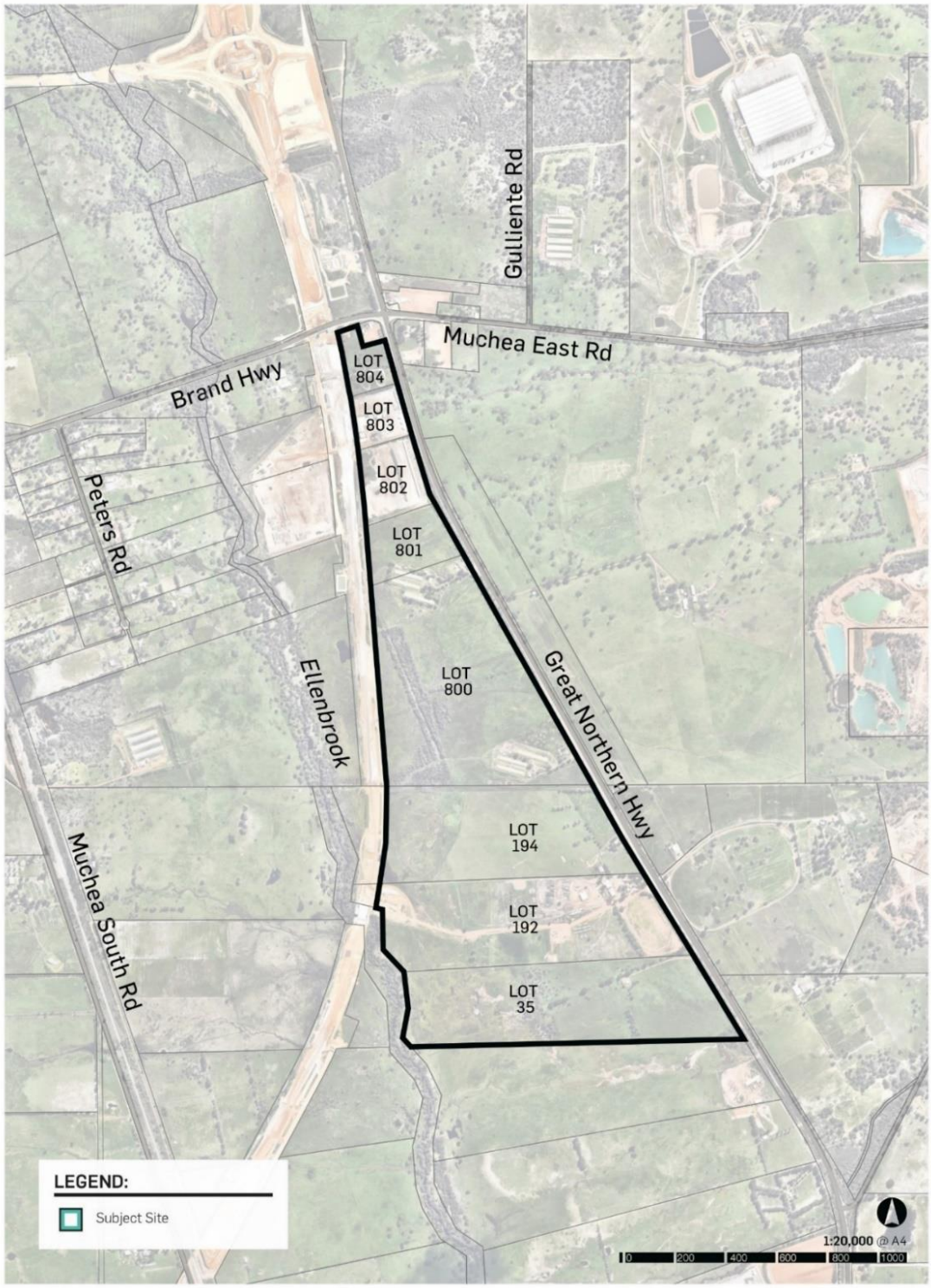
2. SITE DESCRIPTION

2.1. LAND DESCRIPTION

2.1.1. Location

The Amendment area, comprising P3, is approximately 185ha in area, and bound by GNH to the east, the PDNH to the west, Brand Highway to the north, and the southern boundary of the Shire of Chittering to the south (refer to **Figure 1 – Location Plan**).

Figure 1 – Location Plan



2.1.2. Area and Land Use

The Scheme Amendment area is 185ha, and comprised of farmland, logistics businesses, manufacturing and three poultry farms (under lease agreements – to end 2019). The following businesses are notable as operating within the Scheme Amendment area:

Lots 802 and 803: Aussie Modular Solutions (AMS)

Lots 800 and 801: Ingham Enterprises (poultry farms)

Lot 192: Road Trains of Australia (RTA)

The land has largely been historically cleared for agricultural purposes and contains stands of large, mature trees with degraded understorey, and a number of rural drainage lines. At its south-west, P3 abuts the Ellen Brook foreshore.

2.1.3. Site Particulars

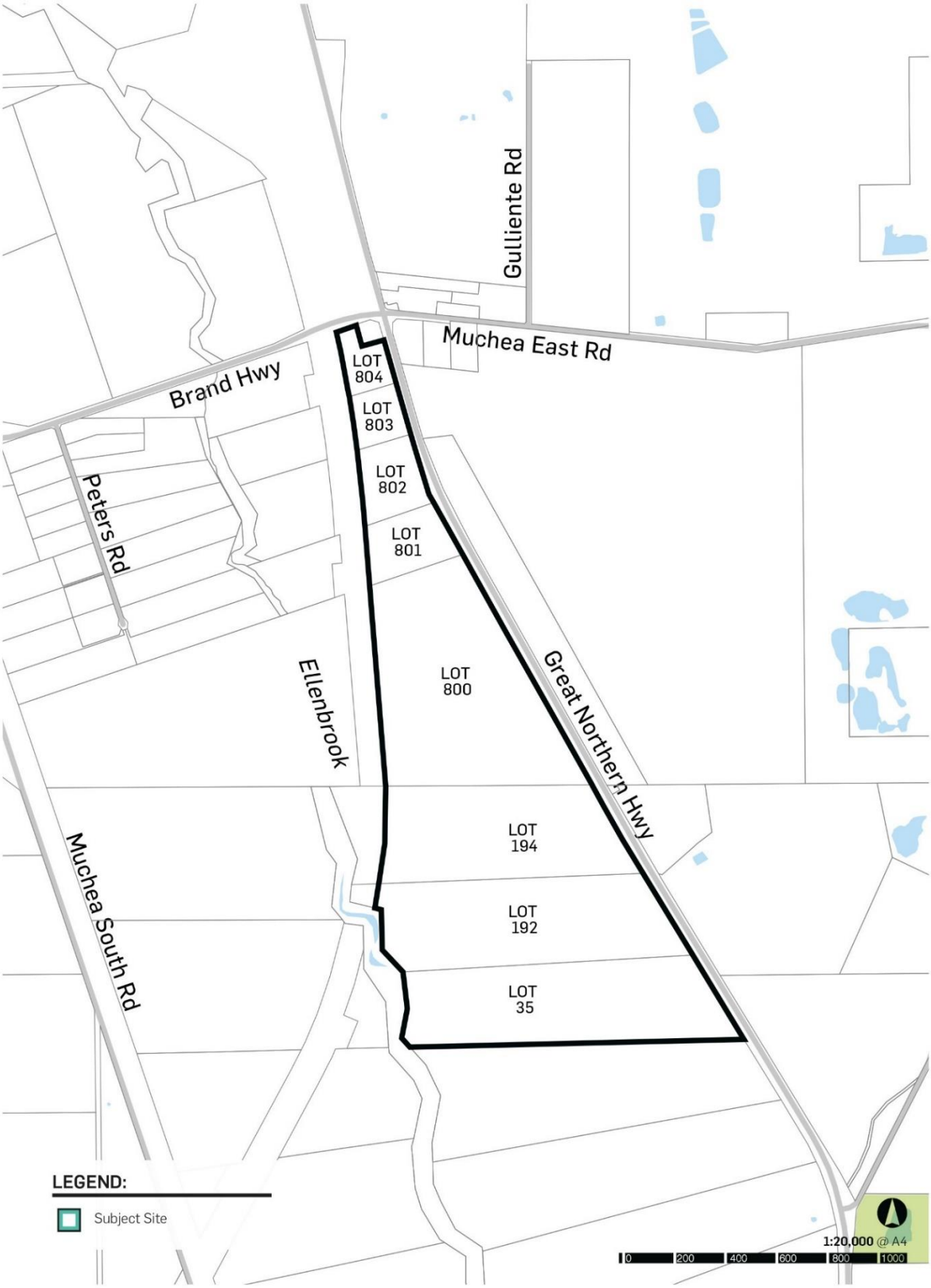
Details of the subject land's legal particulars are provided in **Table 1 and Figure 2 – Cadastral Plan**. Copies of the Certificates of Title are included at **Appendix A – Certificates of Title**.

Table 1 – Certificates of Title: P3 Properties

Lot	Street	Volume/Folio	Plan/Diagram	Owner	Land Area	Encumbrances (easement, caveats etc.)
804	43 Brand Hwy, Muchea	2895/897	Deposited Plan 404617	Andrew Quince	3.9ha	Except and reserving metals, minerals, gems and mineral oil specified in transfer 1132/1935. Caveat by Pure Steel Shed Constructions Pty Ltd as to portion only lodged 3/9/2015.
803	3571 Great Northern Hwy, Muchea	2903/24	Deposited Plan 404616	Karratha Enterprises Pty Ltd	4.3ha	Except and reserving metals, minerals, gems and mineral oil specified in transfer 3000/1933
802	N/A	2903/23	Deposited Plan 404616	Karratha Enterprises Pty Ltd	7.1ha	Except and reserving metals, minerals, gems and mineral oil specified in transfer 3000/1933
801	N/A	2903/33	Deposited Plan 404613	Ingham Rural Property Group Pty Ltd	7.6ha	As per Lot 800
800	N/A	2903/33	Deposited Plan 404613	Ingham Rural Property Group Pty Ltd	51.3ha	Except and reserving metals, minerals, gems and mineral oil specified in transfer 188/1945 Easement benefit (D72548)
194	3383 Great Northern Hwy, Muchea	2862/298	Deposited Plan 405699	Amuse Pty Ltd	33.5ha	Except and reserving metals, minerals, gems and mineral oil specified in transfer 9703/1919 and 9704/1919 Restrictive Covenant Burden. Registered 1/7/1980

Lot	Street	Volume/Folio	Plan/Diagram	Owner	Land Area	Encumbrances (easement, caveats etc.)
						Easement Burden for right of carriageway purposes. See DP 405699 and sketch on Vol 1868 Fol 805. Refer Lot 800.
192	3363 Great Northern Hwy, Muchea	2862/297	Deposited Plan 405698	Barton Cecil Jones David John Cecil Jones	37.9ha	Except and reserving metals, minerals, gems and mineral oil specified in transfer 9703/1919 and 9704/1919 Restrictive Covenant Burden. Registered 1/7/1980.
35	3329 Great Northern Hwy, Muchea	1868/807	Diagram 72548	Neil John Bovenizer	38.9ha	Except and reserving metals, minerals, gems and mineral oil specified in transfer 9703/1919 and 9704/1919
	TOTAL				**184.5ha**	

Figure 2 – Cadastral Plan



2.1.4. Site Context

2.1.4.1. Regional Context

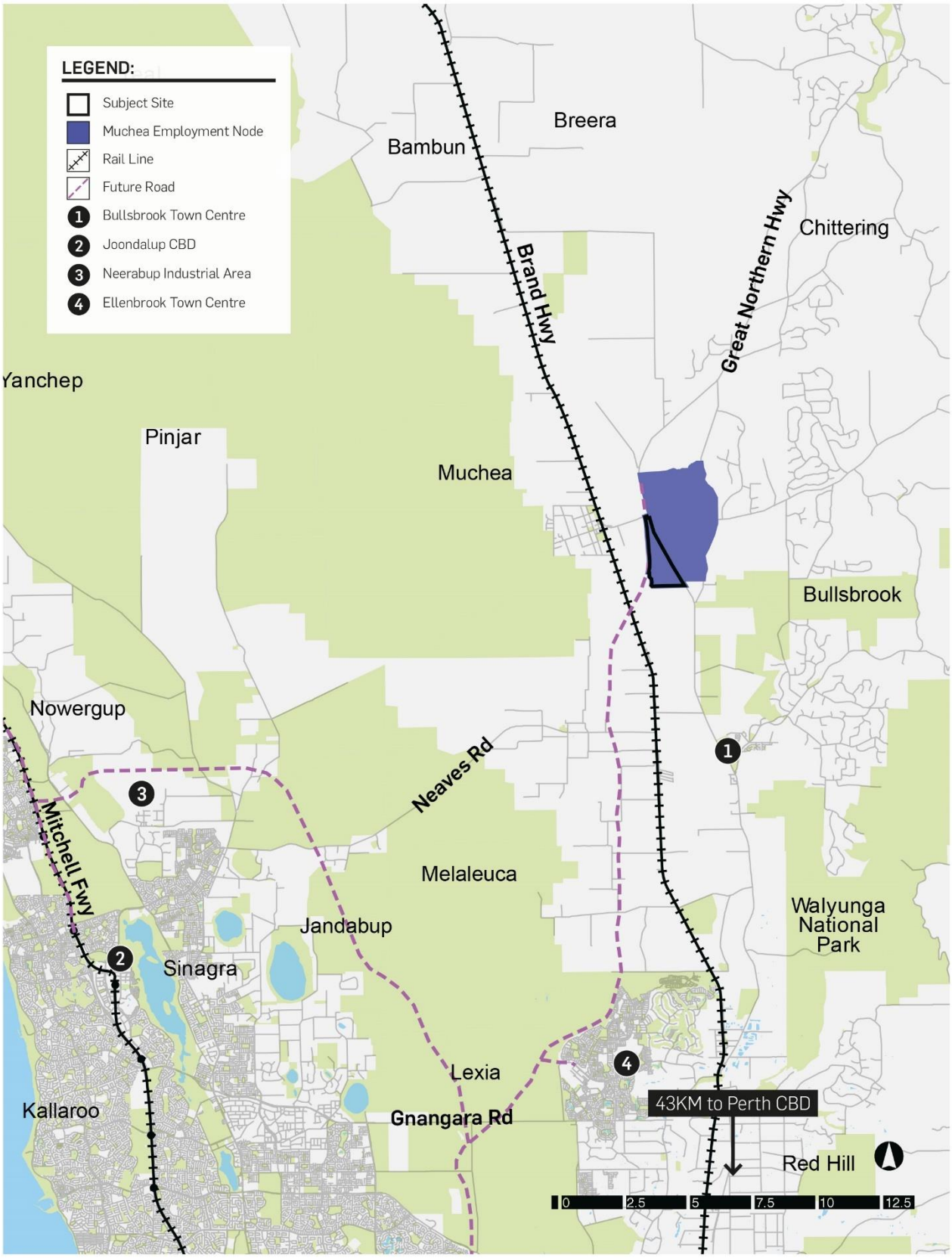
Figure 3 – Regional Context Plan identifies the Amendment area's location in a broader context, being:

- 43km to Perth CBD – Muchea is located within the Wheatbelt region of Western Australia
- High level of commercial exposure and convenient access to GNH within the eastern portion of P3; and commercial exposure to the PDNH (under construction)
- Immediately to the west of the Scheme Amendment area is the Midland-Geraldton railway, providing direct freight access to Fremantle Port and Geraldton
- Joondalup CBD is located 28km south west of the subject site – this is a strategic metropolitan centre and the highest order retail offered in Perth's north
- Neerabup Industrial Area is located 23km south west of the subject site, the current nearest industrial area to the subject site
- P3 forms part of the Muchea Employment Node (also referred to as the MIP) which in time, will provide significant land for a range of industrial purposes

Other key activities within the region include:

- Ellenbrook Town Centre
- Royal Australian Air Force Australia Base (RAAF)
- Numerous national parks and nature reserves

Figure 3 – Regional Context Plan

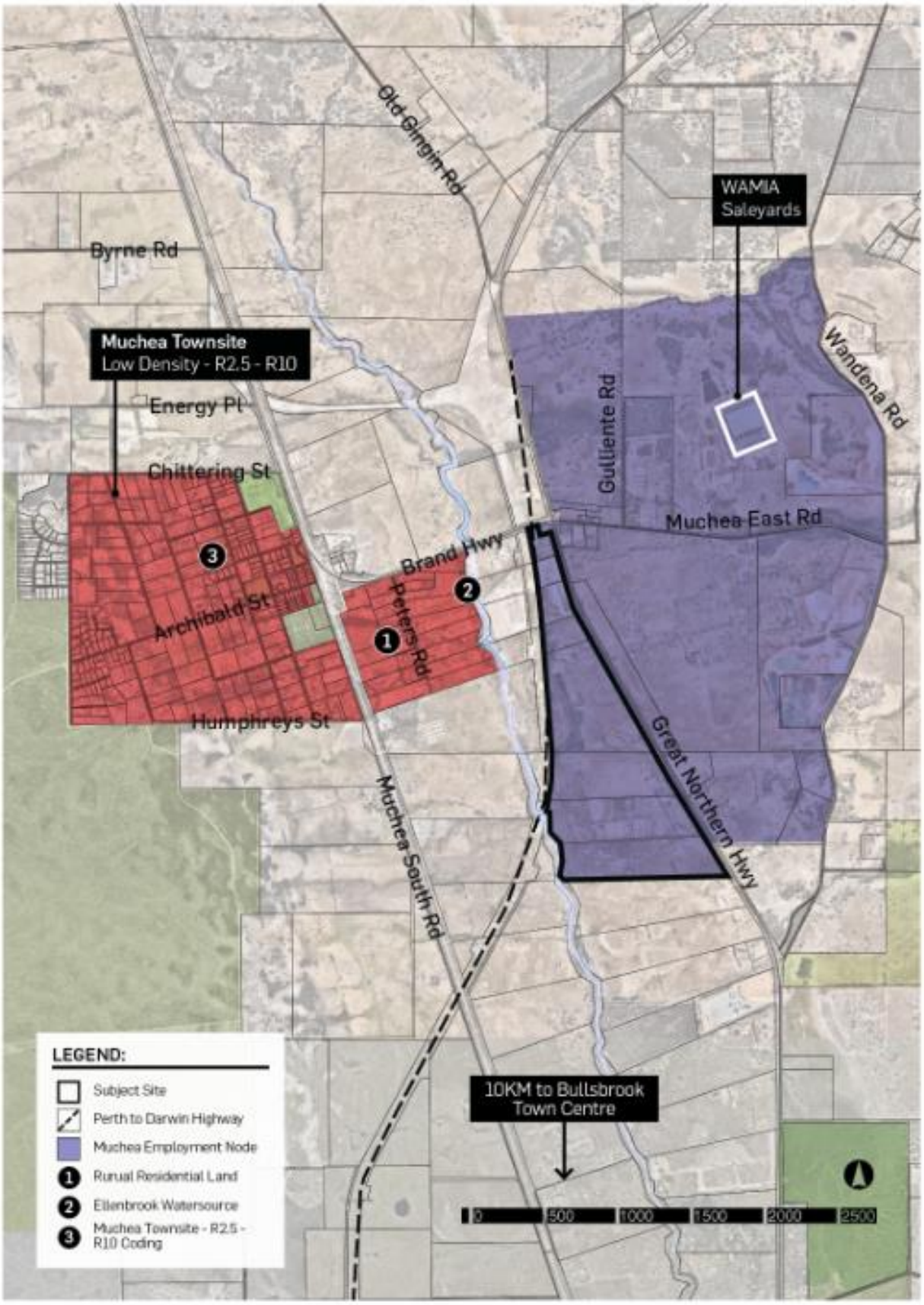


2.1.4.2. Local Context

Figure 4 – Local Context illustrates the Amendment area's local context:

- Muchea is generally characterised by agricultural development with low density and rural residential living opportunities
- Bullsbrook is located 10km south of the subject site – this is the closest service centre
- Immediately to the north-west of the Scheme Amendment area are rural residential lots ranging from 2ha – 6.6 hectares.
- The poultry farms located on Lots 800 and 801 are subject to lease arrangements ending December 2019, leased to Ingham Enterprises
- Lot 802 is an Additional Use 17 (AU17) in the Shire of Chittering's LPS6, allowing P3 to be used for general warehouse/storage purposes, limited to the manufacture, assembly, storage and transportation of transportable buildings
- Lot 192 accommodates Road Trains of Australia (RTA), a well established transport logistics business
- To the east of the subject land including land within P3 is the MENSP area – an area envisioned for a range of industrial uses
- To the north-west of the subject land is Muchea Townsite - a low density (R2.5 – R10) residential area, home to a population of approximately 1000 people (ABS 2016)
- To the north-east of the subject land is the WAMIA Sale Yards which is a substantial employer and contributor to the Chittering and Wheatbelt economies.

Figure 4 – Local Context Plan



3. PLANNING FRAMEWORK

This section details the local planning framework applicable to the Amendment area.

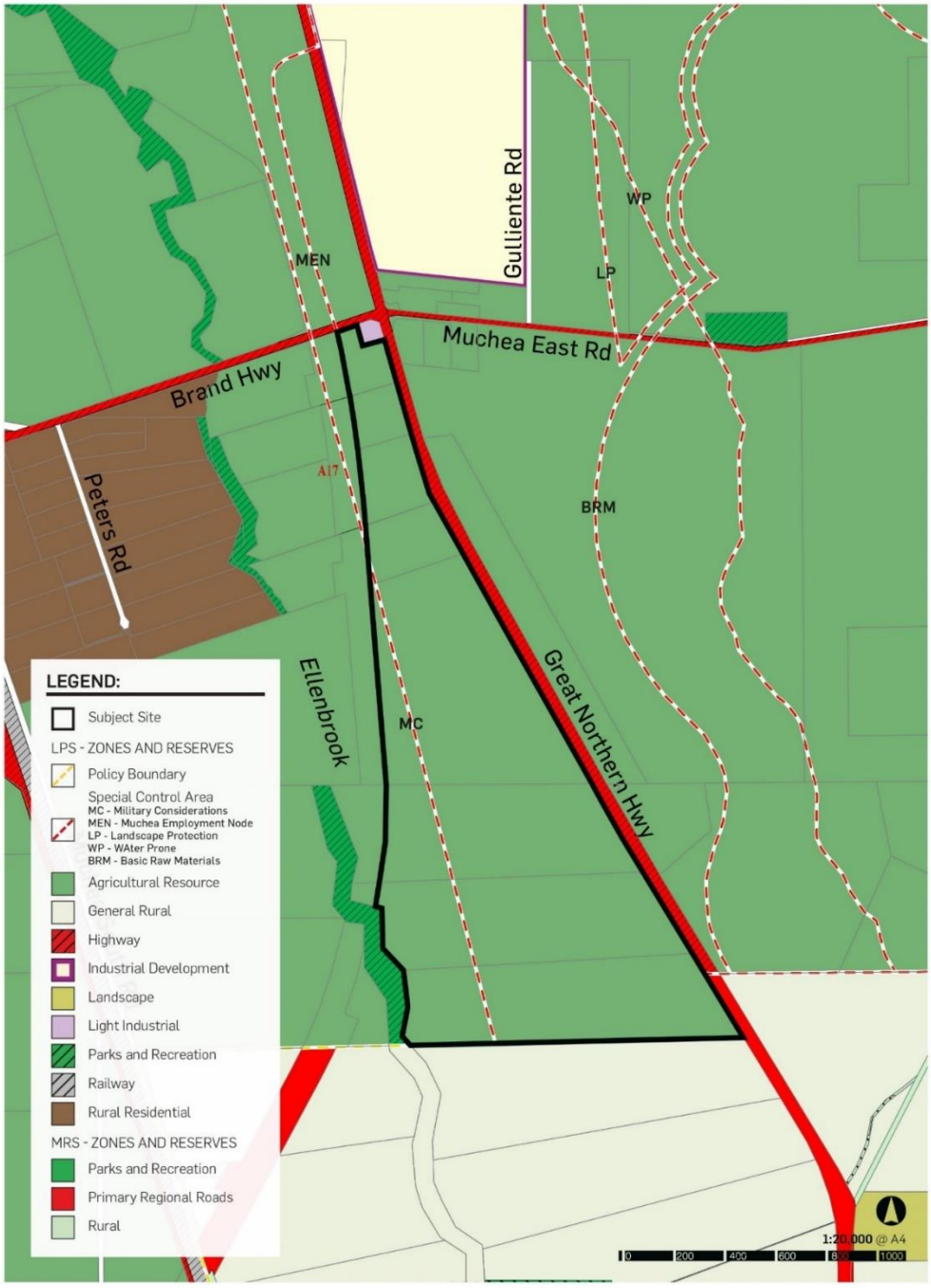
3.1. ZONING, RESERVATIONS AND LAND USE PERMISSIBILITY

3.1.1. Shire of Chittering Local Planning Scheme No.6

The subject land is currently zoned 'Agricultural Resource' under the Shire of Chittering LPS6 and has frontage to GNH which has a 'Highway' reservation, and exposure to the PDNH (under construction). Refer **Figure 5 – Shire of Chittering Local Planning Scheme No.6**.

The subject land is located just outside the boundary of the Perth Metropolitan Area and is therefore not affected by the Metropolitan Region Scheme (MRS).

Figure 5 – Shire of Chittering Local Planning Scheme No.6



3.1.1.1. Light Industrial Zone

To facilitate industrial development over the Scheme Amendment area, it is proposed that the land will be included in the 'Light Industrial' zone. The objectives of the 'Light Industrial' zone within LPS6 are as follows:

'a) To provide for a range of industrial uses and service industries generally compatible with urban areas, that cannot be located in commercial zones.

b) To ensure that where any development adjoins zoned or developed residential properties, the development is suitably set back, screened or otherwise treated so as to not detract from the residential amenity'.

The purpose of this Scheme Amendment is to facilitate the development of the subject land for light industrial development in accordance with the planning framework, in a manner which protects residential amenity and environmental values.

3.1.1.2. Land Use Permissibility

Land use permissibility for P3 will be in accordance with the Light Industrial Zone of LPS6 (as amended). The Scheme Amendment proposes to introduce new definitions for Concrete Batching Plant and Workforce Accommodation into Schedule 1 of the Scheme and apply land use permissibility of 'D' (discretionary) for these uses in the Light Industrial Zone, along with allowing Fast Food Outlet as a 'D' use within the zone.

It is noted that the MENSP sets out a range of land uses and their related permissibility, along with the uses considered most suitable for the highway location. There are a number of inconsistencies, however, in terminology and permissibility between the land uses listed in the MENSP. In addition, the MENSP is currently under review and the Shire of Chittering is approaching gazettal of Amendment No.65 which proposes modifications to the Zoning Table.

Determination of land use and lot size will be subject to servicing provision, the requirements of business, vehicle access and egress and other factors, and further discussion with the Shire at the subdivision and development stage will be required.

Development standards will be otherwise consistent with the 'Light Industrial' zone and Schedule 11 of the Scheme.

Clause 4.9 of LPS6 sets out development requirements for industrial zones includes the following relevant requirements:

- *Emissions are to be avoided or suitably managed*
- ***Where an on-site wastewater disposal system is proposed, land capability assessment, use of fill or drains and land area to distribute treated sewerage is required (with secondary treatment systems where required)***
- ***Industrial development not connected to reticulated sewerage is to be restricted to 'dry industry'*** *being land use that intends to dispose of wastewater on site to the environment of a kind and volume ordinarily discharged from a habitable building*
- *Trade waste is to be managed and appropriately disposed of*
- *Caretakers accommodation requirements apply*

  (Note: caretaker accommodation is <u>not</u> permitted as per MENSP and LPS6)
- *A structure plan may be required* (in the case of land within the MENSP, a structure plan <u>is</u> required)

Points 2 and 3 relating to on site wastewater disposal above are particularly relevant to the Structure Plan and are addressed below in the servicing section.

3.1.1.3. Military Considerations Special Control Area

The Military Considerations Special Control Area (SCA) affects the eastern portion of the Scheme Amendment area. Development approval is required for any development within the SCA, with any dwelling constructed to comply with AS2021-2000 Aircraft Noise Intrusion – Building Siting and Construction. One dwelling per lot only is allowed. Given the proposed development is for industrial purposes, there are no implications for the Scheme Amendment, unless any structures are proposed above 90m.

3.1.1.4. Muchea Employment Node SCA and Schedule 11

As noted above, the subject land is located within the Muchea Employment Node SCA and Schedule 11. The purpose of the MENSP SCA is to implement the MENSP, and to require development approval for any development within the SCA.

No residential development or caretaker accommodation is permitted within the SCA.

A Scheme Amendment is required for land proposed for industrial development, with subdivision or development in accordance with the provisions and requirements of Schedule 11 of LPS6. Reticulated water and suitable servicing including reserving/construction of roads is required. Other provisions relating to separation distances, visual impact and protection of environmental assets are required to be addressed.

Where basic raw materials are located on the lot, proposals need to consider whether the proposed development will impact upon extraction of the resource.

Schedule 11 lists a range of strategies required to support a Structure Plan comprising:

- Requirement for preparation of a Structure Plan
- Preparation of Environmental Management Plans to inform the design and proposed subdivision and development of the Scheme Amendment area, being (where appropriate):
    - Local Water Management Strategy
    - Environmental Assessment and Management Strategy
    - Strategic Noise Assessment and Management Strategy
    - Strategic Odour Assessment and Management Strategy
    - Transport Assessment and Management Strategy
    - Flora, Vegetation, Wetland and Waterway Management Plans
    - Acid Sulphate Soils (ASS) Site Assessment Management Plan
    - Urban Water Management Plan
    - Geotechnical Report
    - Water Supply and Wastewater Disposal Strategy
    - Noise Management Plan
    - Construction Management Plan
    - Odour Management Plan
    - Waste Management Plan

In addition, the provisions require the following:

- Reticulated water supply and wastewater disposal systems at the first stage of subdivision
- Reticulated water and wastewater systems to be provided by licensed service providers
- Provision of water and wastewater systems subject to a Development Contribution Plan (*note that the Shire has since advised that it does not intend to prepare a Development Contribution Plan for the MENSP area*)
- Separation distances as set out by State Planning Policy (SPP) or the Environmental Protection Authority (EPA)
- Where a licensed reticulated water scheme is not available and connected to the estate's reticulated system at the time of development, land uses shall be generally limited to Transport Depot, Storage, Warehouse and Landscape Supplies. In the case of P3, reticulated water will be provided.

Development applications are required to demonstrate that the proposed use/development has an adequate and sustainable water supply to service the day to day operational needs of the land use on an ongoing basis and the proposed use shall be consistent with the objectives of the zone, and any applicable Structure Plan.

4. REGIONAL AND SUBREGIONAL PLANNING CONTEXT

This section details the State and sub-regional planning framework applicable to the subject land.

4.1. PLANNING STRATEGIES

4.1.1. State Planning Strategy (2014)

The State Planning Strategy (SPS) details strategic goals and objectives for regional planning issues. The SPS aims to achieve 'strong and resilient regions' through embracing diverse (employment) opportunities and building strong networks, while also 'planning for economic development' through the development of industrial and economic clusters. The identification of the MENSP for industrial development is consistent with the State's objectives.

4.1.2. Perth & Peel @ 3.5 Million (2018)

While P3 sits outside of the Perth & Peel @ 3.5 million study area, the document identifies the nearby Bullsbrook townsite as a centre for expansion for the north-east metro area. Muchea is expected to reap the benefits of this growth through the expansion of the Bullsbrook Intermodal Terminal and completion of the PDNH. This will enable greater accessibility to P3, and promote Muchea as an emerging employment node for the expanded Bullsbrook townsite and surrounding areas.

4.1.3. Wheatbelt Regional Planning and Infrastructure Framework (2015)

The Wheatbelt Regional Planning and Infrastructure Framework provides an overview of regional planning issues and a basis for ongoing planning and development. The MENSP area is recognised as being important in providing serviced industrial land to provide opportunities in the short and long term for the establishment of new industries in, and relocation of existing industries, to the Wheatbelt. It is a high level document and there are no implications of direct relevance to the Scheme Amendment area.

4.1.4. Muchea Employment Node Scheme Amendment (MENSP) (2011)

As noted, the Scheme Amendment area forms part of P3 of the MENSP (refer **Figure 6 - MENSP**). The MENSP provides the 20 year land use planning framework for industrial development in order to concentrate local employment opportunities within the Shire of Chittering and its surrounds. Intended land uses are industrial service based, such as transport, livestock, fabrication, warehousing, wholesaling and general commercial use.

The subject land is identified for 'Proposed Industrial Development', and is affected by the following:

- 500m poultry farm buffer (Note: the Poultry Farms are under lease to Ingham Poultry until end 2019)
- 500m rural residence buffer
- Proposed access road (service road) running parallel with GNH
- Reserves for conservation, recreation, foreshore management or regional open space over minor waterway (non-perennial)
- The western portion of the land is also affected by a 1000m townsite buffer and the 500m rural residence buffer

4.1.4.1. Separation Distances

The separation distances (or buffers) noted above limit sensitive uses, such as residential development, being allowed within proximity to uses such as industry and poultry farms. Reference to the Rural Residence and Townsite Buffers is limited within the MENSP plan to the following text:

'Residences in and surrounding the Scheme Amendment area are deemed to be sensitive receivers. They pose a constraint to the future development of the Scheme Amendment area, with regard to noise emissions subject to assessment under the Environmental Protection (Noise) Regulations 1997 and State Planning Policy 5.4. This must be taken into further consideration in the determination of land use applications for future industrial development'

As noted, the Poultry Farms will be removed to facilitate development of the land for industrial purposes.

4.1.4.2. Development Contribution Plan

The MENSP notes that a Development Contribution Plan (DCP) is intended to be prepared to require developers to provide contributions for improvements and intersection treatments for existing and future primary regional roads.

It is understood that the Shire has, however, since decided not to prepare a DCP, and therefore any infrastructure requiring cost sharing (if required) will need to be addressed by private landowner agreements in accordance with State Planning Policy 3.6: Development Contributions.

4.1.4.3. Development Provisions

Provisions for P3 include:

- Low water type industries with a minimum lot size of 10,000m2 unless wastewater can be otherwise managed
- ATU's are required with secondary pond treatment
- Development to not conflict with the PDNH
- The access road (loop road) shall have a road reserve of 30m
- Structures higher than 90m require referral to RAAF

Land use permissibility is discussed above.

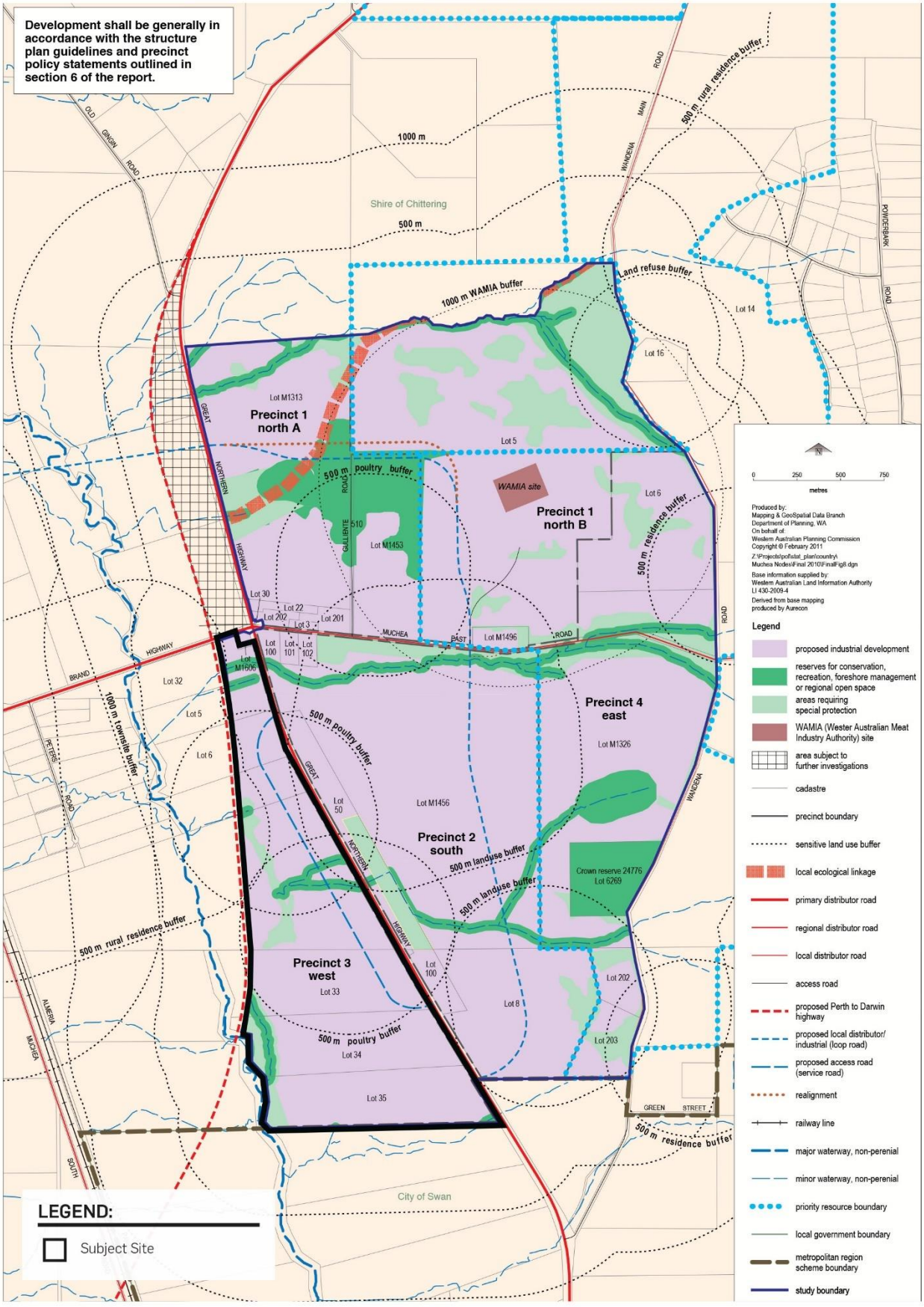
Servicing and vehicle movement are addressed in sections 7 and 10 below and comply with the above development provisions. The other requirements will largely be addressed at the development application stage.

4.1.4.4. Zoning

The MENSP proposes a 'Future Industry Zone' for the area which would be a new zone in LPS6, requiring Scheme Amendments to be prepared over individual precincts.

Following liaison with the DPLH and the Shire of Chittering, it has been agreed that the proposed land be zoned 'Light Industrial' under LPS6.

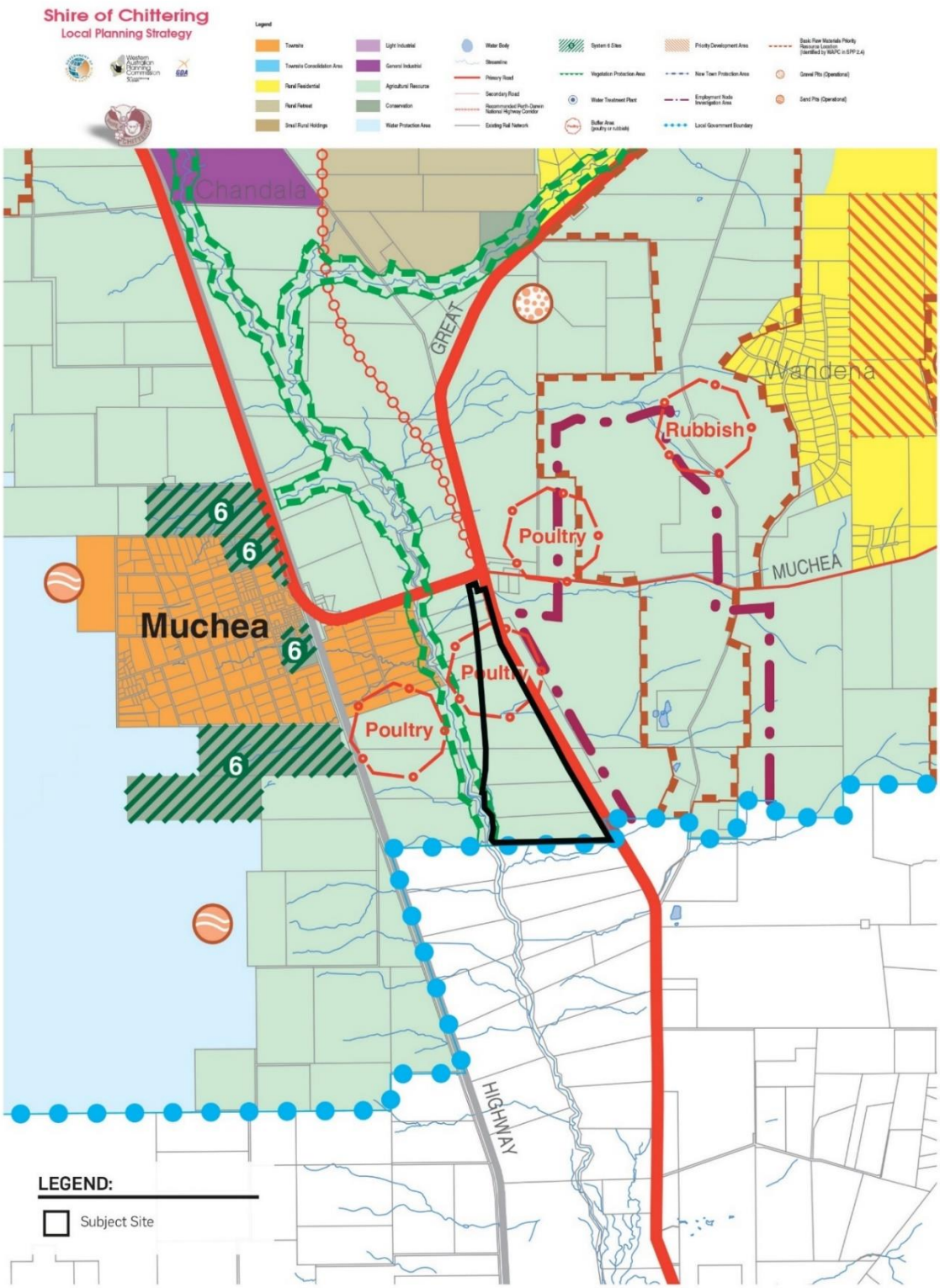
Figure 6 – Muchea Employment Node Scheme Amendment



4.1.5. Local Planning Strategy 2001-2015 (2004)

The Shire of Chittering LPS identified the current Ellen Brook water course on the property, GNH and current poultry operation buffers, and the current extent of the Agricultural Resource Zone. The LPS preceded the MENSP (refer **Figure 7 – LPS Extract**) and has been superseded in mid 2019 by the updated LPS (refer section 4.1.6).

Figure 7 – LPS Extract (2001 – 2015)



4.1.6. Local Planning Strategy

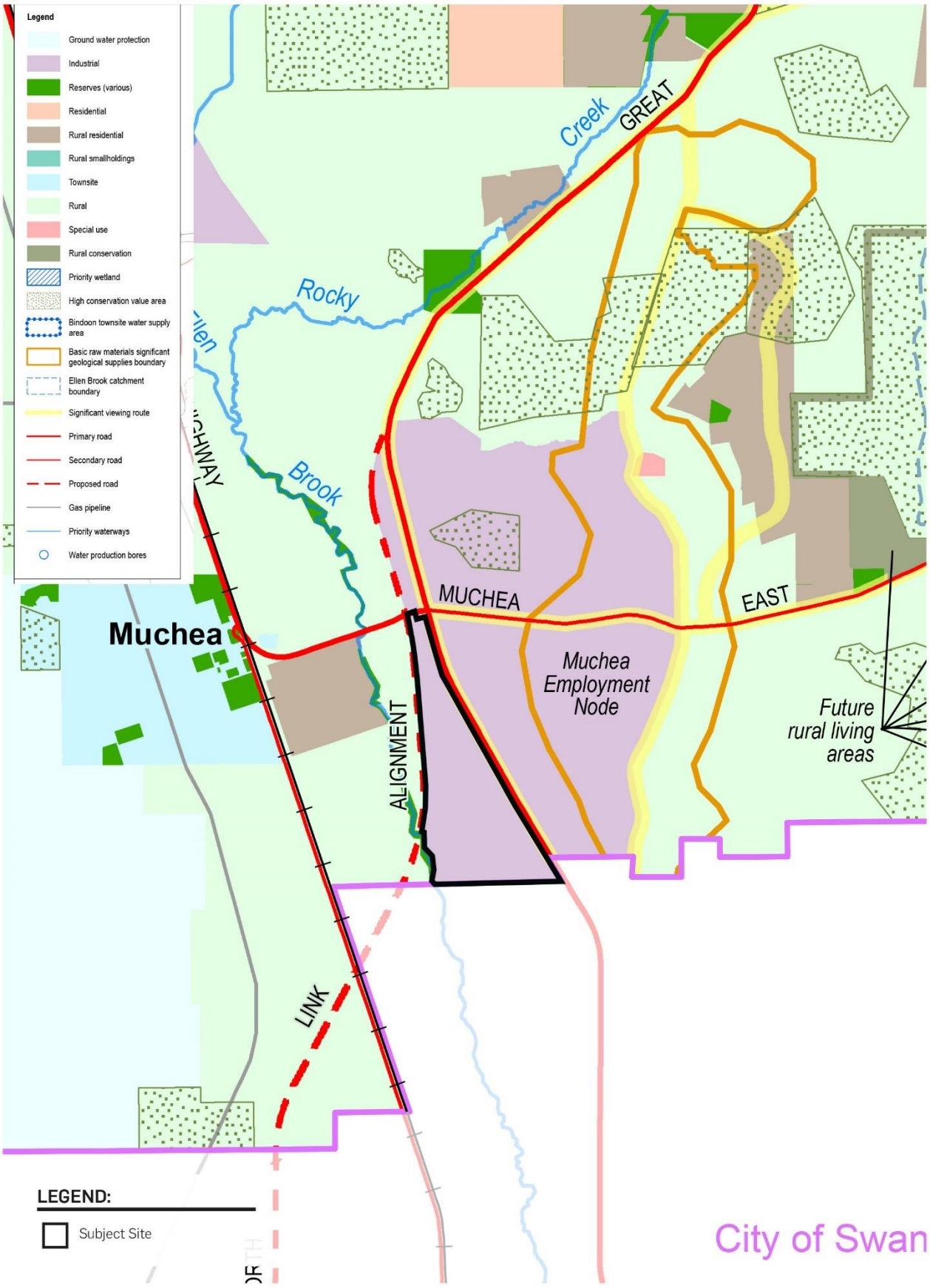
The Shire of Chittering's LPS identifies the MENSP as a planning precinct, referred to as Muchea Industrial Park (MIP) (refer **Figure 8 – Draft LPS Extract**). MIP is expected to both facilitate and contain all of the Shire's future industrial activity. Upon its completion in 2019, the PDNH and an intended GNH upgrade is expected to stimulate the MIP's industrial development to become a 'major employment hub of (Perth's) north-east corridor'.

The Draft LPS also provides strategic provisions and actions for the MIP's development. This includes protecting and preserving areas of high environmental value within P3. Future development of precincts within the MENSP will require consideration of the following:

- Ensure 324ha of vegetation within the MENSP (MIP) is reserved for conservation
- Have primary regard for the Ellen Brook catchment, including water quality in planning industrial land uses
- Be separated from all residential and rural residential areas by a 1km buffer to ensure sufficient separation of incompatible uses
- Reflect the potential for mineral sands to exist on the coastal plain
- Provision of an acceptable means of wastewater disposal, stormwater management and drainage, effluent disposal and water supply
- Removal of uses that are permissible within the 'Agricultural Resource Zone', but are not compatible with primary production
- Subdivision design of P3 to accommodate servicing by RAV vehicles
- Establishment of compatible design features over screening design elements such as fencing, vegetation, buffers and open space

The Scheme Amendment has been prepared in the context of the Draft LPS and addresses the above considerations.

Figure 8 – LPS Extract (2019)



4.2. PLANNING POLICIES

4.2.1. State Planning Policy No.3.7 – Bush Fire Risk Management

As P3 is identified to be within a designated bushfire prone area, the Scheme Amendment will be accompanied by a Bushfire Management Plan. Compliance with bushfire protection criteria will is required in accordance to the policies set out within SPP 3.7. This will include a Bushfire Hazard Level assessment and BAL Contour Map. Bush Fire Management is addressed below.

4.2.2. State Planning Policy No.2.4 – Basic Raw Materials

SPP2.4 sets out matters which are to be taken into account when considering zoning, subdivision and development applications in the vicinity of identified basic raw material resource areas. P3 is currently zoned Agricultural Resource; a zone which permits the extraction of basic raw material resources, although no extraction areas are identified within P3. The Tiwest processing plant is the nearest raw material extraction land use to the Scheme Amendment area, located 3km to the north.

4.2.3. Draft State Planning Policy No.2.4 – Basic Raw Materials (October 2018)

SPP2.4 was recently reviewed by the WAPC, with a draft revised version of the policy advertised until late January 2019. The Policy requires the conservation of key resources areas, and the protection of existing resource and extraction areas from development or incompatible land uses. To achieve this, key considerations include:

- Avoiding development on low lying areas that require large volumes of fill, or by using different design and construction methods, and alternative earthworks strategies such as subsoil drainage
- Use of existing extraction sites and significant geological supply areas, favouring those sites located within the local vicinity to minimise transportation requirements and potential related impacts on communities, amenity, safety and the environment
- Existing significant geological supply areas and extraction site (and relevant buffers) should not be developed for any other purpose unless the proposed use is compatible, or until the resource is extracted

Advice received from the Department of Mining, Industry Regulation and Safety (DMIRS) confirms that there are no resources present within the Scheme Amendment area, following extensive mineral exploration along the foot of the scarp over some years. If, through development or further site excavations, an individual landowner finds a quality deposit, then DMIRS advised it would be a private matter between the landowner and the exploration license holder if it were decided to proceed with any removal of the resource. In addition, advice received from the DMIRS confirms that there is no land within P3 affected by separation buffers or key resource areas.

4.2.4. State Planning Policy No.3.6 – Development Contributions

This policy sets out the principles and considerations that apply to development contributions for the provision of infrastructure in new and established urban areas, and the form, content and process to be followed. The funding mechanisms for future infrastructure requirements will be a consideration for the Shire and landowners.

4.2.5. Other State Policies

Table 2 – Other State Planning Policy considerations details other relevant state planning policies.

Table 2 – Other State Planning Policy Considerations

State Planning Policy	Details
SPP 2 Environment and Natural Resource Policy	SPP2 sets out to create sustainable development outcomes by resolving conflicts between land use and protection of natural resources. Ecological, social and economic factors must be considered to allow for integrated decision making. Future land uses within P3 will be assessed based on their adherence to requirements for air quality, water resources, soil & land quality, landscape, basic raw material resources, greenhouse gas emissions and energy efficiency. Given P3's proximity to the Ellen Brook, potential impact from changes in climate and weather from human activities, natural resources, and water resources may also be considered in relation to the area.
SPP 2.5 Agricultural and Rural Land Use Planning	The Scheme Amendment area is currently zoned Agricultural Resource. SPP 2.5 aims to protect and sustainably manage environmental, landscape, and water resource assets within the state's rural areas. SPP2.5 aims to avoid land use conflict in rural areas. As P3 is to be developed for industrial purposes, future development applications will need to address separation requirements. Given the proximity of P3 to the Muchea Town Centre (1km to the north east), separation distances will need to comply with EPA requirements.
SPP 2.9 Water Resources	SPP2.9 outlines policy concerning environmental and natural resources to be considered during Scheme Amendment. This includes identifying and prioritising water resources for potential state, regional, and local significance, as well as ameliorating environmental impacts on site. The Scheme Amendment identifies water resources situated within P3 (incl. Ellen Brook) and an assessment of their value. Integration and protection of water resources within the MENSP is vital to ensure state environmental goals are achieved.
SPP3.7 Planning in Bush Fire Prone Areas	This policy provides the foundation for land use planning to address bushfire risk management in Western Australia. It is used to inform and guide decision-makers, referral agencies and landowners/ proponents to help achieve acceptable bushfire protection outcomes. The subject site is identified as being within a Fire Prone Area. A Bush Fire Management Plan is required to be prepared at the Scheme Amendment and Structure Plan stage.
SPP 4.1 State Industrial Buffer Policy	Buffer areas are inevitably determined by the size, scale, and form of industrial land uses. Separation between the industrial land use and residential or other sensitive land uses will be determined at the development stage.
SPP 5.4 Road and Rail Transport Noise and Freight Considerations in Land Use Planning **And DRAFT revised SPP5.4 (September 2017)**	Road and rail transport corridors play a vital role in moving people and goods safely, efficiently and effectively, while providing wide-ranging economic and social benefits to the community. However excessive noise from road and rail traffic can also have the potential to affect the health and amenity. As P3 is to be developed for industrial purposes, no noise assessments at the Scheme Amendment stage are required, as advised by DPLH.

4.2.6. EPA Guidance for the Assessment of Environmental Factors No.3

This document provides guidelines for separation distances between industrial and sensitive land uses. P3 is located approximately 1km from Muchea and largely in excess of 500m from any sensitive uses, also separated by the PDNH alignment. It is therefore unlikely that any issues relating to separation or buffers will arise.

At the development application stage, proponents will need to give consideration to separation distances between the proposed land use and any affected residential or other sensitive uses in accordance with the Guidance Statement.

4.3. LOCAL PLANNING POLICIES

Table 3 – Local Planning Policy Considerations details the relevant local planning policies (LPP) that impact the subject site.

Table 3 – Local Planning Policy Considerations

Local Planning Policy	Details
LPP 10. Basic Raw Materials and Extractive Industries	LPP10 provides development guidelines for all material extraction industry within the Shire of Chittering. Supported by the previous Local Planning Strategy 2001-2015 (2004), Extractive Industries are an "A" use in Agricultural Resources zoned land, with preferred development to have access to either Brand or GNH. LPP 10 highlights the TiWest (Tronox) Processing Plant in Muchea as the only extractive industry location within the Shire. The plant is located on Brand Highway, approximately 3km North of the MENSP. The policy has no direct implications for the subject land.
LPP 16. Roads and Drainage	LPP16 provides guidelines for the construction and development of roads and new drainage systems within the Shire. Drainage is to be constructed in accordance with Water Sensitive Urban Design (WSUD) principles.
LPP 18. Setbacks	Introduced to protect the Shire's environmental and aesthetic assets, LPP18 establishes setback requirements in addition to those set out in TPS 6. Aside from maintaining the rural character of the Shire, LPP18 also seeks to protect water courses and wetlands, while also preserving natural vegetation from increased development. Whilst the setbacks do not refer to industrial zones, the setback to a drainage easement is 10m. Setbacks also apply to bores and wells in all zones.
DRAFT LPP 33. Muchea Industrial Park Design Guidelines and Road and Drainage Guidance Note	Draft LPP33 and its associated Road and Drainage Guidance Notes were advertised during December 2018. The intention of the Design Guidelines is to achieve a reasonable level of design and visual consistency, and requirement for structures to be constructed of new materials. Submissions on the Policy are currently being considered and the Policy finalised.

4.4. KEY OUTCOMES FROM REVIEW OF STRATEGIC AND STATUTORY PLANNING CONTEXT

Overall, the proposed development of P3 for industrial purposes is consistent with P3's strategic and statutory context. The development of P3 will address the current and expected future shortage of industrial land within this area, and provide for business growth, increased employment and industrial support for logistics operations, consistent with the objectives of the various strategic documents reviewed, and with the

substantial improvements in the regional transport network provided by the construction of the PDNH and the proposed upgrade of GNH.

The key considerations arising from the above review are relevant:

- The MENSP proposed P3 to be developed for industrial land use of the nature proposed in this Scheme Amendment
- A number of development provisions are applicable to the land, including the low water type industries with a minimum lot size of 1ha (unless wastewater can be managed), ATU's required with secondary pond treatment, access road reserves to be 30m, structures higher than 90m to be referred to RAAF and development to ultimately not conflict with the PDNH. These requirements will largely be addressed at the development stage
- The land is impacted by two 500m buffers associated with a poultry farm and rural residence, and a 1000m townsite buffer, which establish separation distances between residential and sensitive uses, and industrial development proposed on individual lots within P3. The poultry farms within P3 will be discontinued in due course to enable the land to be developed for industrial purposes. Other separation distances will be addressed via the EPA's Guidance Statement via the development approval process
- There is a focus on protecting and preserving areas of high environmental value within P3, including land adjacent to Ellen Brook within the southern portion of P3
- In relation to basic raw materials, advice received from the DMIRS confirms that there are no resources present within the area, nor is there land within P3 affected by separation buffers or key resource areas
- Integration and protection of water resources within the MENSP is essential

Each of these items is addressed, and demonstrated to be complied with, in this Scheme Amendment.

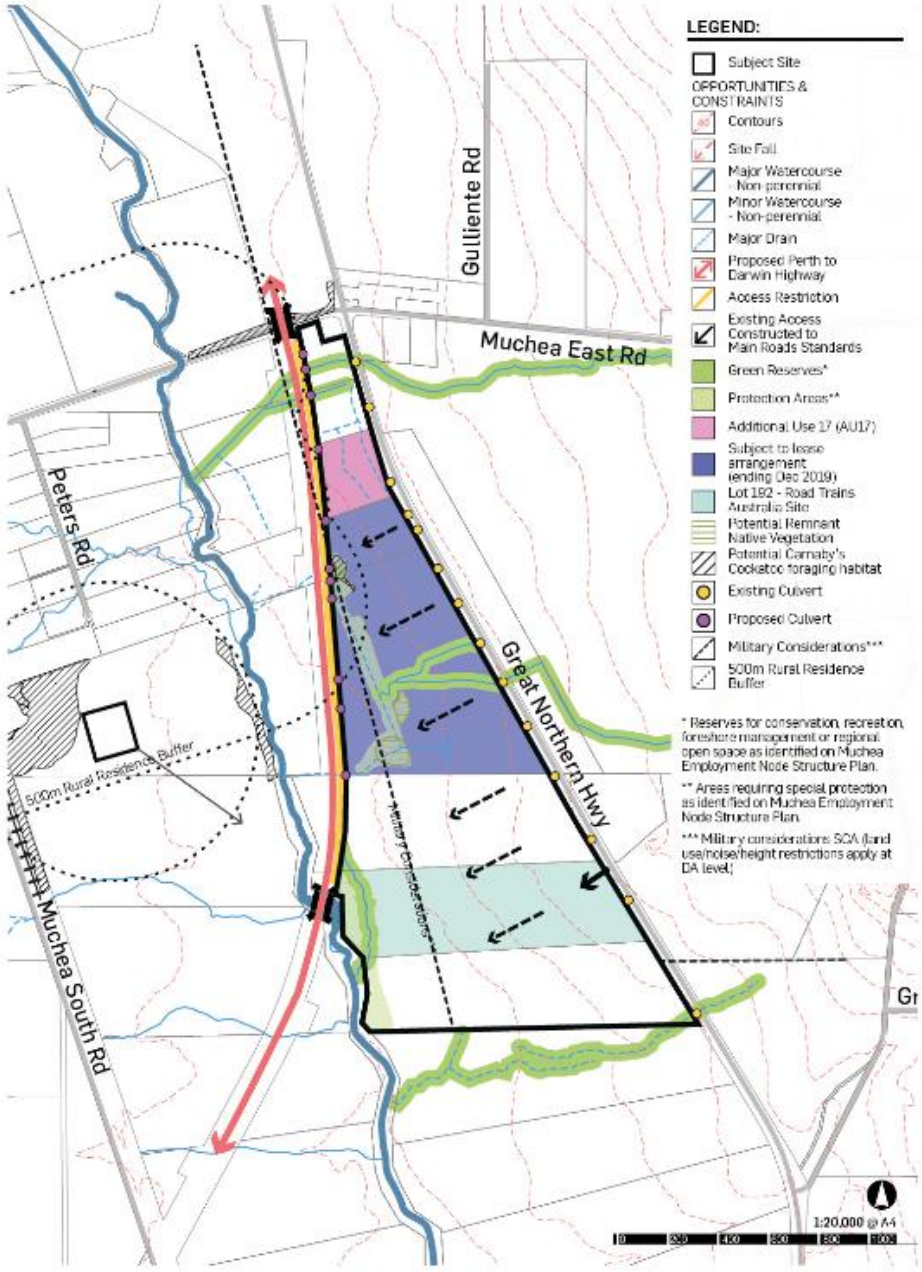
5. SITE CONDITIONS AND CONSTRAINTS

Key opportunities and constraints of the Scheme Amendment area are detailed on **Figure 9 – Opportunities and Constraints Plan**.

The following section outlines these opportunities and constraints in further detail, informed by the technical reports appended to the Scheme Amendment including:

- Environmental Assessment and Management Strategy (EAMS) prepared by Bayley Environmental (**Appendix B – EAMS**)
- Transport Impact Assessment (TIA) prepared by GTA (**Appendix C – TIA**); and
- Engineering Servicing Report prepared by Cossill & Webley (**Appendix D – Engineering Servicing Report**)

Figure 9 – Opportunities and Constraints



5.1. LANDFORM AND SOILS

5.1.1. Topography

The Scheme Amendment area ranges in elevation from RL59m AHD at the eastern boundary with GNH to RL 42m AHD abutting PDNH. P3 slopes gently to the west-southwest at gradients of up to 2.5%, decreasing to less than 0.4% near Ellen Brook. The subject land provides suitable grade for drainage purposes, though some re-grading of the natural topography may be required for industrial land uses.

5.1.2. Landscape

P3 is visible from GNH and Brand Highway. The view is screened in part by roadside trees and vegetation within P3. The landscape consists mostly of a mix of cleared paddocks with scattered trees and existing intensive commercial operations including Road Trains of Australia (RTA), Aussie Modular Solutions (AMS) and Inghams' Enterprises (poultry farms). The PDNH works have caused a major change to the landscape, particularly near the northern end of the Scheme Amendment area.

5.1.3. Geology, Landform and Soils

P3 is located on the Pinjarra Plain, with soils of pebbly silt and sand over pebbly silt, and a spine of sand in the vicinity of the Ellen Brook, within the Guildford Formation. These soils are described by the Geological Survey of Western Australia as "*strong brown silt with common fine to occasionally coarse grained, sub-rounded quartz, heavily weathered granite pebbles, some fine to medium-grained quartz sand, of alluvial origin".*

Testing found silty soils containing varying proportions of clay, with the clay content increasing with depth. The low-lying western parts of P3 are underlain in places by an ironstone (laterite) hardpan at depths of around one metre. At the western edge of P3 the alluvial deposits are overlain by a thin veneer of grey sand transported by floods in Ellen Brook.

Appendix E contains the Geotechnical Assessment undertaken by Structerre over the Scheme Amendment area.

5.1.4. Soil Permeability

The permeability of P3 soils is variable, depending on the clay content. Pebbly Silt contains lower permeability material, and may increase the area required for stormwater infiltration. The ironstone hardpan in low-lying areas would impede vertical groundwater movement but its restricted extent means that its effect would be localised. In the south-east of P3, clay subsoils impede groundwater flow and cause a perched water table to develop in that area.

The presence of a water table at the ground surface in winter across much of P3 means that all infiltration of drainage and effluent will be within fill, so the permeability of the natural soils is of reduced importance. The soil conditions across the Scheme Amendment area are consistent with the general Muchea area, and do not pose an impediment to industrial development.

5.1.5. Contaminated Sites

Historic Landgate aerial photography shows that the project area has been cleared and used for farming since at least 1965. The DWER Contaminated Sites Database shows no record of any contaminated sites in the project area.

5.1.5.1. Acid Sulfate Soils

Most of P3 is mapped as Low to Nil risk of Acid Sulfate Soils (ASS). Areas within 50-250m of Ellen Brook are mapped as Low to Moderate risk. Bore sampling in August 2018 found no indicators of potential or actual ASS in the groundwater and no further investigation of ASS is considered necessary.

5.2. EXISTING MOVEMENT NETWORK

5.2.1. PDNH

PDNH is a 37km link currently under construction by Main Roads WA (MRWA) from the intersection of Reid and Tonkin Highways to GNH and Brand Highway at Muchea, to the immediate north of the Scheme Amendment area. This new route will increase efficiency, and support the development of the MENSP when

completed by the end of 2019. Once completed, this road is expected to carry in the order of 11,500vpd by 2031 south of Brand Highway.

The proposed Highway will consist of a four-lane divided rural road, with an off-road Principle Shared Path (PSP) within the reserve to the east of the main road. Batters for the road and PSP are contained within the proposed reserve.

Construction of the PDNH will sever access to a number of the parent lots within the Scheme Amendment area, which MRWA proposes to service with a slip road off Brand Highway to the west of the PDNH alignment. There will be no access onto PDNH at Brand Highway, with the nearest interchange proposed an additional 1 kilometre north.

5.2.2. Great Northern Highway

GNH is a Primary Distributor road controlled by MRWA with a posted speed limit of 110km/h except on the southern approach to the intersection of Brand Highway/Muchea East Road where it drops to 80km/h. It is also currently the key route to the Perth Metropolitan Region. GNH experiences 8,605vpd with 25.6% heavy vehicles (including RAVs).

GNH transitions from a four lane road at the south-eastern corner of P3 to a two lane road at the north-eastern corner. There are overtaking lanes for both northbound and southbound traffic flows near the Scheme Amendment area. The pavement is in good condition and includes sealed shoulders and table drains both sides of the road. There is an existing uncontrolled T-intersection with passing lanes into Lot 192 (the RTA site), with all other lots being accessed via standard driveway cross-overs.

5.2.3. Brand Highway

The Brand Highway forms the northern boundary of P3, and consists of a single carriageway two lane rural style unkerbed road. The existing intersection of Brand Highway and GNH is controlled by traffic signals. A fly-over of PDNH across Brand Highway is proposed as part of the PDNH construction, which requires reconstruction, by MRWA, of a portion of the Brand Highway abutting the Scheme Amendment area.

5.2.4. Muchea East Road

Muchea East Road is a Regional Distributor and has a posted speed limit of 80km/h for approximately 1.5km east from the GNH intersection then 100km/h and 90km/h when it reaches Lower Chittering.

5.2.5. RAV Network

Most major roads in the vicinity of the Scheme Amendment area allow the movement of RAVs up to RAV7. GNH is presently a high/wide load route for the transit of over-dimensional loads. This section of GNH is proposed by MRWA to be incorporated in the RAV10 network.

5.3. BIODIVERSITY AND NATURAL ASSETS

5.3.1. Vegetation

The Scheme Amendment area is mostly cleared of native vegetation, consisting of current and former farm paddocks and industrial sites.

Remnant native vegetation consists of a few mature paddock trees (Marri, Flooded Gum and Wandoo), including several very large Marri trees that have been retained within Lots 802 & 803 and a few large Wandoo trees in Lot 804. Native regrowth is present near the large drain on Lot 800 with a small (0.5ha) thicket of species over grasses. Nearby is a smaller thicket on a drainage line with regrowth.

The area around the large drain on Lot 800 has been densely planted with native tree species. The drain itself contains a heavy growth of sedges and grasses. Other areas near the large drain and in other low-lying parts of P3 contain dense growths of declared pests, along with *Juncus kraussii* in some areas.

Lot 35 contains a few large isolated Flooded Gums and a 2.5ha patch of open woodland of young *E. rudis* regrowth over grass. Elsewhere on P3 there are lines and clumps of planted trees, mostly Flooded Gums, Bluegums, River Red Gums and other non-local eucalypts. There are also scattered regrowth of sedges and isolated shrubs.

Overall the condition of the vegetation is classed as Cleared to Completely Degraded. There is no vegetation in Good or better condition. Adjacent to Ellen Brook there is a sparse to dense woodland species which thins rapidly with distance from the Brook and is mostly outside the Scheme Amendment area. The

ground cover over most of this area consists of a heavy growth of pasture grasses and weeds, which extend into the waterway itself.

The condition of the Brook vegetation is mostly Degraded to Completely Degraded, with a few areas in Good condition. Lots 800 & 801 are accessible to cattle and are in poorer condition than the rest due to grazing. On Lots 801-804 there is a dense growth of *Watsonia meriana ssp bulbillifera* in areas not accessed by cattle.

The vegetation of the project area is mapped as Yanga Complex, described by Heddle et al. (1980) as a low open-forest.

5.3.2. Rare and Significant Flora

The DBCA's Naturemap database lists no Declared Rare Flora, Priority Flora or other significant flora species as occurring within the Scheme Amendment area. Given the farmland cleared nature of the area, no rare or significant species are likely to be present. The Naturemap database lists six Declared Rare Flora (DRF) taxa and twelve Priority Flora taxa as occurring within a 5km radius of the Scheme Amendment area.

5.3.3. Fauna

The Scheme Amendment area contains little habitat for native fauna apart from scattered mature paddock trees and small areas of regrowth and planted vegetation around the drains near the PDNH reserve. The largest area of fauna habitat is the fringing vegetation along Ellen Brook, which borders the south western part. Fauna including kangaroos are likely to use this habitat as refuge and venture out to feed on paddocks.

Bandicoot (Quenda) diggings were observed around Sharp Rush thickets along a drain in Lot 800.

The DBCA's Naturemap database lists three Threatened Fauna and one Priority Fauna species as occurring within a 5km radius of the Scheme Amendment including Carnaby's Black Cockatoo, the Forest Red-tailed Black Cockatoo, Australasian Bittern and the Blackstriped Burrowing Snake. The two species of black cockatoo both nest in large hollows in mature eucalypts. The few large remaining eucalypts present in the project area might contain suitable hollows but their isolation and the lack of nearby food resources mean that they are unlikely to be used for nesting. Other species are not expected to be present within the area as the habitat is not suitable.

5.4. GROUNDWATER AND SURFACE WATER

5.4.1. Groundwater

Groundwater occurs at a shallow depth across the Scheme Amendment area. The DWER maps minimum groundwater levels at 39-48m AHD (2-7m below ground), flowing south-west towards Ellen Brook. In winter, the groundwater rises to the ground surface across the lower western parts of P3 and creates surface discharge to creeks, drainage lines and Ellen Brook. In the higher eastern parts of P3, rainfall infiltration is impeded by the low-permeability subsoils, creating a perched water table which flows downslope and discharges as surface flow on the lower parts of P3. The net result of these two processes is that groundwater is at or near the ground surface over much of P3 in winter.

Groundwater levels measured in August 2018 were slightly above the AAMGL, and the MGL is above the ground surface over much of P3. This does not take into account the effects of existing drains and surface runoff, which would generally limit the groundwater levels to at or just below the ground surface.

5.4.2. Surface Water

The high water tables and low permeability soils result in surface flow in channels, and sheet flow across the ground surface during wet winters. Several natural and artificial drainage lines cross P3 from 15 culverts beneath GNH. All drainage from P3 flows into Ellen Brook which is normally confined to the defined channel of the Brook, although high flows can cause inundation of adjacent land.

MRWA modelled the 100-year ARI floodplain of Ellen Brook for the PDNH project. Further flood modelling was carried out by BG&E for the Scheme Amendment area (refer **Appendix F – Ellen Brook Flood Modelling**), in order to define the foreshore reserve.

5.4.3. Water Resources

The Amendment area is within the Lake Mungala sub-area of the Gingin Groundwater Area for the superficial and semi-confined (Mirrabooka) aquifers, and the SA3 South sub-area for the confined

Leederville and Yarragadee aquifers. Groundwater allocations are fully or over allocated, and no new allocations are available. The DWER intends to release a new Gnangara Groundwater Allocation Plan in late 2018, which may further reduce allocation limits.

The DWER Water Register shows a number of licensed bores within the project area, abstracting water from the superficial and Leederville aquifers. For non-potable uses, purchase of water entitlements from existing licensed users within or outside of the Precinct is possible. The landowners group will negotiate with existing licence holders within and outside of P3 with a view to purchasing an existing groundwater allocation, and will submit a groundwater licence application to the DWER in due course. Potable water will be provided by a licensed water provider, addressed in section 10.3 of this report.

5.4.4. Water Quality

5.4.4.1. Groundwater

Groundwater quality within the project area is Moderate, which is to be expected given the soil types and the history of agriculture. Nitrogen and phosphorus concentrations are generally Moderate with the exception of a notably high reading for total phosphorus in the north-west of the project area.

5.4.4.2. Surface Water

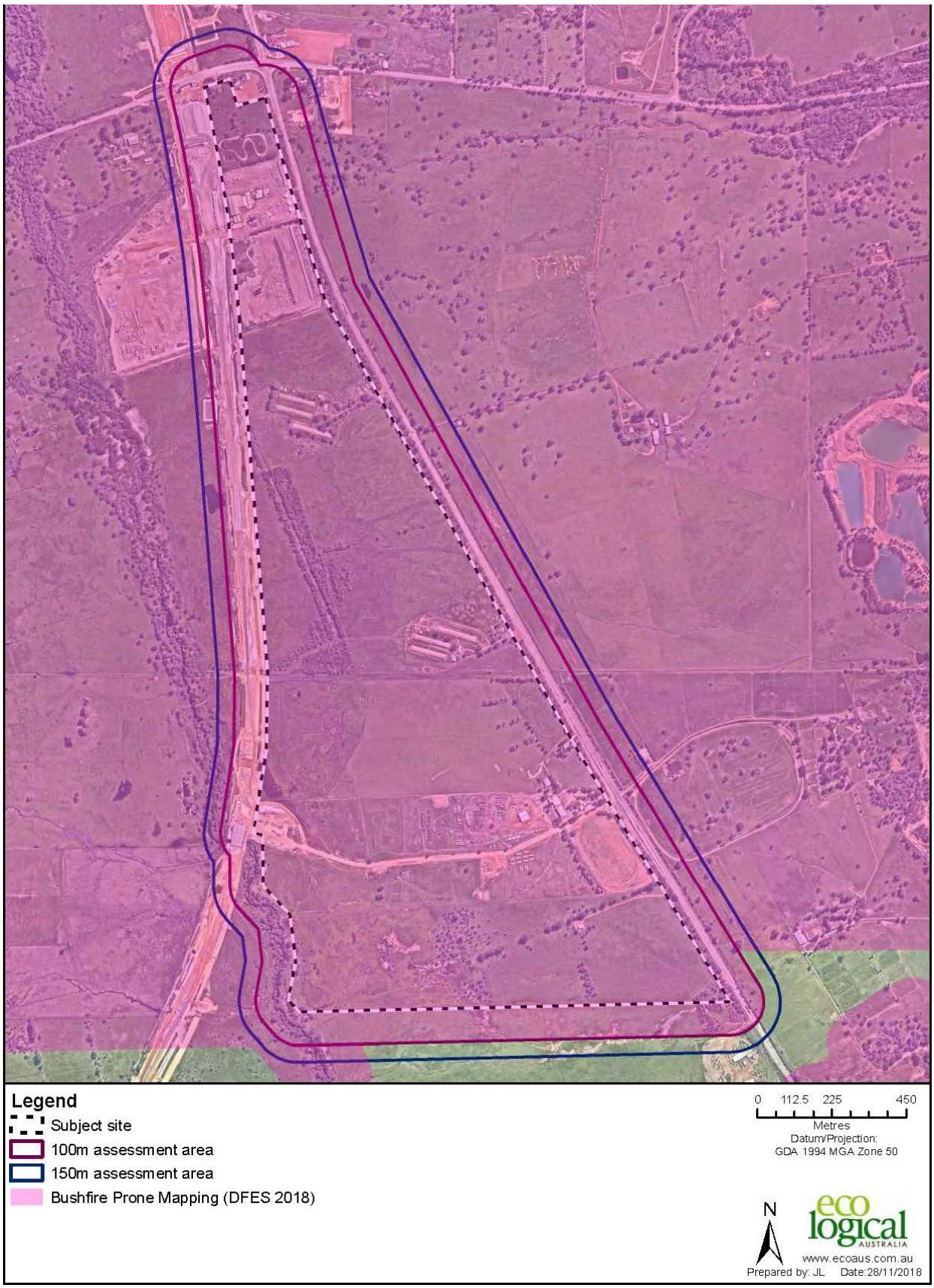
Surface water quality upstream of the project area is variable with Ellen Brook having high phosphorus levels. Suspended sediment levels in surface water upstream and downstream are generally low.

5.5. BUSHFIRE HAZARD

A Bushfire Management Plan has been prepared by EcoLogical Australia for the Scheme Amendment area and is included in **Appendix G – Bush Fire Management Plan.**

The Scheme Amendment area is within a designated Bushfire Prone Area (refer **Figure 10 – Bushfire Prone Area**) which triggers bushfire planning requirements under State Planning Policy 3.7: Planning in Bushfire Prone Areas (SPP3.7) and reporting to accompany the Scheme Amendment in accordance with the associated Guidelines for Planning in Bushfire Prone Areas.

Figure 10 – Bushfire Prone Area



5.5.1. Bushfire Assessment Results

Table 4 and **Figure 11 – Bushfire Hazard Level** contain a summary of the Bushfire Hazard Level (BHL) assessment for each vegetation class or exclusion with ratings of Low to Extreme. Clearing and revegetation will be undertaken within the subject site for development purposes, and consequently the pre-development BHLs are subject to change (refer **Figure 12 – Likely BHL – Post Development**). A post-development BHL, following clearing for subdivision works, will be required.

Table 4 – Bushfire Hazard Level (BHL) Assessment

Table 1: Bushfire Hazard Level (BHL) Assessment

Plot	Vegetation Classification	Effective Slope	Bushfire Hazard Level
1	Class B Woodland	Upslope/flat	Extreme
2	Class G Grassland	Upslope/flat	Moderate
3	Excluded as per clause 2.2.3.2 (e) & (f)	N/A	Low

Figure 11 – Bushfire Hazard Level

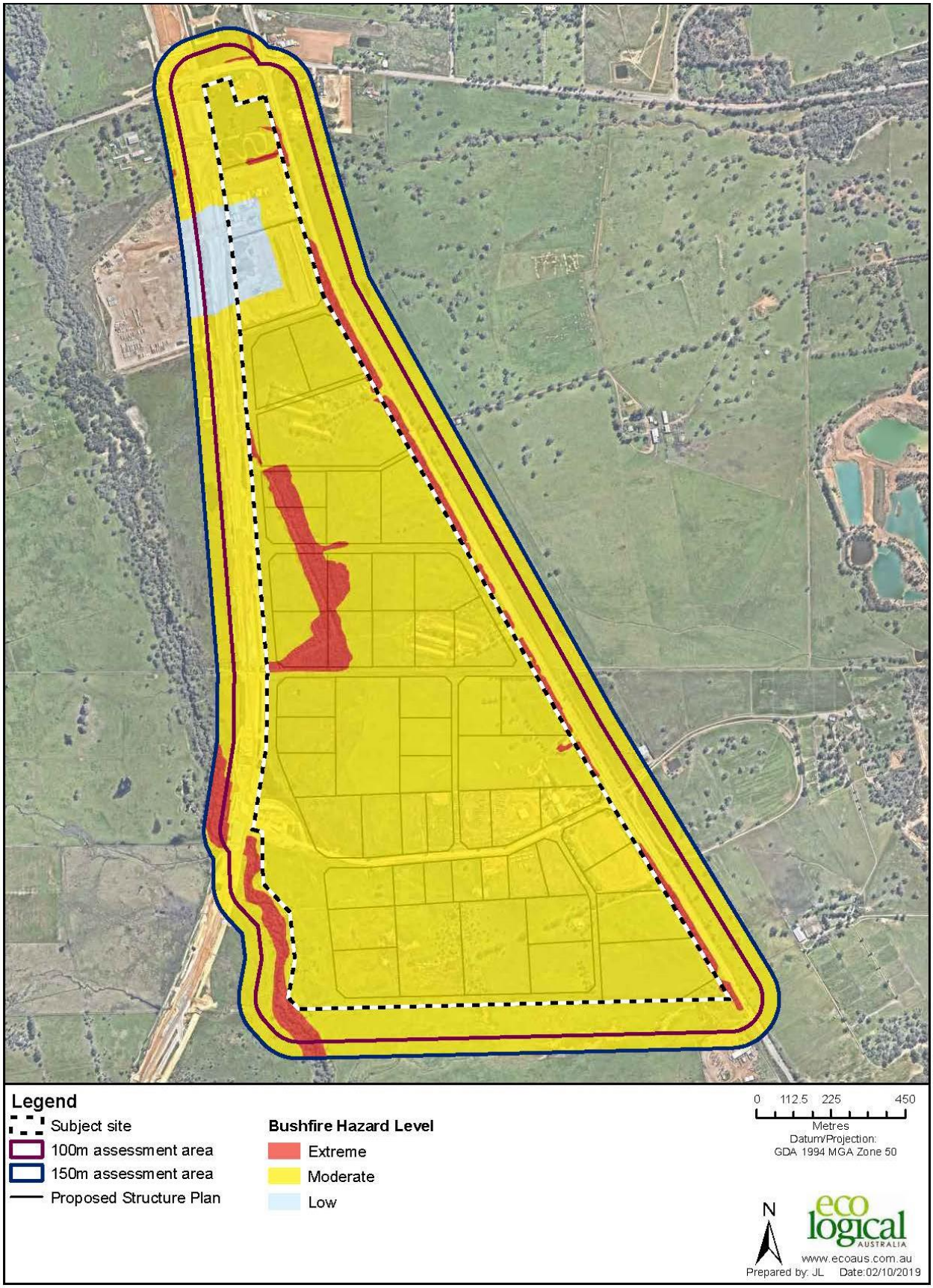
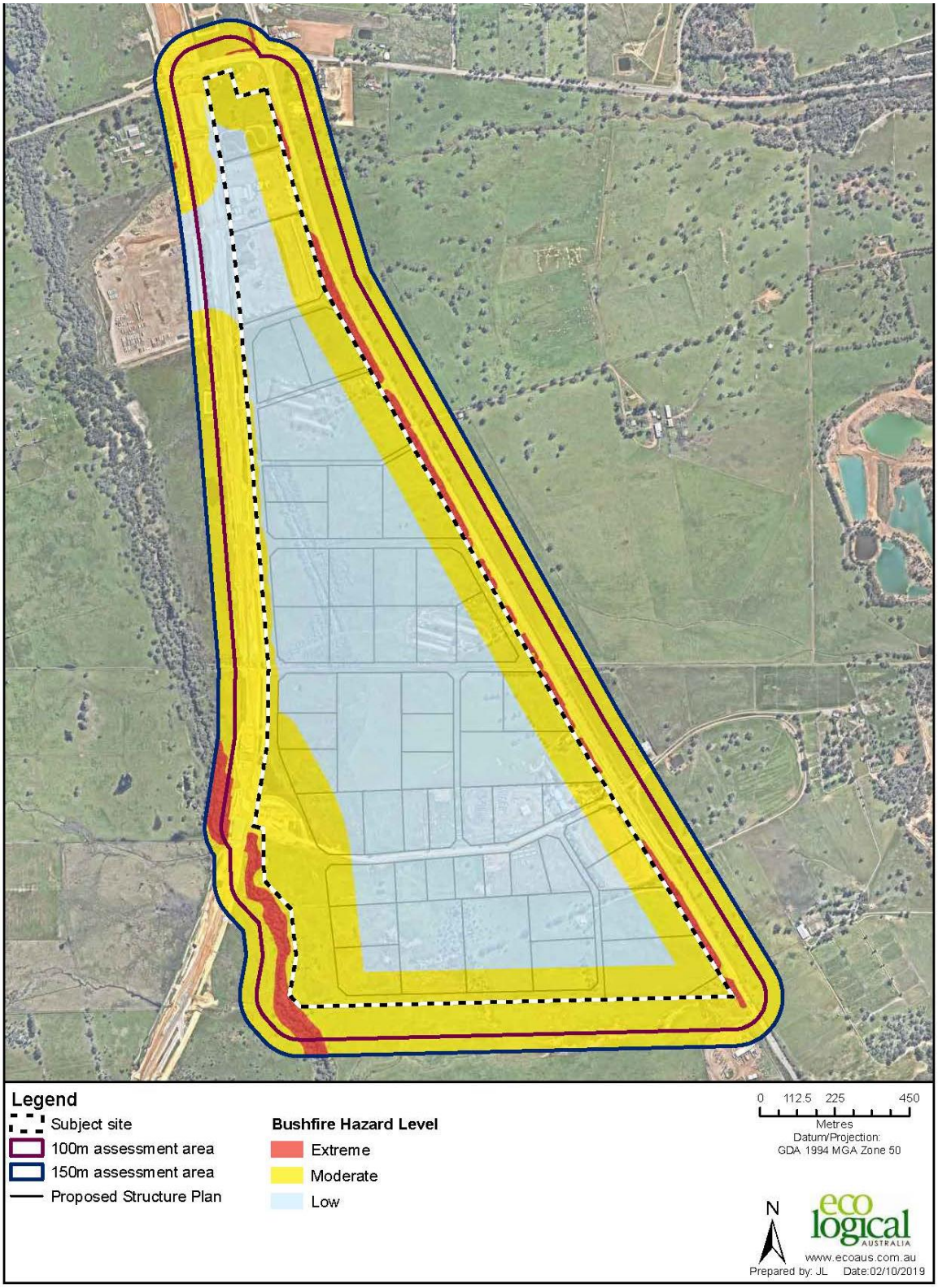


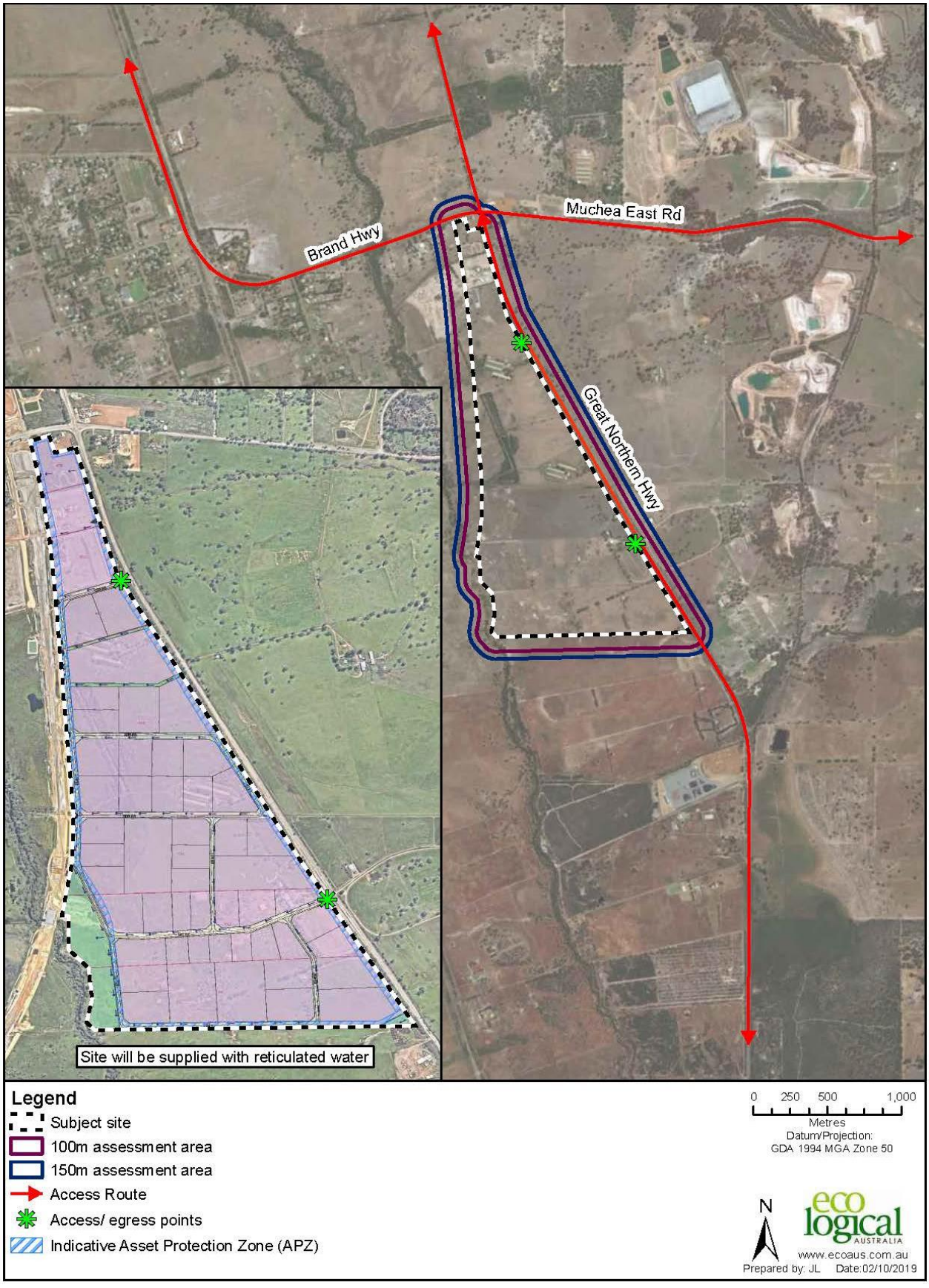
Figure 12 – Likely BHL Post Development



Bushfire management can be addressed through a staged clearing process, adequate separation of future built assets from classified vegetation, and ongoing fuel management that can be undertaken in and around individual development stages.

Bushfire hazards within and adjacent to the Scheme Amendment area are considered to be readily manageable through standard management responses and compliance with acceptable solutions outlined in the Guidelines and AS 3959-2009. Bushfire management measures contained within the BMP demonstrate that the proposed measures meet the intent of each element of the bushfire protection criteria (refer **Figure 13 – Bushfire Management Measures**).

Figure 13 – Bushfire Management Measures



5.6. INDIGENOUS HERITAGE

The DPLH's online database shows one registered site (ID 3525 Ellen Brook: Upper Swan) and seven "other" sites within P3. The DAA has advised that registered sites do occur within the subject land, in connection with Ellen Brook and tributary creeks. Any disturbance of the registered sites will require approval under Section 18 of the Aboriginal Heritage Act 1972.

5.7. ACOUSTICS

Certain industrial uses generate noise via traffic, machinery, power tools, ventilators and impacts. The eastern part of P3 currently experiences high levels of noise from GNH, which carries a high volume of heavy traffic including road trains. With the opening of the PDNH, the noise from GNH will diminish significantly, with the noise impact shifting to the western side of the project area near the PDNH.

Noise sensitive premises (residences) are located in Muchea, to the north-west of P3. Isolated residences are also located east of GNH, 70m east and 150m south-east of the project area. Other noise sources include a clay quarry located 1km east and air traffic (including jets) from Pearce RAAF Base located 6.5km south. The project area is in line with the main runway at Pearce. In the case of P3, noise emissions are expected to be relatively low, given that the area is primarily expected to accommodate logistics operations.

Reference to the Rural Residence and Townsite Buffers within the MENSP provide the following in relation to separation distances for noise considerations:

'Residences in and surrounding the Structure Plan area are deemed to be sensitive receivers. They pose a constraint to the future development of the Scheme Amendment area, with regard to noise emissions subject to assessment under the Environmental Protection (Noise) Regulations 1997 and State Planning Policy 5.4. This must be taken into further consideration in the determination of land use applications for future industrial development'

5.8. DUST

Industrial land uses may generate dust, depending on the activities carried out and the condition of the ground surface. Potentially dusty activities include processing (materials handling), unsealed roads and exposed soil surfaces. The silty soils of the project area are susceptible to dust generation when disturbed. The main dust risk will be during construction work. Sensitive dust receptors are the town of Muchea and residences located east of PDNH. A Construction Management Plan will be required at the development stage in this regard.

6. PROPOSED SCHEME AMENDMENT

6.1. ZONING AND LAND USE

6.1.1. Zoning

6.1.1.1. Proposed Light Industrial Zoning

The land the subject of this Scheme Amendment is proposed to be zoned Light Industrial under LPS6.

Under LPS6, the objectives of the Light Industrial Zone are:

a) To provide for a range of industrial uses and service industries generally compatible with urban areas, that cannot be located in commercial zones.

b) To ensure that where any development adjoins zoned or developed residential properties, the development is suitably set back, screened or otherwise treated so as to not detract from the residential amenity.

Whilst LPS6 doesn't specifically require a Structure Plan to be prepared for the Light Industrial Zone, the fragmentation of land and the various land use and development complexities associated with the land warrant preparation of a Structure Plan in accordance with the *Planning and Development (Local Planning Schemes) Regulations 2015.*

6.1.1.2. MENSP

It is noted that the MENSP proposes a 'Future Industry Zone' for the area which would be a new zone in LPS6, requiring Scheme Amendments to be prepared over individual precincts.

Following liaison with DPLH and the Shire of Chittering, it has been agreed that the land should be rezoned to the 'Light Industrial' Zone.

6.1.2. Land Use and Development

The land will be developed for industrial purposes, consistent with the Light Industrial zone, as amended by Amendment 65, which at the time of writing this report, was expected to be imminently finalised and gazetted.

The land uses set out in LPS6 for the Light Industrial zone, as amended, are considered to be the most appropriate uses to the proposed P3 area. There are, however, a number of other uses considered to be appropriate to the P3 area which currently are not considered under the Light Industrial zone. Amendment No.67 therefore proposes to allow the following uses to be considered as follows:

- Introducing a new land use of Concrete Batching Plant as a 'D' use in the Light Industrial zone
- Introducing a new land use of Workforce Accommodation as a 'D' use in the Light Industrial zone
- Allowing Fast Food Outlet as a 'D' use in the Light Industrial Zone.

The above uses are considered to be appropriate within P3 and consistent with the purposes set out in the Structure Plan and MENSP for this area.

Whilst the MENSP sets out land use permissibility within the MENSP area, land uses and permissibilities are currently inconsistent with LPS6, and therefore Amendment No.67 seeks to rationalise and clarify these provisions as set out above.

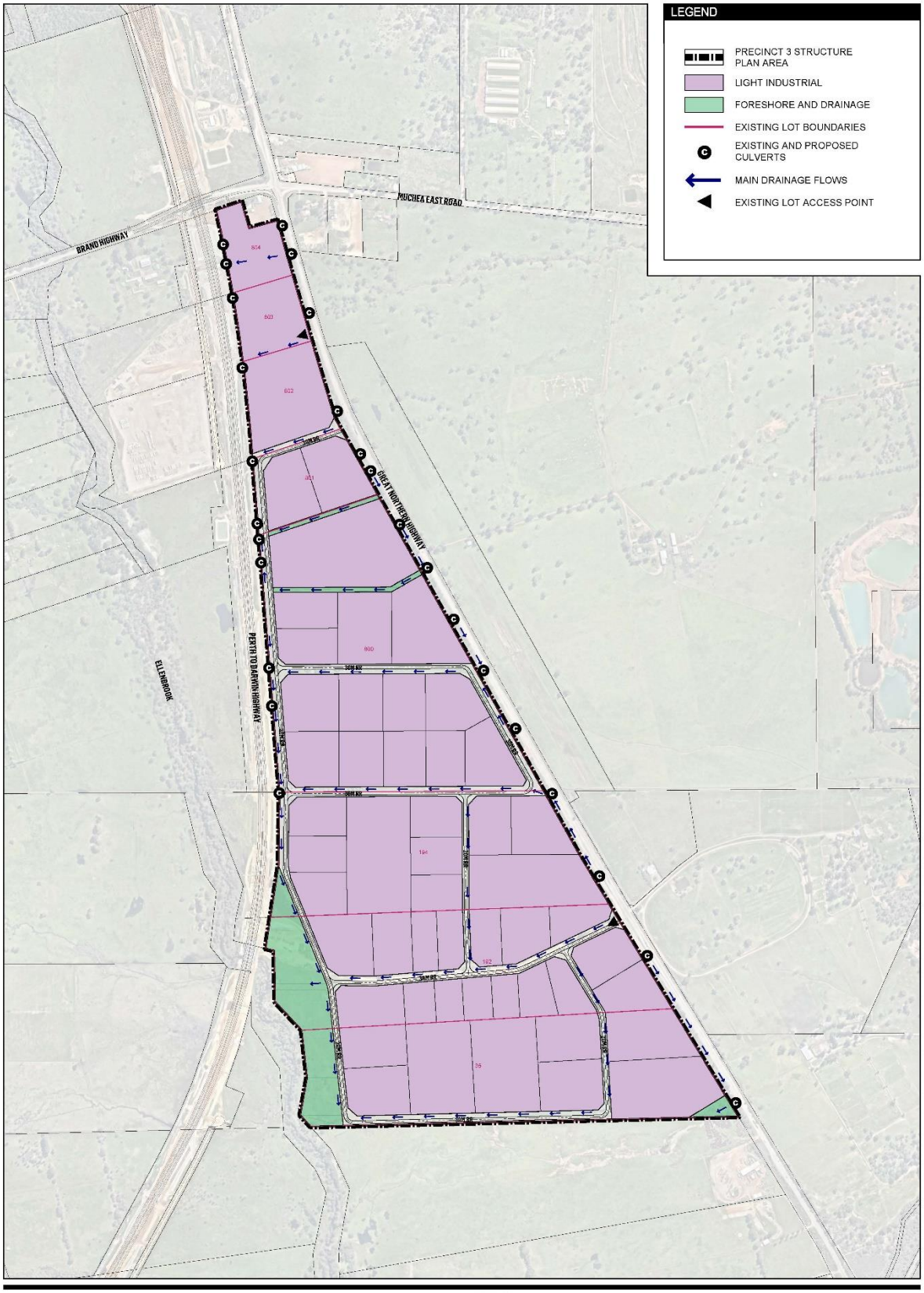
Land use and development standards within the 'Light Industrial' zone are required to be in accordance with LPS6.

6.2. DESIGN CONCEPT

The Scheme Amendment provides the framework for the development of the P3 area for industrial land uses.

A preferred Design Concept was identified through the design exploration phase. The design Concept Option is considered to be one potential spatial outcome for the subject land at maturity (refer **Figure 14 – Design Concept**). The plan should be used only as a guide for interpretation and decision making, but in no should be viewed as a requirement or standard.

Figure 14 – P3 Concept Plan



7. MOVEMENT NETWORK

7.1. PROPOSED ROAD NETWORK

Access to the Scheme Amendment area will be via GNH. This access is proposed to be via two intersections, a northern intersection closer to Brand Highway and a southern intersection near the southern boundary of the Scheme Amendment Area. The loop road through the proposed Scheme Amendment area will cater for vehicles up to RAV10 size with other roads accommodating RAV7 vehicles.

When the PDNH is opened, vehicles up to RAV7 will be allowed placing less reliance on GNH for RAV use. RAV10 vehicles are expected to travel to and from the wider MENSP plan area via the northern approaches whilst RAV7 vehicles would be able to approach P3 from both north and south approaches of GNH.

Road cross-sections will be designed to cater for utility services, on standard verge alignments, accommodating drainage requirements. Due to the proximity of the groundwater table, and the clay foundations of the Scheme Amendment area, the inclusion of subsoil drainage adjacent to the road pavement may be required to protect the road base.

7.2. CHANGES TO EXTERNAL TRANSPORT NETWORKS

Other than the proposed full movement T-junction at the northern and southern intersections leading into the Scheme Amendment area, no other changes to the external transport network are proposed.

The PDNH construction work will not impact the access nor the current form of GNH, but there will be a decrease in traffic volumes on GNH. Currently there is approximately 8,600vpd utilising this section of GNH travelling at speeds up to the 110km/h posted speed limit. Once completed at the end of 2019, traffic volumes on GNH are expected to decrease.

Estimates for 2031 have indicated that there would be approximately 2,250vpd on this section of GNH (this prior to any consideration of MENSP traffic effects). Even with this substantial drop from 8,600 to 2,250vpd in traffic, the function of GNH is expected be retained as a Primary Distributor under the control of MRWA. It is expected the speed limit may also decrease in due course.

8. LOCAL WATER MANAGEMENT

A Local Water Management Strategy (LWMS) has been prepared by Bayley Environmental and is included in this Scheme Amendment as **Appendix H.**

8.1. WATER EFFICIENCY MEASURES

P3 will be designed as a low water-use precinct, with industries preferred being those with low water consumption. This is driven largely by the hydrology of P3 and its proximity to Ellen Brook, which demands that wastewater disposal be minimised. Potable water use within P3 will be limited to consumption for domestic use in toilets, bathrooms and kitchens. Groundwater will be used mainly for irrigation of landscape plantings and swales.

8.2. STORMWATER MANAGEMENT STRATEGY

8.2.1. Principles and Objectives

The stormwater management strategy aims to comply with the principles and objectives for stormwater management identified in the Stormwater Management Manual for WA and Better Urban Water Management. Nutrient concentrations and loads in water leaving P3 will be managed to comply with the targets of the draft Swan Canning Water Quality Improvement Plan for the Ellen Brook catchment.

8.2.2. Drainage Management System

The drainage system will be designed to maintain surface flow rates and volumes within and from the developed site at their pre-development levels. The priorities for managing the various sizes of storm event will be:

- 1 year ARI Infiltrate all flows as close to the source as possible. Maintain pre-development flow rates and volumes. Minimise export of nutrients and sediments.
- 5 year ARI Detain water prior to discharge. Maintain pre-development flow rates and volumes. Maintain amenity and serviceability. Prevent scouring and damage.
- 100 year ARI Maintain pre-development flow rates and volumes. Prevent flooding and damage.

8.2.3. Through Drainage

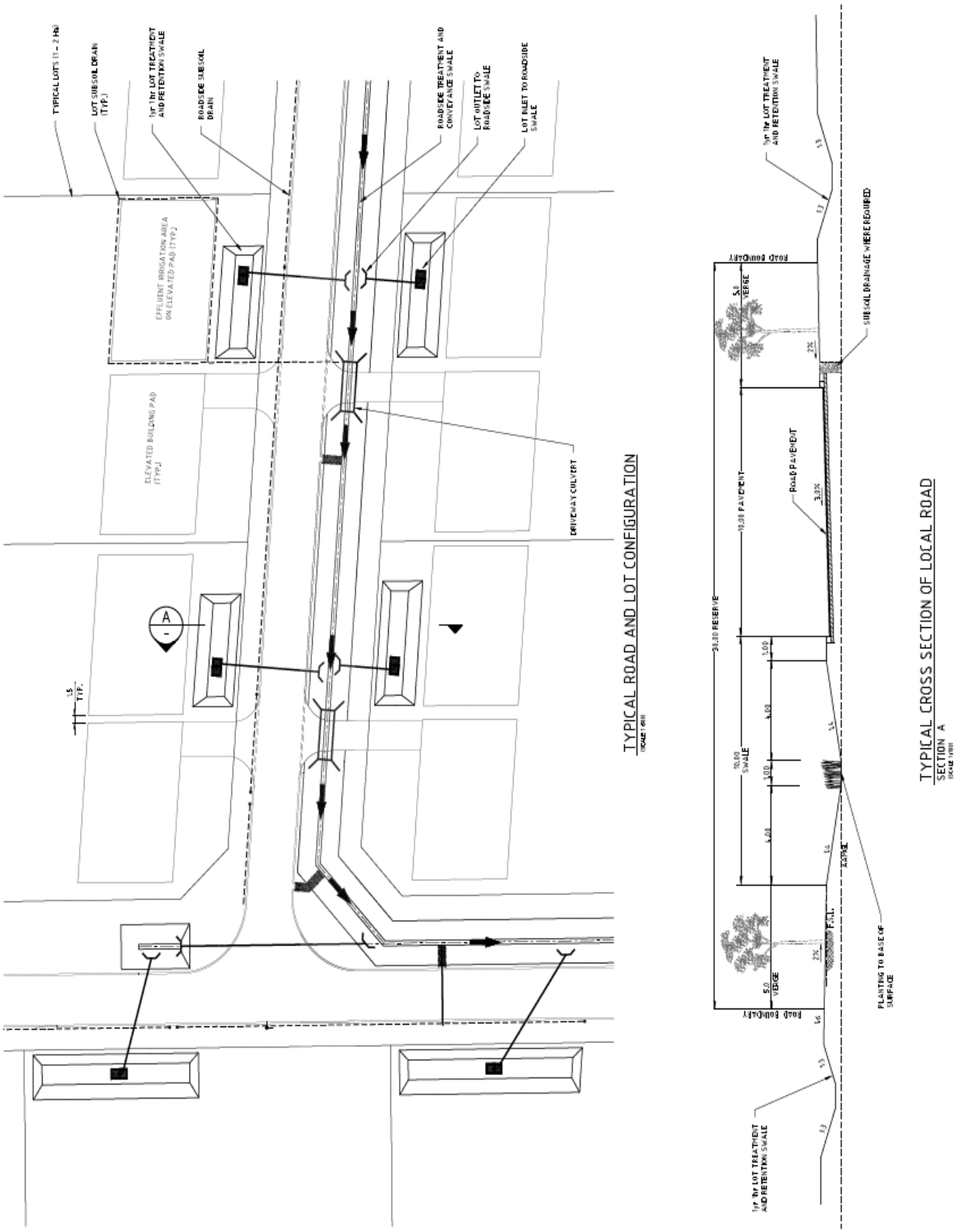
The existing drainage lines will be either preserved within easements or realigned and consolidated in vegetated swales within road reserves, which will be wider than normal to accommodate the swales. The swales will be sized to accommodate the flow from a 100-year ARI critical storm from the upstream and internal catchments. A series of low weirs within the swales will capture and detain or infiltrate road runoff from storms up to 1-year ARI 1-hour. The invert of the swales will be at or above the AAMGL. The swales will be configured as living streams and densely planted with sedges and shrubs to slow the water flow and help to remove sediments and nutrients from the water.

8.2.4. Internal Drainage

Runoff from roofs, paved surfaces and hardstand areas within private lots from storms up to 1-year ARI 1-hour duration (about 15mm) will be retained and infiltrated within each lot in soakwells, swales and/or landscaping areas. These will be subject to detailed design on individual lots. Lot runoff from larger storms will overflow via pipes into the roadside swales. The overflow pipes will be sized to regulate the flow to predevelopment rates.

Runoff from public roads from up to the 1-year ARI 1-hour storm will be retained and infiltrated in roadside swales. The invert of the swales will be at or above the AAMGL. The swales will be constructed with low internal weirs set at a height that captures the 1-year 1-hour storm. In road reserves that also include a through-drainage swale, the weirs may incorporate underdrains to promote infiltration of the 1-year flows. Alternatively, the 1-year ARI swale may be formed in the bank of the through-swale to create a double swale. The configuration of the swales and internal weirs will be subject to detailed design (refer **Figure 15 – Typical Drainage Design Concept**).

Figure 15 – Typical Drainage Design Concept



8.2.5. Major Storm Drainage

Road runoff from larger storms will overtop the weirs and flow along the swales to the western boundary, where eleven culverts beneath the PDNH embankment will carry it across to Ellen Brook. Because the PDNH was designed in the context of a rural setting, the culverts are not large enough to carry the full flow from upstream in a 100-year storm event. The drainage design therefore incorporates a swale running adjacent to the southern part of the PDNH embankment. During a 100-year storm, flows that exceed the capacity of the PDNH culverts will be carried south within this swale to the next culvert or into the drainage/landscape reserve, where it will slowly make its way overland through dense vegetation to Ellen Brook.

8.2.6. Ellen Brook Floodplain

The 100-year ARI floodplain of Ellen Brook was modelled by BGE in 2017 on behalf of MRWA for the PDNH project. The modelling mapped only the floodplain extent, and not the floodway. BGE revisited the modelling in 2018 for this project to define the 100-year floodway of Ellen Brook (refer **Appendix F – Ellen Brook Flood Modelling**). The modelling focussed only on the part of Ellen Brook south of the PDNH crossing and adjacent to the project area, and was carried out in consultation with DWER.

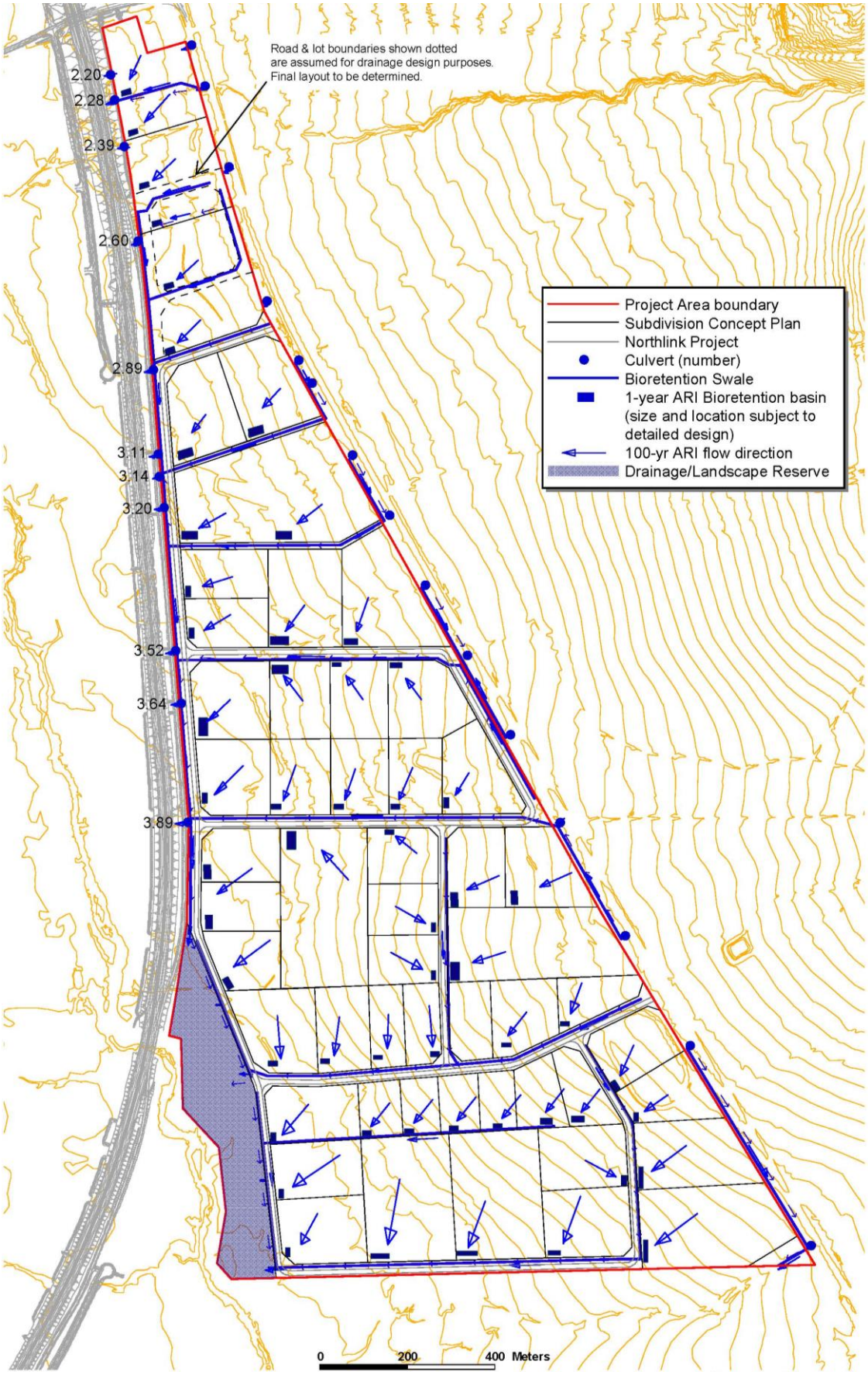
The floodplain is the area expected to be inundated by a 100-year ARI flood. Development within the floodplain but outside the floodway is permitted provided that roads and other infrastructure are not damaged by floodwaters and all habitable buildings have a floor level at least 0.5m above the 100-year flood level.

8.2.7. Surface Water Quality Management

The drainage system will be designed to maximise on-site retention of nitrogen and phosphorus. This will be achieved by:

- Retaining and infiltrating all lot runoff from storms up to 1-year ARI within the lots
- Infiltrating all road runoff from storms up to 1-year ARI 1-hour duration (estimated by the DWER to carry more than 99% of total flows and nutrients) in vegetated bioretention swales with a minimum soil PRI of 15
- Conveying all runoff from storms between 1-year and 100-year ARI in densely vegetated bioretention swales to allow suspended particles to be filtered out (refer **Figure 16**).

Figure 16 – Drainage Concept



8.2.8. Groundwater Management Strategy

8.2.8.1. Groundwater Levels

The AAMGL is at or near the ground surface over much of P3. In the west of P3, groundwater rise in winter is limited by intersecting the ground surface, giving rise to surface runoff. The drainage system for the Scheme Amendment area is designed to minimise changes to the existing groundwater regime. Roadside swales and subsoil drains will be set with their invert at or above the AAMGL.

Subsoil drainage within lots will be generally limited to the location and immediate surrounds of buildings and structures, associated site area as required for business operations, and the irrigation areas of effluent disposal systems.

8.2.8.2. Subsoil Drainage

Subsoil drainage will be employed within lots to maintain groundwater clearance for building pads and effluent disposal areas. The subsoil drains will discharge into roadside swales. Subsoil drains may also be employed within road reserves to prevent groundwater rise from damaging the road base and pavement. All subsoil drains will be set with their invert at or above the AAMGL. Therefore, changes to the groundwater hydrology of P3 will be minimal.

8.2.8.3. Groundwater Quality

Groundwater beneath P3 contains low to moderate concentrations of nitrogen and phosphorus. This is to be expected given the nature of the soils and the land use history of P3.

The aim of nutrient management will be to limit nutrient inputs to P3 so that nutrient outputs are minimised. As an industrial precinct, the area of fertilised gardens and lawns will be minimal. Landscaping areas including street trees, swales and vegetation buffers will be established with minimal fertilisers and irrigation.

Measures available to minimise nutrient inputs and exports in the development will include:

- Regular street sweeping to remove accumulated contaminants; and
- Selection of native species with low water and fertiliser requirements for public open space and landscape areas.

9. SERVICING AND INFRASTRUCTURE

Cossill & Webley has prepared an Engineering Servicing Report which is included in this Scheme Amendment as **Appendix D.**

9.1. STORMWATER MANAGEMENT

Ellen Brook is an ephemeral river which typically flows from May to December. P3 naturally grades towards Ellen Brook, hence it is anticipated discharge will be permitted from the Scheme Amendment area at the pre-development flow rates.

It is anticipated that stormwater runoff generated from the lots will be treated in swales at the front of the lots sized to retain the 1 hour 63.2% Average Exceedance Probability (AEP) storm event. Larger events will overtop to roadside drainage channels.

All roads will include roadside treatment swales sized to treat the 1 hour 63.2% AEP storm event, with larger storm events from the roads and lots contained in the wider drainage swales within the road reserves, conveyed westward with the natural topography, towards the Ellenbrook. Road-side drainage swales will be sized to convey the critical 1% AEP event. Some areas of piped drainage may be included where driveway cross-overs, or planning considerations do not support swale designs.

Flows to the Ellen Brook will be either via existing culverts constructed under PDNH, with any flow exceeding the culvert capacity diverted south to a detention basin at the southern area of the Scheme Amendment area abutting Ellen Brook.

9.2. EFFLUENT DISPOSAL

The Water Corporation has advised that P3 is not within a current wastewater catchment, and there is no proposal to extend the catchment boundary at this stage.

An alternative option proposed by the MENSP is to manage general wastewater (wastewater from buildings/site offices) on an individual inter-allotment scale utilising Aerobic Treatment Units (ATUs). For ATU's, the individual lot must provide sufficient landscaped area to avoid inundation and surface runoff. A typical lot configuration showing the extent of landscaped area for the effective disposal of effluent is included in **Figure 17 - Typical Drainage Design Concept.**

Sewer reticulation and a centralised treatment system may be considered for parts of the Scheme Amendment area where there are smaller industrial lots which have reduced capacity for irrigation volumes, or lots with a requirement for a large volume of sewer treatment. These options have not been assessed, and will require the relevant approvals prior to any agreements with potential industrial developments.

Wastewater produced on lots from industrial processes will be required to be treated appropriately on each lot. Where appropriate treatment is not achievable (due to the volumes or contaminants) industrial process wastewater will be captured and removed from site to an appropriate treatment facility.

9.2.1. Land Capability for On-Site Effluent Disposal

The proposed lots are located on land mapped mostly as Guildford Formation where the more elevated parts are rated Fair to High for effluent disposal, while the lower-lying parts are rated as Low to Very Low for effluent disposal. The main constraints to effluent disposal in the lower areas are high water tables and poor drainage.

The revised draft Government Sewerage Policy currently being considered by the WAPC identifies the project area as being within a Sewage Sensitive Area (SSA) due to its location within the catchment of the Swan-Canning Estuary. The draft Policy places additional site requirements in terms of groundwater clearance and lot density on effluent disposal within SSAs.

9.2.1.1. Phosphorus Retention Index

The Health Department's draft Code of Practice for Onsite Sewage Management (2012) recommends a PRI of at least 20 for soils beneath effluent irrigation areas. Testing demonstrates the soils of the Scheme Amendment area have a very high capacity to bind phosphorus.

9.2.1.2. Depth to Groundwater

The current Country Sewerage Policy requires that land used for effluent disposal have a minimum clearance of 0.5m from the natural ground surface to the highest seasonal or permanent water table. Under the Policy, the required clearance cannot be achieved solely by filling but can be achieved by subsoil drainage, provided that the land has sufficient fall and area to dispose of the drained water and the drainage does not affect water flows or quality downstream.

A revised Draft Government Sewerage Policy currently being considered by the WAPC applies the 0.5m natural ground surface clearance requirement only to lots smaller than 1ha. For larger lots in SSA (including the Scheme Amendment area area), the revised draft Policy requires a separation of 1.5m from the effluent discharge point to the groundwater, which may be achieved by drainage, filling or a combination of both.

As the AAMGL is within 0.5m of the ground surface over much of the P3 area, a combination of subsoil drainage and fill will be required over most of P3 where effluent disposal is proposed. In lower parts of the project area where the AAMGL is at the ground surface, subsoil drains will be set at the existing ground level and fill will be used to achieve the required groundwater clearance.

9.2.1.3. Slope

The Country Sewerage Policy prohibits on-site effluent disposal on land with a slope of more than 1 in 5 (20%), in order to prevent runoff of effluent. The slope of the subject land does not exceed 2.5%. Therefore, effluent disposal in P3 is not constrained by slope.

9.2.2. System Selection and Location

All effluent generated within the Scheme Amendment area will be treated and disposed by means of individual on-site effluent disposal systems. Given the hydrology of P3 and its proximity to Ellen Brook, all lots will be required to employ nutrient-attenuating alternative systems such as aerobic treatment units (ATUs) with high-PRI irrigation areas or modified leach drain systems. Effluent disposal systems will be located at least 30m from watercourses.

ATU irrigation areas will be filled to approximately 2m above the AAMGL in order to provide 1.5m clearance from the AAMGL to the effluent drip lines allowing for 0.3m groundwater mounding and 0.2m soil cover over the drip lines. The effluent irrigation areas will be filled with soil either sourced from on site or imported. The soil will be tested to confirm a PRI of at least 20. The ATU irrigation area on each lot will be sized to suit the expected population of the lot.

9.2.3. Subsoil Drainage

Where fill is used to raise pads for effluent disposal, surface cutoff drains and/or subsoil drains will be placed upslope of the pad to prevent groundwater rise into the fill. The drains will be set with their inverts at or above the AAMGL and will discharge into the roadside swales, where the water will be further treated by infiltration and/or vegetation uptake within the swales. Because the water will be draining from high-PRI soil, it will be of high quality.

9.3. WATER RETICULATION

The Water Corporation has advised that the Scheme Amendment area is not within a current water catchment, and there are no plans to extend the water catchment boundary at this stage.

A proposed water project for the Lower Chittering Valley is currently in development by Aqua Ferre, which includes construction of a water treatment facility on Lot 2 Reserve Road, Chittering capable of supplying potable water to residential and commercial properties in the Lower Chittering-Muchea area. Aqua Ferre is in the process of applying for a Water Service Provider Licence from the Economic Regulation Authority.

The project proposes to draw water from the Leederville Aquifer, with treatment to meet drinking water quality guidelines. Aqua Ferre has confirmed they have capacity within their proposed licence to service the proposed industrial development of the Scheme Amendment area with potable water, and have advised the most likely strategy would include an extension of the proposed Harvis network (to the north) to service the proposed development (refer **Figure 17 – Aqua Ferre Water Strategy**).

Provision to P3 is still subject to mutually agreeable commercial terms with Aqua Ferre, though from the Scheme Amendment perspective, P3 can be serviced with water reticulation by a licensed provider, as required by the MENSP, and that there are no engineering impediments to the provision of water to the proposed development.

Figure 17 – Aqua Ferre Water Strategy

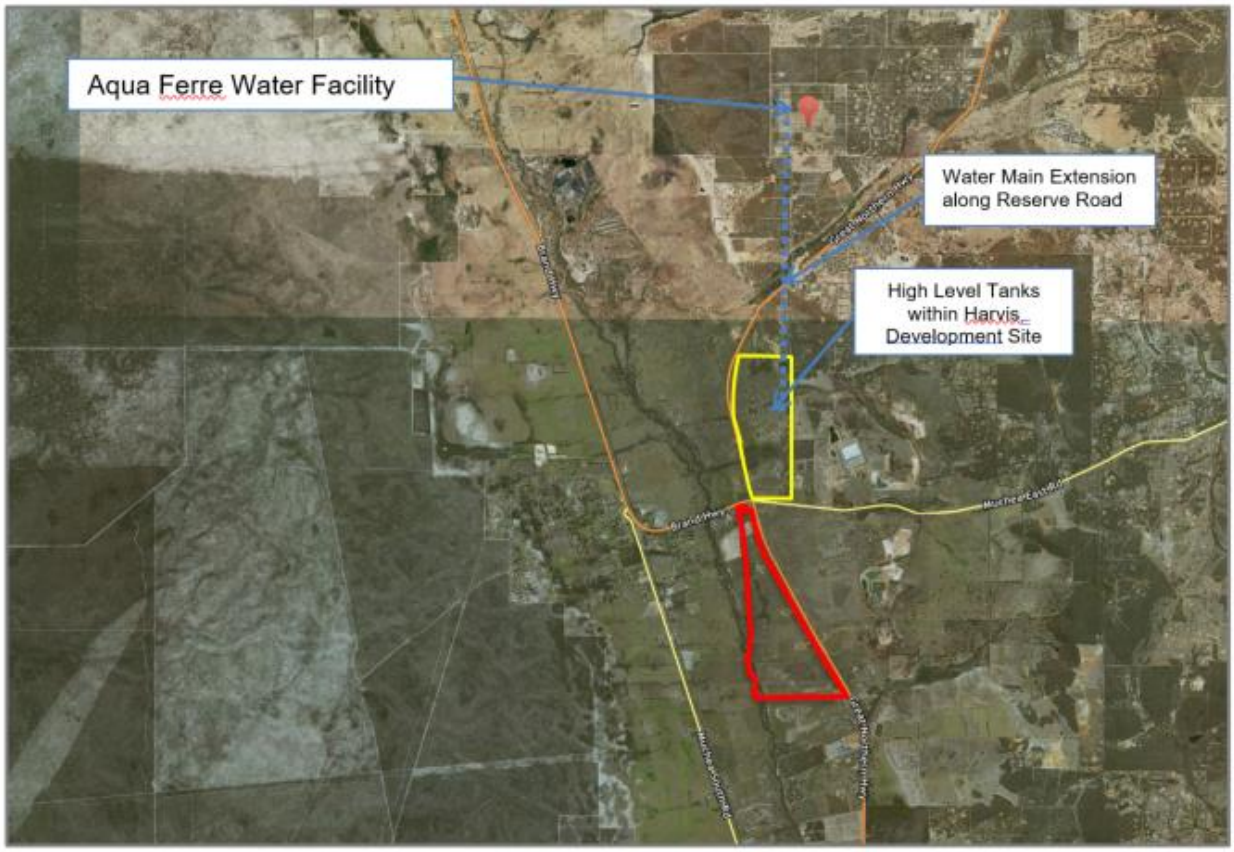


Figure 7: Aqua Ferre Water Strategy (Aqua Ferre, 2018)

9.4. POWER

There are existing overhead 22kV high voltage overhead power cables in the eastern verge of GNH and southern verge of Brand Highway which are fed from the existing Muchea Zoned Sub-Station.

The Western Power Network Capacity Mapping Tool was used to determine future forecast remaining capacity in the electricity network, which confirmed the network will have more than 30MVA remaining capacity in 2020. This capacity will be sufficient to service the future power requirements of the development, though Western Power will need to confirm the connection locations and capacity of the existing system as part of a feasibility assessment at the next stage of the planning process.

A series of HV feeds, switch stations and transformers will be required throughout the development to meet individual site requirements. Additional distribution mains from the Muchea Sub-Station may be required in the future to augment the existing supply network, depending on industrial uses proposed and likely power requirements.

9.5. GAS

There is no proposed gas distribution within the vicinity of the Scheme Amendment area. The supply of a gas distribution network in the future is not ruled out, however it will depend on economics and likely demand of the broader Muchea area.

9.6. EARTHWORKS

Siteworks for the proposed development will generally comprise clearing of existing vegetation and, where necessary, earthworking the existing ground to facilitate a required form of development. Following clearing, topsoil is likely to be stripped. The grades from east to west are generally about 2%, and typical industrial grades are preferred to be flatter, at approximately 1%.

The extent of siteworks and earthworks will be dictated by the proposed industrial usage, which may involve some filling of parts (or all) of the lot to provide flood protection from prevailing groundwater, level out grade across the lots and provide sufficient area for the effective disposal of treated effluent. As a guide, the following earthworks are anticipated, which will be confirmed as part of the subdivision and subsequent development process, once further certainty on proposed land use, flood protection and effluent disposal requirements are known:

- Roads – approximately 800mm separation between the finished road pavement and prevailing groundwater may be required to ensure the road pavement remains flood protected. This will be confirmed as part of the future detailed design, which will include the road pavement requirements and more accurately determine the depth to groundwater from the existing natural surface
- Lots – the extent of fill is likely to vary across the lots depending on the needs and sensitivity of the proposed land-use. Some fill may be provided to buildings areas (say 1 metre over the building pad), though this will be confirmed at the detailed design stage. Utilising the existing east/west grade across P3, there may be opportunity to minimise fill (to ensure adequate flood protection) by constructing cut-off diversion drains and grading P3 to ensure any surface flows are directed away from proposed building pads
- Effluent irrigation areas will be filled and sized to suit anticipated effluent disposal requirements
- Subsoil drainage may be installed locally around existing building pads and effluent disposal areas to provide protection from prevailing groundwater
- The filling of land willl be minimised and generally be limited to the location and immediate surrounds of buildings and structures, associated site area as required for business operations, and the irrigation areas of effluent disposal systems.

9.7. TELECOMMUNICATIONS

The Scheme Amendment area has not yet been served with NBN, but there is existing Telstra communications in GNH servicing the area.

Using the NBN Co ‘Check your address’, the Scheme Amendment area is planned to be connected to the NBN network in January-June 2020 with a fixed wireless connection. It is likely the area will be connected to the NBN network by the time development commences and no offsite upgrade by the developer would be applicable.

10. LANDSCAPE MASTERPLAN

A Landscape Masterplan has been prepared by Bayley Environmental and is included in this Scheme Amendment report in **Appendix I.**

The Landscape Masterplan has been prepared in the context of the Draft Shire of Chittering Local Planning Strategy and Draft Design Guidelines for the Muchea Industrial Park. Precinct 3 will constitute the southern gateway to the Shire of Chittering. A priority of the Shire is that the precinct should present an attractive visual landscape for observers travelling on the main approaches into Chittering. This includes preserving native vegetation where it occurs (mostly roadside trees), landscape plantings within the precinct, building design and layout of development within lots.

The Shire of Chittering has set out its priorities in its Muchea Industrial Park Design Guidelines (2018). The Guidelines deal with development layout within lots, streetscaping, landscaping, bushfire management, fencing, signage and building design. LPS6 also contains provisions relating to landscape within industrial zones. The Landscape Master Plan recognises and reflects the recommendations of the Design Guidelines and the Scheme provisions.

The project area is visible from GNH and Brand Highway. The view is screened in part by roadside trees and vegetation within P3. The landscape consists mostly of a mix of cleared paddocks with scattered trees and existing intensive commercial operations. The PDNH works have caused a major change to the landscape, particularly near the northern end of the project area.

Figures 18-21 shows an overview of the conceptual landscaping strategy and the Landscape Masterplan sets out landscaping anticipated for the various landscaping zones. Lot layout to accommodate landscaping, swale treatment and landscaping anticipated around Ellen Brook within the Scheme Amendment area are also depicted.

Figure 18 – Landscape Masterplan

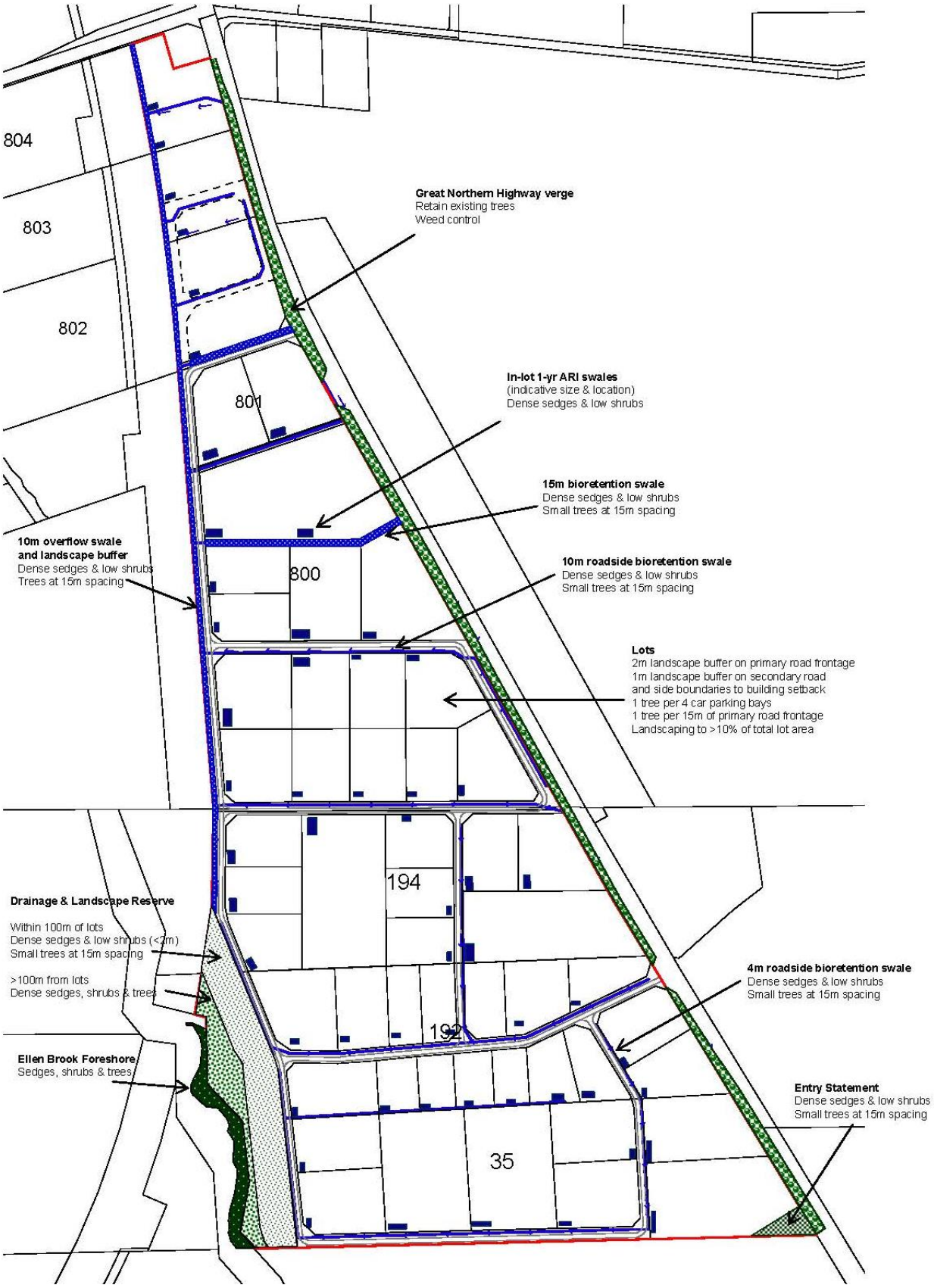


Figure 19 – Landscaping of Bio-Retention Swales

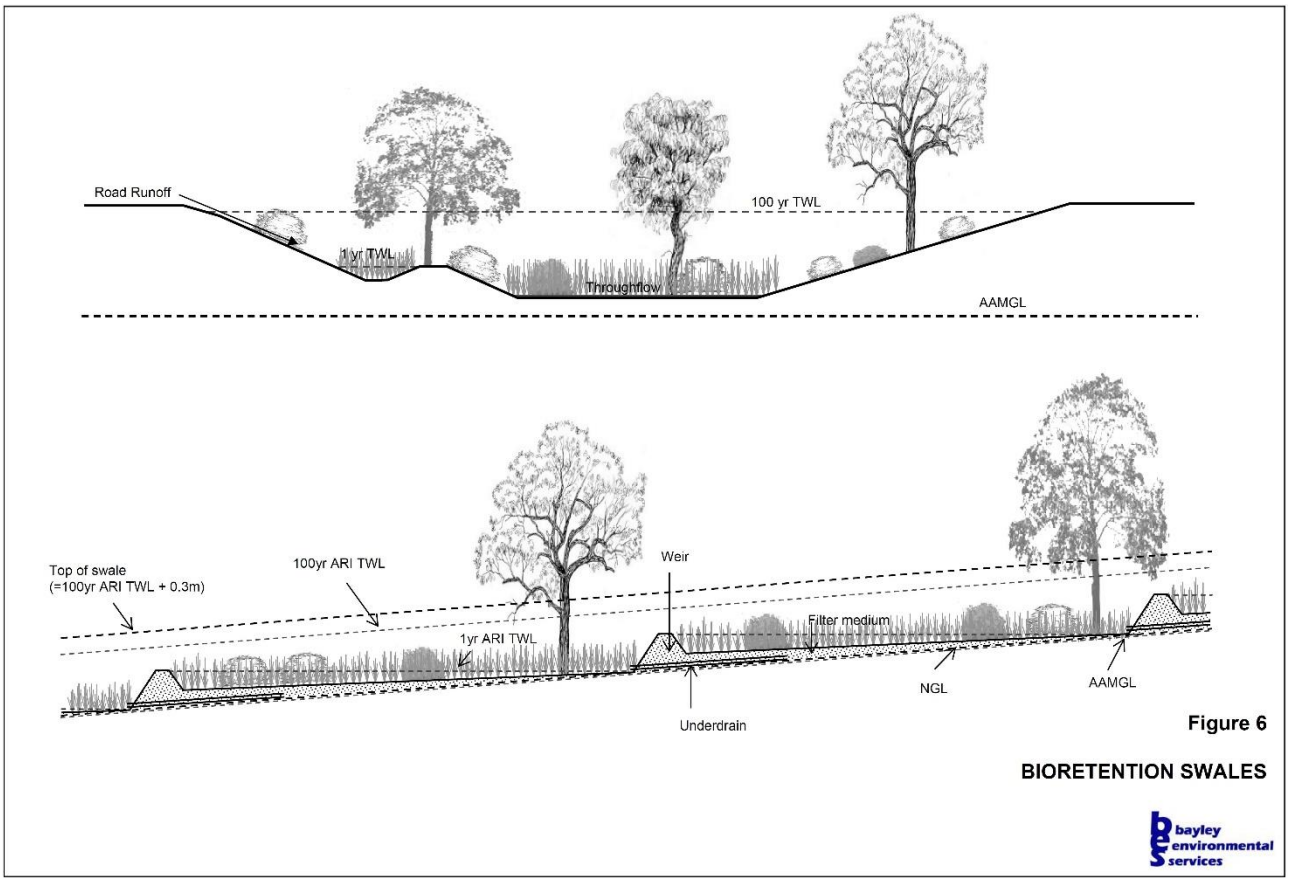


Figure 20 – Individual Lot Landscaping Concept

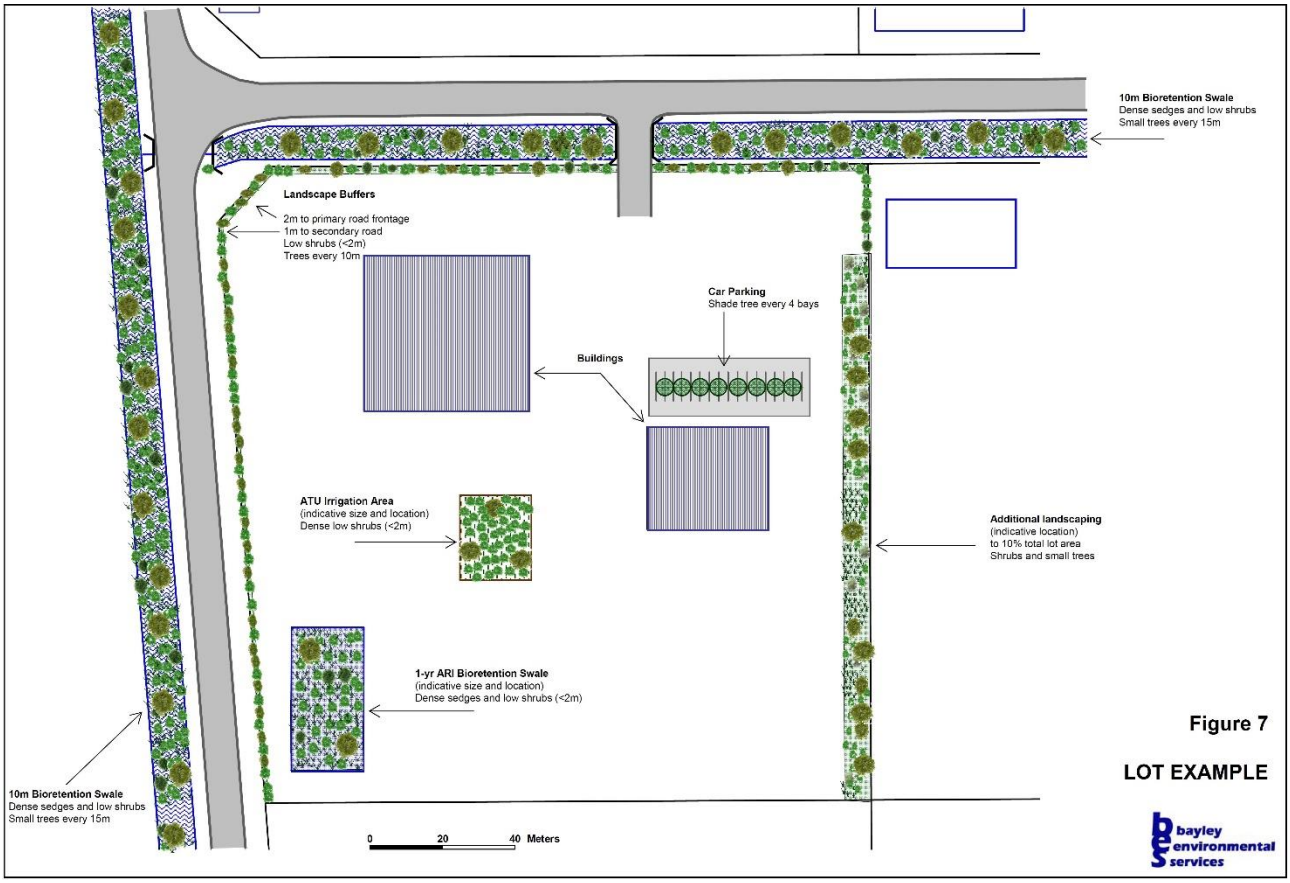
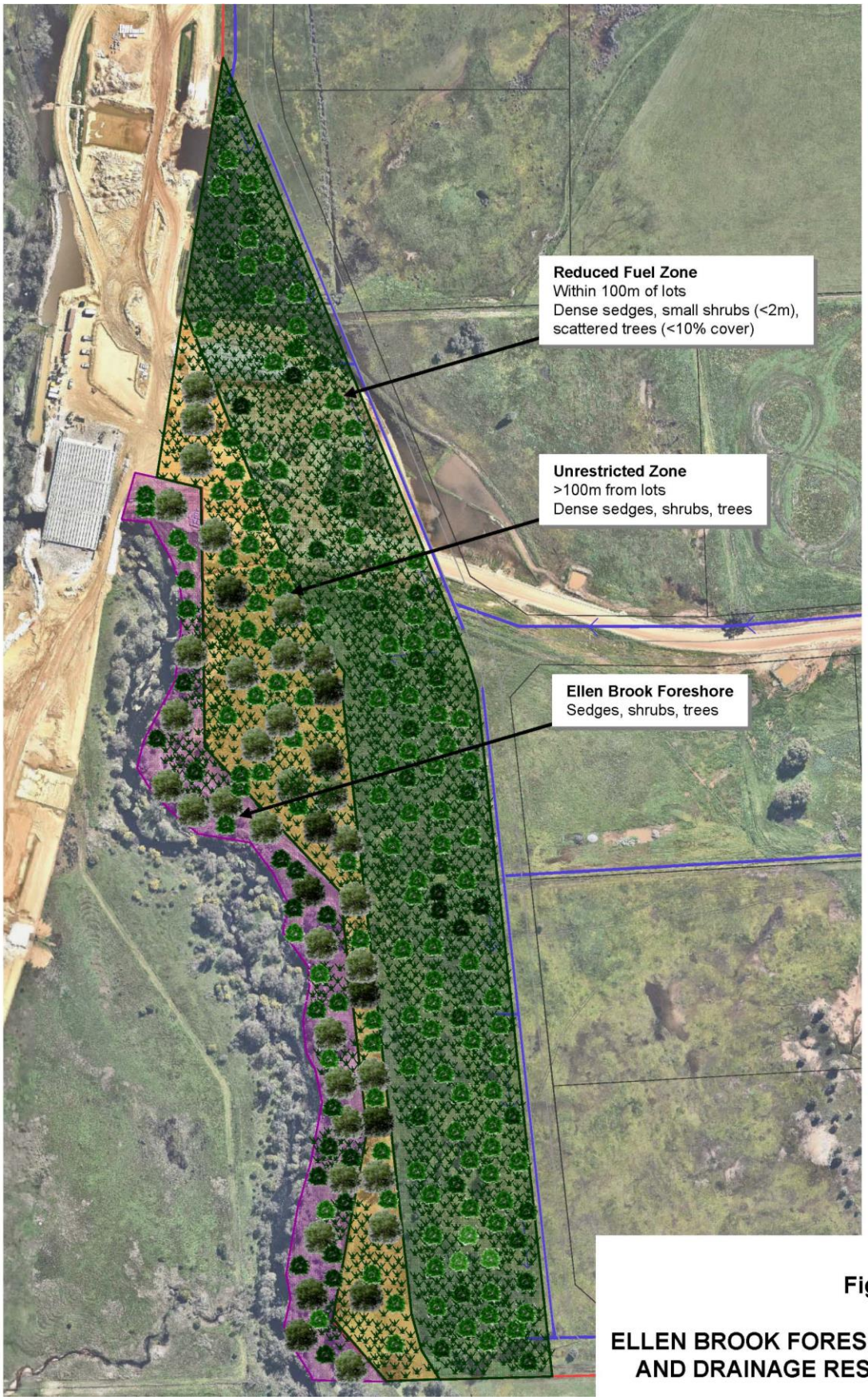


Figure 21 – Ellen Brook Landscaping



11. ENVIRONMENTAL MANAGEMENT

Environmental management is set out in the EAMS and LWMS; and referred to in Schedule 11 of LPS6 (refer **Appendices B and H**).

11.1. ACOUSTICS

Given the presence of GNH and particularly PDNH, noise generated by the industrial activities anticipated within P3, does not warrant preparation of a Strategic Noise Assessment and Management Strategy at the Scheme Amendment or Structure Plan stage. At the development application stage, should a proposed industrial land use be expected to generate substantial noise that may impact residential (or other sensitive) uses in areas outside P3, such applications will need to demonstrate that they comply with EPA requirements by way of preparation of a suitable assessment and management plan.

11.2. ODOUR

Where odour causing industries are proposed, a Strategic Odour Assessment and Management Strategy would need to be prepared. In the case of P3, industries proposed are not expected to generate unreasonable levels of odour. As is the case with noise, at the development application stage, should a proposed industrial land use be expected to generate substantial odour that may impact residential (or other sensitive) uses in areas outside P3, such applications will need to demonstrate that they comply with EPA requirements by way or preparation of a suitable management plan.

11.3. DUST

Individual lot owners within the Scheme Amendment area will be required to manage dust to prevent dust escape beyond their boundaries. Industries that generate appreciable dust will be required to hold a DWER licence, which will include dust limits and specify monitoring requirements. Management of construction impacts will be the subject of conditions attached to subdivision approvals, works approvals and development approvals. In general, control of construction impacts will be the responsibility of the construction contractor by way of a Construction Management Plan prepared to satisfy a condition of development approval.

11.4. VEGETATION AND FLORA

The largest area of native vegetation near the project area is the fringing vegetation of Ellen Brook. This will be preserved in the foreshore reserve. Remnant trees within the development area will be preserved where possible. No remnant trees may be cleared without a Development Approval from the Shire of Chittering and/or a clearing permit from the DWER. Approximately 48 hectares of native sedges, shrubs and trees will be planted in the Ellen Brook foreshore, in drainage swales and within lots, within the Scheme Amendment area.

11.5. FAUNA

There is little native fauna habitat in the project area, although the adjacent Ellen Brook provides substantial habitat for faun which may venture into the project area to forage and graze. The existing fauna habitat within the project area will be retained and enhanced by new plantings of native vegetation in the Ellen Brook foreshore and minor drainage lines. Additional fauna habitat will be created in the revegetation of drainage swales and basins. Street trees planted within the project area will focus on native tree species that provide habitat for nectar-eating and seed-eating birds.

11.6. GROUNDWATER MONITORING

Groundwater levels and quality will continue to be monitored and compared against baseline levels and relevant guidelines. Water quality in the creeklines and Ellen Brook will be monitored upstream and downstream of the project area to determine what (if any) impacts the development may be having on the watercourses. Water quality sampling will be conducted nominally once a year in late winter. Detailed water monitoring and response procedures will be developed as part of the UWMPs to be prepared for each stage of subdivision.

12. CONCLUSION

It is requested that the Shire of Chittering initiate an Amendment to rezone P3 from ‘Agricultural Resource’ to ‘Light Industrial’, and introduce relevant provisions into Schedule 11 as set out in this Amendment.

The Amendment will facilitate the future development of the subject site for industrial purposes providing for a range of industrial activities including transport logistics and general industry purposes in accordance with the State and local planning framework.

The proposed development of P3 will ensure the timely supply and release of industrial land within Muchea. This Scheme Amendment is supported by a range of technical inputs, and demonstrates that the land can be developed for industrial purposes, consistent with the strategic and statutory planning framework.

This Amendment will facilitate the development of the subject land for industrial purposes as intended by the MENSP and ensure the timely supply and release of industrial land within the Shire of Chittering.

We therefore request the Shire of Chittering initiate an Amendment to rezone P3 as proposed in this Amendment from ‘Agricultural Resource’ to ‘Light Industrial’ supported by the preparation of a Structure Plan prepared in accordance with the Regulations and the WAPC Scheme Amendment Framework.

Planning and Development Act 2005

RESOLUTION TO AMEND LOCAL PLANNING SCHEME

Shire of Chittering Local Planning Scheme No.6
Amendment No.67

Resolved that the Local Government pursuant to section 75 of the *Planning and Development Act* 2005, amend the above Local Planning Scheme by:

1. ***Rezoning Lots 800-804, 192, 194 and 35 Great Northern Highway, Muchea from 'Agricultural Resource' zone to 'Light Industrial' zone.***

   And amending the Scheme Maps accordingly.

2. ***Amending clause 5.1.1 Operation of Special Control Areas to include 'Muchea Employment Node' as new dot point 6; and reflecting Precinct 3 of the Muchea Employment Node on the Scheme Maps accordingly.***

3. ***Introducing the following uses into Schedule 1 – Dictionary of Defined Words and Expressions of Local Planning Scheme 1 as follows:***

   'Concrete Batching Plant means premises used for concrete batching, as defined in the Environmental Protection Regulations 1987'

   'Workforce Accommodation means premises, which may include modular or relocatable buildings, used –
   (c) Primarily for the accommodation of workers engaged in construction, resource, agricultural or other industries on a temporary basis; and
   (d) For any associated catering, sporting and recreation facilities for the occupants and authorised visitors'

4. ***Amending Schedule 2 – Zoning Table to identify the uses:***
   i. 'Concrete Batching Plant' as a 'D' use in the Light Industrial and General Industrial zones, and an 'X' use otherwise
   II. 'Workforce Accommodation' as a 'D' use in the Light Industrial zone, and an 'X' use otherwise
   iii. 'Fast Food Outlet' in the Light Industrial Zone as a 'D' use

5. ***Amending clause 4.9: Requirements for Industrial Zones and Land Uses, of Local Planning Scheme 1 to introduce the following provisions:***

   (g) where Workforce Accommodation is a discretionary use-
   i. the accommodation is to have a maximum floor area of 250m2
   ii. the accommodation is to be incidental to the industrial land use
   iii. subdivision of the accommodation from the parent lot will not be permitted

iv. the local government will not consider applications for Workforce Accommodation prior to the primary site activity being either approved or constructed

v. where simultaneous approval has been granted by local government for both Workforce Accommodation and the main activity on the same lot, the main activity must be developed and be operational prior to the occupation of the Workforce Accommodation

vi. Workforce Accommodation must be carefully sited and constructed so the potential site (or estate) impacts from noise, dust, odour, amenity and heavy vehicle access/egress from the site are minimised

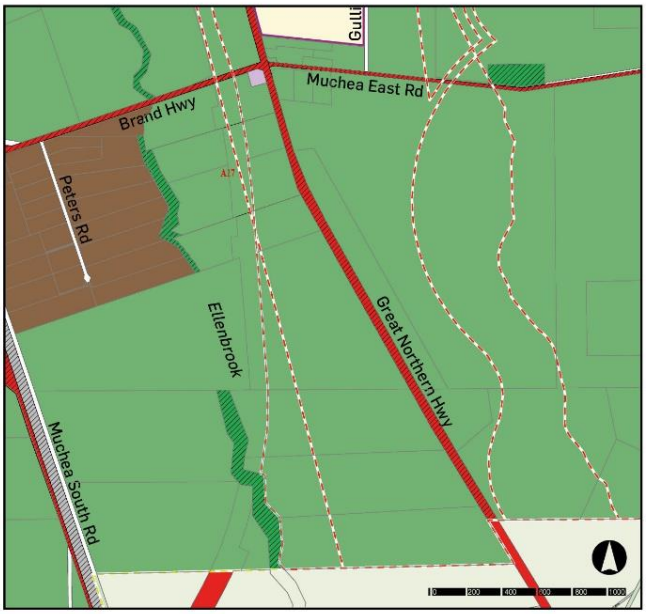
And renumber the subsequent clauses accordingly.

6. Amending Schedule 11 – Muchea Employment Node Special Control Area of Local Planning Scheme No.1 to add Precinct 3, by including provisions for Precinct 3 of the Muchea Industrial Precinct No.1 as follows:

NO.	DESCRIPTION OF LAND	CONDITIONS
2.	Precinct 3 (P3) of the Muchea Industrial Park	**1. Hierarchy of Plans** Structure planning, subdivision and development shall be undertaken in accordance with the Scheme. **2. Structure Plan** a. Structure Plan Preparation A Structure Plan shall be prepared in accordance with the provisions of the deemed provisions over the entire area of Precinct 3 of the Muchea Industrial Park. b. Environmental Management Plans The following Environmental Management Plans shall be prepared as part of the Structure Plan process and approved as required by the relevant agency: i. Local Water Management Strategy ii. Environmental Assessment and Management Strategy iii. Transport Impact Assessment Environmental Management Plans shall be implemented to the satisfaction of the local authority. **3. Subdivision** i. An Urban Water Management Plan shall be prepared by the developer, consistent with the Local Water Management Strategy, for approval by the relevant agency, to satisfy a condition of subdivision approval. ii. A reticulated water supply provided by a licensed operator shall be provided at the first stage of subdivision.

NO.	DESCRIPTION OF LAND	CONDITIONS
		iii. Road Reservation and Construction a. An internal Loop Road, constructed to accommodate RAV10 vehicles, shall be constructed in accordance with Austroads and MRWA standards b. When a lot is subdivided, the totality of land required for all road reserves within that lot shall be ceded to the Crown c. The full length of roads within the subdivision area is to be constructed on the creation of all lots. A staging plan and triggers for road construction, to ensure construction of all roads within the subdivided area is to be outlined in an approved Structure Plan. iv. Subdivision applications shall demonstrate that a suitable temporary turning circle for the Loop Road can be provided within the boundaries of the subdivision area until the entire Loop Road is constructed to allow RAV10 vehicles access and egress onto Great Northern Highway. At that time, the temporary turning circle shall be removed and the land suitably remediated. v. Drainage a. The drainage approach for Precinct 3 is set out in the Structure Plan. b. When the first lot in a subdivision is created, any works or ceding of land associated with the drainage network is to be implemented. c. Where staging of drainage infrastructure is determined to be acceptable by the WAPC and relevant agencies including DWER and the local authority, proposals are to make provision for connection to the overall drainage network, and the approach is to be outlined in an UWMP that accompanies the subdivision application. **4. Development** **i.** Development of land shall be generally in accordance with the Scheme and approved Structure Plan. ii. Land use permissibility within Precinct 3 shall be in accordance with the Light Industrial Zone of LPS6 (as amended).

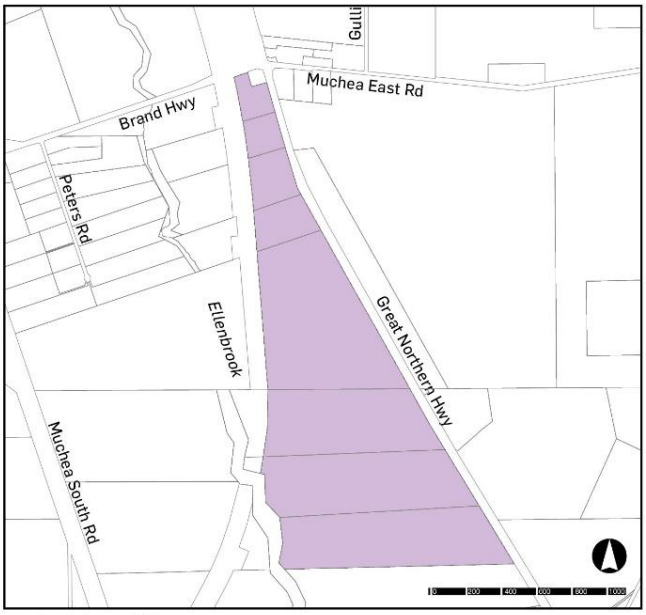
SHIRE OF CHITTERING
LOCAL PLANNING SCHEME NO. 6
AMENDMENT NO. 67



LEGEND:

LPS - ZONES AND RESERVES
- Special Control Area
- Agricultural Resource
- Highway
- Industrial Development
- Light Industrial
- Parks and Recreation
- Railway
- Rural Residential

EXISTING SCHEME



LEGEND:

LPS - ZONES AND RESERVES
- Special Control Area
- Agricultural Resource
- Highway
- Industrial Development
- Light Industrial
- Parks and Recreation
- Railway
- Rural Residential

PROPOSED SCHEME

URBIS

LPS AMENDMENT
MUCHEA EMPLOYMENT NODE

DATE: 21.01.2019
JOB NO: P02540
DWG NO: DWG-11
REV: B

FORM 6A

COUNCIL ADOPTION

This Standard Amendment was adopted by resolution of the Council of the Shire of Chittering at the Ordinary Meeting of the Council held on the …….. day of ……., 20……

.....

SHIRE PRESIDENT

.....

CHIEF EXECUTIVE OFFICER

COUNCIL RESOLUTION TO ADVERTISE

by resolution of the Council of the Shire of Chittering at the Ordinary Meeting of the Council held on the ……. day of ……., 20..... proceed to advertise this Amendment.

.....

SHIRE PRESIDENT

.....

CHIEF EXECUTIVE OFFICER

COUNCIL RECOMMENDATION

This Amendment is recommended for support/not to be supported by resolution of the Shire of Chittering at the Ordinary Meeting of the Council held on the …… day of ……., 20…… and the Common Seal of the Shire of Chittering was hereunto affixed by the authority of a resolution of the Council in the presence of:

.....

SHIRE PRESIDENT

.....

CHIEF EXECUTIVE OFFICER

WAPC ENDORSEMENT (r.63)

.....

DELEGATED UNDER S.16 OF THE P&D ACT 2005

DATE.....

FORM 6A - CONTINUED

APPROVAL GRANTED

.....

MINISTER FOR PLANNING

DATE.....

TECHNICAL APPENDICES

APPENDIX A CERTIFICATE OF TITLES AND SKETCHES

WESTERN AUSTRALIA

REGISTER NUMBER	
804/DP404617	
DUPLICATE EDITION	DATE DUPLICATE ISSUED
1	28/2/2017

VOLUME 2895 FOLIO 897

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

LAND DESCRIPTION:

LOT 804 ON DEPOSITED PLAN 404617

REGISTERED PROPRIETOR:
(FIRST SCHEDULE)

ANDREW QUINCE OF LOT 4 BRAND HIGHWAY,MUCHEA

(AF N339402) REGISTERED 27/5/2016

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

1. EXCEPT AND RESERVING METALS, MINERALS, GEMS AND MINERAL OIL SPECIFIED IN TRANSFER 1132/1935.
2. *N112518 CAVEAT BY PURE STEEL SHED CONSTRUCTIONS PTY LTD AS TO PORTION ONLY LODGED 3/9/2015.

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:	DP404617
PREVIOUS TITLE:	2577-167
PROPERTY STREET ADDRESS:	43 BRAND HWY, MUCHEA.
LOCAL GOVERNMENT AUTHORITY:	SHIRE OF CHITTERING

LANDGATE COPY OF ORIGINAL NOT TO SCALE Fri Oct 5 09:32:22 2018 JOB 57788649

Landgate
www.landgate.wa.gov.au

WESTERN AUSTRALIA

REGISTER NUMBER	
803/DP404616	
DUPLICATE EDITION	DATE DUPLICATE ISSUED
N/A	**N/A**

VOLUME **2903** FOLIO **24**

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

LAND DESCRIPTION:

LOT 803 ON DEPOSITED PLAN 404616

REGISTERED PROPRIETOR:
(FIRST SCHEDULE)

KARRATHA ENTERPRISES PTY LTD OF POST OFFICE BOX 419, MORLEY BC
(AF N339403) REGISTERED 27/5/2016

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

1. *EXCEPT AND RESERVING METALS, MINERALS, GEMS AND MINERAL OIL SPECIFIED IN TRANSFER 3000/1933.
2. *N470501 CAVEAT BY AUSSIE MODULAR SOLUTIONS PTY LTD LODGED 28/10/2016.

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: DP404616
PREVIOUS TITLE: 1689-590
PROPERTY STREET ADDRESS: 3571 GREAT NORTHERN HWY, MUCHEA.
LOCAL GOVERNMENT AUTHORITY: SHIRE OF CHITTERING

NOTE 1: DUPLICATE CERTIFICATE OF TITLE NOT ISSUED AS REQUESTED BY DEALING L740226

LANDGATE COPY OF ORIGINAL NOT TO SCALE Fri Oct 5 09:32:21 2018 JOB 57788649

Landgate
www.landgate.wa.gov.au

WESTERN AUSTRALIA

REGISTER NUMBER	
192/DP405698	
DUPLICATE EDITION	DATE DUPLICATE ISSUED
N/A	N/A

VOLUME 2862 FOLIO 297

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 192 ON DEPOSITED PLAN 405698

REGISTERED PROPRIETOR:
(FIRST SCHEDULE)

BARTON CECIL JONES OF PO BOX 4188, KALGOORLIE
DAVID JOHN CECIL JONES OF 43 JUTLAND PARADE, DALKEITH
AS JOINT TENANTS

(AF N023683) REGISTERED 10/6/2015

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

1. *EXCEPT AND RESERVING METALS, MINERALS, GEMS AND MINERAL OIL SPECIFIED IN TRANSFER 9703/1919. AS TO PORTION ONLY SEE SKETCH ON VOL 1868 FOL 806.
2. *EXCEPT AND RESERVING METALS, MINERALS, GEMS AND MINERAL OIL SPECIFIED IN TRANSFER 9704/1919. AS TO PORTION ONLY SEE SKETCH ON VOL 1868 FOL 806.
3. *B946572 RESTRICTIVE COVENANT BURDEN. REGISTERED 1/7/1980.
4. *M965766 MORTGAGE TO WESTPAC BANKING CORPORATION REGISTERED 13/4/2015.
5. *N191401 CAVEAT BY SHIRE OF CHITTERING AS TO PORTION ONLY LODGED 2/12/2015.

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:	DP405698
PREVIOUS TITLE:	1868-806
PROPERTY STREET ADDRESS:	3363 GREAT NORTHERN HWY, MUCHEA.
LOCAL GOVERNMENT AUTHORITY:	SHIRE OF CHITTERING

NOTE 1: DUPLICATE CERTIFICATE OF TITLE NOT ISSUED AS REQUESTED BY DEALING M965766

LANDGATE COPY OF ORIGINAL NOT TO SCALE Mon Aug 7 08:37:31 2017 JOB 54549792

Landgate
www.landgate.wa.gov.au

WESTERN AUSTRALIA

REGISTER NUMBER	
194/DP405699	
DUPLICATE EDITION	DATE DUPLICATE ISSUED
N/A	N/A

VOLUME 2862 FOLIO 298

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

LAND DESCRIPTION:

LOT 194 ON DEPOSITED PLAN 405699

REGISTERED PROPRIETOR:
(FIRST SCHEDULE)

AMUSE PTY LTD OF 28 ROWLEY PLACE, MARIGINIUP

(AF N023684) REGISTERED 3/9/2015

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

1. *EXCEPT AND RESERVING METALS, MINERALS, GEMS AND MINERAL OIL SPECIFIED IN TRANSFER 9703/1919. AS TO PORTION ONLY SEE DEPOSITED PLAN 405699 AND SKETCH ON VOL 1868 FOL 805.
2. *EXCEPT AND RESERVING METALS, MINERALS, GEMS AND MINERAL OIL SPECIFIED IN TRANSFER 9704/1919. AS TO PORTION ONLY SEE DEPOSITED PLAN 405699 AND SKETCH ON VOL 1868 FOL 805.
3. *B946572 RESTRICTIVE COVENANT BURDEN. REGISTERED 1/7/1980.
4. *B946572 EASEMENT BURDEN FOR RIGHT OF CARRIAGEWAY PURPOSES. SEE DEPOSITED PLAN 405699 AND SKETCH ON VOL 1868 FOL 805. REGISTERED 1/7/1980.
5. *G921742 MORTGAGE TO ST. GEORGE BANK LTD REGISTERED 8/10/1998.

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:	DP405699
PREVIOUS TITLE:	1868-805
PROPERTY STREET ADDRESS:	3383 GREAT NORTHERN HWY, MUCHEA.
LOCAL GOVERNMENT AUTHORITY:	SHIRE OF CHITTERING

NOTE 1: N023684 THIS LOT/TITLE CREATED AFTER PORTION OF THE LAND TAKEN FROM THE FORMER LOT WITHOUT PRODUCTION OF THE DUPLICATE TITLE BY TAKING ORDER N023684. CURRENT DUPLICATE FOR THE WITHIN LAND IS STILL VOL.1868 FOL.805

LANDGATE COPY OF ORIGINAL NOT TO SCALE Fri Oct 5 09:32:17 2018 JOB 57788649

Landgate
www.landgate.wa.gov.au

WESTERN AUSTRALIA

REGISTER NUMBER	
N/A	
DUPLICATE EDITION	DATE DUPLICATE ISSUED
1	19/12/2016

VOLUME 2903 FOLIO 33

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

THIS IS A MULTI-LOT TITLE

LAND DESCRIPTION:

LOTS 800 & 801 ON DEPOSITED PLAN 404613

REGISTERED PROPRIETOR:
(FIRST SCHEDULE)

INGHAM RURAL PROPERTY GROUP PTY LTD OF DARLING PARK TOWER 2, 201 SUSSEX STREET, SYDNEY, NEW SOUTH WALES

(XA N357645) REGISTERED 17/6/2016

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

1. EXCEPT AND RESERVING METALS, MINERALS, GEMS AND MINERAL OIL SPECIFIED IN TRANSFER 188/1945.
2. B946572 EASEMENT BENEFIT SEE DIAGRAM 72548. AS TO LOT 800 ON DP 404613 ONLY REGISTERED 1/7/1980.
3. M195093 LEASE TO INGHAMS ENTERPRISES PTY LTD OF 203-209 NORTHUMBERLAND STREET, LIVERPOOL, NEW SOUTH WALES EXPIRES: SEE LEASE. REGISTERED 25/2/2013.
   M276626 EXTENSION OF LEASE M195093. REGISTERED 17/5/2013.

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:	DP404613
PREVIOUS TITLE:	2903-30, 2903-31
PROPERTY STREET ADDRESS:	NO STREET ADDRESS INFORMATION AVAILABLE.
LOCAL GOVERNMENT AUTHORITY:	SHIRE OF CHITTERING

END OF PAGE 1 - CONTINUED OVER

LANDGATE COPY OF ORIGINAL NOT TO SCALE Tue Jan 9 14:29:48 2018 JOB 55721095

Landgate
www.landgate.wa.gov.au

NOTE 1: N339401 THIS LOT/TITLE CREATED AFTER PORTION OF THE LAND TAKEN FROM THE FORMER LOT WITHOUT PRODUCTION OF THE DUPLICATE TITLE BY TAKING ORDER N339401. CURRENT DUPLICATE FOR THE WITHIN LAND IS STILL VOL.1868 FOL.801 EDITION 3

LANDGATE COPY OF ORIGINAL NOT TO SCALE Tue Jan 9 14:29:48 2018 JOB 55721095

Landgate
www.landgate.wa.gov.au

WESTERN AUSTRALIA

REGISTER NUMBER	
N/A	
DUPLICATE EDITION	DATE DUPLICATE ISSUED
1	19/12/2016

VOLUME 2903 FOLIO 33

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

THIS IS A MULTI-LOT TITLE

LAND DESCRIPTION:

LOTS 800 & 801 ON DEPOSITED PLAN 404613

REGISTERED PROPRIETOR:
(FIRST SCHEDULE)

INGHAM RURAL PROPERTY GROUP PTY LTD OF DARLING PARK TOWER 2, 201 SUSSEX STREET, SYDNEY, NEW SOUTH WALES

(XA N357645) REGISTERED 17/6/2016

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

1. EXCEPT AND RESERVING METALS, MINERALS, GEMS AND MINERAL OIL SPECIFIED IN TRANSFER 188/1945.
2. B946572 EASEMENT BENEFIT SEE DIAGRAM 72548. AS TO LOT 800 ON DP 404613 ONLY REGISTERED 1/7/1980.
3. M195093 LEASE TO INGHAMS ENTERPRISES PTY LTD OF 203-209 NORTHUMBERLAND STREET, LIVERPOOL, NEW SOUTH WALES EXPIRES: SEE LEASE. REGISTERED 25/2/2013.
   M276626 EXTENSION OF LEASE M195093. REGISTERED 17/5/2013.

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:	DP404613
PREVIOUS TITLE:	2903-30, 2903-31
PROPERTY STREET ADDRESS:	NO STREET ADDRESS INFORMATION AVAILABLE.
LOCAL GOVERNMENT AUTHORITY:	SHIRE OF CHITTERING

END OF PAGE 1 - CONTINUED OVER

LANDGATE COPY OF ORIGINAL NOT TO SCALE Tue Jan 9 14:29:48 2018 JOB 55721095

Landgate
www.landgate.wa.gov.au

NOTE 1: N339401 THIS LOT/TITLE CREATED AFTER PORTION OF THE LAND TAKEN FROM THE FORMER LOT WITHOUT PRODUCTION OF THE DUPLICATE TITLE BY TAKING ORDER N339401. CURRENT DUPLICATE FOR THE WITHIN LAND IS STILL VOL.1868 FOL.801 EDITION 3

LANDGATE COPY OF ORIGINAL NOT TO SCALE Tue Jan 9 14:29:48 2018 JOB 55721095

Landgate
www.landgate.wa.gov.au

WESTERN AUSTRALIA

REGISTER NUMBER	
802/DP404616	
DUPLICATE EDITION	DATE DUPLICATE ISSUED
N/A	N/A

VOLUME 2903 FOLIO 23

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

LAND DESCRIPTION:

LOT 802 ON DEPOSITED PLAN 404616

REGISTERED PROPRIETOR:
(FIRST SCHEDULE)

KARRATHA ENTERPRISES PTY LTD OF 50 CLUNE STREET, BAYSWATER

(AF N339403) REGISTERED 27/5/2016

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

1. *EXCEPT AND RESERVING METALS, MINERALS, GEMS AND MINERAL OIL SPECIFIED IN TRANSFER 3000/1933.
2. *N477988 MORTGAGE TO AUSTRALIA & NEW ZEALAND BANKING GROUP LTD REGISTERED 8/11/2016.
3. *N477989 CAVEAT BY AUSSIE MODULAR SOLUTIONS PTY LTD AS TO PORTION ONLY LODGED 8/11/2016.
4. *N477990 CAVEAT BY KELAIR HOLDINGS PTY LTD AS TO PORTION ONLY LODGED 8/11/2016.

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: DP404616
PREVIOUS TITLE: 1689-591
PROPERTY STREET ADDRESS: NO STREET ADDRESS INFORMATION AVAILABLE.
LOCAL GOVERNMENT AUTHORITY: SHIRE OF CHITTERING

NOTE 1: DUPLICATE CERTIFICATE OF TITLE NOT ISSUED AS REQUESTED BY DEALING L324122

LANDGATE COPY OF ORIGINAL NOT TO SCALE Fri Oct 5 09:32:17 2018 JOB 57788649

Landgate
www.landgate.wa.gov.au

WESTERN AUSTRALIA

REGISTER NUMBER	
35/D72548	
DUPLICATE EDITION	DATE DUPLICATE ISSUED
2	9/9/2016

VOLUME 1868 FOLIO 807

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 35 ON DIAGRAM 72548

REGISTERED PROPRIETOR:
(FIRST SCHEDULE)

NEIL JOHN BOVENIZER OF 12A CADDY AVENUE WEST LEEDERVILLE

(T E989850) REGISTERED 17/9/1992

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

1. EXCEPT AND RESERVING METALS, MINERALS, GEMS AND MINERAL OIL SPECIFIED IN TRANSFER 9703/1919. AS TO PORTION ONLY SEE SKETCH ON VOL 1868 FOL 807.
2. EXCEPT AND RESERVING METALS, MINERALS, GEMS AND MINERAL OIL SPECIFIED IN TRANSFER 9704/1919. AS TO PORTION ONLY SEE SKETCH ON VOL 1868 FOL 807.

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:	1868-807 (35/D72548)
PREVIOUS TITLE:	1869-417
PROPERTY STREET ADDRESS:	3329 GREAT NORTHERN HWY, MUCHEA.
LOCAL GOVERNMENT AUTHORITY:	SHIRE OF CHITTERING

LANDGATE COPY OF ORIGINAL NOT TO SCALE Fri Oct 5 09:32:17 2018 JOB 57788649

Landgate
www.landgate.wa.gov.au

APPENDIX B ENVIRONMENTAL ASSESSMENT MANAGEMENT PLAN

MUCHEA EMPLOYMENT NODE
PRECINCT 3

ENVIRONMENTAL ASSESSMENT AND MANAGEMENT STRATEGY

Prepared for

Muchea Employment Node
Precinct 3 Landowner Group
c/- Tomahawk Property
8/355 Stirling Hwy
CLAREMONT WA 6010

Report No. J18015a
4 February 2019

BAYLEY ENVIRONMENTAL SERVICES
30 Thomas Street
SOUTH FREMANTLE WA 6162

Sundowner Nominees Pty Ltd as trustee for the Bayley Cook Family Trust ABN 20 822 598 897
trading as Bayley Environmental Services

TABLE OF CONTENTS

		Page
1.0	**INTRODUCTION**	**1**
1.1	**Background**	**1**
1.2	**Scope of the EAMS**	**1**
1.3	**Relevant Guidelines and Policies**	**1**
1.3.1	Better Urban Water Management	1
1.3.2	Shire of Chittering Town Planning Scheme No. 6	2
1.3.3	Country Sewerage Policy	6
1.3.4	DoW Operational Policy 4.3: Identifying and Establishing Waterways Foreshore Areas	7
2.0	**EXISTING ENVIRONMENT**	**8**
2.1	**Rainfall**	**8**
2.2	**Physiography**	**8**
2.2.1	Topography	8
2.2.2	Geology, Landforms and Soils	9
2.2.3	Soil Permeability	9
2.2.4	Acid Sulphate Soils	10
2.2.5	Phosphorus Retention Index	10
2.3	**Hydrology**	**10**
2.3.1	Groundwater	10
2.3.2	Surface Drainage	11
2.3.3	Water Resources	12
2.4	**Water Quality**	**13**
2.4.1	Groundwater	13
2.4.2	Surface Water	14
2.5	**Vegetation**	**21**
2.5.1	Vegetation Type and Condition	21
2.5.2	Vegetation Complexes	22
2.5.3	Rare and Significant Flora	22
2.6	**Fauna**	**23**
2.7	**Land Uses and Potential Contamination**	**24**
2.8	**Aboriginal and European Heritage**	**25**
2.9	**Landscape**	**25**
3.0	**ENVIRONMENTAL IMPACTS AND MANAGEMENT**	**26**
3.1	**Surface Water Protection**	**26**
3.2	**Groundwater Protection**	**27**
3.3	**Noise**	**28**
3.4	**Dust**	**28**
3.5	**Construction Impacts**	**29**
3.6	**Vegetation and Flora**	**30**
3.7	**Fauna**	**31**

3.8 Aboriginal Heritage 31
3.9 Landscape 31
3.9.1 Overview 31
3.9.2 Landscape Plantings 32
3.9.3 Streamline Revegetation 32
3.9.4 Ellen Brook Foreshore 32

4.0 MONITORING 34

5.0 IMPLEMENTATION AND FURTHER MANAGEMENT PLANS 35

6.0 REFERENCES 36

LIST OF TABLES

Table	Title	Page
2.1	Groundwater Depths and Levels 22 August 2018	11
2.2	Groundwater Quality 22/8/2018	15
2.3	Upstream Surface Water Quality 22/8/2018	17
2.4	Downstream Surface Water Quality 22/8/2018	19
2.5	Significant Flora Within 5km Radius	22

LIST OF FIGURES

Figure	Title
1	Muchea Employment Node Structure Plan
2	The Site and Surroundings
3	Proposed Plan of Subdivision
4	Pearce RAAF Mean Rainfall (p. 8 of document)
5	Physiography
6	Hydrology Overview
7	Groundwater
8	Surface Hydrology
9	Vegetation
10	Views from Great Northern Highway and Brand Highway
11	Drainage Concept

LIST OF APPENDICES

Appendix	Title
A	Soil Logs
B	Infiltration Test Results
C	Floodway Modelling Report
D	Aboriginal Sites Search Report
E	Local Water Management Strategy

1.0 INTRODUCTION

1.1 Background

The owners of Lots 35, 192, 194 and 800-804 Great Northern Highway, Muchea (the site) have applied to the WAPC for the lots to be rezoned from Rural to Industrial Development. The Muchea Employment Node Structure Plan 2011 (MENSP) showed the eastern parts of the subject lots as future industrial Precinct 3, bordered on the east by Great Northern Highway and on the west by the new Perth-Darwin National Highway (PDNH) and Ellen Brook. Figure 1 shows the location of the site within the Muchea Employment Node Structure Plan.

The total area of the rezoning is approximately 185 hectares. Figure 2 shows the boundaries of the site.

The MENSP concept for Precinct 3 is for low water-use industries with a minimum lot size of one hectare, with effluent disposed on-site using aerobic treatment units and evaporation ponds. This recognises the site constraints posed by the land's low elevation and high winter water table. Figure 3 shows a preliminary conceptual plan of subdivision for the site.

1.2 Scope of the EAMS

The scope of this Environmental Assessment & Management Strategy (EAMS) is to:

- document the existing environment on the site;
- briefly describe the proposed development;
- examine the potential impacts of development;
- propose management strategies to avoid or mitigate impacts; and
- outline a proposed monitoring program.

This EAMS is accompanied by a Local Water Management Strategy (LWMS), which deals specifically with water-related matters including drainage, groundwater management and wastewater disposal.

1.3 Relevant Guidelines and Policies

1.3.1 Better Urban Water Management

Better Urban Water Management (WAPC, 2008) sets out the following objectives for water sensitive urban design:

Water Conservation

- Consumption of 100kL/p/yr including less than 40-60 kL/p/yr scheme water.

Water Quantity

- Ecological Protection – Maintain pre-development flow rates and volumes for the 1 year ARI event. Maintain or restore desirable environmental flows and/or hydrological cycles.

- Flood Management – Maintain pre-development flow rates and volumes for the 100 year ARI event.

Water Quality

- Maintain pre-development nutrient outputs (if known) or meet relevant water quality guidelines (e.g. ANZECC & ARMCANZ, 2000).

- Treat all runoff in the drainage network prior to discharge consistent with the Stormwater Management Manual.

- As compared to a development that does not actively manage stormwater quality, achieve:

  - at least 80% reduction of 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.

Mosquitoes and Midges

- Design detention structures so that, between the months of November and May, stormwater is fully infiltrated within 96 hours.

- Design permanent water bodies (where accepted by DWER) to maximise predation of mosquito larvae by native fauna.

1.3.2 Shire of Chittering Town Planning Scheme No. 6

"The following development requirements shall apply to the development and subdivision of land within industrial zones and to industrial land uses –

(a) the effect on the environment by means of discharge of pollutants or contaminants into the air, ground and water be avoided, or managed within acceptable limits;

(b) where an on-site wastewater disposal system is proposed –

i. land capability assessment may be required to demonstrate the capability of the site to manage wastewater and the suitability of the proposed system;
ii. the use of fill and drains to achieve the required separation from groundwater is to be limited; and
iii. a suitable and unencumbered land application area is to be set aside to distribute treated sewage, where required;

(c) within sewerage sensitive areas secondary treatment systems with nutrient removal are to be utilised;

(d) notwithstanding any other provisions of this scheme, industrial development not connected to reticulated sewerage (for treatment on-site or off-site) is to be restricted to 'dry industry' being land uses that intend to dispose of wastewater on site to the environment of a kind and volume ordinarily discharged from a habitable building at a daily volume of less than 540 litres per 1,000m^2 of the site area [R10 equivalent];

(e) where trade waste is to be managed and/or disposed of on-site or off-site the associated risks must be identified and addressed, including the vulnerability of the receiving environment where relevant;

(f) where a caretaker's dwelling is a discretionary use –

i. only one dwelling be permitted on each lot;
ii. the dwelling is to have a maximum floor area of 100m²;
iii. the dwelling is to be incidental to the industrial land use;
iv. subdivision of the dwelling from the parent lot will not be permitted;
v. the use of notifications on title may be considered to advise prospective purchasers of potential impacts from noise, dust, odour or amenity that may arise from the location of a residential land use within the zone;
vi. the local government will not consider applications for caretakers' dwellings prior to the primary site activity being either approved or constructed;
vii. where simultaneous approval has been granted by local government for both a caretaker's dwelling and the main activity on the same lot, the main activity must be developed and operational prior to occupation of the dwelling; and
viii. caretaker's dwellings are to be carefully sited and constructed so the potential site (or estate) impacts from noise, dust, odour or amenity are minimised;

(g) in considering rezoning proposals for industrial zones, the local government may require the preparation of a structure plan, and any information relevant to the site conditions, in keeping with the matters listed in clause 67 of the deemed provisions and clause 5.7 of the scheme; and

(h) any other requirement as included in a Local Planning Policy adopted by the local government."

The Scheme shows Precinct 3 and its surroundings as part of a Water Prone Area (Ellen Brook Palusplain), within which the following special provisions apply:

"5.3.3 Planning Requirements

The local government will impose conditions on any Development approval relating to -

a) the construction and occupation of any dwelling or outbuilding;

b) the type of effluent disposal system used in this area shall be high performance with bacterial and nutrient stripping capabilities to the specifications of local government and the Health Department and shall be located in a position determined by local government.;

c) minimum floor levels for any building above the highest known water levels;

d) any land use that may contribute to the degradation of the surface or sub-surface water quality.

e) no development other than for conservation purposes will be permitted within 30 metres of any natural water body; AMD 21 GG 3/4/09

f) damming, draining or other developments which may alter the natural flow of surface water will not be permitted unless such works are part of an approved Catchment Management Plan."

Schedule 11 of the Scheme contains the following provisions that apply to the Muchea Employment Node:

"2.2 Environmental Management Plans

The following Environmental Management Plans shall be prepared and used to inform the design and proposed subdivision and development within the Structure Plan area. They shall be submitted as an additional detail of a Structure Plan unless otherwise determined by the Western Australian Planning Commission.

2.2.1 Local Water Management Strategy

The developer shall submit to the Local Authority a Local Water Management Strategy (LWMS) for approval as an additional detail of a Structure Plan pursuant to clause 5.19 in order to ensure that surface and ground waters are managed with the aim of maintaining the natural water balance. The Local Authority must notify and consult with the authority responsible for water and the environment on the proposed strategy in advertising the Local Structure Plan(s) pursuant to Part 4 of the deemed provisions.

The LWMS shall be prepared in accordance with Better Urban Water Management or its successor document.

The Structure Plan design shall respond to the LWMS required by 2.2.1 and shall be implemented to the satisfaction of the Local Authority, having regard to any advice from the Department of Water.

2.2.2 Environmental Assessment and Management Strategy

The developer shall submit to the Local Authority an Environmental Assessment and Management Strategy for approval as an additional detail of a Local Structure Plan pursuant to Part 4 of the deemed provisions in order to ensure the local structure plan provides a comprehensive and coordinated response to all environmental features within the Structure Plan area and in accordance with the Muchea Employment Node Structure Plan.

The Environmental Assessment and Management Strategy is to include the following:

- Identification of significant environmental features within the local structure plan area including flora, vegetation, fauna, wetlands and waterways;

- Identification of appropriate management strategies, consistent with industry best practice, to ensure that the local structure plan responds appropriately to these environmental features. Appropriate management strategies might include identification of buffers / setbacks, potential areas of revegetation / rehabilitation, public open space and fauna relocation; and

- Consideration of Acid Sulphate Soils (if present) and identification of the likely requirement for ASS management during future planning stages.

- Identification of, and the means for retention and protection of, key cockatoo habitat trees / locations

- Identification of measures to retain the rural character of views of the Structure Plan area from roads within, adjoining, or in the vicinity of the Structure Plan area, by providing details of vegetation screen planting, as well as the details for the siting and design of structure and major earthworks within the Structure Plan area.

The Local Authority must consult with the relevant environmental agencies regarding the proposed strategy in advertising the Local Structure Plan pursuant to clause 5.19.

The Environmental Assessment and Management Strategy shall be consistent with the EPA's current Guidance Statement No. 33 Environmental Guidance for Planning and Development, or any successor Guidance Statement.

The Environmental Assessment and Management Strategy required by 2.2.2 shall be implemented to the satisfaction of the Local Authority on the advice of the applicable environmental agencies."

This Environmental Assessment and Management Strategy (EAMS) has been prepared to satisfy the requirements of Clause 2.2.2 of Schedule 11.

1.3.3 Country Sewerage Policy

The draft Country Sewerage Policy requires that all new subdivision and development should be deep-sewered unless it is exempt for one of several reasons. For exempt developments, the policy establishes minimum site capability requirements and, where appropriate, density limits.

Commercial and industrial development in towns where no sewer is available may be permitted subject to:

- the overall objectives of the Policy not being compromised; and
- the statutory authority being satisfied after considering the advice of consultative authorities that the intended wastewater disposal arrangements are acceptable.

In this situation, the Health Department does not put a fixed limit on development density but assesses each proposal on its merits including the nature of the proposal and the physical capability of the site to accept the effluent.

Land used for on-site effluent disposal must meet the following requirements:

- The slope must be less than 20% (1 in 5) and the land shall be engineered to prevent runoff.

- The site should not be subject to inundation or flooding at a probability greater than once in 10 years.

- The land should have a minimum depth to the seasonal or permanent water table from the natural ground surface of at least 0.5 metre.

- The site should have free-draining soil (i.e. free from bedrock, impervious clay or groundwater table) to a depth of at least 1.2m below the base of a leach drain or 0.5m below the discharge point of an ATU subsoil dripper system.

- Where site modification involves blasting or fissuring of rock, an imported soil type is required to surround the disposal area unless the local authority grants an exemption.

1.3.4 DoW Operational Policy 4.3: Identifying and Establishing Waterways Foreshore Areas

DoW Operational Policy 4.3 was published in 2012 and sets out the Department of Water's policy on defining and protecting foreshore reserves. It is intended to apply to all waterways within development areas. The policy sets out procedures for identifying, delineating and protecting foreshore areas.

The procedure may vary depending on the size and nature of the waterway and the nature of the proposed adjacent development. The policy provides for standard or nominal foreshore widths to be employed in some cases, such as small subdivisions and/or minor tributary creeks where the waterway is adequately protected and the proposed development poses an insignificant additional risk to the waterway.

2.0 EXISTING ENVIRONMENT

2.1 Rainfall

Muchea, like the rest of the greater Perth region, has a strongly seasonal rainfall, with most of the annual rain falling between May and September in association with winter cold fronts. Occasional heavy falls may occur from summer thunderstorms. The long-term average annual rainfall for Pearce RAAF Base (located 13.6km south of the site) is 679.7mm, of which 77% falls between the months of May and September.

Figure 4 shows a rainfall occurrence chart for Pearce RAAF.

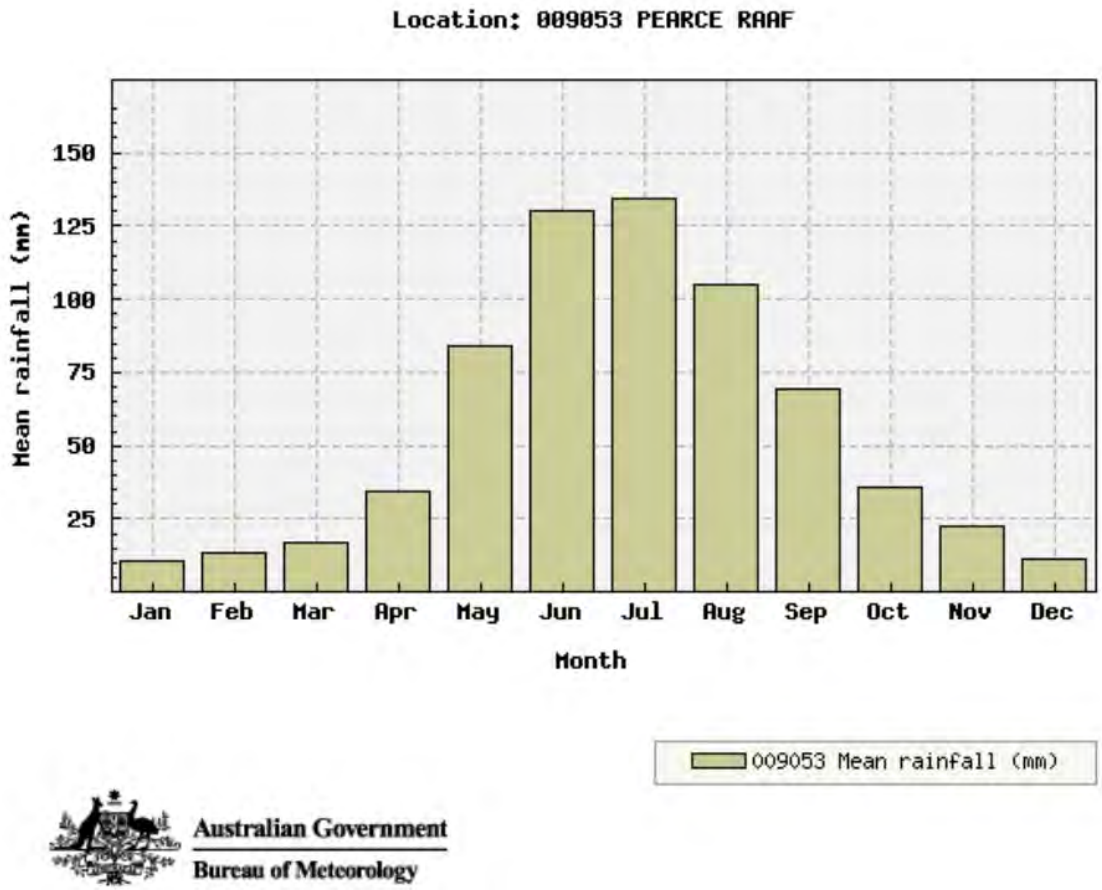


Figure 4 Pearce RAAF Mean Rainfall

2.2 Physiography

2.2.1 Topography

The site lies on a very gently sloping plain on the eastern side of Ellen Brook. The site slopes gently to the west-southwest at gradients of up to 2.5%, decreasing to less than 0.4% near Ellen Brook. Figure 5 shows the topography of the site.

2.2.2 Geology, Landforms and Soils

Precinct 3 is located on the Pinjarra Plain, with soils of pebbly silt belonging to the Guildford Formation. These soils originated as alluvial deposits washed from the Dandaragan Plateau by rivers and streams.

The Guildford Formation soils are described by the Geological Survey of Western Australia (Gozzard, 1982) as “Strong brown silt with common fine to occasionally coarse grained, sub-rounded quartz, heavily weathered granite pebbles, some fine to medium-grained quartz sand, of alluvial origin”.

Drilling at six sites across the project area for this EAMS found silty soils containing varying proportions of clay, with the clay content increasing with depth. The low-lying western parts of the site are underlain in places by an ironstone (laterite) hardpan at depths of around one metre. Bore logs from the drilling are attached in Appendix A.

At the western edge of the site the alluvial deposits are overlain by a thin veneer of grey sand transported by floods in Ellen Brook. Figure 5 shows the site geology.

2.2.3 Soil Permeability

The permeability of the site soils is variable, depending on the clay content. Test pumping during sampling of the on-site bores indicated hydraulic conductivities in the top few metres ranging from about 1 m/day to over 5 m/day.

Constant-head permeability tests in accordance with the method set out in Australian Standard AS1547:2012: – *On-site Domestic Wastewater Management* were undertaken at six sites at depths of 0.5m to 1m in November 2018. The tests returned saturated hydraulic conductivity values ranging from 0.25m/day to 4.2m/day with a mean of 1.8m/day.

Structerre Consulting Engineers carried out falling-head permeability tests at 1m depth at seven sites in November 2018. The falling-head tests returned hydraulic conductivity values ranging from 0.3m/day to 1.2m/day with a mean of 0.7m/day.

Figure 5 shows the locations of the permeability tests. Details of the tests are attached in Appendix B.

The ironstone hardpan in low-lying areas would impede vertical groundwater movement but its restricted extent means that its effect would be localised. In the south-east of the site, clay subsoils impede groundwater flow and cause a perched water table to develope in that area.

The presence of a water table at the ground surface in winter across much of the site (see Section 2.3.2) means that all infiltration of drainage and effluent will be in fill, so the permeability of the natural soils is of reduced importance.

2.2.4 Acid Sulphate Soils

The DBCA maps most of the site as Low to Nil risk of Acid Sulphate Soils (ASS). Areas within 50-250m of Ellen Brook (corresponding to the alluvial sand S11 and ironstone) are mapped as Low to Moderate risk. The nearest mapped High ASS risks are an area of palusplain about 850m to the south-east and a sumpland about 900m to the west of the site. Bore sampling in August 2018 found no indicators of potential or actual ASS in the groundwater. No further investigation of ASS is considered to be necessary, although monitoring should be undertaken during any dewatering activities, with lime dosing of water and/or soil if required.

2.2.5 Phosphorus Retention Index

Previous experience has shown that the gravelly and silty soils of the Guildford Formation generally have moderate to high PRI.

PRI is a measure of the ability of a soil to adsorb and retain phosphorus from solution. A high PRI indicates that a soil is unlikely to leach phosphorus to the water table. Typical ranges for PRI values in soils are as follows:

PRI Range	*Rating*	*Typical soils*
0 – 0.5	Very Low	Bassendean Sand
2 – 4	Low – Moderate	Karrakatta Sands
5 – 12	Moderate – High	Cottesloe Sands
12 – 20	High	Crushed Limestone, Limesand
20 – 1000+	Very High	Clay

The DWER recommends a minimum PRI of 15 for soils beneath infiltration basins and swales.

Soil samples collected from eight boreholes and infiltration test holes on the site (Figure 5) at depths of 0.5m to 1m returned PRI values of 39.3 to 338.1, with an average of 146.8. This shows that the soils of the site have a very high capacity to bind phosphorus.

2.3 Hydrology

The hydrology of the project area is complex, with soils of varying permeability, shallow and deep groundwater, runoff and surface discharge. Figure 6 depicts the overall hydrology of the site.

2.3.1 Groundwater

Groundwater occurs at shallow depth across the site. The DWER maps minimum groundwater levels at 39-48m AHD (2-7m below ground), flowing south-west towards Ellen Brook.

In winter, the groundwater rises to the ground surface across the lower western parts of the site and creates surface discharge to creeks, drainage lines and Ellen Brook. In the higher eastern parts of the site, rainfall infiltration is impeded by the low-permeability subsoils, creating a perched water table which flows downslope and discharges as surface flow on the lower parts of the site. The net result of these two processes is that groundwater is at or near the ground surface over much of the site in winter.

Bores installed and measured in August 2018 (Figure 7), during a wetter than average winter, gave water depths and levels shown in Table 2.1. Simultaneous measurements of DWER bores located 480m south-east (Swan GWA 2-98) and 580m north-east (Gnangara Monitoring GD20) enabled Average Annual Maximum (AAMGL) and Maximum (MGL) groundwater levels at the site to be calculated. Figure 7 shows the calculated AAMGL contours across the site.

Table 2.1 shows that the groundwater levels measured on 22 August 2018 were slightly above the AAMGL. The table also shows that the estimated MGL is above the ground surface over much of the site. This does not take into account the effects of existing drains and surface runoff, which would generally limit the groundwater levels to at or just below the ground surface.

Table 2.1 Groundwater Depths and Levels 22 August 2018

Bore	*Depth (mbgl)*	*Level (m AHD)*	*AAMGL (m AHD)*	*MGL (m AHD)*	*Depth to AAMGL (m)*	*Depth to MGL (m)*
MB1	0.2	51.39	51.14	51.72	0.45	-0.13
MB2	0.34	45.29	45.04	45.62	0.59	0.01
MB3	0.21	52.37	52.12	52.70	0.46	-0.12
MB4	0.02	42.58	42.33	42.91	0.27	-0.31
MB5	0.69	56.1	55.85	56.43	0.94	0.36
MB6	-0.08	42.98	42.73	43.31	0.17	-0.41
MB7	0.32	55.19	54.94	55.52	0.57	-0.01
MB8	0.23	42.64	42.39	42.97	0.48	-0.10
399	0.02	48.42	48.17	48.75	0.27	-0.31
GD20	0.12	61.36	59.85	61.35	1.63	0.13
2-98	1.44	56.85	56.6	57.18	1.69	1.11

2.3.2 Surface Drainage

The high water tables and low permeability soils of the site result in surface flow in channels and sheet flow across the ground surface during wet winters.

Several natural and artificial drainage lines cross the site from fifteen culverts beneath Great Northern Highway. The largest of these is a creek at the northern end, which has a catchment east of Great Northern Highway of 384ha. Two other drainage lines enter on the mid eastern boundary, draining catchments of 67ha and 121ha east of Great Northern Highway. Several other culverts beneath the highway drain into minor drainage lines within

the site. Other small drainage lines rise within the site and flow west. Figure 8 shows the existing drainage within the site.

All drainage from the site flows into Ellen Brook, the major drainage feature of the region. The Ellen Brook catchment is the largest sub-catchment of the Swan-Canning River system, contributing 6% of the total annual flow in the system, and is the largest single contributor of nutrients to the system (WA Govt, 2011).

Ellen Brook has a surface catchment of 715km^2 (WRC, 2012). The Brook rises as Chandala Brook about 20km north-northwest of the site. The Brook is seasonal, flowing generally between May and November with an annual flow ranging from 2.1 to 48.6 GL (SRT, 2009).

Flows in Ellen Brook are normally confined to the defined channel of the Brook, although high flows can cause inundation of adjacent land. Main Roads Western Australia (MRWA) modelled the 100-year ARI floodplain of Ellen Brook for the Perth-Darwin National Highway (PDNH) project. Figure 8 shows the 100-year ARI floodplain as modelled by MRWA.

Further flood modelling was carried out by BG&E for this project, in order to define the floodway of the Brook for the purposes of defining the foreshore reserve. The floodway modelling was confined to the part of Ellen Brook south of the PDNH crossing, where the Structure Plan area interacts with the Brook. The BG&E floodway modelling report is attached in Appendix C. Figure 8 shows the floodway as mapped by BG&E, which falls within the foreshore and drainage/landscape reserve.

2.3.3 Water Resources

The project area is within the Lake Mungala sub-area of the Gingin Groundwater Area for the superficial and semi-confined (Mirrabooka) aquifers, and the SA 3 South sub-area for the confined Leederville and Yarragadee aquifers. Groundwater allocations within the Lake Mungala and SA 3 South sub-areas are managed under the Gnangara Groundwater Areas Allocation Plan. Under the plan, all of the aquifers within the Lake Mungala and SA 3 South sub-areas are fully or over allocated, and no new allocations are available. The DWER intends to release a new Gnangara Groundwater Allocation Plan in late 2018, which may further reduce allocation limits within the plan area (G. Chandler, 2018 pers. comm.).

The DWER Water Register (https://maps.water.wa.gov.au/#/webmap/register) shows a number of licensed bores within the project area, abstracting water from the superficial and Leederville aquifers. The total licensed allocations within the project area are 82,150 KL/yr from the Leederville and 35,000 KL/yr from the superficial aquifer.

The water requirement for the fully developed project area is unknown, although the Muchea Employment Node Structure Plan (WAPC, 2011) implies that the total combined requirement for the Employment Node and the Muchea townsite is less than 288 ML/a. From this it may be deduced, on a area basis, that the ultimate water requirement for the

project area would be somewhat less than 60 ML/yr. This is roughly half of the currently licensed allocations within the project area.

Water supply will be required for both potable and non-potable purposes. The Leederville aquifer is likely to be the preferred source for potable supply due to its generally higher quality and lower risk of contamination. Non-potable groundwater demand is likely to be limited to landscape irrigation, as industries within the Precinct will be limited to those with low water usage.

Potable water will be supplied to the Precinct by a licensed water provider. A proposed water project for the Lower Chittering Valley is currently in development by Aqua Ferre Pty Ltd, which includes construction of a water treatment facility on Lot 2 Reserve Rd, Chittering. Aqua Ferre is in the process of applying for a Water Service Provider's Licence from the Economic Regulation Authority (ERA). Aqua Ferre has confirmed that it has the capacity within its proposed licence to supply Precinct 3 with potable water. Discussions with Aqua Ferre are ongoing.

For non-potable uses, purchase of water entitlements from existing licensed users within or outside of the Precinct is likely to be necessary. The landowners group will negotiate with existing licence holders within and outside of the Precinct with a view to purchasing an existing groundwater allocation., and will submit a groundwater licence application to the DWER in due course.

2.4 Water Quality

2.4.1 Groundwater

Groundwater samples were collected from eight bores within the project area (Figure 7) on 22 August 2018, when groundwater levels were at or near their peak for the year. The results of the analysis are shown in Table 2.2 and summarised below.

Groundwater quality within the project area is moderate, which is to be expected given the soil types and the history of agriculture. Nitrogen and phosphorus concentrations are generally moderate with the exception of a notably high reading for total phosphorus in Bore MB2, in the north-west of the project area. This bore is downstream of a heavily-stocked special rural lot and also has sandy surface soils. The high Total Phosphorus concentration is not reflected in the dissolved (reactive) phosphorus concentration.

The groundwater shows low acidity and sulphate contents, indicating that there is no evidence of acid sulphate soils. Dissolved metals concentrations are low except for aluminium and zinc, which are slightly elevated across much of the site.

2.4.2 Surface Water

Surface water samples were collected on 22 August 2018 from ten drains and creeklines flowing into the project area from culverts beneath Great Northern Highway (Figure 8). A further six samples were collected from drains flowing out of the project area into Ellen Brook. Samples were also collected from Ellen Brook immediately upstream and downstream of the project area, and from two small dams in the south of the project area (Figure 8). The results of the analysis are shown in Tables 2.3 and 2.4 and summarised below.

Surface water quality upstream of the project area is variable, with total phosphorus in ten drains and creeklines flowing into the site (Figure 8) ranging from 0.04mg/L to 0.31mg/L (the ANZECC target for freshwater ecosystems is 0.065mg/L). Total nitrogen in these watercourses ranged from 0.6mg/L to 2.1mg/L, against an ANZECC target of 1.2mg/L.

Water quality downstream of the project area was generally poorer, with six outflowing drains (Figure 8) having total phosphorus of 0.07 - 1.8 mg/L and total nitrogen of 1.3 - 3.0 mg/L.

The most notable feature of surface water quality is Ellen Brook itself, which showed total phosphorus of 0.59mg/L upstream of the project area and 0.54mg/L downstream. Coupled with the high flow at the time, this emphasises the primary role of Ellen Brook in the water quality issues facing the Swan-Canning River system.

Suspended sediment levels in surface water upstream and downstream were generally low except at Site 369 (Figure 8) in Ellen Brook immediately downstream of the confluence of a small drain carrying sediment-laden water from the PDNH roadworks. The effect of this drain was not apparent in samples further down Ellen Brook.

The two dams sampled in the south of the project area, which held a blend of surface and ground water, gave mixed water quality results, with low phosphorus but elevated nitrogen levels.

Table 2.2 Groundwater Quality 22/8/2018

(see Figure 7 for bore locations)

	Parameter	Unit	Aquatic Ecosystems[a]	Irrigation Water[b]	*MB1*	*MB2*	*MB3*	*MB4*	*MB5*	*MB7*	*MB8*
Nutrients	Total Nitrogen	mg/L	1.2	5	**1.7**	**4.3**	**3**	<0.2	**2**	1.2	0.5
	NOx	mg/L	0.15	ng	**1.5**	**2.5**	**3**	<0.01	**2**	**0.21**	0.07
	Total Kjeldahl Nitrogen	mg/L	ng	ng	0.2	1.8	<0.2	<0.2	<0.2	1	0.4
	Total Phosphorus	mg/L	0.065	0.05	0.04	**0.99**	0.03	**0.15**	**0.2**	**0.2**	**0.25**
	Reactive Phosphorus	mg/L	0.04	ng	<0.01	0.01	<0.01	0.02	<0.01	0.02	0.03
Physical	pH		6.5-8.0	6-8.5	6.5	6.9	6.7	**4.7**	6.6	**6.3**	**5.5**
	Conductivity	mS/cm	0.12-0.3	1.3	**4.8**	**1.6**	**0.82**	**2.8**	0.25	**3.5**	**4.4**
	Salinity (from EC)	mg/L	72-180	780	**2880**	**960**	**492**	**1680**	150	**2100**	**2640**
	Acidity	mg/L	40[c]	ng	15	20	9	**63**	15	**77**	**67**
	Alkalinity	mg/L	ng	ng	29	70	22	<5	27	65	<5
	Acidity:Alkalinity Ratio		1[c]	ng	0.52	0.11	0.18	0.57	0.29	0.45	0.37
	Hardness	mg/L	ng	60-350	140	190	51	110	52	170	180
	Sulphate	mg/L	ng	ng	240	130	13	120	12	130	120
	Chloride	mg/L	ng	350	1400	400	230	850	44	1100	1400
	SO_4:Cl Ratio		0.5	ng	0.17	0.33	0.06	0.14	0.27	0.12	0.09
Major Ions	Calcium	mg/L	ng	ng	54	44	20	23	17	54	32
	Sodium	mg/L	ng	230	820	300	110	420	29	630	710
	Potassium	mg/L	ng	ng	1.7	19	0.3	13	2.3	8	24
	Magnesium	mg/L	ng	ng	160	28	23	83	8.8	67	140
	Iron	mg/L	ng	10	0.16	0.19	0.08	0.39	0.08	4.3	18

Notes

ng denotes "no guideline". na denotes "not analysed"

a. ANZECC (2000) Aquatic Ecosystem trigger values (Nutrient, pH and Conductivity are for lowland rivers; Dissolved Metals are for freshwater ecosystems 90% species protection)

b. ANZECC (2000) Irrigation trigger values (long-term irrigation up to 100 years)

c. DEC(20__) oxidation indicator triggers for ASS-affected groundwater.

d. ANZECC (2000) Irrigation trigger values for pasture and fodder for grazing animals except pigs and dairy animals.

Dissolved Metals	Aluminium	mg/L	0.08	5	**0.2**	<0.1	**0.2**	**0.2**	**0.1**	**0.2**	**0.2**	
	Arsenic (III & V)	mg/L	0.136	0.1	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	0.006	
	Cadmium	mg/L	0.0004	0.01	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	
	Chromium (VI)	mg/L	0.006	0.1	<0.002	<0.002	<0.002	<0.002	<0.002	0.003	<0.002	
	Copper	mg/L	0.0018	0.2	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	
	Mercury	mg/L	0.0019	0.002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	
	Nickel	mg/L	0.013	0.2	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	<0.01	
	Lead	mg/L	0.0056	2	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	
	Zinc	mg/L	0.015	2	<0.01	0.01	0.01	**0.06**	<0.01	**0.07**	**0.02**	

Table 2.3 Upstream Surface Water Quality 22/8/2018

(see Figure 8 for sample locations)

	Parameter	Unit	Aquatic Ecosystems[a]	Irrigation Water[b]	*Ellen Brook Upstream*	*407*	*405*	*395*	*393*	*392*	*391*	*410*	*409*	*415*
Nutrients	Total Nitrogen	mg/L	1.2	5	**3**	0.7	**2.1**	1.2	**1.7**	0.6	0.6	**1.7**	**1.7**	**1.7**
	NOx	mg/L	0.15	ng	0.01	0.06	<0.01	0.02	0.12	<0.01	0.01	**0.45**	**0.32**	<0.01
	Total Kjeldahl Nitrogen	mg/L	ng	ng	3	0.6	2.1	1.2	1.6	0.6	0.6	1.2	1.4	1.7
	Total Phosphorus	mg/L	0.065	0.05	**0.59**	**0.11**	**0.27**	**0.08**	**0.09**	0.04	0.04	0.05	**0.24**	**0.31**
	Reactive Phosphorus	mg/L	0.04	ng	**0.47**	<0.01	**0.13**	0.01	0.01	<0.01	<0.01	<0.01	**0.18**	**0.22**
Physical	pH		6.5-8.0	6-8.5	7.2									
	Conductivity	mS/cm	0.12-0.3	1.3	**1.7**									
	Salinity (from EC)	mg/L	72-180	780	**1020**									
	Acidity	mg/L	40[c]	ng	8									
	Alkalinity	mg/L	ng	ng	62									
	Acidity:Alkalinity Ratio		1[c]	ng	0.04									
	Hardness	mg/L	ng	60-350	180									
	TSS	mg/L	ng	ng	7	6	14	<5	<5	<5	<5	<5	<5	<5
	Sulphate	mg/L	ng	ng	49									
	Chloride	mg/L	ng	350	470									
	SO_4:Cl Ratio		0.5	ng	0.10									
Major Ions	Calcium	mg/L	ng	ng	56									
	Sodium	mg/L	ng	230	220									
	Potassium	mg/L	ng	ng	10									
	Magnesium	mg/L	ng	ng	53									
	Iron	mg/L	ng	10	2.8									

Notes

ng denotes "no guideline". na denotes "not analysed"

a. ANZECC (2000) Aquatic Ecosystem trigger values (Nutrient, pH and Conductivity are for lowland rivers; Dissolved Metals are for freshwater ecosystems 90% species protection)

b. ANZECC (2000) Irrigation trigger values (long-term irrigation up to 100 years)

c. DEC(20__) oxidation indicator triggers for ASS-affected groundwater.

d. ANZECC (2000) Irrigation trigger values for pasture and fodder for grazing animals except pigs and dairy animals.

	Aluminium	mg/L	0.08	5	**0.2**									
	Arsenic (III & V)	mg/L	0.136	0.1	<0.002									
	Cadmium	mg/L	0.0004	0.01	<0.002									
	Chromium (VI)	mg/L	0.006	0.1	<0.002									
	Copper	mg/L	0.0018	0.2	<0.01									
	Mercury	mg/L	0.0019	0.002	<0.0002									
	Nickel	mg/L	0.013	0.2	<0.01									
	Lead	mg/L	0.0056	2	<0.01									
	Zinc	mg/L	0.015	2	**0.03**									

Table 2.4 Downstream Surface Water Quality 22/8/2018

(see Figure 8 for sample locations)

	Parameter	Unit	Aquatic Ecosystems[a]	Irrigation Water[b]	*Ellen Brook Down -stream*	*AMS1*	*Ingham1*	*Ingham2*	*MD*	*369*	*362*	*Dam1*	*Dam2*	Notes
Nutrients	Total Nitrogen	mg/L	1.2	5	**2.6**	**1.5**	**2.3**	**1.7**	**1.6**	**3**	**1.3**	**3.2**	**2.9**	ng denotes "no guideline". na denotes "not analysed"
	NOx	mg/L	0.15	ng	0.02	**0.23**	<0.01	<0.01	<0.01	**0.34**	<0.01	**2.4**	**2.9**	a. ANZECC (2000) Aquatic Ecosystem trigger values (Nutrient, pH and Conductivity are for lowland rivers; Dissolved Metals are for freshwater ecosystems 90% species protection)
	Total Kjeldahl Nitrogen	mg/L	ng	ng	2.6	1.3	2.3	1.7	1.6	2.7	1.3	0.8	<0.2	b. ANZECC (2000) Irrigation trigger values (long-term irrigation up to 100 years)
	Total Phosphorus	mg/L	0.065	0.05	**0.54**	**0.12**	**0.14**	**0.07**	**0.16**	**0.18**	**0.12**	0.05	0.04	c. DEC(20__) oxidation indicator triggers for ASS-affected groundwater.
	Reactive Phosphorus	mg/L	0.04	ng	**0.45**	<0.01	0.04	<0.01	0.02	0.04	0.02	<0.01	<0.01	d. ANZECC (2000) Irrigation trigger values for pasture and fodder for grazing animals except pigs and dairy animals.
Physical	pH		6.5-8.0	6-8.5	7.3									
	Conductivity	mS/cm	0.12-0.3	1.3	**1.7**									
	Salinity (from EC)	mg/L	72-180	780	**1020**									
	Acidity	mg/L	40[c]	ng	7									
	Alkalinity	mg/L	ng	ng	65									
	Acidity:Alkalinity Ratio		1[c]	ng	0.04									
	Hardness	mg/L	ng	60-350	200									
	TSS	mg/L	ng	ng	<5	7	10	<5	7	51	<5	<5	<5	
	Sulphate	mg/L	ng	ng	51									
	Chloride	mg/L	ng	350	480									
	SO_4:Cl Ratio		0.5	ng	0.11									
Major Ions	Calcium	mg/L	ng	ng	64									
	Sodium	mg/L	ng	230	220									
	Potassium	mg/L	ng	ng	10									
	Magnesium	mg/L	ng	ng	53									
	Iron	mg/L	ng	10	2.9									

Dissolved Metals	Aluminium	mg/L	0.08	5	**0.2**									
	Arsenic (III & V)	mg/L	0.136	0.1	<0.002									
	Cadmium	mg/L	0.0004	0.01	<0.002									
	Chromium (VI)	mg/L	0.006	0.1	<0.002									
	Copper	mg/L	0.0018	0.2	<0.01									
	Mercury	mg/L	0.0019	0.002	<0.0002									
	Nickel	mg/L	0.013	0.2	<0.01									
	Lead	mg/L	0.0056	2	<0.01									
	Zinc	mg/L	0.015	2	<0.01									

2.5 Vegetation

2.5.1 Vegetation Type and Condition

The project area is mostly cleared of native vegetation, consisting of current and former farm paddocks and industrial sites. Figure 9 shows the vegetation of the project area.

Remnant native vegetation consists of a few mature paddock trees (Marri, Flooded Gum and Wandoo), including several very large Marri trees that have been retained within the AMS site (Lots 802 & 803) and a few large Wandoo trees in Lot 804.

Native regrowth is present near the large drain on Lot 800 in the form of a small (0.5ha) thicket of species including *Allocasuarina fraseriana, Melaleuca preissiana, Eucalyptus rudis, Astartea fascicularis* and *Acacia ?rostellifera* over grasses. Nearby is a smaller thicket on a drainage line with regrowth of *Juncus ?kraussii*, *M. preissiana, A. fascicularis* and *E. rudis*.

The area around the large drain on Lot 800 has been densely planted with native tree species including *E. rudis, A. fraseriana, M. preissiana, M. cuticularis* and *Corymbia calophylla.* The drain itself contains a heavy growth of sedges, Bulrush (*Typha orientalis*) and Kikuyu and Couch grasses.

Other areas near the large drain and in other low-lying parts of the site contain dense growths of Cape Tulip (*Moraea flaccida*), Spiny Rush (*Juncus acutus*) and Narrow-leaf Cotton Bush (*Gomphocarpus fruticosus*), all of which are declared pests in Western Australia (www.agric.wa.gov.au/pests-weeds-diseases/weeds/declared-plants). The native rush *Juncus kraussii* occurs along with the introduced *J. acutus* in some areas.

In the west of Lot 35 in the south of the project area are a few large isolated Flooded Gums. In the central south of the site (Lot 35) is a 2.5ha patch of open woodland of young *E. rudis* regrowth over grass.

Elsewhere on the site there are lines and clumps of planted trees, mostly Flooded Gums, Bluegums (*Eucalyptus globulus*), River Red Gums (*E. camaldulensis*) and other non-local eucalypts. There is also scattered regrowth of sedges (*Juncus* ?kraussii) and isolated shrubs.

Overall the condition of the vegetation is classed as Cleared to Completely Degraded. There is no vegetation in Good or better condition.

Adjacent to Ellen Brook there is a sparse to dense woodland of *Eucalyptus rudis, Allocasuarina fraseriana, Melaleuca preissiana, M. rhaphiophylla, Astartea affinis, Jacksonia furcellata and Acacia saligna.* This woodland thins rapidly with distance from the Brook and is mostly outside of the project area. The ground cover over most of this area consists of a heavy growth of pasture grasses and weeds, which extend into the waterway itself.

The condition of the Brook vegetation is mostly Degraded to Completely Degraded, with a few areas of Good condition. The central part (Lots 800 & 801) is accessible to cattle and is in poorer condition than the rest due to grazing. In the northern part (Lots 801-804) there is a dense growth of *Watsonia meriana* ssp *bulbillifera* in areas not accessed by cattle.

2.5.2 Vegetation Complexes

The vegetation of the project area is mapped as Yanga Complex, described by Heddle *et al.* (1980) as a low open-forest of *Casuarina obesa*, *Actinostrobus* (now *Callitris*) *pyramidalis, Melaleuca* spp. (including *M. lateritia, M. hamulosa*, *M. preissiana and M. rhaphiophylla*) and *Eucalyptus rudis* in the lower-lying areas, with *Banksia* spp., *Eucalyptus todtiana* and *Corymbia calophylla* open-woodland in the higher areas.

2.5.3 Rare and Significant Flora

The DBCA's Naturemap database lists no Declared Rare Flora, Priority Flora or other significant flora species as occurring within the project area. Given the almost completely cleared nature of the project area, no rare or significant species are likely to be present.

The Naturemap database lists six Declared Rare Flora (DRF) taxa and twelve Priority Flora taxa as occurring within a 5km radius of the project area. These are listed in Table 2.5.

Table 2.5 Significant Flora Within 5km Radius

Taxon	*Cons Code*
Acacia anomala	R
Darwinia foetida	R
Grevillea althoferorum subsp. fragilis	R
Grevillea curviloba subsp. curviloba	R
Grevillea curviloba subsp. incurva	R
Verticordia plumosa subsp. pleiobotrya	R
Isotropis cuneifolia subsp. glabra	P2
Acacia drummondii subsp. affinis	P3
Adenanthos cygnorum subsp. chamaephyton	P3
Chamaescilla gibsonii	P3
Cyathochaeta teretifolia	P3
Eryngium pinnatifidum subsp. Palustre	P3
Platysace ramosissima	P3
Stylidium aceratum	P3
Verticordia serrata var. linearis	P3
Drosera occidentalis subsp. occidentalis	P4
Ornduffia submersa	P4
Synaphea grandis	P4

The habitats of the listed DRF species, as recorded in the search area and described in the DBCA's *Florabase*, are as follows:

- *Acacia anomala*
  Florabase: Lateritic soils. Slopes.
  Search area: Marri/*E. todtiana*/Banksia woodland on yellow sand.

- *Grevillea althoferorum* subsp. *fragilis*
  Florabase: Grey sand with gravel.
  Search area: Marri/*E. todtiana*/Banksia woodland on yellow sand.

- *Grevillea curviloba* subsp. *curviloba*
  Florabase: Grey sand. Winter-wet heath.
  Search area: Muchea townsite and the railway reserve south of Muchea.

- *Grevillea curviloba* subsp. *incurva*
  Florabase: Sand, sandy loam. Winter-wet heath.
  Search area: Several locations in the Brand Hwy and railway reserve north of Muchea and the Muchea townsite.

- *Verticordia plumosa* subsp. *pleiobotrya*.
  Florabase: Sandy or clayey soils, gravel, granite. Seasonally wet situations, rock outcrops, undulating plains, hills, road verges.
  Search area: Marri/*E. todtiana* woodland on yellow sandy rise.

2.6 Fauna

The project area contains little habitat for native fauna apart from scattered mature paddock trees and small areas of regrowth and planted vegetation around the drains near the PDNH reserve.

The largest area of fauna habitat in the vicinity is the fringing vegetation along Ellen Brook, which borders the southern part of the project area. Fauna including kangaroos are likely to use this habitat as refuge and venture out into the project area to feed on the paddocks.

Bandicoot (Quenda) diggings were observed around Sharp Rush thickets along a drain in Lot 800 (Figure 9).

The DBCA's Naturemap database lists three Threatened Fauna and one Priority Fauna species as occurring within a 5km radius of the project area. These are:

- Carnaby's Black Cockatoo *Calyptorhynchus latirostris* (T)
- Forest Red-tailed Black Cockatoo *Calyptorhynchus banksii* subsp. *naso* (T)
- Australasian Bittern *Botaurus poiciloptilus* (T)

- Black-striped Burrowing Snake *Neelaps calanotos* (P3).

The two species of black cockatoo both nest in large hollows in mature eucalypts. The few large remaining eucalypts present in the project area might contain suitable hollows (most were unavailable for inspection) but their isolation and the lack of nearby food resources mean that they are unlikely to be used for nesting.

The Australasian Bittern is a water bird that feeds on aquatic animals such as frogs, eels and freshwater crustaceans, and nests in dense wetland vegetation. There is no feeding or nesting habitat for the species in the project area.

The Black-striped Burrowing Snake inhabits sandy areas and Banksia woodlands. The cleared vegetation and silty clay soils of the project area do not provide the preferred habitat for this species.

2.7 Land Uses and Potential Contamination

Historic Landgate aerial photography shows that the project area has been cleared and used for farming since at least 1965.

The DWER Contaminated Sites Database (https://dow.maps.arcgis.com/apps/webappviewer/index.html?id=c2ecb74291ae4da2ac32c441819c6d47) shows no record of any contaminated sites in the project area. The nearest mapped contaminated site is a service station in Muchea, 700m west of the northern end of the project area and on the other side of Ellen Brook. There is no potential for this contamination to directly affect the project area.

The DWER (DoE, 2004) considers intensive agriculture such as the poultry farming operation on Lots 800 and 801 to be a potentially contaminating land use, with potential contaminants including organochlorine, organophosphate and carbamate pesticides, herbicides, metals, salinity and nutrients. Residual soil contamination is most likely to be present around the poultry sheds. Groundwater contamination by nutrients and salinity may be present downgradient of the sheds but would diminish and eventually clear once the sheds were removed. There is no visual or olfactory evidence of soil or groundwater contamination at the poultry farm.

The DWER has advised that, given the proposed use of the land for industry, and assuming the poultry farm has been operating in according with its licence, there should be no need for a site contamination assessment before the land is redeveloped.

There is no visual evidence of other potentially contaminating activities such as piggeries, hydrocarbon storage or landfill.

2.8 Aboriginal and European Heritage

The Department of Planning Lands & Heritage's online database shows one registered site, (ID 3525 Ellen Brook: Upper Swan) and seven "other" sites impinging on the project area. Appendix D shows the search reports.

The DPLH mapping usually extends well beyond the actual registered site boundary in order to protect sensitive sites.

The DAA has advised that registered sites do occur within the subject land, in connection with Ellen Brook and tributary creeks. Any disturbance of the registered sites will require approval under Section 18 of the Aboriginal Heritage Act 1972.

2.9 Landscape

The project area is visible from Great Northern Highway and Brand Highway. The view is screened in part by roadside trees and vegetation within the site. Figure 10 shows views from Great Northern Highway and Brand Highway.

The landscape consists mostly of a mix of cleared paddocks with scattered trees and existing intensive commercial operations including Road Trains of Australia (RTA), Aussie Modular Solutions (AMS) and Inghams' poultry farms. The Perth-Darwin National Highway (PDNH) works have caused a major change to the landscape, particularly near the northern end of the project area.

3.0 ENVIRONMENTAL IMPACTS AND MANAGEMENT

3.1 Surface Water Protection

Ellen Brook is a major tributary of the Swan-Canning River system and the largest contributor of nutrients, mostly from agriculture on the grey sandy soils west of the Brook. Small creeks and drainage lines are important contributors to the flow and water quality of Ellen Brook.

Industrial development has the potential to affect the volume, rate and quality of water flows in the small watercourses and Ellen Brook. The Structure Plan recognises the project area's sensitivity with respect to its proximity to Ellen Brook by restricting future land uses within the project area to industries with low water requirements that do not produce large amounts of industrial waste water. Water outputs from the project area will therefore be limited to stormwater, groundwater and minor process water (such as washdown water).

The Structure Plan has been laid out in order to provide physical protection to Ellen Brook and the significant drainage lines that cross the project area.

Management
The aim of surface water protection is to improve the quality of surface water leaving the project area. Given the site's current use for broadacre and intensive agriculture, this is considered achievable.

The contaminant of major concern in Ellen Brook and the Swan-Canning River system is phosphorus. Monitoring in September 2018 (Tables 2.3 and 2.4) showed that Ellen Brook carries very heavy phosphorus loads. Phosphorus is a major contaminant in agricultural runoff but a minor component in runoff from industrial areas.

Management strategies to be implemented include:

- In accordance with the Shire of Chittering Town Planning Scheme No. 4, industries permitted in the precinct will be those that dispose of domestic-quality wastewater at a rate less than 5,400 litres per hectare per day (R10 equivalent).

- Wastewater from toilets and bathrooms will be treated by nutrient-removing systems (e.g. ATU or modified leach drains) in accordance with Health Department requirements. An analysis of the capability of the site to support on-site effluent disposal is presented in the Local Water Management Strategy (Appendix E).

- Existing major drainage lines crossing the project area will be retained and protected within vegetated streamlines (see LWMS and Landscape Master Plan).

- All road runoff will be captured and infiltrated (up to 1-year ARI 1-hour storm) or detained (up to critical 100-yr storm) in bioretention swales in accordance with DWER guidelines. Stormwater management is detailed in the LWMS. Figure 11 shows an overview of the stormwater management system.

- Any process wastewater generated by industries will be treated on-site to a standard suitable for discharge or disposed offsite.

- All lot drainage from storms up to 1-year ARI will be retained and infiltrated on site.

- A monitoring program for stormwater, internal drainage and Ellen Brook will be implemented as detailed in the LWMS.

- Temporary drainage controls will be implemented during the construction period (see Section 3.5).

3.2 Groundwater Protection

Groundwater is an important contributor to water flow and quality in Ellen Brook. Given the silty clay soils of the project area, groundwater throughflow and discharge is relatively low.

Groundwater reaches the ground surface over much of the project area in wet winters, leading to high rates of surface runoff and groundwater discharge to surface drains.

Bore samples collected in September 2018 show that the quality of groundwater is generally moderate, with moderate concentrations of phosphorus and nitrogen.

The Structure Plan aims to maintain groundwater levels, discharge volumes and quality at their pre-development levels. With the progressive removal of cattle grazing and poultry farms, the quality of groundwater is expected to gradually improve.

Management
Groundwater protection measures are detailed in the LWMS and will include:

- Industries will be restricted to those with low water use and minimal or no waste water (see Structure Plan report).

- Subsoil drains will be set at or above the pre-existing Average Annual Maximum Groundwater Level (AAMGL).

- Subsoil and stormwater drains will discharge to vegetated swales with PRI of at least 15 (see LWMS).

3.3 Noise

Industrial land use is inherently noisy. Noise sources include traffic, machinery, power tools, ventilators and impacts.

The eastern part of the project area currently experiences high levels of noise from Great Northern Highway, which carries a high volume of heavy traffic including road trains. With the opening of the Perth-Darwin National Highway, the noise from Great Northern Highway will diminish significantly, with the noise impact shifting to the western side of the project area near the PDNH.

Noise sensitive premises (residences) are located in Muchea, 400 metres west of the project area. Isolated residences are also located east of Great Northern Highway, 70m east and 150m south-east of the project area.

Other noise sources include a clay quarry located 1km east and air traffic (including jets) from Pearce RAAF Base located 6.5km south. The project area is in line with the main runway at Pearce.

Future noise sources will include the PDNH and industry east of Great Northern Highway (Muchea Employment Node Precinct 2).

Management
Active management of noise within and from the Structure Plan area will not generally be required. Industries with high noise emissions may be required to undertake technical analyses to determine separation requirements. These industries may be restricted to certain parts of the Structure Plan area where suitable separations are available.

3.4 Dust

Industrial land uses may generate significant amounts of dust, depending on the activities carried out and the condition of the ground surface. Potentially dusty activities include processing (materials handling), unsealed roads and exposed soil surfaces.

The silty soils of the project area are susceptible to dust generation when disturbed. The main dust risk will be during construction work. Management of construction impacts is detailed in Section 3.5.

Sensitive dust receptors are the same as those for noise: the town of Muchea and residences located east of Great Northern Highway.

Management
Individual lot holders within the project area will be required to manage dust to prevent dust escape beyond their boundaries. Industries that generate appreciable dust will be

required to hold a DWER licence, which will include dust limits and specify monitoring requirements.

3.5 Construction Impacts

Construction of the Precinct 3 industrial estate will be carried out by various parties at various times, in accordance with individual land owners' preferences. Construction of roads, drainage and other services will be undertaken by the owner(s) of each stage of subdivision.

Construction stage impacts relate mainly to the movement of machinery and the presence of areas of exposed soil, and include noise, vibration, dust, erosion and sedimentation.

Management
Management of construction impacts will be the subject of conditions attached to subdivision approvals, works approvals and development approvals.

In general, control of construction impacts will be the responsibility of the construction contractor. The general principles of construction management will be as follows:

The developer will implement a Construction Management Plan for the development dealing with dust management, erosion and sediment control, containment of environmentally hazardous materials (chiefly fuel and oils) and spill response. The key elements of the Construction Management Plan will include the following:

Dust Minimisation
- No topsoil stripping will be undertaken in dry conditions when the wind speed is greater than 25km/h unless appropriate dust control watering is undertaken prior to and during disturbance..
- No earthworks will be undertaken in dry conditions when the wind speed is greater than 40km/h unless appropriate dust control watering is undertaken prior to and during disturbance.
- Dust will be suppressed on open ground and stockpiles by regular watering, hydromulching, wind fencing and/or covering.
- An adequate supply of water for dust suppression will be kept on site at all times.
- Soil stockpiles will be limited to a height of 2.5m to minimise dust generation and to facilitate watering.
- Other dust minimisation measures will include minimising areas of disturbance, limiting volume and speed of construction traffic and instructing site workers in dust minimisation.

Erosion and Sedimentation
- Drains and bunds will be constructed at the beginning of site disturbance as necessary to capture and direct all runoff from disturbed areas into settling ponds.

Drains, bunds and ponds will be appropriately designed and sized to provide adequate settling of sediments from drained water before release.
- Vehicles and machinery will be kept to designated roads, tracks and work areas.

Water Conservation
- Water consumption during construction will be minimised by:
  - limiting dust suppression watering to prevent ponding and runoff; and
  - use of non-water dust control methods such as wind fencing and hydromulching where appropriate.

Hazardous Materials
- All environmentally hazardous materials will be stored in their original labelled containers (or labelled jerrycans or drums in the case of petroleum fuels) in a ventilated enclosure equipped with appropriate signage, fire extinguishers and a spill response kit.
- Petroleum products will be held in a bunded enclosure.
- Material Safety Data Sheets (MSDS) and a chemical register for all hazardous materials on the site will be maintained by the site supervisor in the site office.

Complaints Register
- The site supervisor will maintain a record of any public complaints and the actions taken in response.

3.6 Vegetation and Flora

The native vegetation of the project area consists of a few paddock trees, rows and thickets of planted trees, sedges and shrubs in drainage lines and a small thicket of regrowth consisting of flooded gums, casuarinas and acacias near the large drain on Lot 800 (Inghams).

The largest area of native vegetation near the project area is the fringing vegetation of Ellen Brook. This will be preserved in the foreshore reserve.

Remnant trees within the development area will be preserved where possible. No remnant trees may be cleared without a Development Approval from the Shire of Chittering and/or a clearing permit from the DWER.

Approximately 31.5 hectares of native sedges, shrubs and trees will be planted in the Ellen Brook foreshore, in drainage swales and within lots. This is described in more detail in the Landscape Master Plan.

3.7 Fauna

There is little native fauna habitat in the project area, although the adjacent Ellen Brook provides substantial habitat for fauna which may venture into the project area to forage and graze.

The existing fauna habitat within the project area will be retained and enhanced by new plantings of native vegetation in the Ellen Brook foreshore and minor drainage lines.

Additional fauna habitat will be created in the revegetation of drainage swales and basins.

Street trees planted within the project area will focus on native tree species that provide habitat for nectar-eating and seed-eating birds.

3.8 Aboriginal Heritage

The development of Precinct 3 may affect three registered Aboriginal heritage sites associated with minor tributaries of Ellen Brook. Any disturbance of these sites will require permission under Section 18 of the *Aboriginal Heritage Act 1972*. Liaison with the Department of Planning, Lands & Heritage will be required before any physical site development works. The major Aboriginal site associated with Ellen Brook itself will be protected by inclusion in the foreshore reserve.

3.9 Landscape

3.9.1 Overview

Development in accordance with the Structure Plan will change the landscape of the project area from a mix of rural and industrial to wholly industrial, in keeping with the industrial landscape of the overall Muchea Employment Node.

With the opening of the Perth-Darwin National Highway, the principal view of the site seen by passers-by will shift from the east (Great Northern Highway) to the west (PDNH).

The objective of landscaping within Precinct 3 will be not to hide the industry from view but to provide vegetation features that “soften” and break up the industrial landscape. This will include plantings within the Ellen Brook foreshore, drainage swales and basins, vegetated creek lines, verge trees within the developed areas and landscape buffers within lots.

3.9.2 Landscape Plantings

The Shire of Chittering Town Planning Scheme imposes a general requirement that all non-residential lots should provide landscaping with approved species to a minimum of 10% of the total site area, including a minimum of one shade tree per four car parking bays.

The Shire of Chittering's *Muchea Industrial Park Design Guidelines* (2018) set out the Council's requirements and recommendations for development layout within lots, streetscaping, landscaping, bushfire management, fencing, signage and building design. The Guidelines require:

- a minimum 2m wide landscape buffer on the primary road frontage;
- a minimum 1m wide landscape buffer on secondary road interface and side boundaries extending to the building setback line;
- one shade tree per four car parking bays; and
- one tree per 10m of road frontage.

The landscape plantings within lots will be of a mix of native trees, shrubs and ground covers. The 1-year ARI 1-hour bioretention swales within each lot will be densely planted with native sedges and low shrubs. This will form part of the 10% landscaping requirement for each lot.

3.9.3 Streamline Revegetation

Roadside bioretention swales and through-drainage swales will be densely planted with native sedges and low shrubs to stabilise the beds and banks of the swales, slow water flows and promote the uptake of sediments and nutrients from the water. The areas to be planted, species and planting densities are described in more detail in the Landscape Master Plan (BES, 2018).

Plantings within the swales will be kept to a height that meets the definition of Shrubland in the Bushfire Management Plan (Eco Logical Australia, 2018) so as not to create an unacceptable fire hazard.

3.9.4 Ellen Brook Foreshore

Ellen Brook is an important waterway in the Swan-Canning River system and is the largest contributor of nutrients (phosphorus and nitrogen) to the system. The major source of nutrients is farmland on grey sandy soils to the west of the Brook, although farmland and intensive agricultural activities (e.g. poultry farms, piggeries, feedlots) to the east of the Brook may contribute significant quantities of nutrients to the Brook.

Lots 35 and 192 within Precinct 3 adjoin Ellen Brook. The other lots within the Precinct are separated from the Brook by the PDNH. Where the Structure Plan area adjoins Ellen Brook, a foreshore reserve has been defined according to the Water & Rivers

Commission's *Water Note 23: Determining Foreshore Reserves* (2001) and *Foreshore Policy 1: Identifying the Foreshore Area* (2002).

The foreshore definition process takes account of physical, biological and cultural factors including soils, landforms, stream morphology, erosion, floodways, vegetation, Aboriginal sites and existing land uses. Figure 3 shows the foreshore reserve defined through this process.

The Ellen Brook foreshore reserve adjoining Lots 35 and 192 will be planted with native vegetation to enhance its landscape amenity and habitat value for native fauna. The species list, planting density and planting areas will be set out in a Foreshore Management Plan to the satisfaction of the Shire of Chittering. Planting of the foreshore reserve will be undertaken by the developer of each stage of subdivision adjoining the Brook and will occur during the subdivision works.

The rezoning process for Precinct 3 does not include any change to the zoning of Ellen Brook, so the foreshore reserve defined here is indicative only and intended only for the purpose of planning land uses outside of the foreshore setback. Future planning undertaken by the WAPC or other parties may change the boundaries or management of the reserve outside of the amendment area.

4.0 MONITORING

Baseline water quality results for the project area and Ellen Brook are shown in Tables 2.2, 2.3 and 2.4. Groundwater levels and quality will continue to be monitored and compared against baseline levels and relevant guidelines. Water quality in Ellen Brook will be monitored upstream and downstream of the project area to determine what (if any) impacts the development may be having on the watercourse.

The proponent of each stage of subdivision will be responsible for monitoring water quality in bores and drainage swales within that stage as well as Ellen Brook upstream and downstream.

Water quality sampling will be conducted nominally once a year in late winter. Detailed water monitoring and response procedures will be developed as part of the Urban Water Management Plans to be prepared for each stage of subdivision.

5.0 IMPLEMENTATION AND FURTHER MANAGEMENT PLANS

Subdivision and development in the project area will be undertaken in accordance with the Structure Plan, this EAMS and the attached LWMS.

Development may occur in accordance with a subdivision approval or, in the absence of subdivision, a Development Approval. Subdivision approvals will include a requirement for an Urban Water Management Plan (UWMP). If development occurs without a subdivision, a Local Water Management Plan (LWMP) may be required to set out drainage design for the development.

6.0 REFERENCES

ANZECC & ARMCANZ (2000). *National Water Quality Management Strategy*. Australian and New Zealand Environment and Conservation Council, Canberra.

BoM (2017). *Climate Statistics for Australian Locations.* http://www.bom.gov.au/climate/averages/tables/ca_wa_names.shtml#name_n Accessed 17/4/2017. Bureau of Meteorology, Perth.

Connell Wagner (2007). Contaminated Sites Desktop Study. Cited in: WAPC (2011). *Muchea Employment Node Structure Plan.* Western Australian Planning Commission, Perth.

CSIRO (2009). *Surface Water Yields in South-West Western Australia*. CSIRO, Perth.

DoE (2004). *Potentially Contaminating Activities, Industries and Landuses.* Contaminated Sites Management Series No. 8. Department of Environment, Perth.

DWER (2004). *Potentially Contaminating Activities and Land Uses.* Contaminated Sites Management Series No. 8. Department of Environmental Regulation, Perth.

DWER (2004). *Stormwater Management Manual for WA*. Department of Water & Environmental Regulation, Perth.

DWER (2006b). *Water Quality Protection Note 70: Wastewater treatment – onsite domestic systems*. DoW, Perth.

DWER (2015). *Gingin Groundwater Allocation Plan*. Water resource allocation and planning report series no. 53. Department of Water, Perth.

Emerge Associates (2015). *Environmental Assessment and Management Strategy: Muchea Employment Node Local Structure Plan 1.* Sirona Capital Management Pty Ltd, Perth.

EPA (2015). *Draft Environmental Assessment Guideline for separation distances between industrial and sensitive land uses.* Environmental Protection Authority, Perth.

Fang X. (2000). *Open Channel Flow Calculator.* https://www.eng.auburn.edu/~xzf0001/Handbook/Channels.html Accessed 17/4/2017. Lamar University, USA.

Gozzard J.R. (1982). *Muchea Sheet 2034 I and part 2134 IV, Perth Metropolitan Region.* Environmental Geology Series. Geological Survey of Western Australia, Perth.

Institute of Engineers, Australia (1987). *Australian Rainfall and Runoff: A Guide to Flood Estimation.* Institute of Engineers, Australia, Barton, ACT.

King P.D. and Wells M.R. (1990). *Darling Range Rural Land Capability Study.* Land Resources Series No. 3. Department of Agriculture, South Perth.

Standards Australia (2012). *Australian/New Zealand Standard 1547:2012 – On-site Domestic Wastewater Management.*

Summers R. & Weaver D. (2008). *Agricultural Nutrients: Presentation to the CSIRO Urban Drainage Workshop*. CSIRO, Perth.

Swan River Trust (2009). *Swan Canning Water Quality Improvement Plan.* Swan River Trust, Perth.

WAPC (2004). *Liveable Neighbourhoods Edition 3.* Western Australian Planning Commission, Perth.

WAPC (2006). State Planning Policy 2.9: Water Resources. WAPC, Perth.

WAPC (2008). *Better Urban Water Management.* WAPC, Perth.

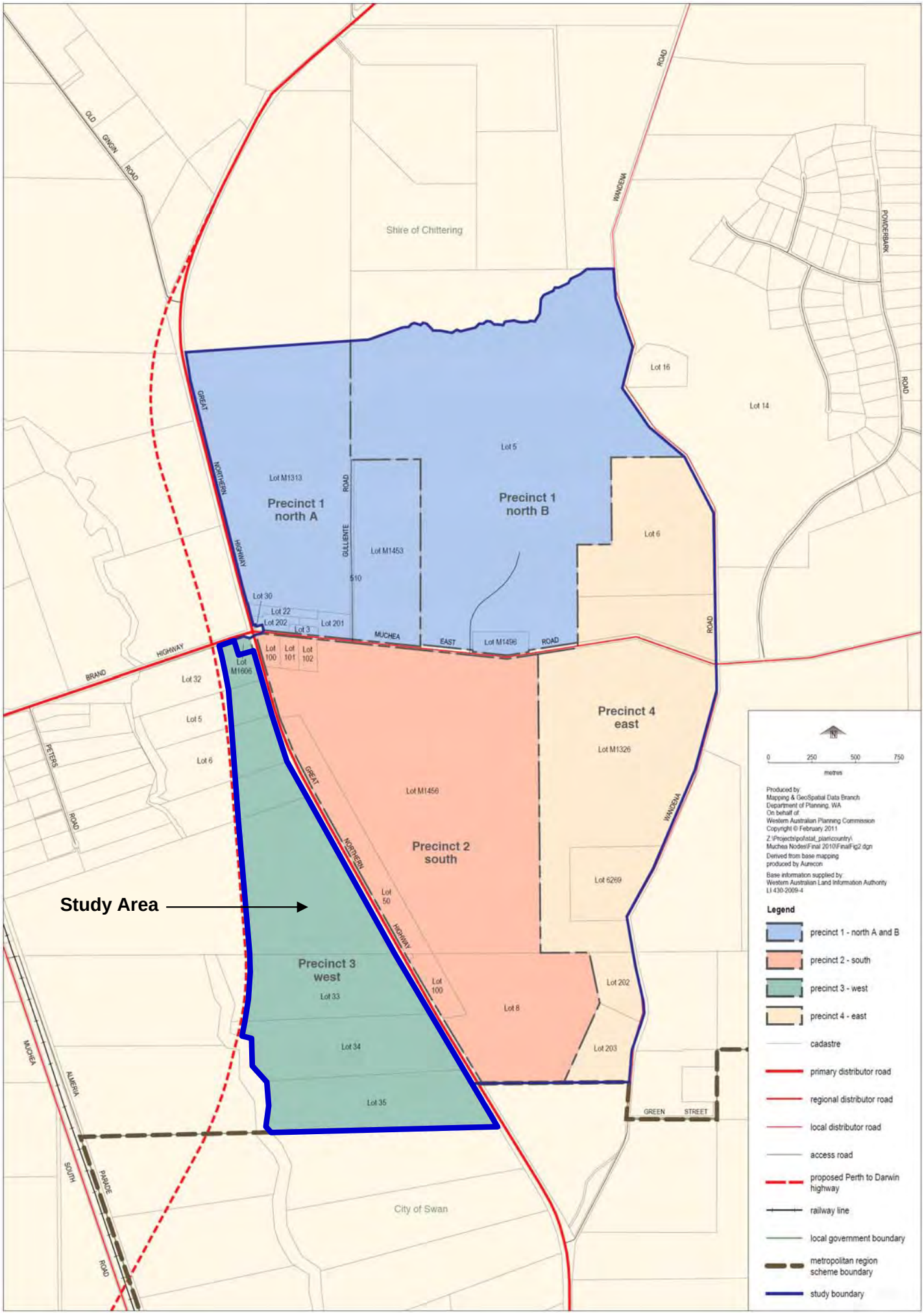
WAPC (2011). *Muchea Employment Node Structure Plan.* WAPC, Perth.

WRC (2001). *Water Note 23: Determining Foreshore Reserves*. Water & Rivers Commission, Perth.

WRC (2002). *Foreshore Policy 1: "Identifying the Foreshore Area".* Water & Rivers Commission, Perth.

–

Figures



Source: WAPC, 2011

Figure 1

MUCHEA EMPLOYMENT NODE STRUCTURE PLAN

bayley environmental services



Figure 2

THE SITE AND SURROUNDINGS

Image: Google Earth

bayley environmental services

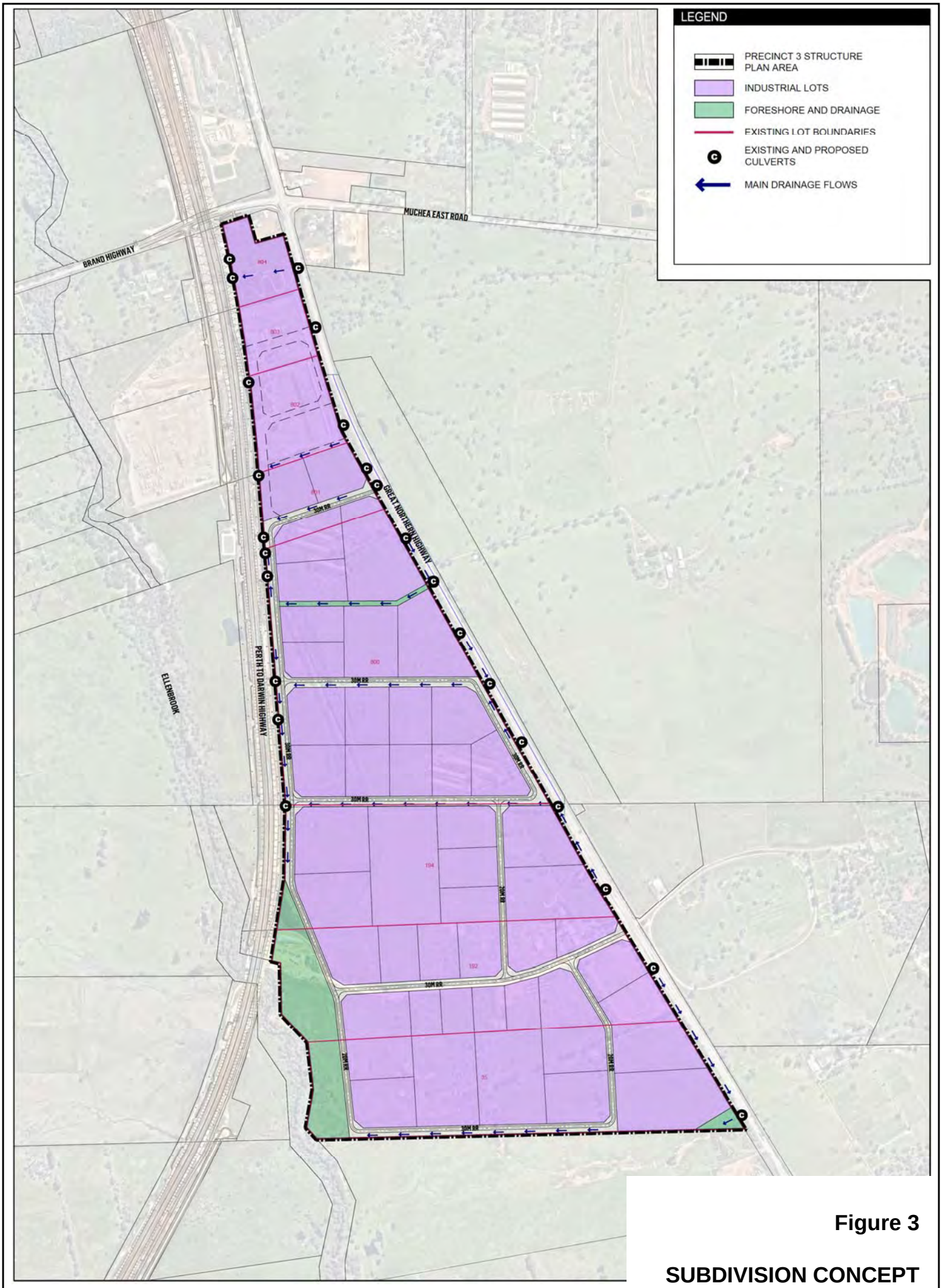


Figure 3

SUBDIVISION CONCEPT

URBIS

bayley environmental services

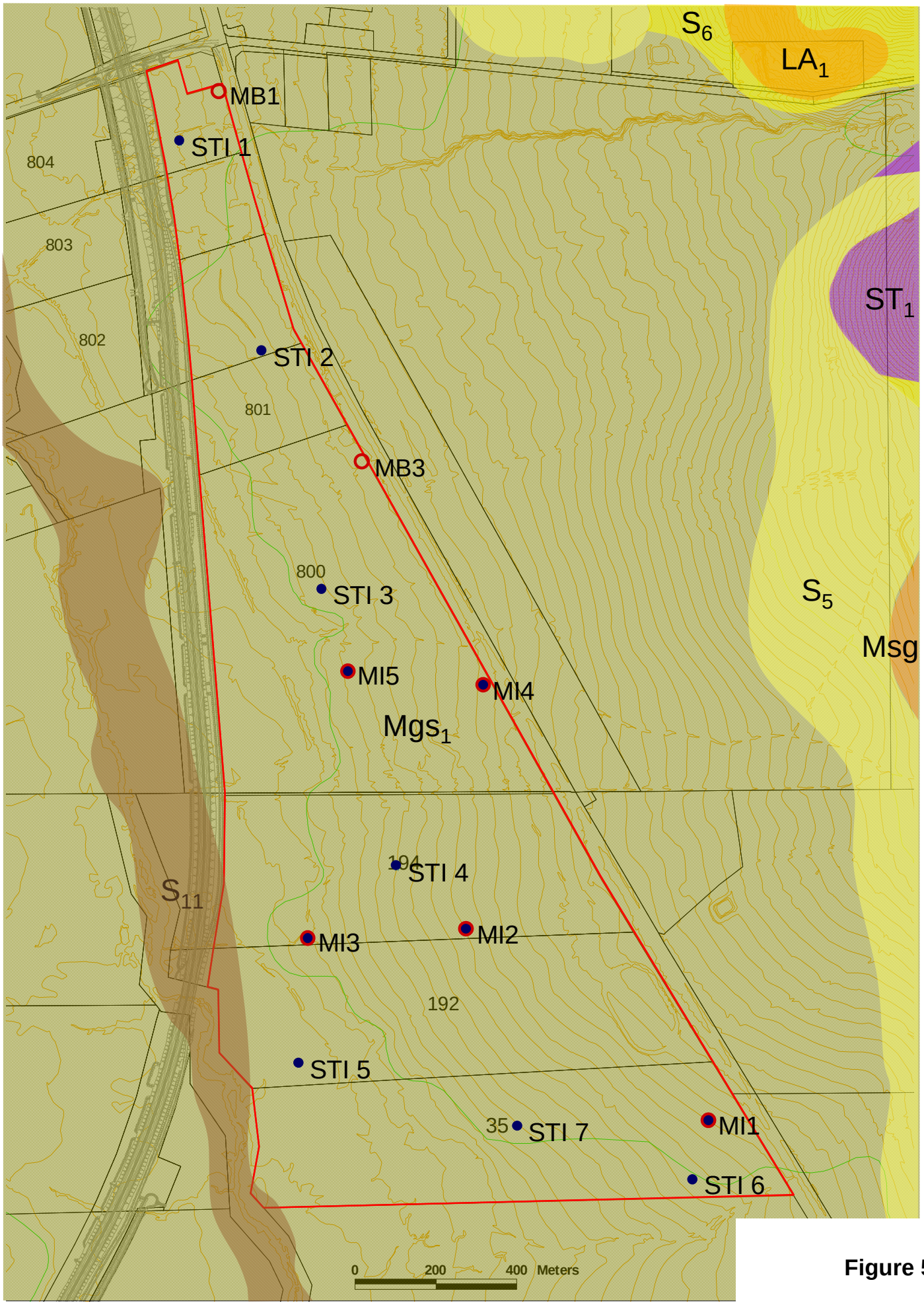


Figure 5

PHYSIOGRAPHY

Permeability Test
PRI Analysis

bayley environmental services

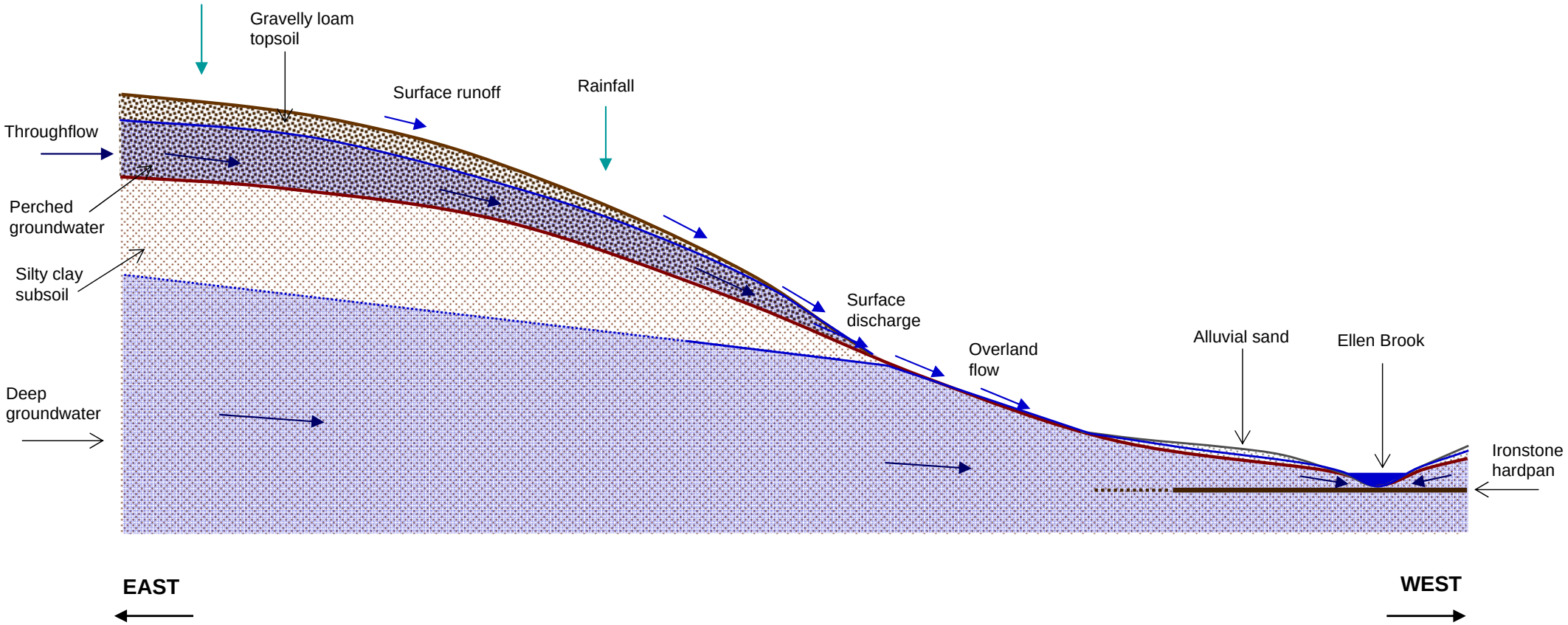
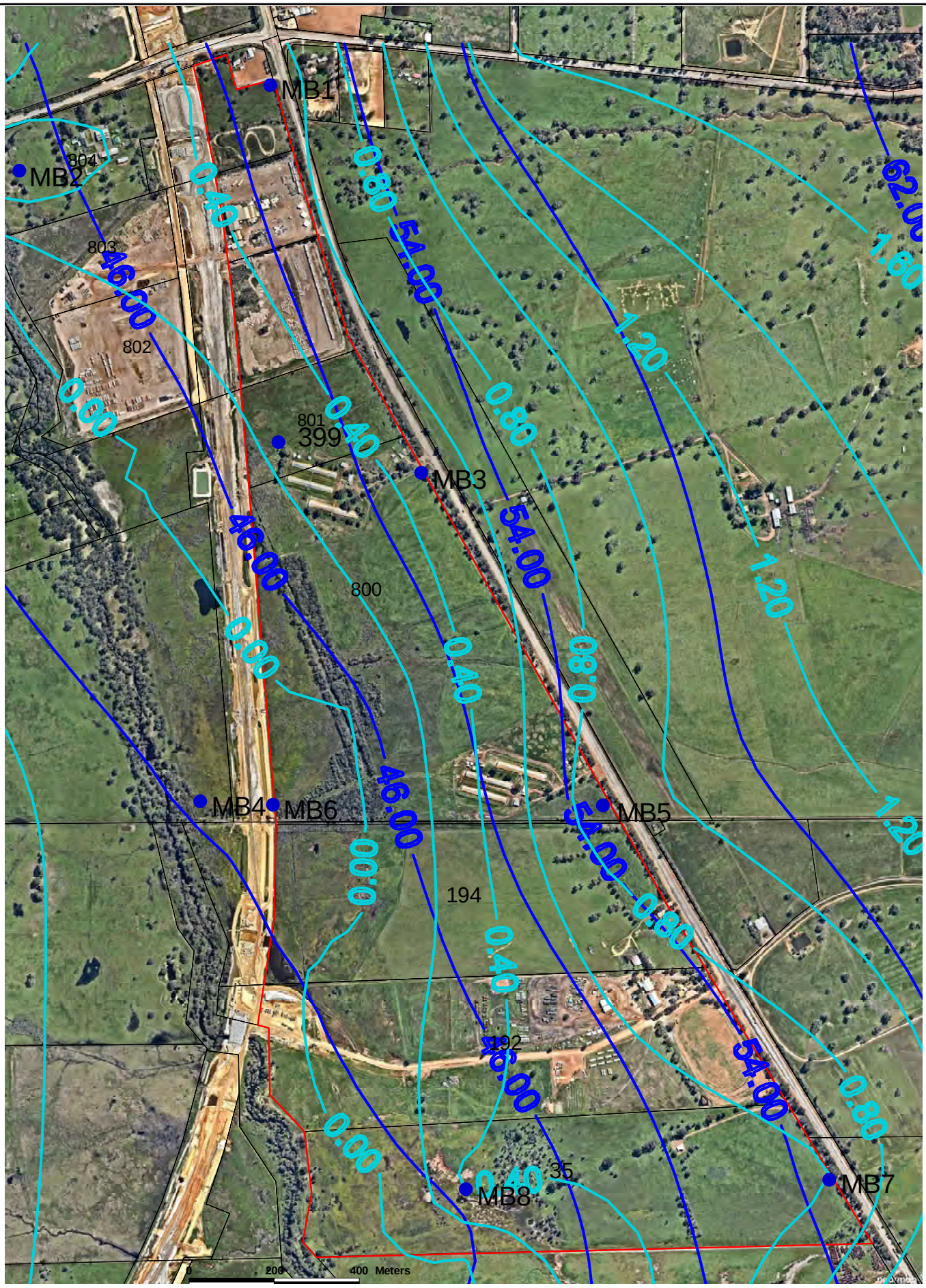


Figure 6

HYDROLOGY OVERVIEW

Not to scale

bayley environmental services



AAMGL Contour
Depth to AAMGL Contour
Bore

Figure 7

GROUNDWATER

bayley environmental services

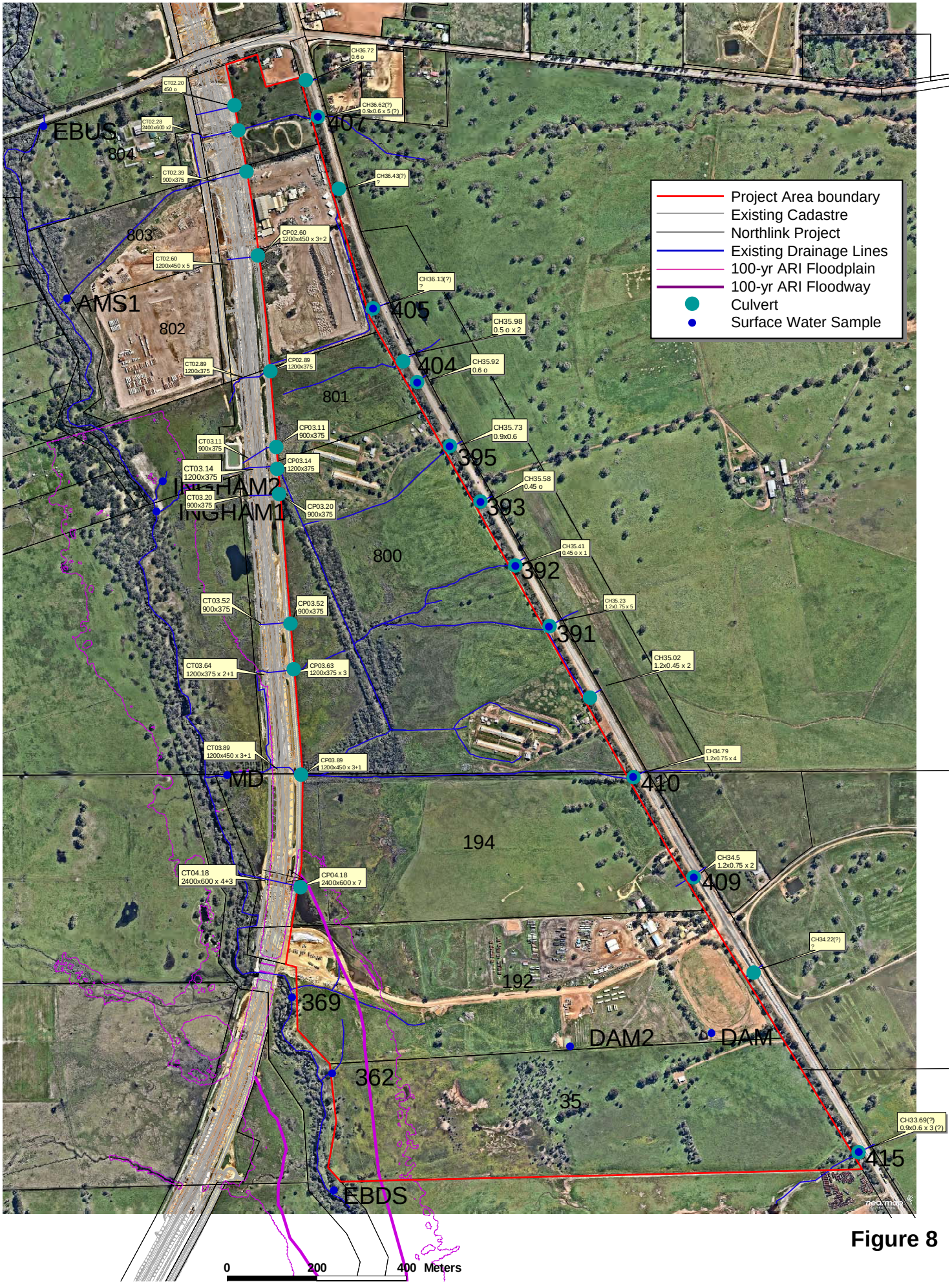


Figure 8

SURFACE HYDROLOGY

bayley environmental services

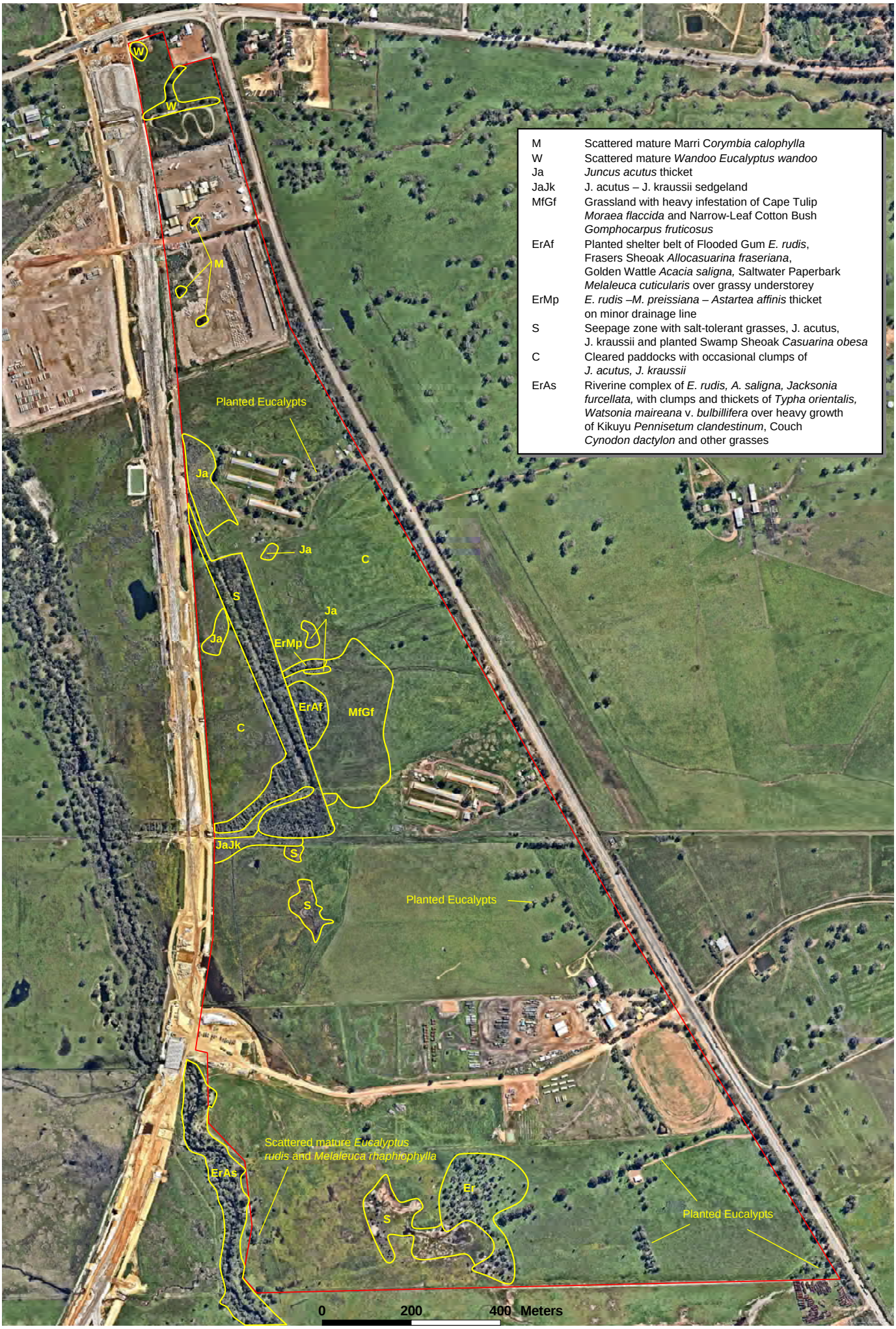


Figure 9

VEGETATION

bayley environmental services



Lot 35 from Great Northern Highway



Lot 192 (RTA) from Great Northern Highway



Lot 800 (Inghams) from Great Northern Highway



803 (AMS) from Great Northern Highway



Lot 804 from Great Northern Highway

Figure 10

VIEWS OF THE SITE

All images: Google

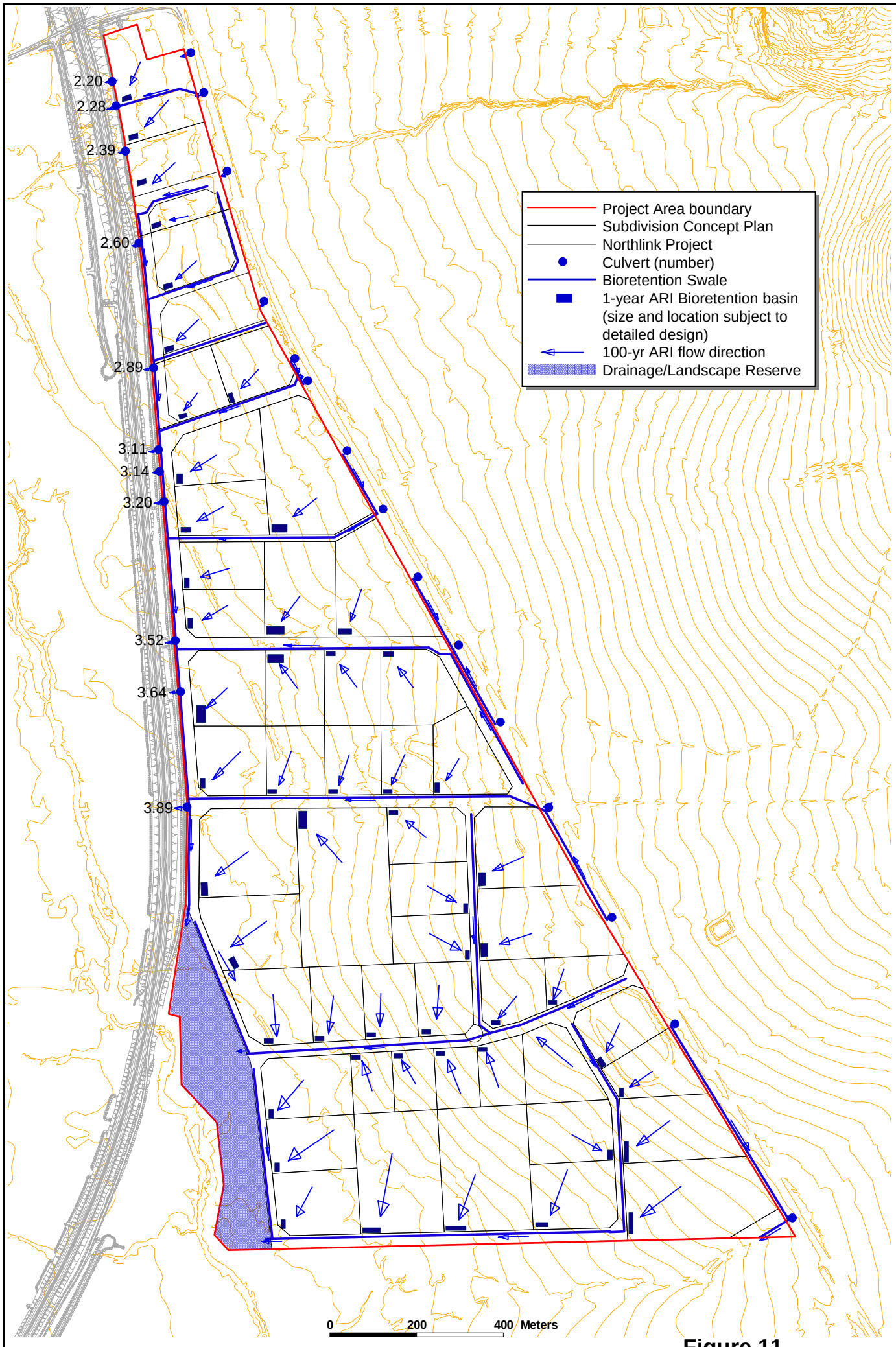


Figure 11

DRAINAGE CONCEPT

bayley environmental services

Appendix A

Soil Logs

SOIL PROFILE LOG

PROJECT NUMBER:	J18015
SITE ID:	MB1
EASTING:	
NORTHING:	
METHOD:	Auger Rig
TOTAL DEPTH (mbgl):	4.5
REFUSAL (Y/N):	N
DATE:	3/08/2018
DEPTH TO WATER (mbgl)	1.0

SOIL PROFILE		SAMPLE DATA	
DEPTH (m)	SOIL DESCRIPTION	SAMPLE ID	INTERVAL (m)
0 - 0.5	Grey-brown gravelly silty loam		
1 - 1.5	Yellow-brown clayey silt, wet		
2 - 3.5	Yellow clayey silt, wet		
4 - 4.5	Pink-grey silty clay, very wet		



SOIL PROFILE LOG

PROJECT NUMBER:	J18015
SITE ID:	MB2
EASTING:	
NORTHING:	
METHOD:	Auger Rig
TOTAL DEPTH (mbgl):	3.0
REFUSAL (Y/N):	N
DATE:	3/08/2018
DEPTH TO WATER (mbgl)	0.5

SOIL PROFILE		SAMPLE DATA	
DEPTH (m)	SOIL DESCRIPTION	SAMPLE ID	INTERVAL (m)
0	Dk grey sandy topsoil		
0.5 - 1	Grey silty sand, wet		
1.5 - 2	Grey brown sandy silt, very wet		
2.5	Yellow-brown clayey silt, very wet		
3	Green-brown clayey silt, very wet		



SOIL PROFILE LOG

PROJECT NUMBER:	J18015
SITE ID:	MB3
EASTING:	
NORTHING:	
METHOD:	Auger Rig
TOTAL DEPTH (mbgl):	4.0
REFUSAL (Y/N):	N
DATE:	3/08/2018
DEPTH TO WATER (mbgl)	3.0

SOIL PROFILE		SAMPLE DATA	
DEPTH (m)	SOIL DESCRIPTION	SAMPLE ID	INTERVAL (m)
0	Grey-brown gravelly loam		
0.5	Brown pebbly silt		
1 - 2.5	Orange-brown gravelly clayey silt		
3 - 3.5	Pink-brown clayey silt, very wet		
4	Pink-grey silty clay, very wet		



SOIL PROFILE LOG

PROJECT NUMBER:	J18015
SITE ID:	MB5
EASTING:	
NORTHING:	
METHOD:	Auger Rig
TOTAL DEPTH (mbgl):	4.0
REFUSAL (Y/N):	N
DATE:	3/08/2018
DEPTH TO WATER (mbgl)	1.0

SOIL PROFILE		SAMPLE DATA	
DEPTH (m)	SOIL DESCRIPTION	SAMPLE ID	INTERVAL (m)
0 - 0.5	Yellow-brown silty loam, moist		
1 - 1.5	Yellow-brown gravelly silt, very wet		
2	Yellow-brown silt, very wet		
2.5 - 4	Yellow-brown clayey silt, moist		



SOIL PROFILE LOG

PROJECT NUMBER:	J18015
SITE ID:	MB7
EASTING:	
NORTHING:	
METHOD:	Auger Rig
TOTAL DEPTH (mbgl):	6.0
REFUSAL (Y/N):	N
DATE:	3/08/2018
DEPTH TO WATER (mbgl)	0.0

SOIL PROFILE		SAMPLE DATA	
DEPTH (m)	SOIL DESCRIPTION	SAMPLE ID	INTERVAL (m)
0	Brown gravelly loam, wet		
0.5	Orange-brown pebbly silt, moist		
1	Red-brown pebbly clay, moist		
1.5 - 2	Orange-brown silty clay, wet grading to moist		
2.5 - 3	Orange-brown clay, moist		
3.5 - 6	Brown clay, wet		





SOIL PROFILE LOG

PROJECT NUMBER:	J18015
SITE ID:	MB8
EASTING:	
NORTHING:	
METHOD:	Auger Rig
TOTAL DEPTH (mbgl):	5.0
REFUSAL (Y/N):	N
DATE:	3/08/2018
DEPTH TO WATER (mbgl)	1.0

SOIL PROFILE		SAMPLE DATA	
DEPTH (m)	SOIL DESCRIPTION	SAMPLE ID	INTERVAL (m)
0 - 1.5	Brown silty clayey gravel, moist		
2 - 2.5	Pale yellow-brown silt, wet		
3 - 5	Grey silty clay, very wet		



Appendix B

Infiltration Test Results

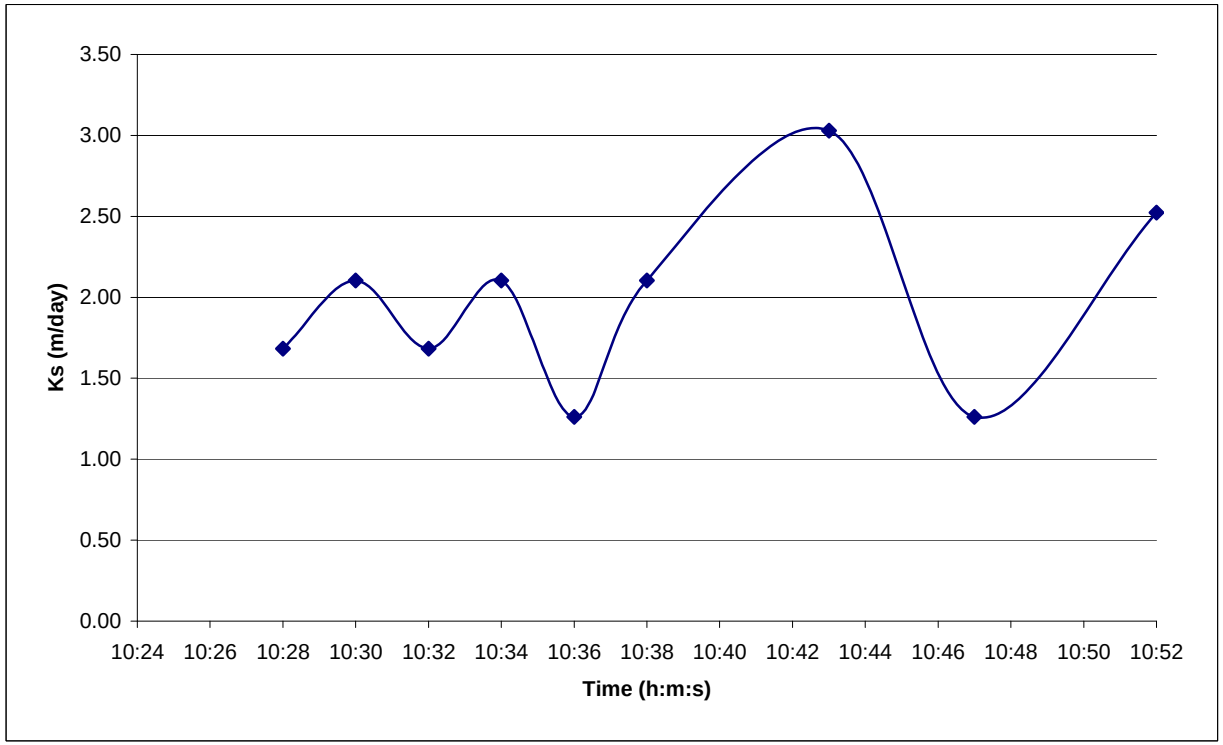
SOIL PERMEABILITY TEST

Site No.	MI1-S
Date	26/11/18
Easting	
Northing	
Depth	0.5m

Time (h:m:s)	Weight (kg)	Change in Weight (kg)	Ks (m/d)
10:26:00	39.8		
10:28:00	39.4	0.4	**1.68**
10:30:00	38.9	0.5	**2.10**
10:32:00	38.5	0.4	**1.68**
10:34:00	38	0.5	**2.10**
10:36:00	37.7	0.3	**1.26**
10:38:00	37.2	0.5	**2.10**
10:43:00	35.4	1.8	**3.03**
10:47:00	34.8	0.6	**1.26**
10:52:00	33.3	1.5	**2.52**
		33.3	

H =	25
r =	**4.5**

Ks = 1.9 m/d



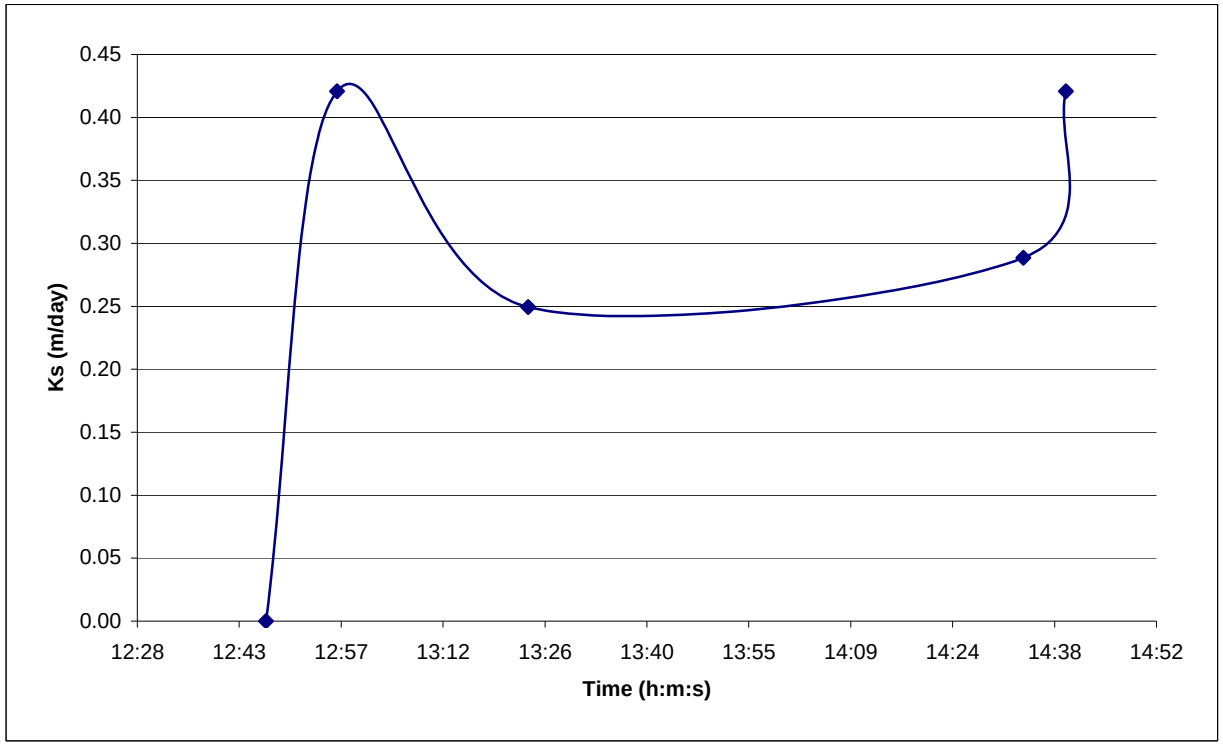
SOIL PERMEABILITY TEST

Site No.	MI1-D
Date	26/11/18
Easting	
Northing	
Depth	1m

Time (h:m:s)	Weight (kg)	Change in Weight (kg)	Ks (m/d)
12:42:00	40.4		
12:47:00	40.4		
12:57:00	39.9	0.5	**0.42**
13:24:00	39.1	0.8	**0.25**
14:34:00	36.7	2.4	**0.29**
14:40:00	36.4	0.3	**0.42**
		36.4	

H =	25
r =	**4.5**

Ks = 0.25 m/d



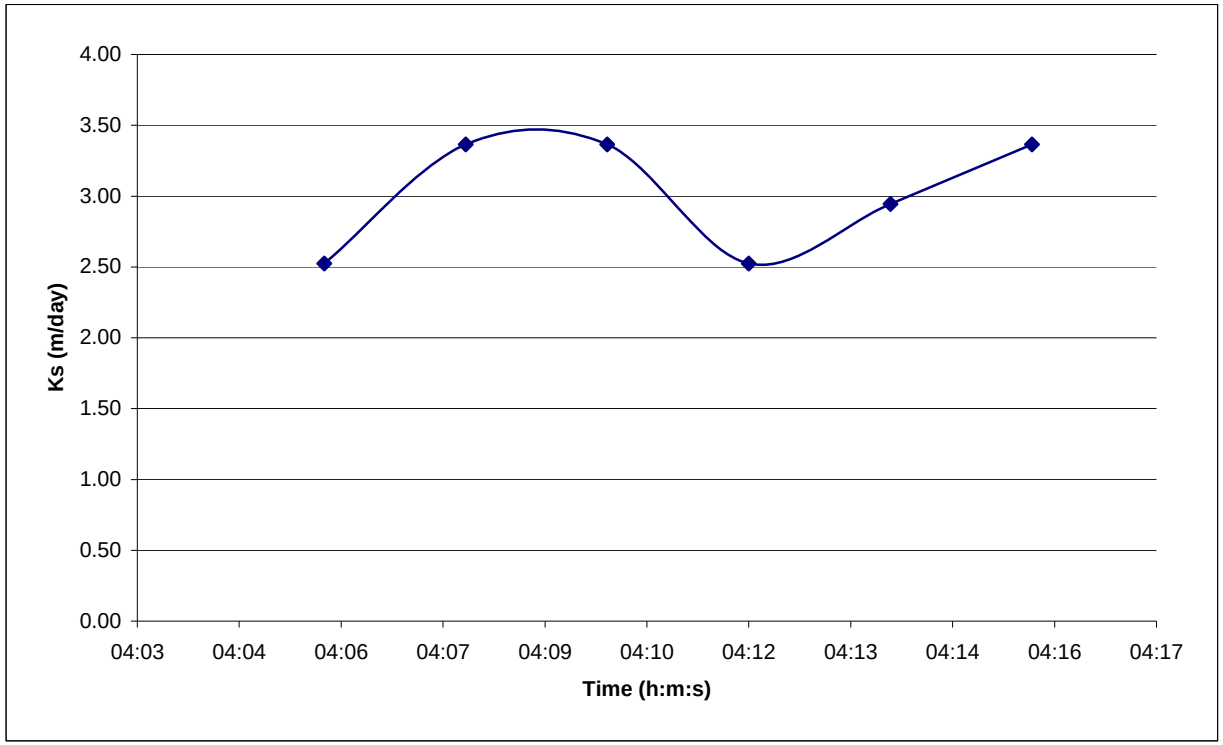
SOIL PERMEABILITY TEST

Site No.	MI2
Date	26/11/18
Easting	
Northing	
Depth	0.5m

Time (h:m:s)	Weight (kg)	Change in Weight (kg)	Ks (m/d)
04:05:00	36.3		
04:06:00	36	0.3	**2.52**
04:08:00	35.2	0.8	**3.37**
04:10:00	34.4	0.8	**3.37**
04:12:00	33.8	0.6	**2.52**
04:14:00	33.1	0.7	**2.94**
04:16:00	32.3	0.8	**3.37**
		32.3	

H =	25
r =	**4.5**

Ks = 3.0 m/d



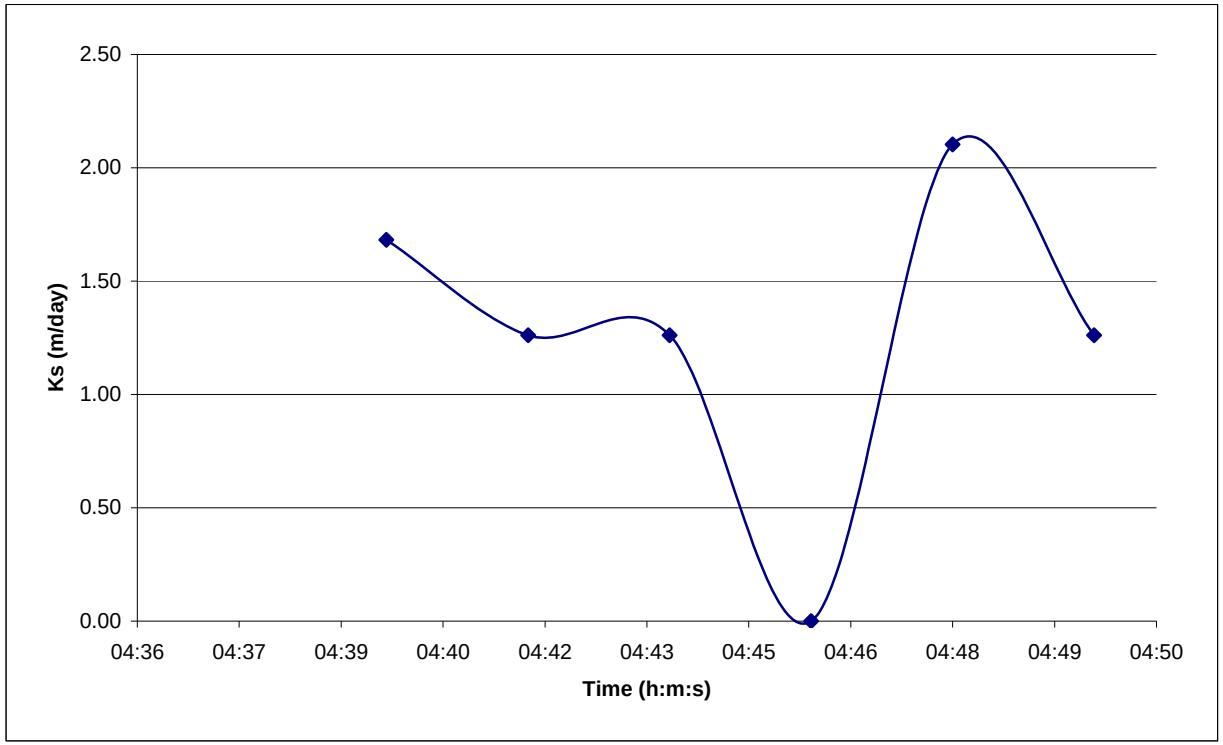
SOIL PERMEABILITY TEST

Site No.	MI3
Date	26/11/18
Easting	
Northing	
Depth	0.5m

Time (h:m:s)	Weight (kg)	Change in Weight (kg)	Ks (m/d)
04:38:00	27.1		
04:40:00	26.7	0.4	**1.68**
04:42:00	26.4	0.3	**1.26**
04:44:00	26.1	0.3	**1.26**
04:46:00	26.1		
04:48:00	25.6	0.5	**2.10**
04:50:00	25.3	0.3	**1.26**
		25.3	

H =	25
r =	**4.5**

Ks = 1.25 m/d



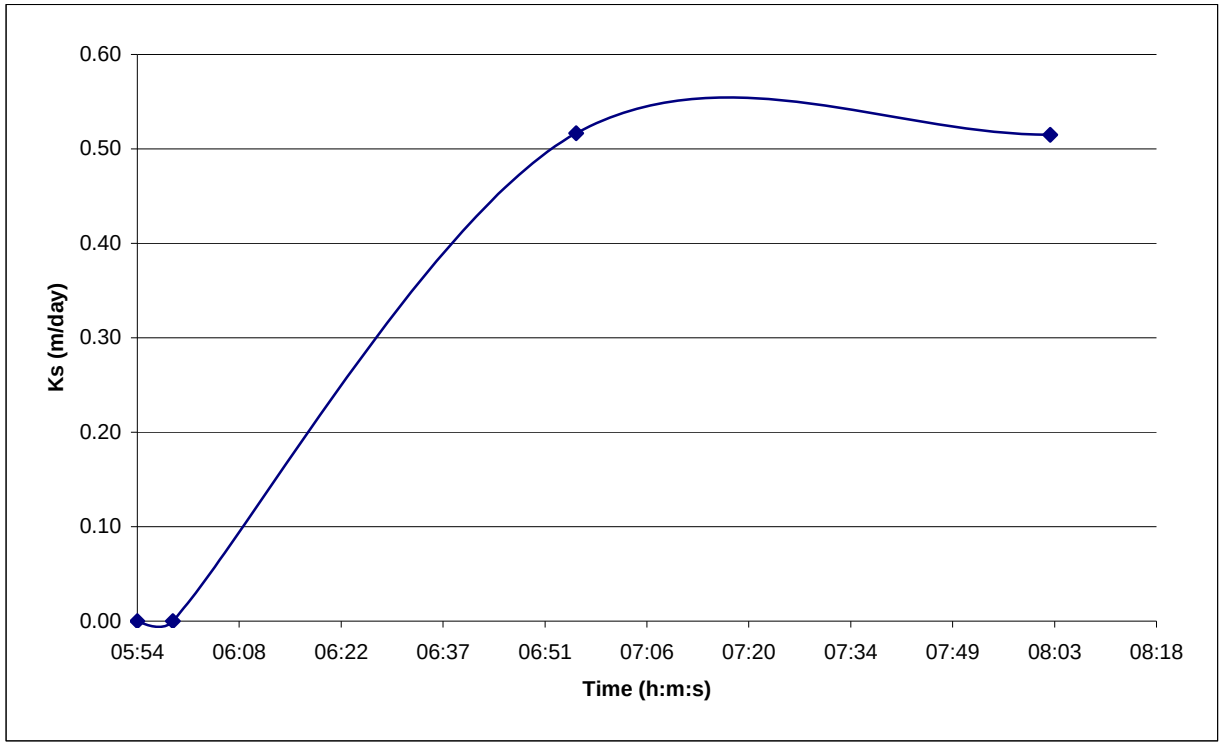
SOIL PERMEABILITY TEST

Site No.	MI4
Date	26/11/18
Easting	
Northing	
Depth	0.5m

Time (h:m:s)	Weight (kg)	Change in Weight (kg)	Ks (m/d)
05:49:00	34		
05:54:00	34		
05:59:00	34		
06:56:00	30.5	3.5	**0.52**
08:03:00	26.4	4.1	**0.51**
		26.4	

H =	25
r =	**4.5**

Ks = 0.5 m/d



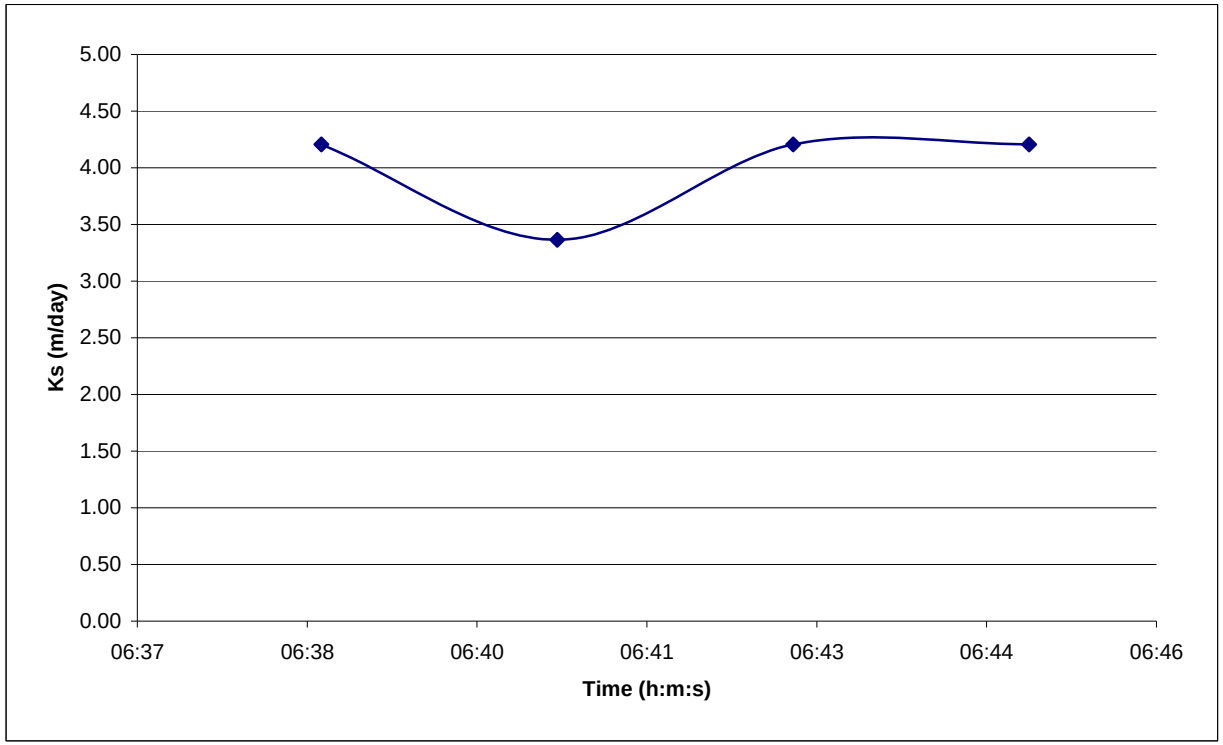
SOIL PERMEABILITY TEST

Site No.	MI5
Date	26/11/18
Easting	
Northing	
Depth	0.5

Time (h:m:s)	Weight (kg)	Change in Weight (kg)	Ks (m/d)
06:36:00	22.9		
06:39:00	21.4	1.5	**4.21**
06:41:00	20.6	0.8	**3.37**
06:43:00	19.6	1	**4.21**
06:45:00	18.6	1	**4.21**
		18.6	

H =	25
r =	**4.5**

Ks = 4.2 m/d



3.2. Groundwater

Groundwater was encountered in boreholes BH01, BH02, BH05 and BH12 at an approximate depth of 1.0m below the existing ground level. Groundwater is expected to perch above the impermeable materials.

3.3. Percolation Testing

Percolation testing of the in situ soils was undertaken in two locations. Results of the testing are summarised below:

Table 3 – In Situ Percolation Test Results

Test Location	Testing Depth	Soil Type	Permeability
1	0 - 1.0m	SAND/Clayey SAND	0.6m/day
2	0 – 0.7m	SAND/Clayey SAND	0.5m/day
3	0 - 1.0m	SAND/Clayey SAND	0.3m/day
4	0 - 1.0m	SAND/Clayey SAND	0.7m/day
5	0 – 0.5m	SAND/Gravelly SAND	1.0m/day
6	0 - 1.0m	SAND/Clayey SAND	1.2m/day
7	0 – 0.6m	SAND/Clayey SAND	0.9m/day

Appendix C

Floodway Modelling Report

MEMORANDUM

Project:	Muchea Employment Node P3 Waterways		Project No:	P18311
To:	Copy:	Name:	Organisation:	Facsimile:
☒	☐	Phil Bayley	Bayley Environmental Services	
☒	☐	Tom Carmody	Tomahawk Property	
☐	☐			
From:	Brett Stinton		Date: 25 January 2019	Total Pages: 9

Subject:	Muchea Employment Node P3 – Floodway Definition

If you do not receive all pages, or some are unclear, please advise immediately

BG&E Pty Limited (BG&E) has been engaged by the Muchea Employment Node Precinct 3 Landowners Group to carry out a waterways assessment for Ellen Brook to inform the development of the Muchea Employment Node Precinct 3.

As part of the Northlink Stage 3 project, BG&E prepared a TUFLOW hydraulic model for the new Perth to Darwin National Highway (PDNH) bridge which crosses Ellen Brook. This model has been utilised and updated to incorporate the boundary of the concept plan for the Muchea Employment Node Precinct prepared by Urbis. The southern section of the development layout is directly adjacent to the Ellen Brook floodplain where public open space and drainage reserve areas are proposed.

SCOPE

The following scope of works was carried out:

1. Review modelling assumptions in accordance with 2016 edition of Australian Rainfall and Runoff
2. Simulate 1 in 100 annual exceedance probability (AEP) event under current day scenario (including new PDNH)
3. Preliminary definition of floodway based on review of hydraulic model results (depths, velocities etc)
4. Meet with representatives from DWER and Main Roads WA to discuss the project and agree on allowable backwater criteria
5. Update hydraulic model to include earthworks up to the preliminary floodway and review 1 in 100 AEP backwater
6. Refine the floodway and update the hydraulic model with revised earthworks extents to achieve suitable backwater (up to 5 post-development iterations have been assumed)
7. Prepare a memo report summarising the methodology and findings of the project, including polygons for floodway and flood fringe areas similar to those provided by DWER for other areas within Ellen Brook.

The scope of works is limited to the Ellen Brook waterway and does not consider local catchment flows which occur throughout the site from the east via existing culverts beneath Great Eastern Highway. It is expected suitable drainage reserves and infrastructure would be required to manage local catchment flows which would need to be identified as part of a separate study.

TUFLOW MODEL

The TUFLOW 2D hydraulic has been updated to include the outline of the proposed development that lies within the flood extents of the Ellen Brook flood plain and other scenarios where the boundary encroaches further toward the main Ellen Brook channel.

MEETING WITH MAIN ROADS AND DWER

A meeting was held on 15th January 2019 with Simon Rodgers (Supervising Engineer - Floodplain Management) from the Department of Water and Environmental Regulation (DWER) and Eric Cheung (Senior Waterways Engineer) from Main Roads WA, to discuss any potential impacts the development may have. Preliminary results showing the impact on flood levels were tabled. The DWER representative indicated that the impacts were not of concern from a DWER perspective. The Main Roads WA representative was concerned of any potential impacts to the recently constructed PDNH alignment that passes adjacent to the proposed development.

FLOODWAY DEFINITION

The Department of Water and Environmental Regulation (DWER) define the Floodway as *"the river channel and a portion of the floodplain where a significant flow or storage of water occurs during floods. If the floodway is even partially blocked then the natural flooding regime of the area may be detrimentally impacted with flood levels being raised and affecting areas which may not have been previously affected"*.

The following items were considered when defining the floodway:

- 1% AEP pre-development velocity and depth mapping (attached) used to identify areas where higher depths and velocities occur which provide an indication of flood conveyance
- The presence of existing flowpaths within the floodplain which includes the main channel and breakout channel downstream of the PDNH culvert crossing to the north of the bridge. These flowpaths should be maintained to avoid redistribution of flow
- Potential impacts to flood levels as a result of partially blocking the floodplain, based on the hydraulic model results
- The floodway extent adopted by DWER for Ellen Brook to the south of the site. Shapefiles were provided by DWER which show the floodway extending to the edge of the floodplain in some areas. Flood behaviour in the northern section of the dataset is expected to be similar to that within the project site (Figure 1).

Refer to attached plots for 1% AEP pre-development and post-development flood extents. These include the proposed floodway and flood fringe extents. The proposed development footprint is close to but does not encroach into the floodway. The results indicate a maximum increase in flood level of approximately 30 mm near the proposed road, reducing to approximately 10mm at the PDNH PSP.

Scenarios where the earthworks footprint encroaches further into the floodway with offsets ranging from 20m to 80m were also simulated in the hydraulic model to assess potential impacts on the adjacent PDNH. The results indicate an increase in flood levels along the PDNH alignment varying between 40mm for a 40m offset to 90mm for an 80m offset.



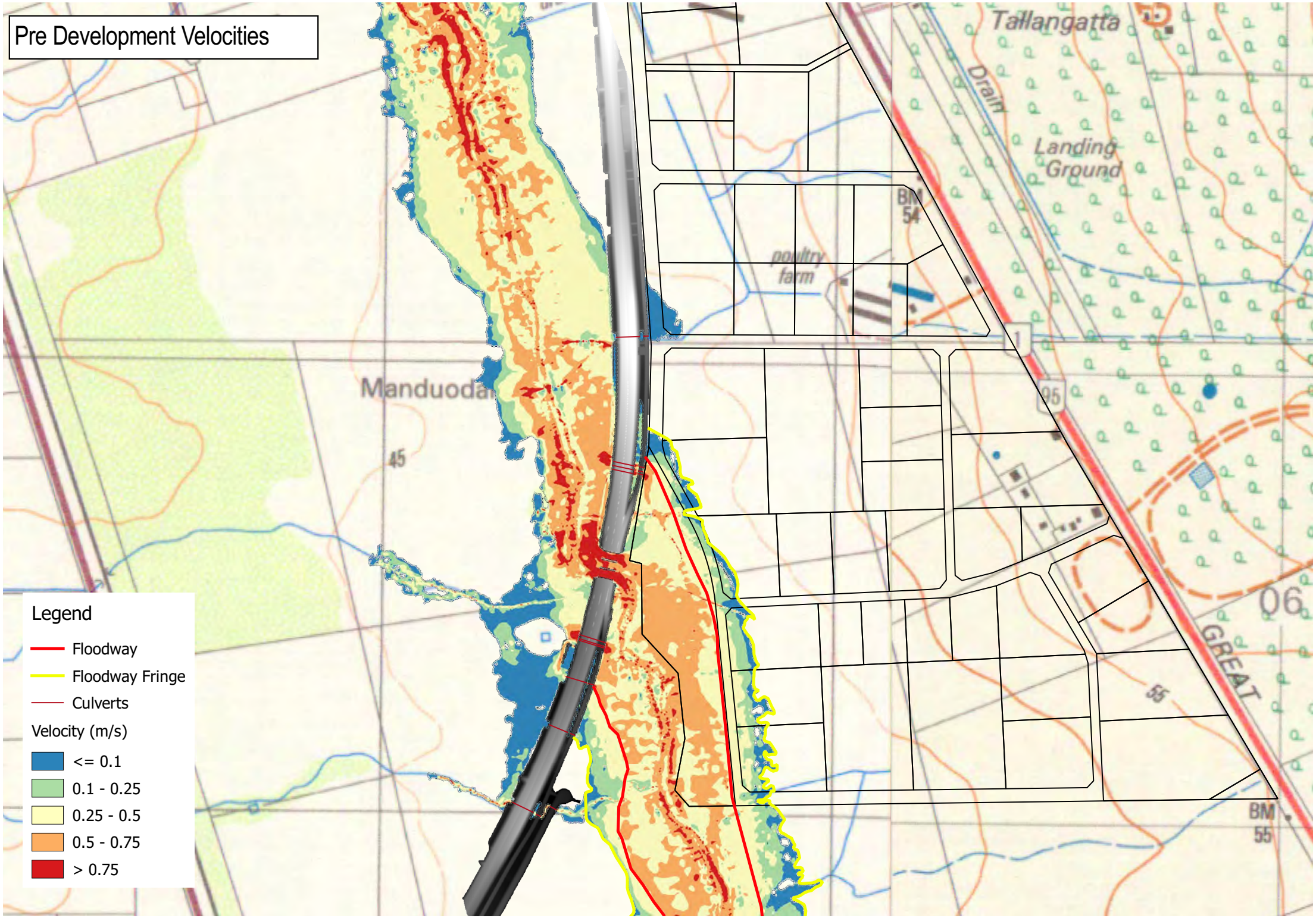
Figure 1 – Downstream floodway definition by DWER

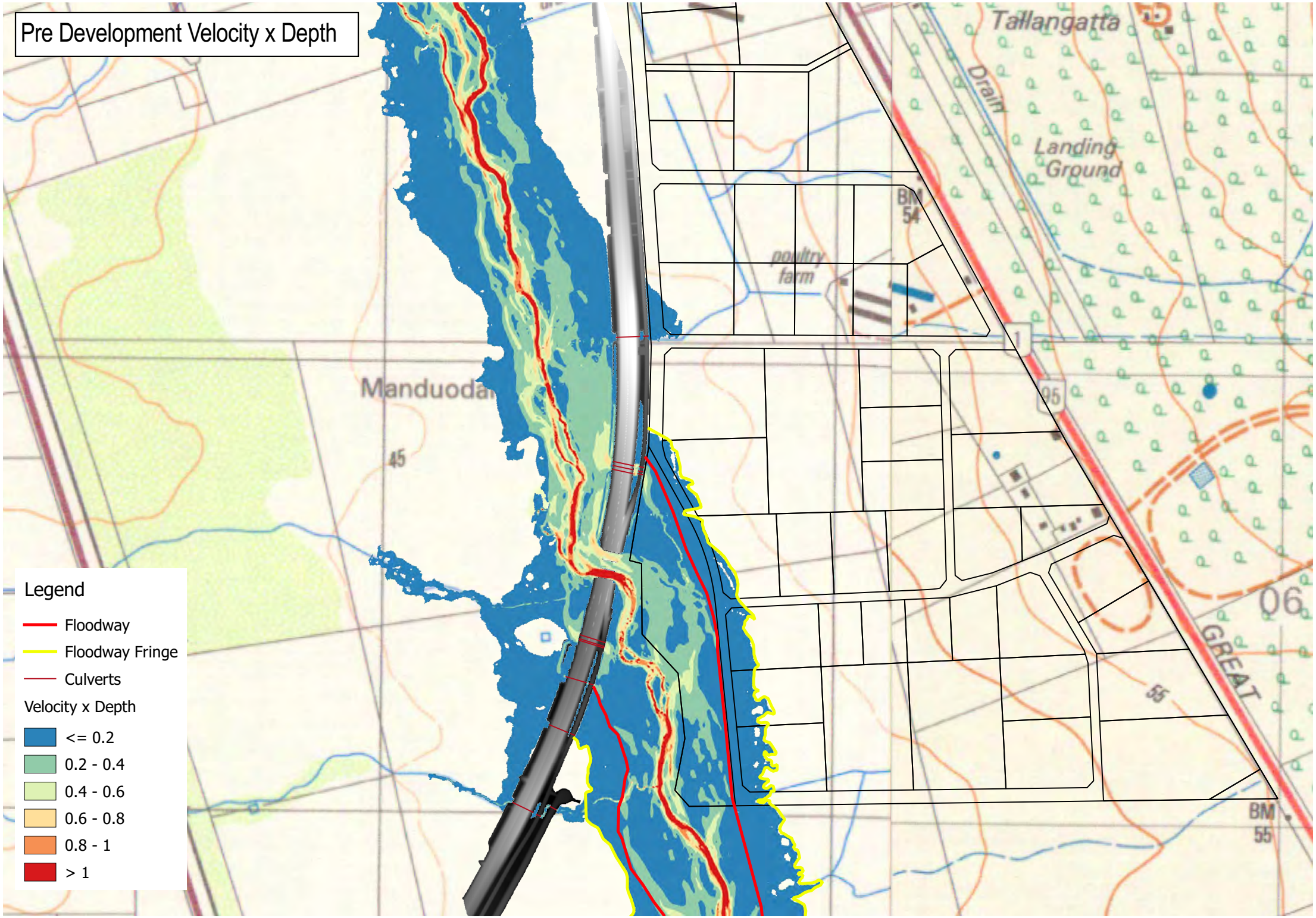
LIMITATIONS

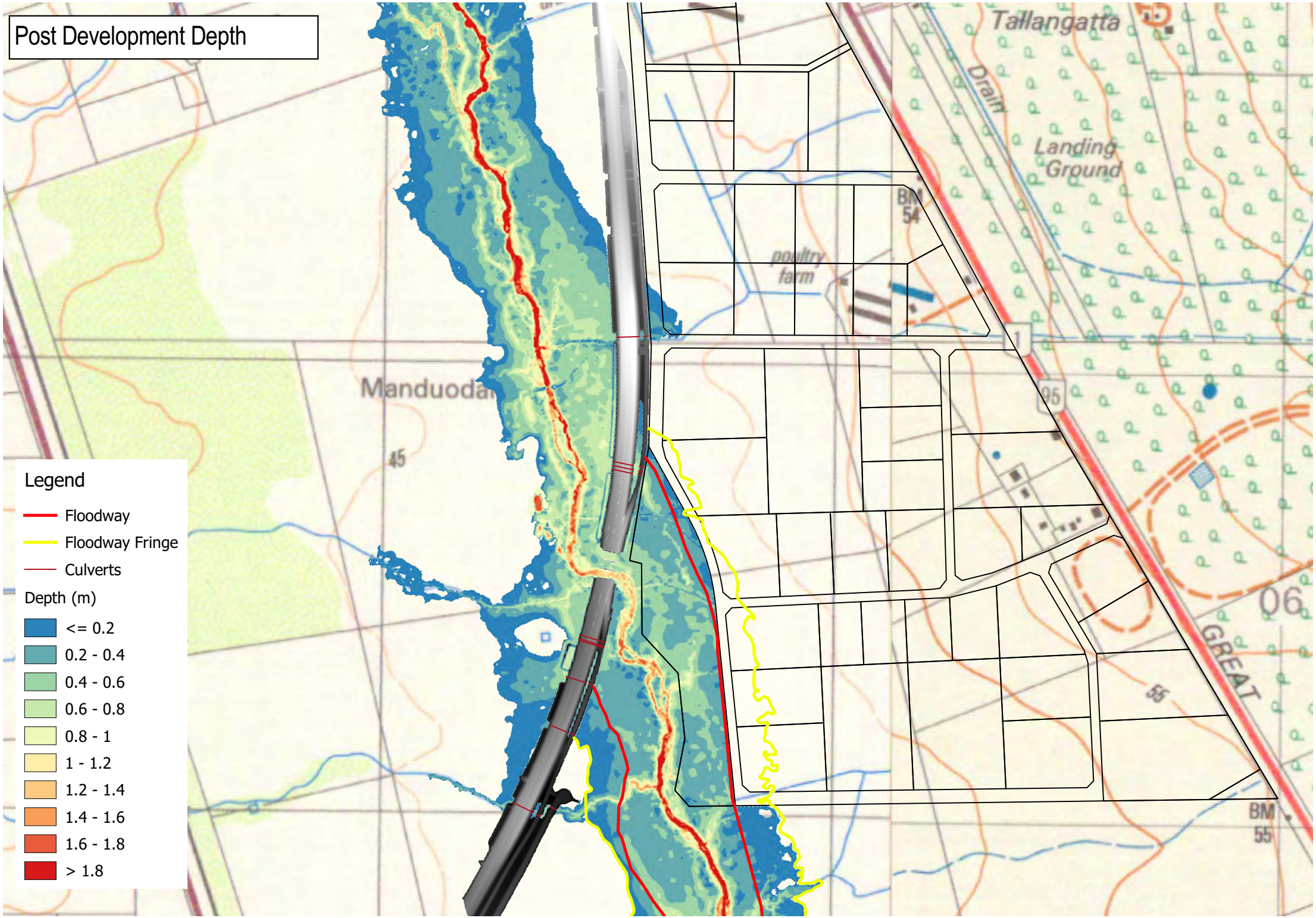
The findings of this study are subject to the following limitations:

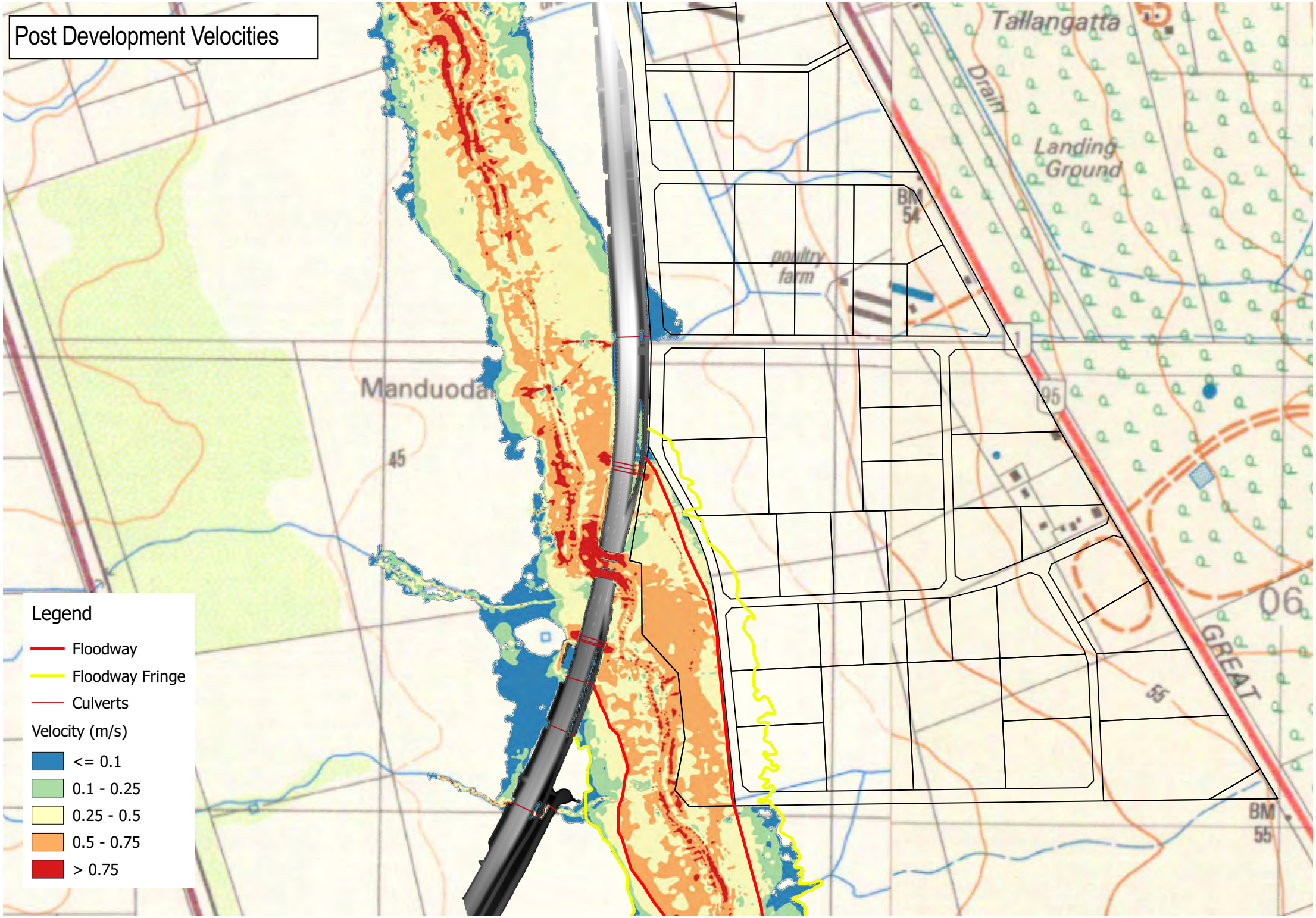
- The scope of works is limited to the Ellen Brook waterway and does not consider local catchment flows which occur throughout the site from the east via existing culverts beneath Great Eastern Highway. It is expected suitable drainage reserves and infrastructure would be required to manage local catchment flows which would need to be identified as part of a separate study.
- No allowance has been made for blockage of drainage infrastructure or increasing flows due to climate change.

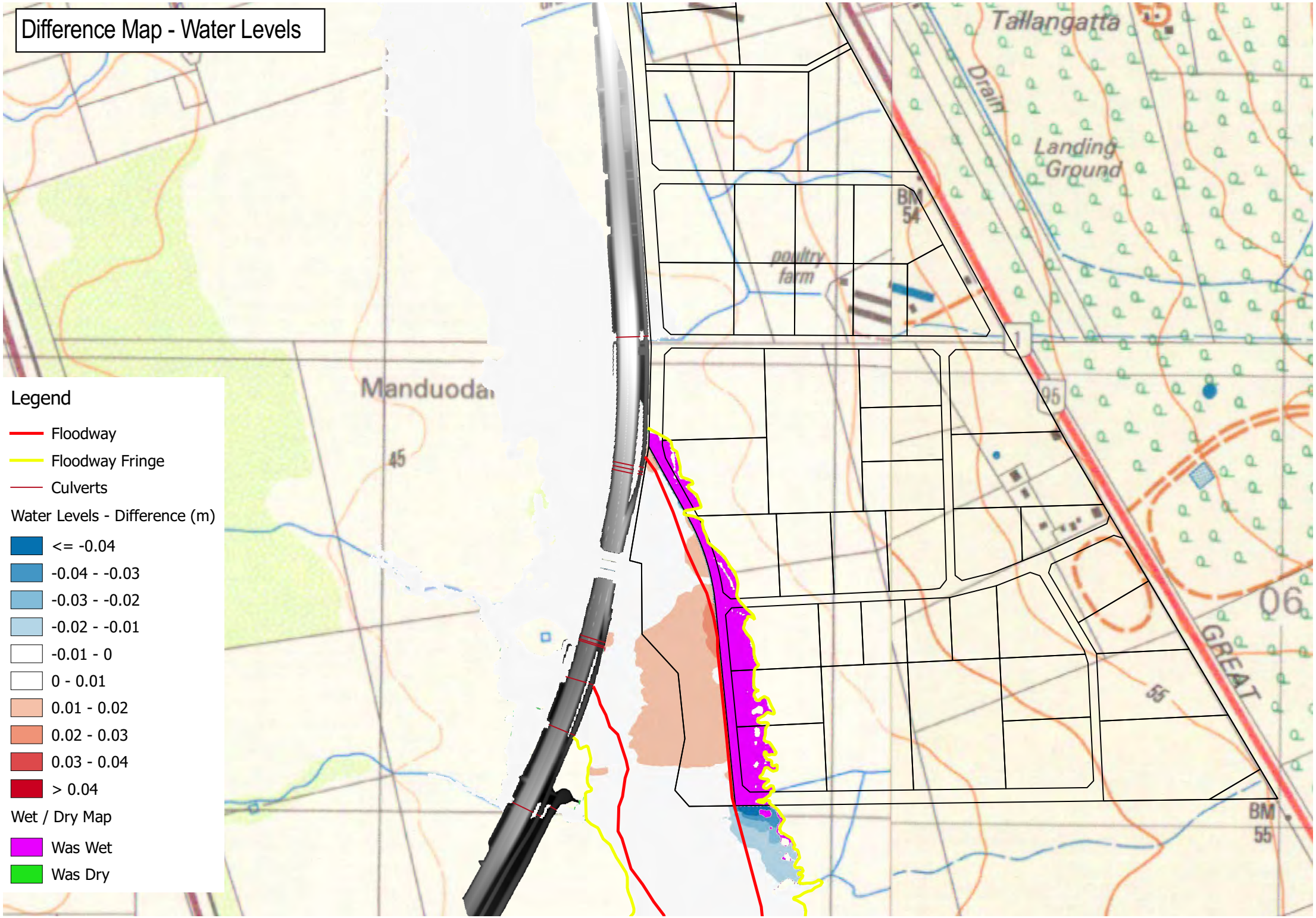

Pre Development Depth
Tallangatta
Drain
Landing Ground
poultry farm
BM 54
Manduoda
45
95
06
GREAT
55
BM 55
Legend
Floodway
Floodway Fringe
Culverts
Depth (m)
<= 0.2
0.2 - 0.4
0.4 - 0.6
0.6 - 0.8
0.8 - 1
1 - 1.2
1.2 - 1.4
1.4 - 1.6
1.6 - 1.8
> 1.8


Pre Development Velocities
Tallangatta
Drain
Landing Ground
poultry farm
BM 54
Manduoda
45
95
06
GREAT
55
BM 55
Legend
Floodway
Floodway Fringe
Culverts
Velocity (m/s)
<= 0.1
0.1 - 0.25
0.25 - 0.5
0.5 - 0.75
> 0.75


Pre Development Velocity x Depth
Tallangatta
Drain
Landing Ground
poultry farm
BM 54
Manduoda
45
95
06
GREAT
55
BM 55
Legend
Floodway
Floodway Fringe
Culverts
Velocity x Depth
<= 0.2
0.2 - 0.4
0.4 - 0.6
0.6 - 0.8
0.8 - 1
> 1


Post Development Depth
Tallangatta
Drain
Landing Ground
poultry farm
BM 54
Manduoda
45
95
06
55
GREAT
BM 55
Legend
Floodway
Floodway Fringe
Culverts
Depth (m)
<= 0.2
0.2 - 0.4
0.4 - 0.6
0.6 - 0.8
0.8 - 1
1 - 1.2
1.2 - 1.4
1.4 - 1.6
1.6 - 1.8
> 1.8


Post Development Velocities
Tallangatta
Drain
Landing Ground
poultry farm
BM 54
Manduoda
45
95
06
GREAT
55
BM 55
Legend
Floodway
Floodway Fringe
Culverts
Velocity (m/s)
<= 0.1
0.1 - 0.25
0.25 - 0.5
0.5 - 0.75
> 0.75


Difference Map - Water Levels
Tallangatta
Drain
Landing Ground
poultry farm
BM 54
Manduoda
45
95
06
55
GREAT
BM 55
Legend
Floodway
Floodway Fringe
Culverts
Water Levels - Difference (m)
<= -0.04
-0.04 - -0.03
-0.03 - -0.02
-0.02 - -0.01
-0.01 - 0
0 - 0.01
0.01 - 0.02
0.02 - 0.03
0.03 - 0.04
> 0.04
Wet / Dry Map
Was Wet
Was Dry

Appendix D

Aboriginal Sites Search Report

Aboriginal Heritage Inquiry System

List of Registered Aboriginal Sites

For further important information on using this information please see the Department of Planning, Lands and Heritage's Terms of Use statement at http://www.daa.wa.gov.au/Terms-Of-Use/

Search Criteria

4 Registered Aboriginal Sites in Custom search area - Polygon - 115.989217491191°E, 31.5787889106247°S (GDA94) : 115.992071361583°E, 31.5777926323064°S (GDA94) : 115.994109840434°E, 31.5771345343663°S (GDA94) : 115.995322198909°E, 31.5769243076562°S (GDA94) : 115.995837183039°E, 31.5771253940844°S (GDA94) : 115.997028083842°E, 31.5805529369397°S (GDA94) : 115.997843475383°E, 31.5832766011182°S (GDA94) : 116.001641483348°E, 31.5892903159333°S (GDA94) : 116.010527060032°E, 31.6024501222606°S (GDA94) : 115.996558115483°E, 31.6026328780459°S (GDA94) : 115.996515200138°E, 31.6000194362091°S (GDA94) : 115.995592520237°E, 31.599233561734°S (GDA94) : 115.99572126627°E, 31.5985938915682°S (GDA94) : 115.994498178959°E, 31.5972414316111°S (GDA94) : 115.988296911717°E, 31.5789081794479°S (GDA94) : 115.988637552262°E, 31.5788634854024°S (GDA94) : 115.989217491191°E, 31.5787889106247°S (GDA94)

Disclaimer

The *Aboriginal Heritage Act 1972* preserves all Aboriginal sites in Western Australia whether or not they are registered. Aboriginal sites exist that are not recorded on the Register of Aboriginal Sites, and some registered sites may no longer exist.

The information provided is made available in good faith and is predominately based on the information provided to the Department of Planning, Lands and Heritage by third parties. The information is provided solely on the basis that readers will be responsible for making their own assessment as to the accuracy of the information. If you find any errors or omissions in our records, including our maps, it would be appreciated if you email the details to the Department at heritageenquiries@dplh.wa.gov.au and we will make every effort to rectify it as soon as possible.

South West Settlement ILUA Disclaimer

Your heritage enquiry is on land **within or adjacent to** the following Indigenous Land Use Agreement(s): Whadjuk People ILUA.

On 8 June 2015, six identical Indigenous Land Use Agreements (ILUAs) were executed across the South West by the Western Australian Government and, respectively, the Yued, Whadjuk People, Gnaala Karla Booja, Ballardong People, South West Boojarah #2 and Wagyl Kaip & Southern Noongar groups, and the South West Aboriginal Land and Sea Council (SWALSC).

The ILUAs bind the parties (including 'the State', which encompasses all State Government Departments and certain State Government agencies) to enter into a Noongar Standard Heritage Agreement (NSHA) when conducting Aboriginal Heritage Surveys in the ILUA areas, unless they have an existing heritage agreement. It is also intended that other State agencies and instrumentalities enter into the NSHA when conducting Aboriginal Heritage Surveys in the ILUA areas. It is recommended a NSHA is entered into, and an 'Activity Notice' issued under the NSHA, if there is a risk that an activity will 'impact' (i.e. by excavating, damaging, destroying or altering in any way) an Aboriginal heritage site. The Aboriginal Heritage Due Diligence Guidelines, which are referenced by the NSHA, provide guidance on how to assess the potential risk to Aboriginal heritage.

Likewise, from 8 June 2015 the Department of Mines, Industry Regulation and Safety (DMIRS) in granting Mineral, Petroleum and related Access Authority tenures within the South West Settlement ILUA areas, will place a condition on these tenures requiring a heritage agreement or a NSHA before any rights can be exercised.

If you are a State Government Department, Agency or Instrumentality, or have a heritage condition placed on your mineral or petroleum title by DMIRS, you should seek advice as to the requirement to use the NSHA for your proposed activity. The full ILUA documents, maps of the ILUA areas and the NSHA template can be found at https://www.dpc.wa.gov.au/swnts/South-West-Native-Title-Settlement/Pages/default.aspx.

Further advice can also be sought from the Department of Planning, Lands and Heritage at heritageenquiries@dplh.wa.gov.au.

Copyright

Copyright in the information contained herein is and shall remain the property of the State of Western Australia. All rights reserved.

Coordinate Accuracy

Coordinates (Easting/Northing metres) are based on the GDA 94 Datum. Accuracy is shown as a code in brackets following the coordinates.

Aboriginal Heritage Inquiry System

List of Other Heritage Places

For further important information on using this information please see the Department of Planning, Lands and Heritage's Terms of Use statement at http://www.daa.wa.gov.au/Terms-Of-Use/

Search Criteria

7 Other Heritage Places in Custom search area - Polygon - 115.989217491191°E, 31.5787889106247°S (GDA94) : 115.992071361583°E, 31.5777926323064°S (GDA94) : 115.994109840434°E, 31.5771345343663°S (GDA94) : 115.995322198909°E, 31.5769243076562°S (GDA94) : 115.995837183039°E, 31.5771253940844°S (GDA94) : 115.997028083842°E, 31.5805529369397°S (GDA94) : 115.997843475383°E, 31.5832766011182°S (GDA94) : 116.001641483348°E, 31.5892903159333°S (GDA94) : 116.010527060032°E, 31.6024501222606°S (GDA94) : 115.996558115483°E, 31.6026328780459°S (GDA94) : 115.996515200138°E, 31.6000194362091°S (GDA94) : 115.995592520237°E, 31.599233561734°S (GDA94) : 115.99572126627°E, 31.5985938915682°S (GDA94) : 115.994498178959°E, 31.5972414316111°S (GDA94) : 115.988296911717°E, 31.5789081794479°S (GDA94) : 115.988637552262°E, 31.5788634854024°S (GDA94) : 115.989217491191°E, 31.5787889106247°S (GDA94)

Disclaimer

The Aboriginal Heritage Act 1972 preserves all Aboriginal sites in Western Australia whether or not they are registered. Aboriginal sites exist that are not recorded on the Register of Aboriginal Sites, and some registered sites may no longer exist.

The information provided is made available in good faith and is predominately based on the information provided to the Department of Planning, Lands and Heritage by third parties. The information is provided solely on the basis that readers will be responsible for making their own assessment as to the accuracy of the information. If you find any errors or omissions in our records, including our maps, it would be appreciated if you email the details to the Department at heritageenquiries@dplh.wa.gov.au and we will make every effort to rectify it as soon as possible.

South West Settlement ILUA Disclaimer

Your heritage enquiry is on land within or adjacent to the following Indigenous Land Use Agreement(s): Whadjuk People ILUA.

On 8 June 2015, six identical Indigenous Land Use Agreements (ILUAs) were executed across the South West by the Western Australian Government and, respectively, the Yued, Whadjuk People, Gnaala Karla Booja, Ballardong People, South West Boojarah #2 and Wagyl Kaip & Southern Noongar groups, and the South West Aboriginal Land and Sea Council (SWALSC).

The ILUAs bind the parties (including 'the State', which encompasses all State Government Departments and certain State Government agencies) to enter into a Noongar Standard Heritage Agreement (NSHA) when conducting Aboriginal Heritage Surveys in the ILUA areas, unless they have an existing heritage agreement. It is also intended that other State agencies and instrumentalities enter into the NSHA when conducting Aboriginal Heritage Surveys in the ILUA areas. It is recommended a NSHA is entered into, and an 'Activity Notice' issued under the NSHA, if there is a risk that an activity will 'impact' (i.e. by excavating, damaging, destroying or altering in any way) an Aboriginal heritage site. The Aboriginal Heritage Due Diligence Guidelines, which are referenced by the NSHA, provide guidance on how to assess the potential risk to Aboriginal heritage.

Likewise, from 8 June 2015 the Department of Mines, Industry Regulation and Safety (DMIRS) in granting Mineral, Petroleum and related Access Authority tenures within the South West Settlement ILUA areas, will place a condition on these tenures requiring a heritage agreement or a NSHA before any rights can be exercised.

If you are a State Government Department, Agency or Instrumentality, or have a heritage condition placed on your mineral or petroleum title by DMIRS, you should seek advice as to the requirement to use the NSHA for your proposed activity. The full ILUA documents, maps of the ILUA areas and the NSHA template can be found at https://www.dpc.wa.gov.au/swnts/South-West-Native-Title-Settlement/Pages/default.aspx.

Further advice can also be sought from the Department of Planning, Lands and Heritage at heritageenquiries@dplh.wa.gov.au.

Copyright

Copyright in the information contained herein is and shall remain the property of the State of Western Australia. All rights reserved.

Coordinate Accuracy

Coordinates (Easting/Northing metres) are based on the GDA 94 Datum. Accuracy is shown as a code in brackets following the coordinates.

Terminology (NB that some terminology has varied over the life of the legislation)

Place ID/Site ID: This a unique ID assigned by the Department of Planning, Lands and Heritage to the place.

Status:

- Registered Site: The place has been assessed as meeting Section 5 of the Aboriginal Heritage Act 1972.
- Other Heritage Place which includes:
  - Stored Data / Not a Site: The place has been assessed as not meeting Section 5 of the Aboriginal Heritage Act 1972.
  - Lodged: Information has been received in relation to the place, but an assessment has not been completed at this stage to determine if it meets Section 5 of the Aboriginal Heritage Act 1972.

Access and Restrictions:

- File Restricted = No: Availability of information that the Department of Planning, Lands and Heritage holds in relation to the place is not restricted in any way.
- File Restricted = Yes: Some of the information that the Department of Planning, Lands and Heritage holds in relation to the place is restricted if it is considered culturally sensitive. This information will only be made available if the Department of Planning, Lands and Heritage receives written approval from the informants who provided the information. To request access please contact heritageenquiries@dplh.wa.gov.au.
- Boundary Restricted = No: Place location is shown as accurately as the information lodged with the Registrar allows.
- Boundary Restricted = Yes: To preserve confidentiality the exact location and extent of the place is not displayed on the map. However, the shaded region (generally with an area of at least 4km^2) provides a general indication of where the place is located. If you are a landowner and wish to find out more about the exact location of the place, please contact the Department of Planning, Lands and Heritage.
- Restrictions:
  - No Restrictions: Anyone can view the information.
  - Male Access Only: Only males can view restricted information.
  - Female Access Only: Only females can view restricted information.

Legacy ID: This is the former unique number that the former Department of Aboriginal Sites assigned to the place. This has been replaced by the Place ID / Site ID.

Basemap Copyright

Map was created using ArcGIS software by Esri. ArcGIS and ArcMap are the intellectual property of Esri and are used herein under license. Copyright © Esri. All rights reserved. For more information about Esri software, please visit www.esri.com.

Satellite, Hybrid, Road basemap sources: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, HERE, DeLorme, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), MapmyIndia, NGCC, © OpenStreetMap contributors, and the GIS User Community.

Topographic basemap sources: Esri, HERE, DeLorme, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community.

Aboriginal Heritage Inquiry System

List of Other Heritage Places

For further important information on using this information please see the Department of Planning, Lands and Heritage's Terms of Use statement at http://www.daa.wa.gov.au/Terms-Of-Use/

ID	Name	File Restricted	Boundary Restricted	Restrictions	Status	Type	Knowledge Holders	Coordinate	Legacy ID
19138	Wetlands & Watercourses Moore River to Bullsbrook	No	No	No Gender Restrictions	Stored Data / Not a Site	Mythological	*Registered Knowledge Holder names available from DAA	396128mE 6561778mN Zone 50 [Reliable]	
19183	Red Gully Creek	No	No	No Gender Restrictions	Stored Data / Not a Site	Mythological, Plant Resource	*Registered Knowledge Holder names available from DAA	396128mE 6561778mN Zone 50 [Reliable]	
20650	Lennard Brook	No	No	No Gender Restrictions	Lodged	Mythological, Natural Feature, Water Source, Other: Creek	*Registered Knowledge Holder names available from DAA	389582mE 6549648mN Zone 50 [Reliable]	
21616	Boonanarring Brook	No	No	No Gender Restrictions	Lodged	Mythological	*Registered Knowledge Holder names available from DAA	396128mE 6561778mN Zone 50 [Reliable]	
21617	Wallering Brook	No	No	No Gender Restrictions	Lodged	Mythological	*Registered Knowledge Holder names available from DAA	396128mE 6561778mN Zone 50 [Reliable]	
21618	Nullilla Brook	No	No	No Gender Restrictions	Lodged	Mythological	*Registered Knowledge Holder names available from DAA	396128mE 6561778mN Zone 50 [Reliable]	
21619	Breera Brook	No	No	No Gender Restrictions	Lodged	Mythological	*Registered Knowledge Holder names available from DAA	396128mE 6561778mN Zone 50 [Reliable]	

Department of Planning, Lands and Heritage

GOVERNMENT OF WESTERN AUSTRALIA

Aboriginal Heritage Inquiry System

Map of Other Heritage Places

For further important information on using this information please see the Department of Planning, Lands and Heritage's Terms of Use statement at http://www.daa.wa.gov.au/Terms-Of-Use/



Legend

- Other Heritage Place
- Search Area
- Town
- Road
- River
- Local Government Authority

1.46 kilometres

Map Scale 1 : 44,300

MGA Zone 50 (GDA94)

Copyright for topographic map information shall at all times remain the property of the Commonwealth of Australia, Geoscience Australia - National Mapping Division. All rights reserved.

Aerial Photos, Cadastre, Local Government Authority, Native Title boundary, Roads data copyright © Western Australian Land Information Authority (Landgate).

Mining Tenement, Petroleum Application, Petroleum Title boundary data copyright © the State of Western Australia (Department of Mines, Industry Regulation and Safety).



Terminology (NB that some terminology has varied over the life of the legislation)

Place ID/Site ID: This a unique ID assigned by the Department of Planning, Lands and Heritage to the place.

Status:

- **Registered Site**: The place has been assessed as meeting Section 5 of the *Aboriginal Heritage Act 1972.*
- **Other Heritage Place which includes:**
  - **Stored Data / Not a Site:** The place has been assessed as not meeting Section 5 of the *Aboriginal Heritage Act 1972.*
  - **Lodged:** Information has been received in relation to the place, but an assessment has not been completed at this *stage* to determine if it meets Section 5 of the *Aboriginal Heritage Act 1972.*

Access and Restrictions:

- **File Restricted = No:** Availability of information that the Department of Planning, Lands and Heritage holds in relation to the place is not restricted in any way.
- **File Restricted = Yes:** Some of the information that the Department of Planning, Lands and Heritage holds in relation to the place is restricted if it is considered culturally sensitive. This information will only be made available if the Department of Planning, Lands and Heritage receives written approval from the informants who provided the information. To request access please contact heritageenquiries@dplh.wa.gov.au.
- **Boundary Restricted = No:** Place location is shown as accurately as the information lodged with the Registrar allows.
- **Boundary Restricted = Yes:** To preserve confidentiality the exact location and extent of the place is not displayed on the map. However, the shaded region (generally with an area of at least 4km²) provides a general indication of where the place is located. If you are a landowner and wish to find out more about the exact location of the place, please contact the Department of Planning, Lands and Heritage.
- **Restrictions:**
  - **No Restrictions:** *Anyone* can view the information.
  - **Male Access Only:** Only *males* can view restricted information.
  - **Female Access Only:** *Only* females can view restricted information.

Legacy ID: This is the former unique number that the former Department of Aboriginal Sites assigned to the place. This has been replaced by the Place ID / Site ID.

Basemap Copyright

Map was created using ArcGIS software by Esri. ArcGIS and ArcMap are the intellectual property of Esri and are used herein under license. Copyright © Esri. All rights reserved. For more information about Esri software, please visit www.esri.com.

Satellite, Hybrid, Road basemap sources: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, HERE, DeLorme, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), MapmyIndia, NGCC, © OpenStreetMap contributors, and the GIS User Community.

Topographic basemap sources: Esri, HERE, DeLorme, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community.

Aboriginal Heritage Inquiry System

List of Registered Aboriginal Sites

For further important information on using this information please see the Department of Planning, Lands and Heritage's Terms of Use statement at http://www.daa.wa.gov.au/Terms-Of-Use/

ID	Name	File Restricted	Boundary Restricted	Restrictions	Status	Type	Knowledge Holders	Coordinate	Legacy ID
3525	ELLEN BROOK: UPPER SWAN	Yes	Yes	No Gender Restrictions	Registered Site	Mythological	*Registered Knowledge Holder names available from DAA	Not available when location is restricted	S02516
20008	Gingin Brook Waggyl Site	Yes	Yes	No Gender Restrictions	Registered Site	Historical, Mythological, Camp, Hunting Place, Plant Resource, Water Source	*Registered Knowledge Holder names available from DAA	Not available when location is restricted	
20749	MOORE RIVER WAUGAL	No	No	No Gender Restrictions	Registered Site	Mythological	*Registered Knowledge Holder names available from DAA	389623mE 6549812mN Zone 50 [Reliable]	
21620	Chandala Brook	No	No	No Gender Restrictions	Registered Site	Mythological	*Registered Knowledge Holder names available from DAA	389626mE 6549540mN Zone 50 [Reliable]	

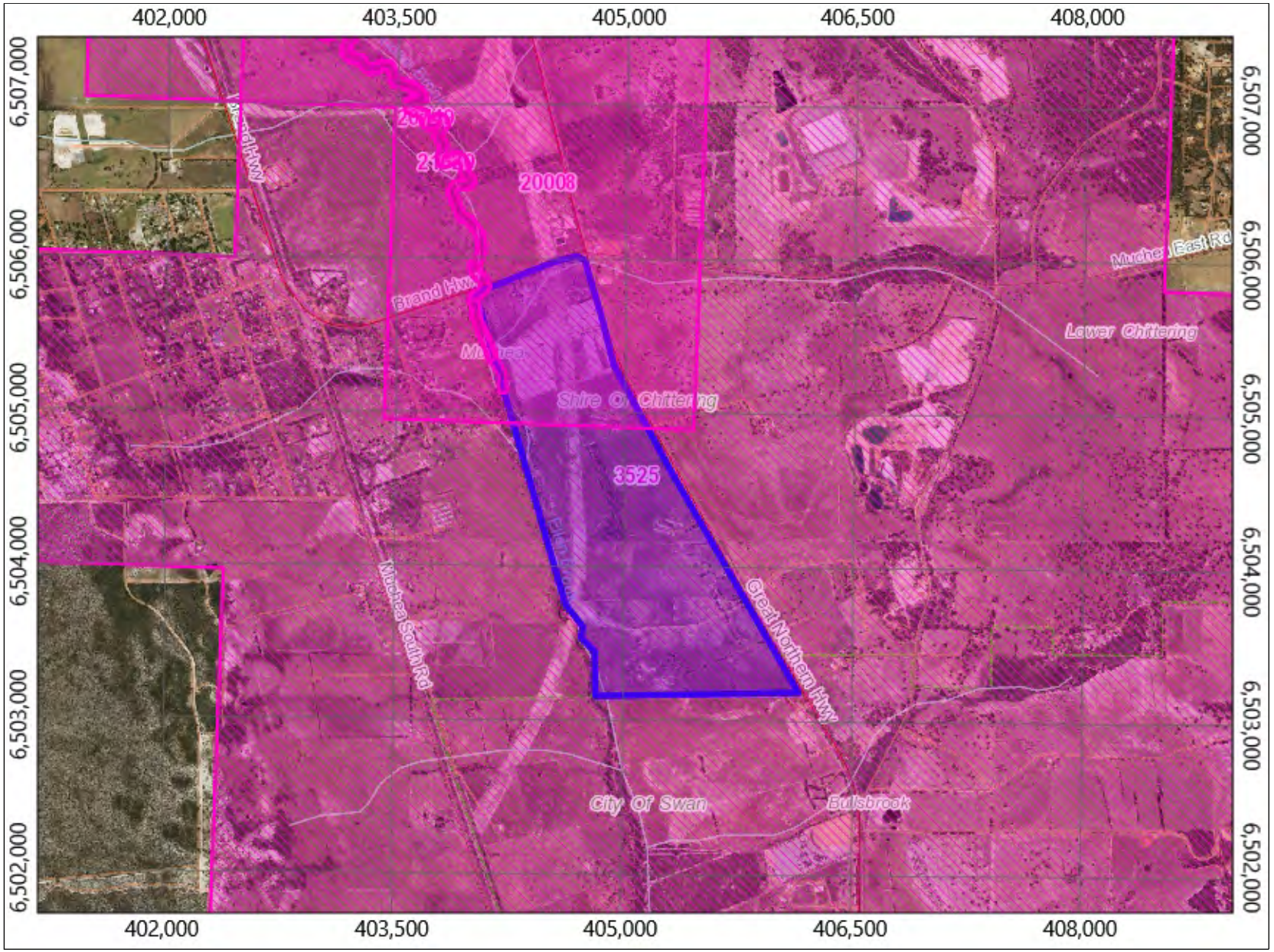
Department of Planning, Lands and Heritage

GOVERNMENT OF WESTERN AUSTRALIA

Aboriginal Heritage Inquiry System

Map of Registered Aboriginal Sites

For further important information on using this information please see the Department of Planning, Lands and Heritage's Terms of Use statement at http://www.daa.wa.gov.au/Terms-Of-Use/



Legend

- Registered Aboriginal Site
- Search Area
- Town
- Road
- River
- Local Government Authority

1.46 kilometres

Map Scale 1 : 44,300

MGA Zone 50 (GDA94)

Copyright for topographic map information shall at all times remain the property of the Commonwealth of Australia, Geoscience Australia - National Mapping Division. All rights reserved.

Aerial Photos, Cadastre, Local Government Authority, Native Title boundary, Roads data copyright © Western Australian Land Information Authority (Landgate).

Mining Tenement, Petroleum Application, Petroleum Title boundary data copyright © the State of Western Australia (Department of Mines, Industry Regulation and Safety).



GOVERNMENT OF WESTERN AUSTRALIA

Department of **Planning, Lands and Heritage**

Our ref: PLH0014-2018A/01
Enquiries: Katrina Bott 65517918

Mr Phil Bayley
Bayley Environmental Services
30 Thomas Street
SOUTH FREMANTLE WA 6162

Dear Mr Bayley

ADVICE REGARDING PROPOSED REZONING MUCHEA

Thank you for your email dated 16 November seeking comment from Department of Planning, Land and Heritage (DPLH) regarding rezoning of land near Muchea.

A review of the Register of Places and Objects, the DPLH Aboriginal Heritage Database and information provided by yourself concludes that the area in question intersects with the boundary of Registered Site ID 3525 (Ellen Brook: Upper Swan), however rezoning of land does not impact heritage. Therefore based on the information held by DPLH no approvals under the *Aboriginal Heritage Act 1972* (AHA) are required at this time.

Future physical works planned as a result of the rezoning may impact heritage, namely tributaries which form part of Registered Site ID 3525 (Ellen Brook: Upper Swan). When possible, please submit plans for works.

DPLH encourages proponents to refer to the State's Aboriginal Heritage Due Diligence Guidelines (Guidelines) which can be found on the DPLH website at the following link:

http://www.dplh.wa.gov.au/heritage/land-use/

The Guidelines allow proponents to undertake their own risk assessment regarding any proposal's potential to impact Aboriginal heritage.

If you have any questions regarding the above, please contact Ms Katrina Bott on 65517918 or email katrina.bott@dplh.wa.gov.au

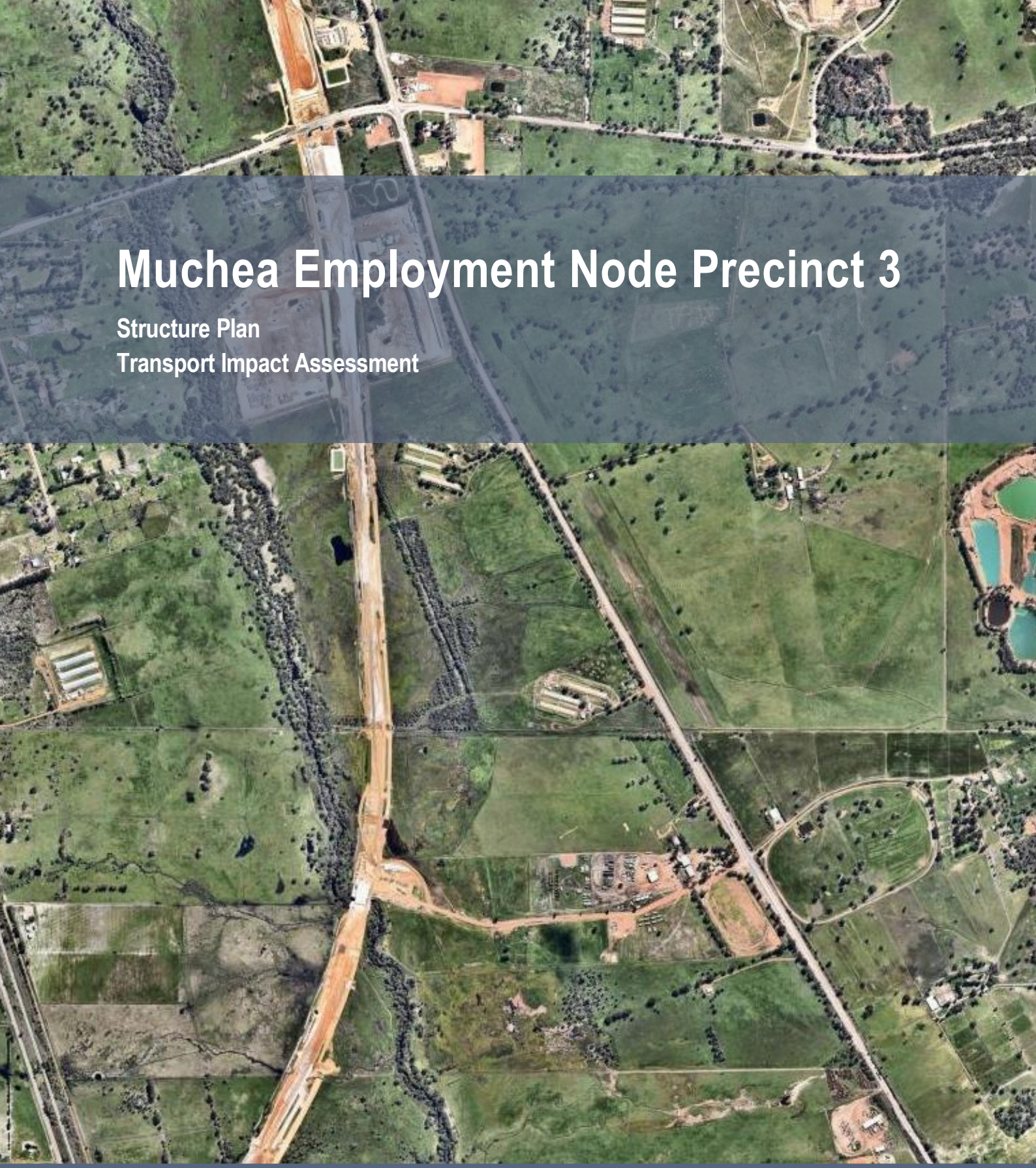
Yours sincerely

Katrina Bott

SENIOR HERITAGE OFFICER

28 November 2018

APPENDIX C TRANSPORT IMPACT ASSESSMENT



Muchea Employment Node Precinct 3

Structure Plan
Transport Impact Assessment

Prepared by: GTA Consultants (WA) Pty Ltd for Tomahawk Property on behalf of the Muchea Precinct 3 Landowners

on 2/10/19

Reference: W150400

Issue #: B-F

GTAconsultants

Muchea Employment Node Precinct 3

Structure Plan
Transport Impact Assessment

Client: Tomahawk Property on behalf of the Muchea Precinct 3 Landowners

on 2/10/19

Reference: W150400

Issue #: B-F

Quality Record

Issue	Date	Description	Prepared By	Checked By	Approved By	Signed
A-F	11/12/18	Final	AZ/RD	TM	TM	
B-F	02/10/19	Final	AZ/RD	TM	TM	

© GTA Consultants (GTA Consultants (WA) Pty Ltd) 2018
The information contained in this document is confidential and intended solely for the use of the client for the purpose for which it has been prepared and no representation is made or is to be implied as being made to any third party. Use or copying of this document in whole or in part without the written permission of GTA Consultants constitutes an infringement of copyright. The intellectual property contained in this document remains the property of GTA Consultants.

GTAconsultants

Melbourne | Sydney | Brisbane
Canberra | Adelaide | Perth

EXECUTIVE SUMMARY

EXECUTIVE SUMMARY

A Structure Plan is currently being prepared for Precinct 3 of the Muchea Employment Node Structure Plan (MENSP) area. The Structure Plan proposes an industrial development consisting of approximately 52 lots of varying size in a total land area of approximately 150Ha.

The Structure Plan area will include a proportion of river foreshore for Ellen Brook proposed to be located in the south west corner of the Structure Plan area.

Overall traffic volumes expected to be generated by the Structure Plan area is to be approximately 4,400 vehicle movements per day, with most of these vehicles accessing Great Northern Highway via the main proposed access loop road at the southern end of the Structure Plan area.

Total traffic volumes expected on Great Northern Highway with the advent of the entire MENSP by 2031 are expected to be significantly less than traffic volumes recorded in 2012/13. This is due to the opening of the Perth-Darwin National Highway (Northlink) in 2019 which will redistribute traffic off the Great Northern Highway.

The Structure Plan's internal road network has been designed to allow RAV7 and RAV10 vehicles to turn lane correct at intersections and to stay lane correct on road bends.

No footpath or bike network facilities are proposed, owing to the transport logistics uses anticipated.

Great Northern Highway will be upgraded to accommodate these new intersections with left and right turn deceleration lanes. No acceleration lanes are proposed on Great Northern Highway due to the proximity of the northern intersection to Brand Highway/Muchea East Road and the access to overtaking lanes near the southern intersection.

Assessment of the proposed traffic and transport network has shown that the proposed connectivities will function adequately when the Structure Plan area is fully developed, assumed and estimated to be by 2031.

The proposed unsignalised T-junction intersections of the main access loop road with Great Northern Highway have been shown to operate satisfactorily under estimated future PM peak traffic flows.

CONTENTS

1.	**Introduction**	**1**
1.1.	Background & Proposal	2
1.2.	Purpose of this Report	2
1.3.	Summary of key issues	2
1.4.	Previous Studies	2
1.5.	References	2
2.	**Structure Plan Outline**	**3**
2.1.	Regional Context	4
2.2.	Proposed Land Uses	4
2.3.	Attractors or Generators of Traffic (non-residential)	5
2.4.	Specific issues	5
3.	**Existing Situation**	**6**
3.1.	Subject Site	7
3.2.	Existing Movement Network	8
3.3.	Existing Road Network (Within 2km)	11
3.4.	Traffic Counts (within 2km)	12
4.	**Proposed Internal Transport Networks (Movement NetworK)**	**13**
4.1.	Changes to Existing Road Network	14
4.2.	Proposed Road Hierarchy, Road Reserve Widths and Speed Limits	14
4.3.	Road Cross Sections	14
4.4.	Intersection Controls	15
4.5.	Interim and Ultimate Access	15
4.6.	Pedestrian/Cycle Networks and Crossing Facilities	15
4.7.	Public Transport Routes	15
4.8.	Proposed Road Access Strategies	16
5.	**External Transport Networks**	**17**
5.1.	Changes to External Transport Networks	18
6.	**INTEGRATION with surrounding area**	**20**
6.1.	Surrounding Attractors	21
6.2.	Trip Attractors/Generators within 800m	22
6.3.	Proposed Changes to Land Uses within 800m	22

6.4. Travel Desire Lines from Structure Plan to these Attractors/Generators 22
6.5. Adequacy and Deficiencies in External Transport Networks 22
6.6. Remedial Measures to Address Deficiencies 23
7. Analysis of internal transport networks 24
7.1. Assessment Year(s) and Time Period(s) 25
7.2. Structure Plan Generated Traffic 25
7.3. Extraneous (Through) Traffic 25
7.4. Design Traffic Flows (i.e. Total Traffic) 25
7.5. Road Cross-Sections 26
7.6. Access Strategy and Intersection Controls 26
7.7. Pedestrian / Cycle Networks 26
7.8. Pedestrian Permeability & Efficiency 27
7.9. Access to Public Transport 27
8. analysis of external transport networks 28
8.1. Extent of Analysis 29
8.2. Impact Assessment 29
8.3. Road Cross-Sections 31
8.4. Intersection Layouts & Controls 31
8.5. Pedestrian/Cycle Networks 31
9. Conclusion 32

A. Structure Plan Area
B. RAV Swept Paths
C. Porter Consulting cross sections
D. Traffic Flows
E. Sidra Intersection Output
F. WAPC Checklist

1. INTRODUCTION

01

1.1. Background & Proposal

A Structure Plan is currently being prepared for land identified in the Muchea Employment Node Structure Plan (MENSP) as Precinct 3 - West. The Structure Plan is for a predominantly Industrial development as well as supporting land reserved for conservation recreation, foreshore management and/or regional open space.

GTA Consultants (GTA) was engaged by Tomahawk Property on behalf of the Muchea Employment Node Precinct 3 Landowner Group in October 2018 to undertake a transport impact assessment of the proposed development.

1.2. Purpose of this Report

Volume 2 of the Western Australian Planning Commission Transport Assessment Guidelines (WAPC Guidelines) provide direction on the preparation of a Transport Impact Assessment (TIA) for Planning Schemes and Structure Plans. The WAPC Guidelines identify that a TIA for a Structure Plan is to provide a broad-brush assessment.

The current WAPC policy requires all structure plans to be supported by a transport assessment.

In accordance with the WAPC Guidelines, this TIA outlines:

- Existing transport conditions proximate to the site
- The adequacy of the proposed site layout
- The traffic generating characteristics of the proposed development
- The anticipated impact of the proposed development on the surrounding road network.

1.3. Summary of key issues

From a traffic and transport point of view, the following key provisions are immediately identified for this TIA:

- Suitable internal road network for the expected maximum sized Restricted Access Vehicle (RAV)
- Suitable modification to the external road network to accommodate RAVs to and from the Structure Plan area.

1.4. Previous Studies

The following studies were previously prepared and are relevant to the subject site due to their proximity:

- Muchea Employment Node Structure Plan (DoP/WAPC, August 2011).

1.5. References

In preparing this report, reference has been made to the following:

- Shire of Chittering Town Planning Scheme No.6 (TPS 6)
- Development Control Policy 4.1 – Industrial Subdivision
- WAPC Transport Assessment Guidelines for Development
- Australian Standard, Parking Facilities, Part 2: Off-Street Commercial Vehicle Facilities AS 2890.2:2002
- plans for the proposed structure plan dated 21 November 2018 prepared by Urbis
- traffic surveys undertaken by GTA Consultants as referenced in the context of this report
- various technical data as referenced in this report
- an inspection of the site and its surrounds
- other documents as nominated.

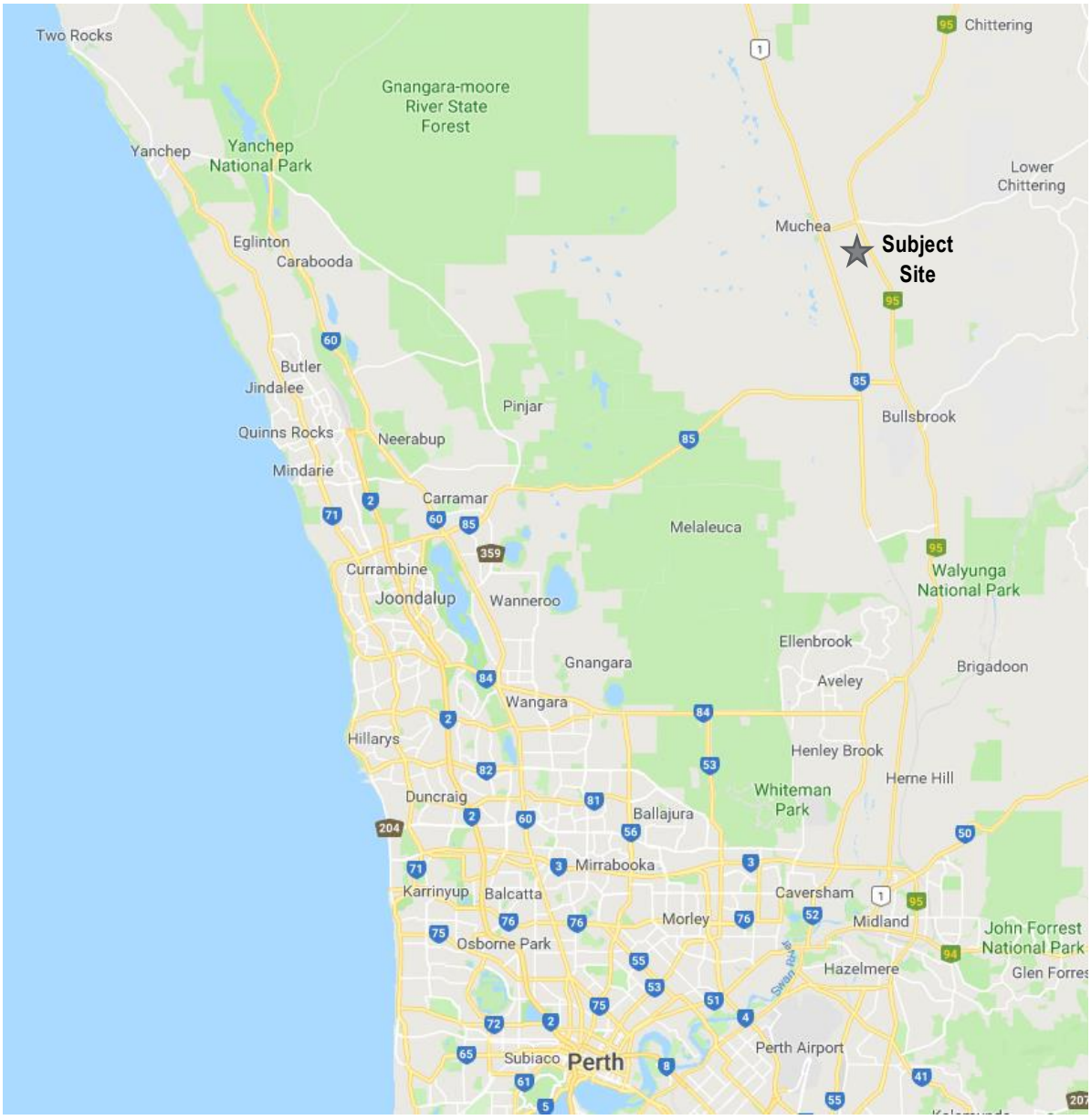
2. STRUCTURE PLAN OUTLINE

02

2.1. Regional Context

The subject site is located on the western side of Great Northern Highway, in Muchea, approximately 3km south-east of the Muchea Town Site, and approximately 55km north-east of the Perth CBD. The subject site is approximately 12km north of Bullsbrook, approximately 26km north of Ellenbrook and approximately 39km north of Midland. The State Government's Perth-Darwin National Highway (PDNH / Northlink) will bound the subject site to the west and south-west.

Figure 2.1: Location Map



(PhotoMap courtesy of GoogleMaps)

2.2. Proposed Land Uses

The structure plan proposes Industrial zoning which is consistent with the MENSP. The use of the lots will be typically for road transport purposes with RAV vehicles accessing the site from both north and south of Great Northern Highway. The

overall structure plan area is approximately 150 hectares, and this is proposed to be developed into lots ranging in size from 1.6Ha to 7.7Ha with the varying lot sizes spread throughout the structure plan area. The layout of the Structure Plan Area is shown in Appendix A.

Table 2.1: Land Uses

Land Use	No./Area
Industrial/Road Transport Purposes	52 lots with a total area of ~150Ha

2.3. Attractors or Generators of Traffic (non-residential)

Given that the structure plan area is Industrial, a major employment attractor, there are numerous generators of traffic within this structure plan area. The intensity of the traffic generation however is expected to be low given the anticipated business type carried out by transport operators using the area for transport logistics uses.

2.4. Specific issues

Access to the Structure Plan area will be via Great Northern Highway. This access is proposed to be via two intersections, a northern intersection closer to Brand Highway and a southern intersection near the southern boundary of the Structure Plan Area. In discussion with the Shire of Chittering and the client, there is a desire to provide access to the site for vehicles up to RAV10 size. Vehicles of this size can be up to 53.5m in length and would be the largest vehicle ordinarily permitted on the road system under permit. Specific provision for RAV10 vehicles has been allowed for the "loop" road within the site connecting the northern intersection with the southern intersection (showed marked in blue in Appendix A), with the remainder of the roads within the area designed with the intention to provide RAV7 access (vehicles up to 36.5m length).

When the PDNH is opened vehicles up to RAV7 combination access will be allowed on the PDNH placing less reliance on Great Northern Highway for RAV use. However, Great Northern Highway in the vicinity of the Structure Plan Area is proposed to remain under the control of Main Roads WA as a Primary Distributor.

RAV10 vehicles are expected to travel to and from the wider MEN structure plan area via the northern approaches (PDNH and Muchea East Road), whilst RAV7 vehicles would be able to approach the site from both north and south approaches of Great Northern Highway.

3. EXISTING SITUATION



03

3.1. Subject Site

The subject site comprises of 8 existing lots to the west of Great Northern Highway in Muchea with the alignment of the new PDNH forming the western edge. The Structure Plan has changed slightly to the MENSP to now include a longer internal loop road connecting the northern and southern intersections on Great Northern Highway. The adjustment to the road alignment has resulted from a site-specific analysis which identified drainage requirements necessitating a realignment of roads in the Structure Plan Area.

TPS 2 states that the Industrial Development Zone requires a structure plan to further guide development, and as such this Structure Plan was prepared.

The surrounding properties include a mix of zones including the Rural Water Resource, Parks and Recreation and Rural Agricultural Zones.

The location of the subject site and the surrounding environs is shown in Figure 3.1.

Figure 3.1: Subject Site and its Environs



(PhotoMap courtesy of NearMap Pty Ltd)

3.2. Existing Movement Network

3.2.1. Roads (inc RAV Networks)

The development of the Muchea area is limited and the land is currently largely rural. Current development on the existing lots includes chicken farms, transport depot and other low impact land uses.

Perth-Darwin National Highway (Northlink)

The State Government has committed to the Perth-Darwin National Highway, which is a new 37km link from the intersection of Reid and Tonkin Highways to Great Northern Highway and Brand Highway at Muchea, adjacent to the structure plan area. This new route will increase efficiency and support the development of the Muchea Employment Node. The project is currently being developed by Main Roads Western Australia (MRWA).

Works on the route started in 2017 and is expected to be completed by the end of 2019.

Once complete this road is expected to carry in the order of 11,500vpd by 2031 south of Brand Highway[1].

Great Northern Highway

Great Northern Highway is a Primary Distributor road which runs north-south and forms the eastern frontage of the structure plan area. It has a posted speed limit of 110km/h as per the MRWA Road Information Mapping System except on the southern approach to the intersection of Brand Highway/Muchea East Road where it drops to 80km/h approximately 500m south of this intersection. It is also currently the key route to the Perth Metropolitan Region. Traffic volumes in 2018/19 recorded by MRWA showed 8,605 vehicles per day (vpd) with 25.6% heavy vehicles (including RAVs). Great Northern Highway has a typical carriageway of width of 7.2m and includes sealed shoulders either side of this within a 40m wide road reserve. There are overtaking lanes for both northbound and southbound traffic flows near the proposed location of the new southern intersection with these being approximately:

- Southbound: 1.2km long (500m is south of proposed intersection)
- Northbound: 800m long (800m is north of proposed intersection).

Muchea East Road

Muchea East Road continues east from Brand Highway at the Great Northern Highway intersection, at the northernmost part of the structure plan area. Muchea East Road is a Regional Distributor and has a posted speed limit of 80km/h for approximately 1.5km east from the Great Northern Highway intersection then 100km/h and 90km/h when it reaches Lower Chittering.

RAV Network

Most major roads in the vicinity of the site allow the movement of RAVs. Presently the largest size vehicle permitted are vehicles up to RAV7 size which can be up to 36.5m length. These vehicles are referred to as triple road trains and include combinations of:

- Prime mover, semi-trailer and B-double
- B-double towing a dog trailer.

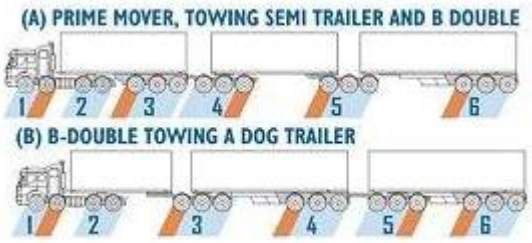
Refer to Figure 3.2 below.

In addition to the above, Great Northern Highway is presently a high/wide load route for the transit of over-dimensional loads.

[1] Muchea Employment Node Structure Plan (DoP/WAPC, August 2011).

Discussed elsewhere in this report, this section of Great Northern Highway is proposed to be incorporated in the RAV10 network. An application for this use would need to be made once intersection modifications and new roads have been constructed.

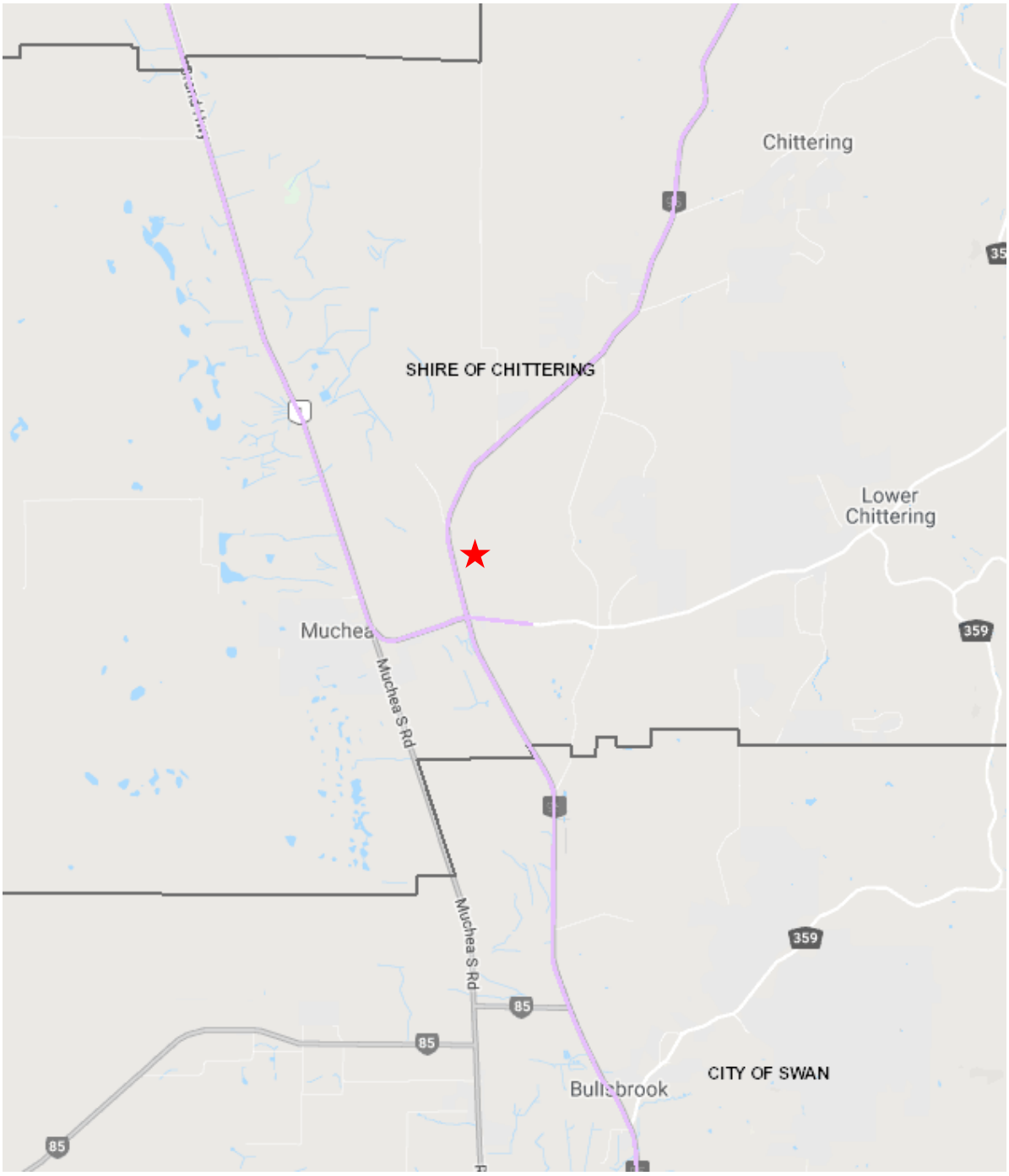
Figure 3.2: RAV7 Prime Mover, Trailer Combinations



(Source: Main Roads WA)

These routes are shown below in Figure 3.3, an excerpt from the Main Roads RAV Mapping tool.

Figure 3.3: RAV7 Network in Vicinity on SP Area



3.2.2. Pedestrian and Cyclist Network

There are limited pedestrian and cycling facilities in the network due to the rural location of the structure plan area. The MENSP also sets out that no formal cycle or pedestrian facilities are provided in the structure plan, however it recommends a sealed shoulder which could be used by cyclists. With 10m wide carriageways within the Structure Plan Area, where kerbed, cyclists are expected to ride on the carriageway and where unkerbed, they will be expected to ride on the sealed shoulder.

3.2.3. Public Transport

The MENSP sets out that the provision of public transport facilities has not been included in the structure plan, and notes that the nature of the land uses within the structure plan would make it difficult to provide public transport. However, given that the network is to be designed by trucks, buses would have the geometric road space to also use the network.

TransWA runs services once daily to Muchea from the East Perth Terminal to Kalbarri route.

3.3. Existing Road Network (Within 2km)

In addition to roads discussed above which directly abut the structure plan area, there are also a number of other roads within a 2km radius of the site.

Brand Highway

Brand Highway runs east-west at the northernmost portion of the site and continues north to Geraldton. It is a Primary Distributor road and has a posted speed limit of 80km/h from the intersection to Chittering Street as per the MRWA Road Information Mapping System.

Muchea South Road

Muchea South Road runs south off Brand Highway, and north-south adjacent to the structure plan area. It is currently identified as a Regional Distributor road and has a posted speed limit of 60km/h between Brand Highway and Porter Street, and then 90km/h south of Porter Street as per the MRWA Road Information Mapping System.

Muchea East Road

Muchea East Road runs west to east from the intersection of Brand Highway and Great Northern Highway. It is currently identified as a Regional Distributor road and has a posted speed limit of 60km/h near Great Northern Highway and 80km/h further to the east as per the MRWA Road Information Mapping System. Approximately 800vpd (2018/19) utilise Muchea East Road, just east of Great Northern Highway.

3.4. Traffic Counts (within 2km)

Figure 3.4: Location of Counters

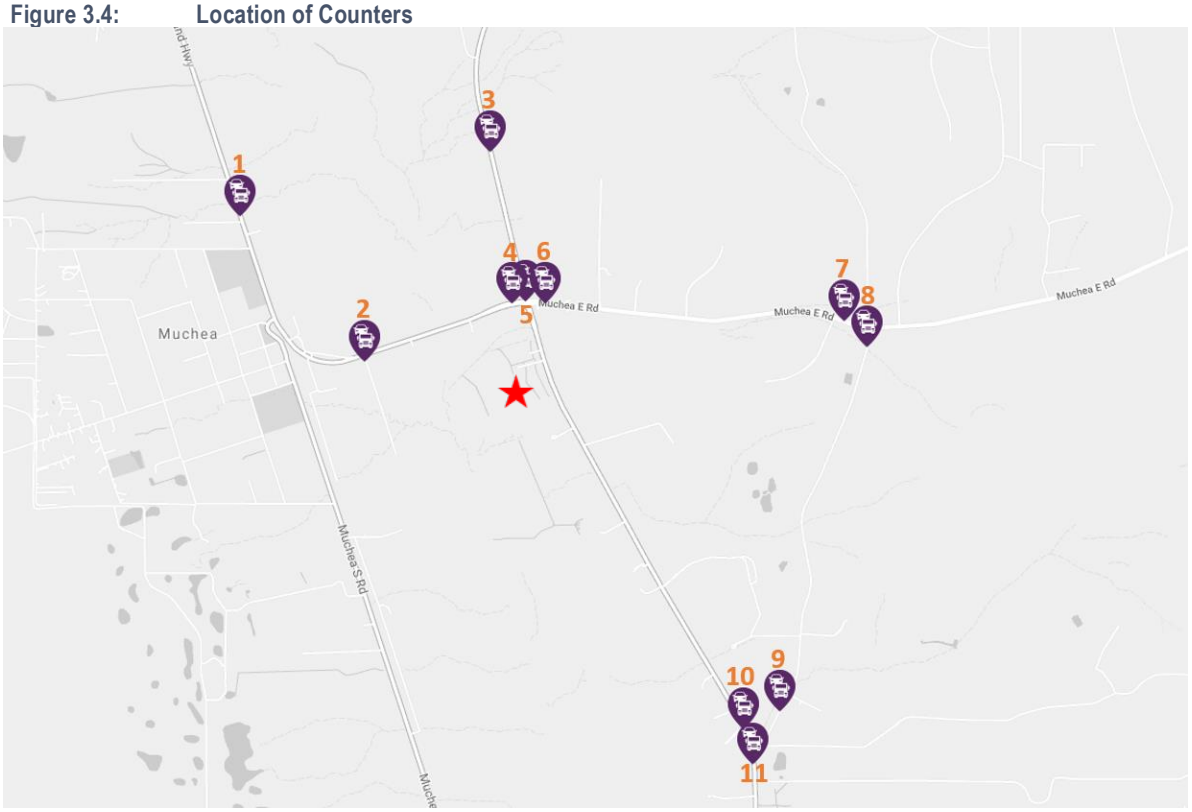


Table 3.1: Traffic Counts;

	Location	Monday to Sunday Average	Year	% Cars	% Trucks
1	Brand Hwy (North of Muchea South Rd)	4,524	2017/18	74.4%	26.6%
2	Peters Rd (South of Brand Hwy)	150	2013/14	86.7%	13.3%
3	Great Northern Hwy (North of Muchea East Rd)	3,965	2015/16	77%	23%
4	Brand Hwy (East of Great Northern Hwy)	3,700	2014/15	76.8%	23.2%
5	Brand Hwy (West of Great Northern Hwy)	3,655	2014/15	77%	23%
6	Muchea East Rd (East of Great Northern Hwy)	804	2018/19	80.7%	19.3%
7	Muchea East Rd (West of Wandena Rd)	597	2015/16	49.1%	50.9%
8	Wandena Rd (South of Muchea East Rd)	2,108	2015/16	62%	38%
9	Wandena Rd (North of Great Northern Hwy)	2,347	2015/16	81.6%	18.4%
10	Great Northern Hwy (North of Wandena Rd)	8,605	2018/19	74.4%	25.6%
11	Great Northern Hwy (South of Wandena Rd)	9,014	2015/16	73%	27%

4. PROPOSED INTERNAL TRANSPORT NETWORKS (MOVEMENT NETWORK)

04

4.1. Changes to Existing Road Network

The current Structure Plan area does not have any public roads within it. The Structure Plan area only abuts the existing road network at Great Northern Highway to the east, Brand Highway to the north and the new PDNH to the west. None of these roads are proposed to change in configuration in the foreseeable future. Great Northern Highway is expected to be maintained as a Primary Distributor under the control of Main Roads WA. The main access to and from the Structure Plan area is proposed to be via two new intersections constructed to intersect with Great Northern Highway. Each of these are proposed to be T-junctions under either Stop of Give Way sign control.

The intersections will require the construction of right and left turn deceleration lanes on Great Northern Highway as discussed in Section 6.6.

The southern access would merely formalise the current access at this location into an intersection design format suitable for RAV10 access to and from the north and RAV7 access to and from the south of Great Northern Highway.

There is not a requirement to provide acceleration lanes for the southern access as there is presently overtaking lanes at this location which will allow faster moving vehicles to pass slower moving and accelerating RAVs travelling both north and south along Great Northern Highway. The northern access should not require acceleration lanes for the northbound direction as the intersection of Brand Highway/Muchea East Road is in close proximity to the site. The southern departure for the northern intersection would also operate satisfactorily without an acceleration lane as there are overtaking lanes located approximately 650m south of this intersection which is considered to be near the point of entry of road trains from the intersection onto Great Northern Highway.

4.2. Proposed Road Hierarchy, Road Reserve Widths and Speed Limits

The Structure Plan area identifies an indicative loop road network and local access streets within the Structure Plan area. There is proposed to be a main loop road connecting the northern intersection with the southern intersection. This route is proposed to have a near 90-degree bend in the road and then an intersection back onto the southern intersection.

4.2.1. Local Distributor

Loop Road

The internal loop road connecting the northern intersection to the southern intersection is a proposed is proposed to be a Local Distributor under the Functional Road Hierarchy. It is intended to be a two-lane single carriageway road with an operating speed of 50-60km/h. It is proposed to be a 20m wide road reserve (augmented with 10m wide drainage area as required) incorporating a 10m wide two-way single carriageway.

4.2.2. Local Access Roads

The Structure Plan area comprises largely of local access roads due to its Industrial nature. The local roads proposed as part of this area are detailed below and are in accordance with DCP 4.1.

- 20m wide road reserve (augmented with 10m wide drainage area as required) incorporating a 10m wide two-way single carriageway. These roads are intended to have a speed limit of 50km/h.

4.3. Road Cross Sections

As this Structure Plan area is to be an Industrial development, under Development Control Policy 4.1 (DCP 4.1), a minimum road reserve of 20m is required and this will allow a typical 10m wide two-lane single carriageway. This has been generally adopted, but with the augmentation of an additional 10m for drainage purposes.

With the large size of vehicles access the site (RAV10 for the "loop" road and RAV7 for the remainder of the road network, unless amended by individual landowners at the subdivision stage) these cross-sections will allow vehicles of RAV7/10 size

to drive along them. The only exception is at intersections or right angle bends where the swept paths of these vehicles will require intersection widenings and larger than normal truncations to suit. These intersection widenings allow for RAV10s to turn and be lane correct in such a manner that other RAV10 vehicles stopped at intersections or negotiating right angle bends in the roadway, will not impede the movement of other RAV10 vehicles.

Examples of these are shown at Appendix B.

When accessing properties directly adjacent to the RAV10 network vehicles of this size will be able to utilise the full width of both the crossovers and the roadway.

Examples of this are shown at Appendix C, from work undertaken by Porter Consulting Engineers.

4.4. Intersection Controls

No formal signage is proposed to be installed for roads within the Structure Plan area. Intersections will all be T-junctions with the standard road rules applying for right of way. To assist to correct positioning of vehicles within the road network, holding lines are recommended at these intersections.

4.5. Interim and Ultimate Access

In discussion with MRWA, the current authority under which Great Northern Highway is under, access to and from the site will ultimately be required to be from the internal road network with no lot access direct to/from Great Northern Highway. This will be achievable for all proposed lots, with one exception. There will be required to be direct access to either Brand Highway, west of Great Northern Highway or Great Northern Highway, south of Brand Highway for the northern most lot proposed north of the proposed drainage way. This site presently has direct access and it is intended the site will continue to maintain this access once the Structure Plan area is fully developed.

Advice from MRWA is that interim access could be permitted to allow the Structure Plan area to be developed over time. Once access from an internal access road could be achieved, then the direct access would need to be removed from Great Northern Highway.

4.6. Pedestrian/Cycle Networks and Crossing Facilities

There being no desire lines for internal pedestrian movements between land uses and no access to public transport network, there is no plan to provide a footpath network at this stage. The type of land use proposed within the development would not lend the wider Structure Plan area to have and support a footpath network.

Similarly, no specific cycling facilities are proposed. The 10m wide proposed road network would allow employees to ride their bikes if so desired, but the probability of their use is expected to be low given the remoteness of the MENSP area to residential areas. The nearest residential area of note is Bullsbrook, approximately 8-9km via Great Northern Highway.

4.7. Public Transport Routes

No public transport routes are proposed within the structure plan area. However, should the current Route 311 to Bullsbrook, or any other route, be extended to Muchea, then the development could take advantage of such a route. The current and proposed road geometries would not preclude such an extension or new bus route and would allow the wider MENSP area to be less reliant on private motor vehicles travel to and from the area.

4.8. Proposed Road Access Strategies

The lots proposed as part of this structure plan area will not have any direct access onto Great Northern Highway, with the exception of the northern most lots previously discussed. All access will be via internal roads, and two new access points/intersections onto Great Northern Highway.

Access of the internal lots onto the internal road network will be direct via typical crossovers designed to allow access for the required vehicles. These could be up to RAV10 vehicles for the loop road but would be no greater than for RAV7 vehicles for the remainder of the road network, unless amended by individual landowners at subdivision stage.

5. EXTERNAL TRANSPORT NETWORKS

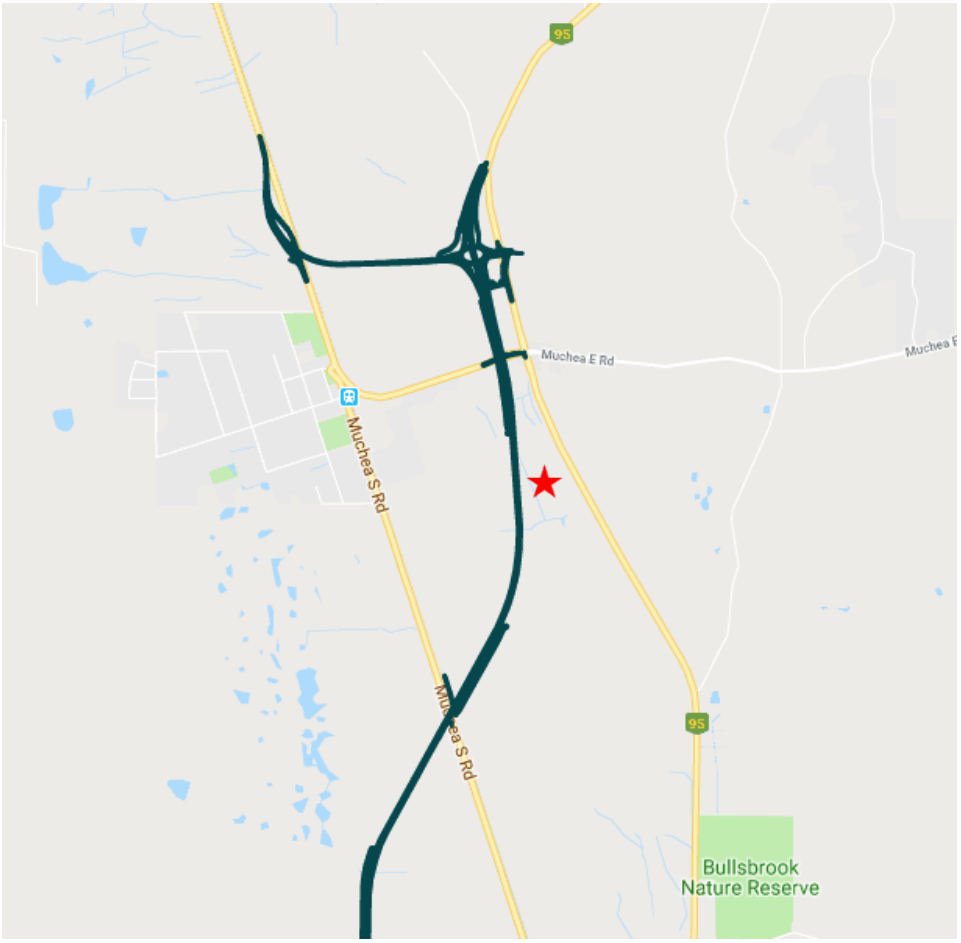
05

5.1. Changes to External Transport Networks

Other than the proposed full movement T-junction at the northern and southern intersections leading into the structure plan area, this development will not result in any other changes to the external transport network.

The other major changes proposed in the vicinity of the development include the construction of the new PDNH, refer to Figure 5.1 below. This work will not impact the access nor the current form of Great Northern Highway, but there will be a decrease in traffic volumes on Great Northern Highway. Currently there is approximately 8,600vpd utilising this section of Great Northern Highway travelling at speeds up to the 110km/h posted speed limit.

Figure 5.1: Northlink WA works in Vicinity of SP Area



Once completed at the end of 2019, traffic volumes on Great Northern Highway are expected to decrease. Estimates for 2031 have indicated that there would be approximately 2,250vpd on this section of Great Northern Highway (this prior to any consideration of MENSP traffic effects). Even with this substantial drop from 8,600 to 2,250vpd in traffic, the function of Great Northern Highway is expected be retained as a Primary Distributor under the control of Main Roads WA. It is expected the speed limit may also decrease so as to act a deterrent so that vehicles do not use Great Northern Highway in lieu of the new PDNH. An appropriate speed limit would be in the order of 80-90km/h.

The RAV10 network presently only extends from the northern areas of the state as far south as Wubin, via the Great Northern Highway. The initial concept was for a road train assemble area to be located within the south-east quadrant of the new PDNH/Brand Highway interchange. In discussion with the Shire of Chittering there is now a desire to allow these vehicles to extend further and utilise the road network within the wide MENSP. To allow this use to be considered, once

roads have been constructed, the road network within the MENSP should be designed allow these vehicles to access to and from the north.

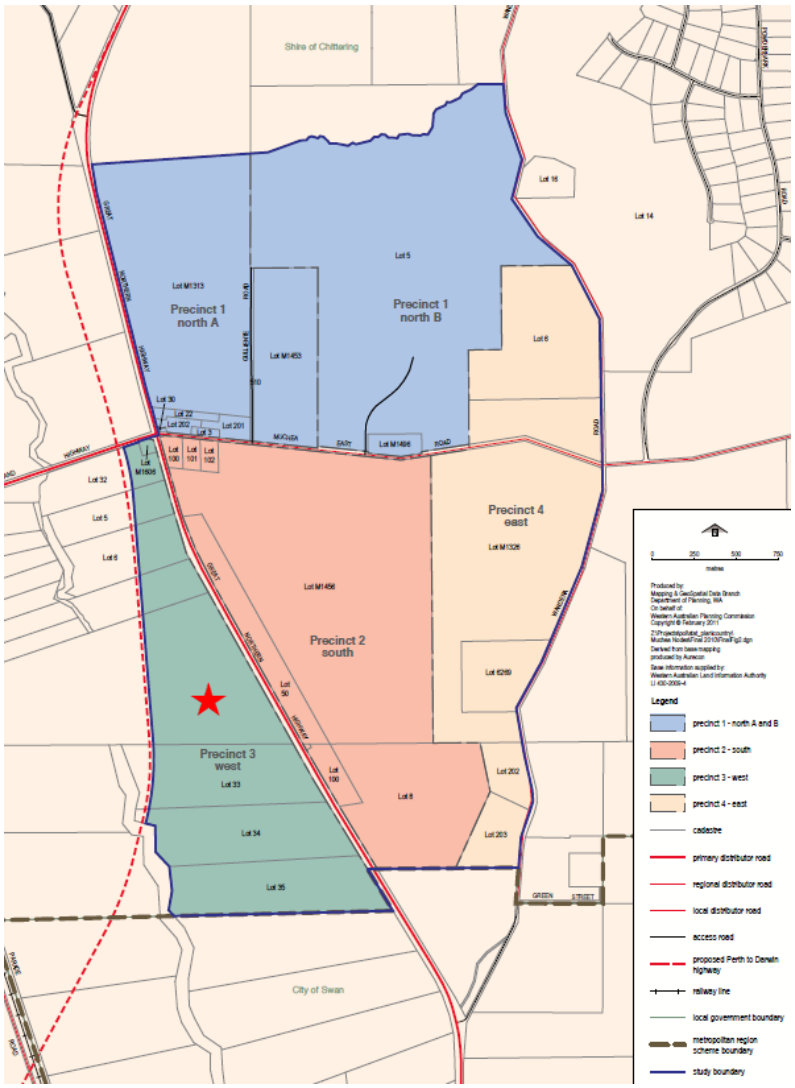
6. INTEGRATION WITH SURROUNDING AREA

06

6.1. Surrounding Attractors

Other than the current structure plan, the MENSP identifies three other industrial precincts Precinct 1 (north), 2 (south) and 4 (east), comprising of new long-term development area. This is located east of Great Northern Highway and further to the north, north of Muchea East Road. Refer to Figure 6.1 below.

Figure 6.1: MENSP Precincts



(Source: MENSP Final Report 2011)

In terms of wider regional access to and from the Structure Plan area, the majority of traffic to and from the Structure Plan is expected to be via the northern approaches of Great Northern Highway, via the PDNH. It is estimated[2] that this will account for approximately 67% of vehicle movements with the remaining 33% travelling to and from the south via Great Northern Highway in its downgraded classification format.

[2] Based on Muchea Employment Node Structure Plan (DoP/WAPC, August 2011).

6.2. Trip Attractors/Generators within 800m

The Industrial areas identified in the MENSP will be a key generator of traffic (both car and truck). There may be some trips to and from sites within 800m of the Structure Plan area, but as the Structure Plan area is more of a regional transport hub, these trips are likely to be insignificant with most trips to and from the Structure Plan area expected to be to areas outside the MENSP.

6.3. Proposed Changes to Land Uses within 800m

The Structure Plan area is intended to be developed from rural to Industrial as will be areas located east of Great Northern Highway and falling under the MENSP. The land uses permitted and total net area, as per Table 1 of MENSP is included as Figure 6.2 to provide an indication of the likely future uses within the Structure Plan.

Figure 6.2: Muchea employment node indicative land use area split (hectares) (MENSP 2011)

Indicative land use split	WAMIA	Complementary Uses	Local	Strategic location	Metropolitan spill over	Total
primary/rural	272		7.0	0	0	279.0
manufacturing/ processing/ fabrication	1		30.6	20	5	56.5
storage/distribution	18.7	1.75	48.7	52.3	22.5	143.9
service industry	10	2	41.7	20.9	20	94.6
shop/retail		1	0.0	0	0	1.0
other retail		5	1.4	0	0	6.4
office/business		0.25	5.6	0	0	5.8
health/welfare/ community services			0.0	0	0	0.0
entertainment/ recreation/ culture			0.0	0	0	0.0
residential	0.3		0.0	0	0	0.3
utilities/ communications			4.2	1.9	2.5	8.6
TOTAL	302	10	139	95	50	596

6.4. Travel Desire Lines from Structure Plan to these Attractors/Generators

The desire lines to and from the local attractions are expected to be via roads and intersections constructed as part of development in the wider MENSP. With access to the wider regional destinations, the current Great Northern Highway to the south and PDNH/Northlink will provide for those desire lines to the wider network.

6.5. Adequacy and Deficiencies in External Transport Networks

The provision of the new intersections on Great Northern Highway will need to be adequately designed so as not to create a hazard for vehicles travelling north and south. Due to the expected traffic entering and exiting these intersections, there will be occasions for vehicles to stop on Great Northern Highway to turn into the Structure Plan area, or to decelerate on Great Northern Highway and then turn left. Stopped vehicles on the highway would be extremely hazardous as would be vehicles decelerating when turning left into the site. As such, remedial measures are discussed in the next section.

6.6. Remedial Measures to Address Deficiencies

To address the access to the site via Great Northern Highway, the intersection designs would need to incorporate, as a minimum, left and right turn pockets on the north and south approaches to the new intersections. These should be designed in accordance with Austroads:

Right turn Deceleration Lanes	125m length (based on 90km/h speed) plus storage of 60m for one stopped RAV10 for a total of 185m.
Left turn Deceleration Lanes	120m length (based on 90km/h approach speed and 20km/h speed at end of the lane).

Also, there would typically be the requirement to consider acceleration lanes for RAVs exiting these intersections. However, due to the provision of existing overtaking lanes near the southern intersection and the proximity of the northern intersection to the intersection of Brand Highway/Muchea East Road, there would be insufficient spacing and no requirement to provide these. Therefore, RAVs exiting these two intersections would not impact adversely on traffic flow on Great Northern Highway due to the combination of the ability of traffic to overtake RAVs near the southern intersection and the lower expected traffic flows.

7. ANALYSIS OF INTERNAL TRANSPORT NETWORKS

07

7.1. Assessment Year(s) and Time Period(s)

The development has been assumed to be fully developed by 2031, or approximately in 13 years' time. As this is an Industrial area the assessment period should be the PM peak as recommended in the WAPC guidelines. This period would place the most stress on the internal road network exiting onto Great Northern Highway.

7.2. Structure Plan Generated Traffic

7.2.1. Trip Generation Rate

The MENSP Final Report 2011 was referenced and the traffic generation rate for this was approximately 23 trips per day per gross hectare for the 8,200 trips expected across the 356Ha of the MENSP. This trip rate has been adopted for the assessment of the internal road network and the effects of this traffic on the two new intersections on Great Northern Highway.

7.2.2. Trip Generation of Site

Based on the gross area to be developed in the Structure Plan area, approximately 150Ha, the Structure Plan area is expected to generate approximately 3,500 trips per day. To allow a robust assessment this traffic volume has been increased by approximately 25% to approximately 4,400 trips per day. With 10% of these trips occurring in the PM peak approximately 440 trips would occur in the PM peak. This would comprise of approximately 350 exiting the Structure Plan Area and 90 entering the Structure Plan Area.

7.3. Extraneous (Through) Traffic

No through traffic is expected through the actual Structure Plan area, but there is expected to be through traffic utilising Great Northern Highway.

Without consideration of the MENSP, the MENSP 2011 report for 2026 and 2037 years derived a traffic flow of approximately 2,250vpd on Great Northern Highway in 2031. This accounts for the effects of the new PDNH and other works associated with the Northlink WA project.

With the consideration of the MENSP, this is expected to add approximately 2,725vpd to this section of Great Northern Highway for a final traffic volume of approximately 5,000vpd. This traffic flow on Great Northern Highway is similar to traffic flow experienced well before 2012/13 when traffic volumes were recorded at 6,430vpd AADT (average annual daily traffic).

7.4. Design Traffic Flows (i.e. Total Traffic)

The internal road network and the proposed size and location of lots suggest that the southern intersection will carry the majority of traffic to and from the Structure Plan area. Approximately 3,000vpd are expected to utilise this intersection at the end of the loop road nearest Great Northern Highway. The northern intersection, although closer to the PDNH interchange, is expected to carry less traffic due to the smaller number of lots, with approximately 1,400vpd utilising this intersection and the section of the loop road. Internal traffic flows are expected to decrease from these maximum flows near Great Northern Highway as the local road network distributes the traffic in the Structure Plan area. Traffic flows on the loop road adjacent to the PDNH are expected to be approximately 800vpd with most other local roads having traffic flows less than 1,000vpd. These flows are shown at Appendix D.

7.5. Road Cross-Sections

All the above traffic flows are appropriate for the proposed road cross sections as discussed previously. The general 10.0m wide pavement road throughout the Structure Plan area can cater for daily flows up to 3,000 vpd.

Based on the calculated traffic volumes expected for the Structure Plan area, the proposed road cross sections discussed previously are considered appropriate.

7.6. Access Strategy and Intersection Controls

The Structure Plan area is proposed to have access to the existing road network via the two access roads connecting onto Great Northern Highway. These are proposed to be a T-junction format under either Give Way or Stop sign control. Assessing the expected traffic volumes in the Structure Plan area, the proposed intersection controls are still valid and appropriate. The traffic volumes estimated (refer Chapter 8) are within acceptable ranges for roads of the proposed width and there are no notable imbalances in traffic flows at T-junctions.

With regards to intersections, Table 2.4 from the Austroads publication, *Guide to Traffic Management Part 6 – Intersections, Interchanges and Crossings* provides advice as to intersection performance in peak flow conditions with regards to possible further analysis. This is summarised in Table 7.1.

Table 7.1: Austroads Guidelines

Major Road Type	Major Road Flow (two-way, vph)	Minor Road Flow (two-way, vph)
Two-lane	400	250
	500	200
	650	100
Four-lane	1,000	100
	1,500	50
	2,000	25

The peak volume per hour (vph) would be approximately 10% in the PM peak. The traffic volumes are low enough so as to not warrant further assessment for the structure plan internal roads. For example, the highest flow intersection would be near the southern intersection where the loop road would have a major road flow of approximately 300 vph and approximately 100 vph on the road immediately intersection to the south. This falls well below the first row of the above table and thus requires no further assessment. It is therefore concluded that all internal intersections are acceptable and should operate at a high level of service (LOS) A with minimal delays and queues.

7.7. Pedestrian / Cycle Networks

There is expected to be minimal pedestrian activity due to the transport depot nature of the proposed land uses within the Structure Plan area and the lack of public transport and thus no access requires to and from bus stops. If employees do decide to cycle to the Structure Plan area, the traffic flows the 10m wide carriageways and relatively low traffic volumes on these roads would not create an adverse cycling environment. The only issue would be the effects of the large RAVs as they traverse the road network. However, apart from along the main entry roads and intersections, there is expected to be low traffic flows.

7.8. Pedestrian Permeability & Efficiency

Being no bus stops nor neighbourhood centres, this assessment as per the WAPC Guidelines is not required. Suffice to say that the network would be permeable to some degree if bus stops were appropriately located on Great Northern Highway, approximately 50% of the lots would be located within 400m of Great Northern Highway, which would be below the requirement.

7.9. Access to Public Transport

In terms of the broad Transperth requirements of a bus stop within 500m of 95% of Perth's population, this distance measured in a straight line from the current bus stops, none of the Structure Plan area falls within this 500m straight line distance.

8. ANALYSIS OF EXTERNAL TRANSPORT NETWORKS

08

8.1. Extent of Analysis

With the reduction in traffic flows on Great Northern Highway with the advent of the PDNH and the additional of the MENSP traffic, generally traffic flows are expected to be well below current traffic flows on the wider road network. The only exceptions are the two new proposed intersections of the loop road with Great Northern Highway. As such, only these two new intersections are the subject of assessment.

8.2. Impact Assessment

8.2.1. Trip Distribution

Assessment of traffic flows to and from the wider MENSP has revealed that traffic flows to and from the Structure Plan area are expected to be along similar lines. Based on this the expected distribution is as follows:

- To and from the North via Great Northern Highway 67%
- To and from the South via Great Northern Highway 33%.

8.2.2. Traffic Impact of Development Traffic

All bordering and connecting roads are expected to have traffic volumes within their theoretical capacities. These volumes are not expected to exceed the maximum daily flow rates expected for roads of their classification and should be manageable (see the following intersection assessments). The maximum flows that these roads should carry are shown in Table 8.1 and Table 8.2.

Table 8.1: Current Traffic Flows

Road	Indicative Maximum Daily Flow (two-way)	Actual Daily Flow (two-way)
Great Northern Highway	16,000	8,600

Table 8.2: Expected Traffic Flows

Road	Indicative Maximum Daily Flow (two-way)	Expected Daily Flow (two-way)
Great Northern Highway	16,000	5,000
Northern Loop Road	3,000	1,400
Southern Loop Road	3,000	3,000

It can be seen that traffic is expected to decrease in Great Northern Highway near the Structure Plan area by about 3,600 to 5,000 vpd, this being less than traffic counts recorded on this section of road in 2012/13 when 6,430vpd was recorded.

Loop Road Intersections Performance

To further assess the performance of the road network within the Structure Plan area the two new intersections of the loop road with Great Northern Highway were assessed in the PM peaks. A computer program, SIDRA Intersection (Version 7), was utilised for this purpose. The summary of this analysis is from the output tables from SIDRA for the expected traffic flows are shown on the following page in Table 8.3. Details of this assessment are at Appendix E for reference.

Table 8.3: Future External Intersection & Structure Plan Area Intersection Performance – 2031 with Development

Intersection	Peak Hour	Approach	DOS	Average Delay (sec)	LOS	95th %tile Queue (m)
North	PM	Great Norther Highway (RT)	0.03	9	A	1
		North Road (RT)	0.08	9	A	3
		Intersection	**0.20**	**4**	-	**4**
South	PM	Great Norther Highway (RT)	0.06	9	A	2
		North Road (RT)	0.19	10	A	7
		Intersection	**0.20**	**5**	-	**9**

With the proposed Structure Plan development traffic, the two intersections are expected to operate at a level of service A for the critical right turns across on-coming traffic. This assessment takes into account the acceleration profile of the larger RAVs with the actual percentage of heavy vehicles based on the current classification data recorded on Great Northern Highway.

8.2.3. Level of Service Concepts

The level of service concept describes the quality of traffic service in terms of six levels, designated A to F, with level of service A (LOS A) representing the best operating condition (i.e. at or close to free flow), and level of service F (LOS F) the worst (i.e. forced flow). More specifically:

- *LOS A*: Primarily free flow operations at average travel speeds, usually about 90% of the FFS (free flow speed) for the given street class. Vehicles are completely unimpeded in their ability to manoeuvre within the traffic stream. Control delay at signalised intersections is less than 10 seconds. At non-signalised movements at intersections the average control delay is less than 10 seconds;
- *LOS B*: Reasonably unimpeded operations at average travel speeds, usually about 70% of the FFS for the street class. The ability to manoeuvre within the traffic stream is only slightly restricted, and control delays at signalised intersections are between 10 and 20 seconds. At non-signalised movements at intersections the average control delay is between 10 and 15 seconds;
- *LOS C*: Stable operations; however, ability to manoeuvre and change lanes in mid-block locations may be more restricted than at LOS B, and longer queues, adverse signal coordination, or both may contribute to lower average travel speeds of about 50% of the FFS for the street class. Signalised intersection delays are between 20 and 35 seconds. At non-signalised movements at intersections the average control delay is between 15 and 25 seconds;
- *LOS D*: A range in which small increases in flow may cause substantial increases in delay and decreases in travel speed. LOS D may be due to adverse signal progression, inappropriate signal timing, high volumes, or a combination of these factors. Average travel speeds are about 40% of FFS. Signalised intersection delays are between 35 and 55 seconds. At non-signalised movements at intersections the average control delay is between 25 and 35 seconds;
- *LOS E:* Characterised by significant delays and average travel speeds of 33% of the FFS or less. Such operations are caused by a combination of adverse progression, high signal density, high volumes, extensive delays at critical intersections (between 55 and 80 seconds), and inappropriate signal timing. At non-signalised movements at intersections the average control delay is between 35 and 50 seconds; and,

- *LOS F*: Characterised by urban street flow at extremely low speeds, typically 25% to 33% of the FFS. Intersection congestion is likely at critical signalised locations, with high delays (in excess of 80 seconds), high volumes, and extensive queuing. At non-signalised movements at intersections the average control delay is greater than 50 seconds.

In addition to the above:

- Average Delay: is the average of all travel time delays for vehicles through the intersection; and,
- Queue: is the queue length below which 95% of all observed queue lengths fall.
- Degree of Saturation: Ratio of the traffic flow to the capacity for that particular lane/movement

The above is summarised below in Table 8.4 for reference.

Table 8.4: LOS/DOS Summary

Level of Service		Intersection Degree of Saturation (DOS)		
		Unsignalised Intersection	Signalised Intersection	Roundabout
A	Excellent	<=0.60	<=0.60	<=0.60
B	Very Good	0.60-0.70	0.60-0.70	0.60-0.70
C	Good	0.70-0.80	0.70-0.90	0.70-0.85
D	Acceptable	0.80-0.90	0.90-0.95	0.85-0.95
E	Poor	0.90-1.00	0.95-1.00	0.95-1.00
F	Very Poor	>=1.0	>=1.0	>=1.0

8.2.4. Traffic Impact of Development on Local Area

Based on the above assessment it is concluded that the Structure Plan area will have an acceptable impact on the surrounding roads and intersections with no changes required to either the road network or geometry of intersections due to the amendment alone. There will be a need to install right turn and left turn pockets on Great Northern Highway for the approaches to the new intersections, but this is a requirement for good safe design and not a requirement to address any capacity concerns.

8.3. Road Cross-Sections

The current road geometry and cross section of Great Northern Highway will be adequate to cater for the reduced traffic flows expected as a result of both the new PDNH and the impacts of the additional traffic due to the wider MENSP and the traffic generated by this Structure Plan area.

8.4. Intersection Layouts & Controls

From the above assessments, the intersection layouts and controls proposed in earlier sections of this report are not required to be modified.

8.5. Pedestrian/Cycle Networks

With a lack of internal pedestrian and cycle network the traffic volumes on the road network adjacent to the site will have little effect on the pedestrian and cycle network on Great Northern Highway. If bus routes are modified and extended to the MENSP then provision of these should be provided to allow safe access across Great Northern Highway, if such bus routes are limited to Great Northern Highway. Traffic volumes on Great Northern Highway and speeds are expected to decrease and the combination of these effects will improve cyclist's safety, for those to choose to ride along Great Northern Highway.

9. CONCLUSION

9

CONCLUSION

As a result of the traffic analysis undertaken for the proposed development of Precinct 3 of the Muchea Employment Node, Muchea the following findings and recommendations are made:

- The proposed Structure Plan Area is expected generate in the order of 3,500 vehicular trips per day with and 350 in the PM peak;
- The assessed impacts of the traffic volumes associated with the Structure Plan Area on the road network are considered acceptable in the future. Total traffic volumes on Great Northern Highway including the development traffic and the wider MENSP traffic is expected to be less than the recorded 2012/13 figures, this effect due to the construction of Northlink;
- There is no requirement for any of the existing road network to be modified on the wider road network as a result of this development;
- The proposed intersection form and control (left and right turn deceleration lanes) on Great Northern Highway is appropriate as per the requirements of Austroads
- Acceleration lanes are not required due to the provision of overtaking lanes near the southern intersection and the proximity of the northern intersection to the Brand Highway/Muchea East Road intersection; and,
- Delays and queues at the main entries to the Structure Plan area are expected to be minimal with good levels of service to 2031.

The WAPC checklist is included at Appendix F.

A. STRUCTURE PLAN AREA



LEGEND

- PRECINCT 3 STRUCTURE PLAN AREA
- LIGHT INDUSTRIAL
- FORESHORE AND DRAINAGE
- EXISTING LOT BOUNDARIES
- C — EXISTING AND PROPOSED CULVERTS
- MAIN DRAINAGE FLOWS
- EXISTING LOT ACCESS POINT

BRAND HIGHWAY
MUCHEA EAST ROAD
GREAT NORTHERN HIGHWAY
PERTH TO DARWIN HIGHWAY
ELLENBROOK
804
803
802
801
800
194
192
35
30M RR

Concept Plan

Muchea Employment Node - Precinct 3

DATA SOURCE
Landgate & Bayley Environmental

PROJECTION
MGA Zone 50

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

DISCLAIMER
Copyright by Urbis Pty. Ltd. This drawing or parts thereof may not be reproduced for any purpose or used for another project without the consent of Urbis. The plan must not be used for ordering, supply or installation and no relevance should be placed on this plan for any financial dealing of the land. This plan is conceptual and is for discussion purposes only and subject to further detail study, Council approval, engineering input, and survey. Cadastral boundaries, areas and dimensions are approximate only. Written figured dimensions shall take preference to scaled dimensions.

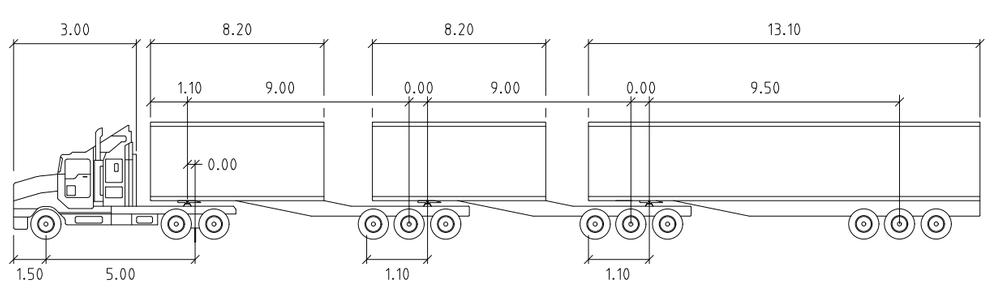
CLIENT
Tomahawk Property

1:5000 @ A1 | 1:10000 @ A3
50 100 150 200 250 m

PROJECT NO. P0002540
DATE 25.09.19
DRAWING NO. 02
REVISION f

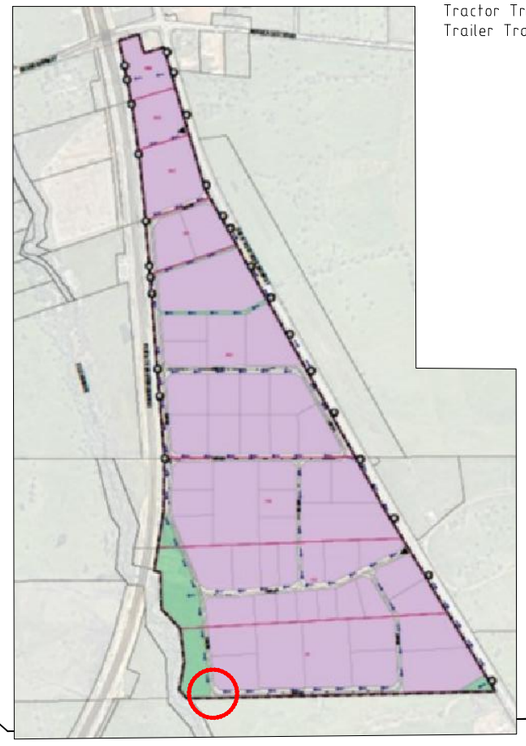
B. RAV SWEPT PATHS

B



MRWA RAV 6(B) REV 1

	meters		
Tractor Width	: 2.50	Lock to Lock Time	: 6.0
Trailer Width	: 2.50	Steering Angle	: 21.2
Tractor Track	: 2.50	Articulating Angle	: 70.0
Trailer Track	: 2.50		



SWEPT PATH KEY

- VEHICLE CENTRE LINE
- VEHICLE TYRE PATH
- VEHICLE BODY PATH
- **500**mm CLEARANCE FROM VEHICLE BODY

ASSUMED SPEED **5**km/h

3.0

7.1

2.2

GTA consultants
www.gta.com.au

Melbourne 03 9851 9600
Sydney 02 8448 1800
Brisbane 07 3113 5000
Adelaide 08 8334 3600
Perth 08 6169 1000

PRELIMINARY PLAN
FOR DISCUSSION PURPOSES ONLY
SUBJECT TO CHANGE WITHOUT NOTIFICATION

WARNING
BEWARE OF UNDERGROUND SERVICES
THE LOCATIONS OF UNDERGROUND SERVICES ARE APPROXIMATE ONLY AND THEIR EXACT POSITION SHOULD BE PROVEN ON SITE. NO GUARANTEE IS GIVEN THAT ALL EXISTING SERVICES ARE SHOWN.

DESIGNED	S. PEDRETTI
DESIGN CHECK	R.DING
APPROVED BY	R.DING
DATE ISSUED	01.10.2019
SCALE	A3 (0, 2.5, 5, 10 — 1:500)
CAD FILE NO.	W150400-XC-DESN-3.DWG

MUCHEA EMPLOYMENT NODE
PRECINT 3
RAV 7
SWEPT PATH

DRAWING NO. W150400-SK01 SHEET 1 OF 6 ISSUE P2

T:\W15000-15099\W150400 MUCHEA EMPLOYMENT NODE STRUCTURE\CAD\W150400-XC-DESN-3.DWG PLOTTED BY SIMON PEDRETTI ON 01/10/2019 AT 15:21

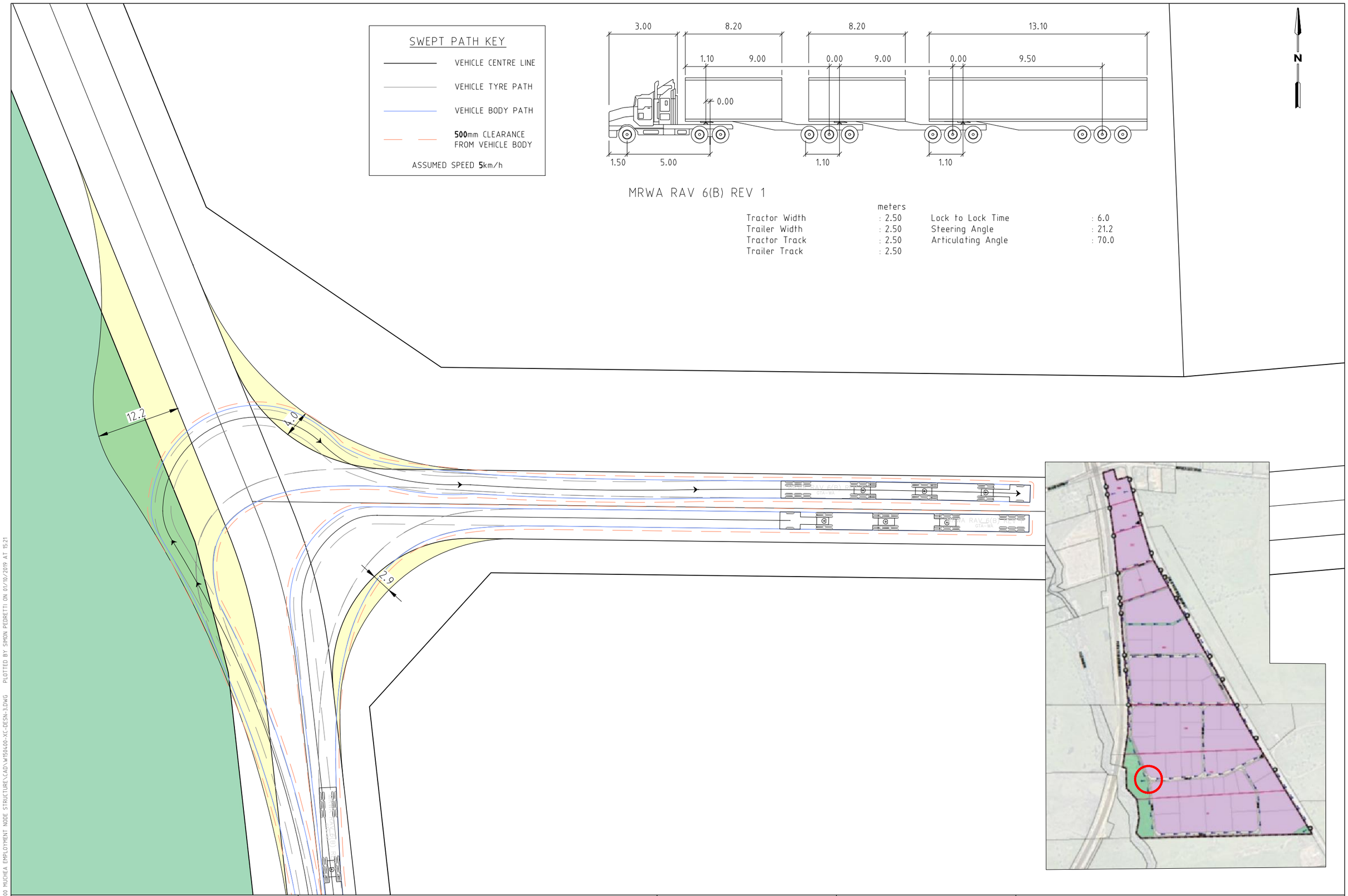
SWEPT PATH KEY

- VEHICLE CENTRE LINE
- VEHICLE TYRE PATH
- VEHICLE BODY PATH
- **500**mm CLEARANCE FROM VEHICLE BODY

ASSUMED SPEED **5**km/h

MRWA RAV 6(B) REV 1

	meters		
Tractor Width	: 2.50	Lock to Lock Time	: 6.0
Trailer Width	: 2.50	Steering Angle	: 21.2
Tractor Track	: 2.50	Articulating Angle	: 70.0
Trailer Track	: 2.50		



GTAconsultants
www.gta.com.au

Melbourne 03 9851 9600
Sydney 02 8448 1800
Brisbane 07 3113 5000
Adelaide 08 8334 3600
Perth 08 6169 1000

PRELIMINARY PLAN
FOR DISCUSSION PURPOSES ONLY
SUBJECT TO CHANGE WITHOUT NOTIFICATION

WARNING
BEWARE OF UNDERGROUND SERVICES
THE LOCATIONS OF UNDERGROUND SERVICES ARE APPROXIMATE ONLY AND THEIR EXACT POSITION SHOULD BE PROVEN ON SITE. NO GUARANTEE IS GIVEN THAT ALL EXISTING SERVICES ARE SHOWN.

DESIGNED S. PEDRETTI
DESIGN CHECK R.DING
APPROVED BY R.DING
DATE ISSUED 01.10.2019

SCALE A3 0 2.5 5 10 1:500
CAD FILE NO. W150400-XC-DESN-3.DWG

MUCHEA EMPLOYMENT NODE
PRECINT 3
RAV 7
SWEPT PATH

DRAWING NO. W150400-SK02 SHEET 2 OF 6 ISSUE P2

T:\W15000-15099\W150400 MUCHEA EMPLOYMENT NODE STRUCTURE\CAD\W150400-XC-DESN-3.DWG PLOTTED BY SIMON PEDRETTI ON 01/10/2019 AT 15:21

SWEPT PATH KEY

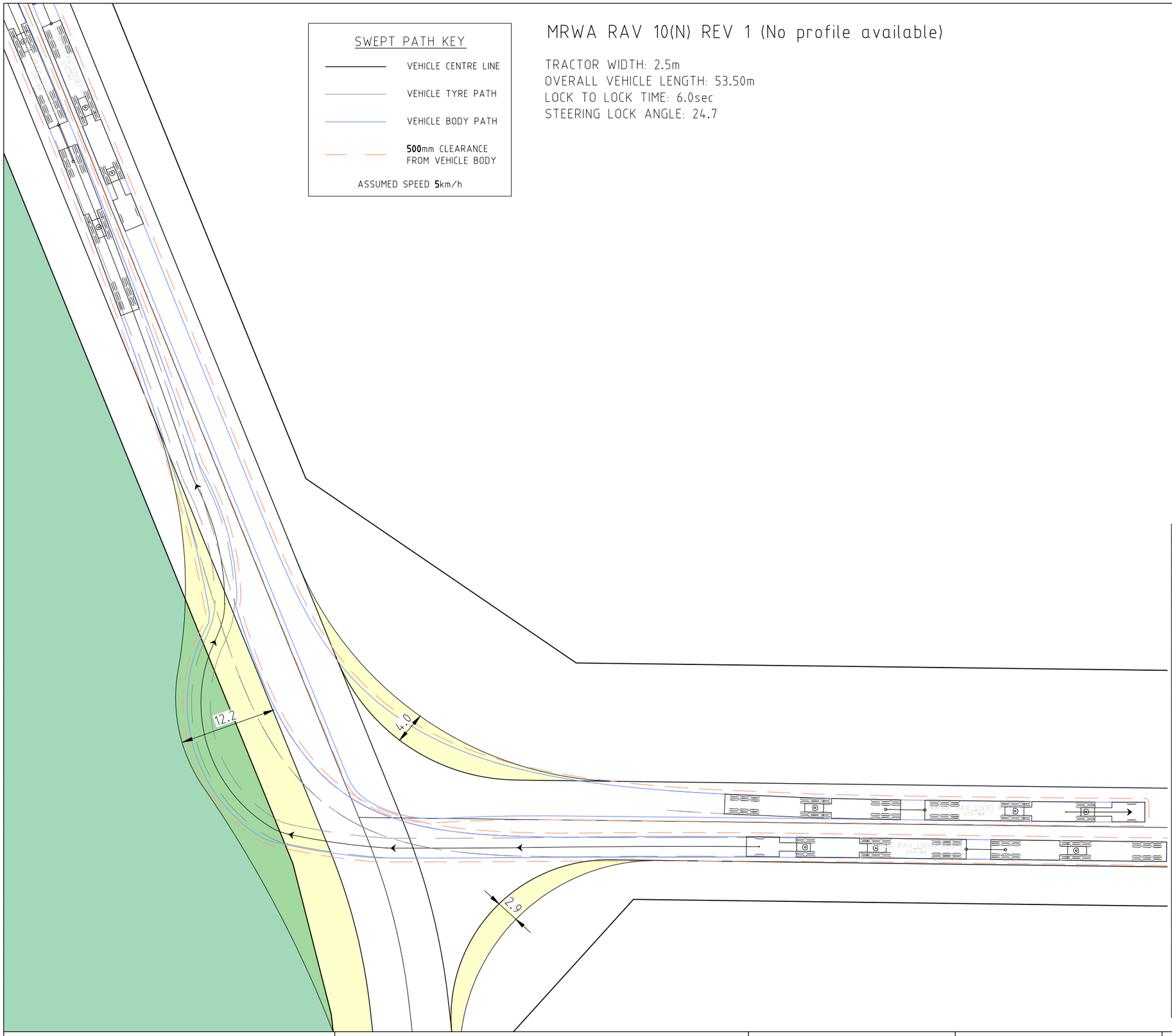
- VEHICLE CENTRE LINE
- VEHICLE TYRE PATH
- VEHICLE BODY PATH
- **500**mm CLEARANCE FROM VEHICLE BODY

ASSUMED SPEED **5**km/h

MRWA RAV 10(N) REV 1 (No profile available)

TRACTOR WIDTH: 2.5m
OVERALL VEHICLE LENGTH: 53.50m
LOCK TO LOCK TIME: 6.0sec
STEERING LOCK ANGLE: 24.7

N



GTA consultants
www.gta.com.au

Melbourne 03 9851 9600
Sydney 02 8448 1800
Brisbane 07 3113 5000
Adelaide 08 8334 3600
Perth 08 6169 1000

PRELIMINARY PLAN
FOR DISCUSSION PURPOSES ONLY
SUBJECT TO CHANGE WITHOUT NOTIFICATION

WARNING
BEWARE OF UNDERGROUND SERVICES
THE LOCATIONS OF UNDERGROUND SERVICES ARE APPROXIMATE ONLY AND THEIR EXACT POSITION SHOULD BE PROVEN ON SITE. NO GUARANTEE IS GIVEN THAT ALL EXISTING SERVICES ARE SHOWN.

DESIGNED S. PEDRETTI	DESIGN CHECK R.DING
APPROVED BY R.DING	DATE ISSUED 01.10.2019

SCALE A3 0 2.5 5 10 1:500

CAD FILE NO. W150400-XC-DESN-3.DWG

MUCHEA EMPLOYMENT NODE
PRECINT 3
RAV 10
SWEPT PATH

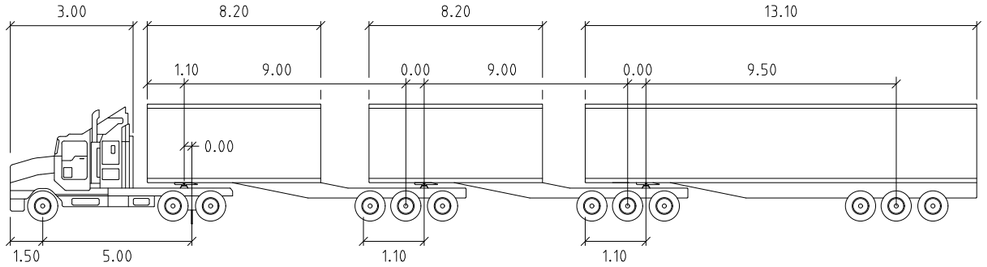
DRAWING NO. W150400-SK03 SHEET 3 OF 6 ISSUE P2

T:\W15000-15099\W150400 MUCHEA EMPLOYMENT NODE STRUCTURE\CAD\W150400-XC-DESN-3.DWG PLOTTED BY SIMON PEDRETTI ON 01/10/2019 AT 15:21

SWEPT PATH KEY

- VEHICLE CENTRE LINE
- VEHICLE TYRE PATH
- VEHICLE BODY PATH
- **500**mm CLEARANCE FROM VEHICLE BODY

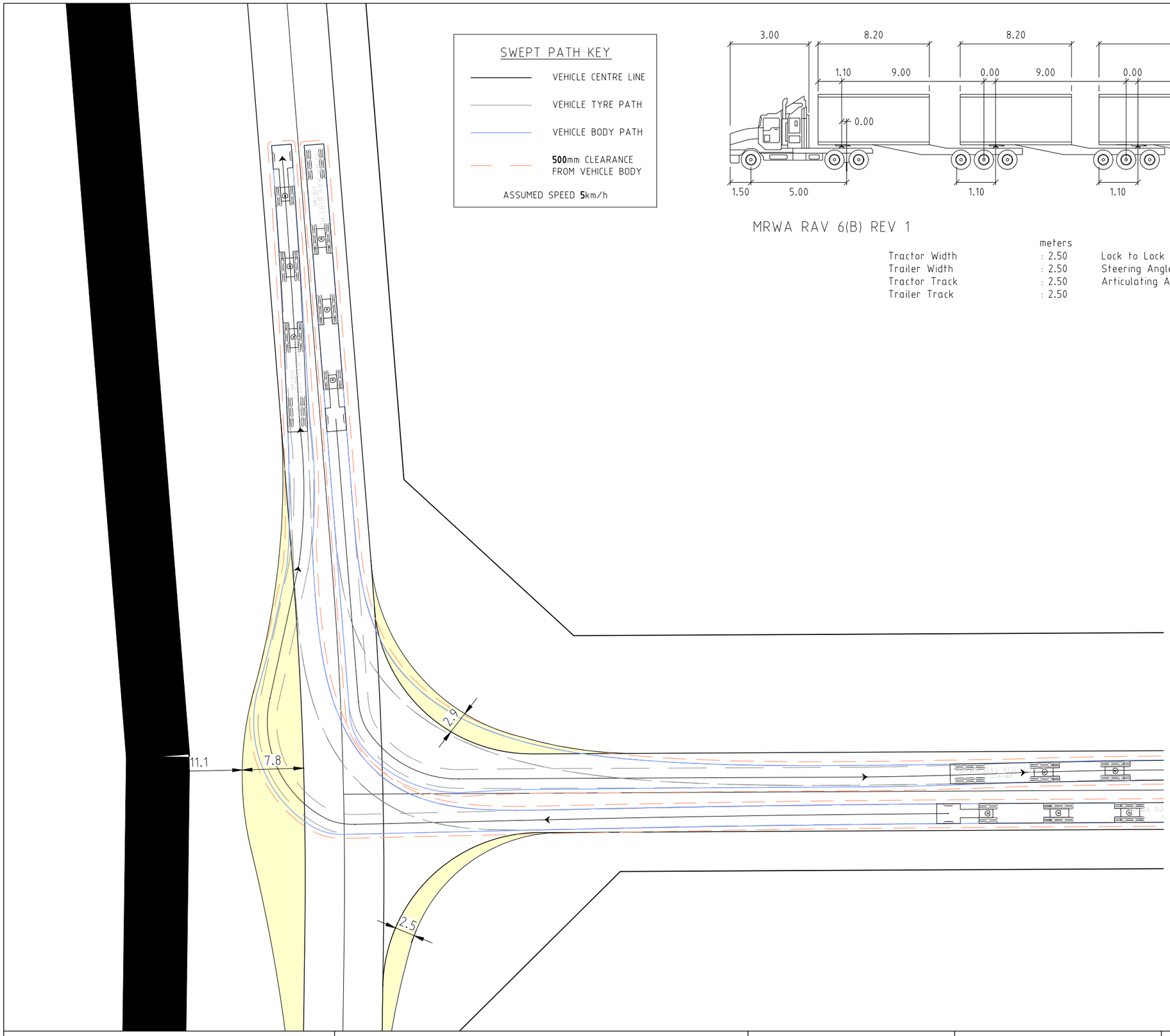
ASSUMED SPEED **5**km/h

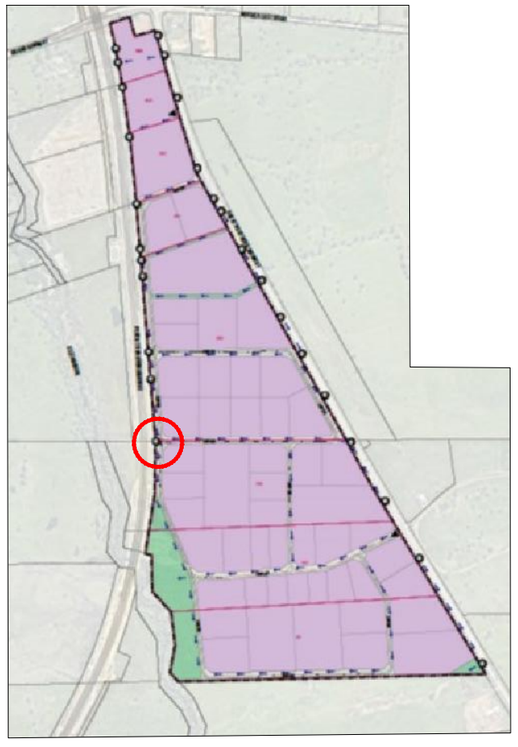


MRWA RAV 6(B) REV 1

	meters		
Tractor Width	: 2.50	Lock to Lock Time	: 6.0
Trailer Width	: 2.50	Steering Angle	: 21.2
Tractor Track	: 2.50	Articulating Angle	: 70.0
Trailer Track	: 2.50		

N





GTA consultants
www.gta.com.au

Melbourne 03 9851 9600
Sydney 02 8448 1800
Brisbane 07 3113 5000
Adelaide 08 8334 3600
Perth 08 6169 1000

PRELIMINARY PLAN
FOR DISCUSSION PURPOSES ONLY
SUBJECT TO CHANGE WITHOUT NOTIFICATION

WARNING
BEWARE OF UNDERGROUND SERVICES
THE LOCATIONS OF UNDERGROUND SERVICES ARE APPROXIMATE ONLY AND THEIR EXACT POSITION SHOULD BE PROVEN ON SITE. NO GUARANTEE IS GIVEN THAT ALL EXISTING SERVICES ARE SHOWN.

DESIGNED	S. PEDRETTI
DESIGN CHECK	R.DING
APPROVED BY	R.DING
DATE ISSUED	01.10.2019
CAD FILE NO.	W150400-XC-DESN-3.DWG
SCALE	A3 — 0 2.5 5 10 — 1:500

MUCHEA EMPLOYMENT NODE
PRECINT 3
RAV 7
SWEPT PATH

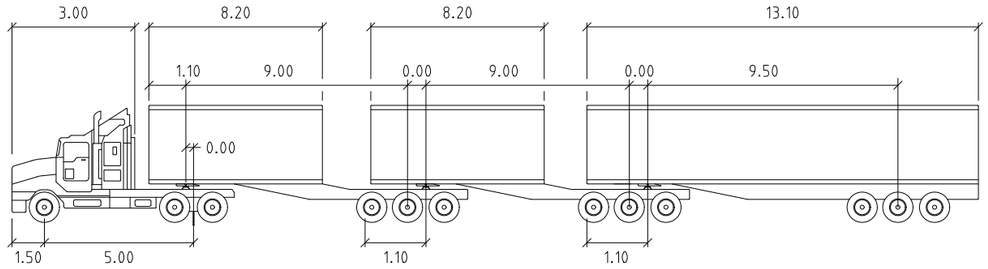
DRAWING NO. W150400-SK04 SHEET 4 OF 6 ISSUE P2

T:\W15000-15099\W150400 MUCHEA EMPLOYMENT NODE STRUCTURE\CAD\W150400-XC-DESN-3.DWG PLOTTED BY SIMON PEDRETTI ON 01/10/2019 AT 15:21

SWEPT PATH KEY

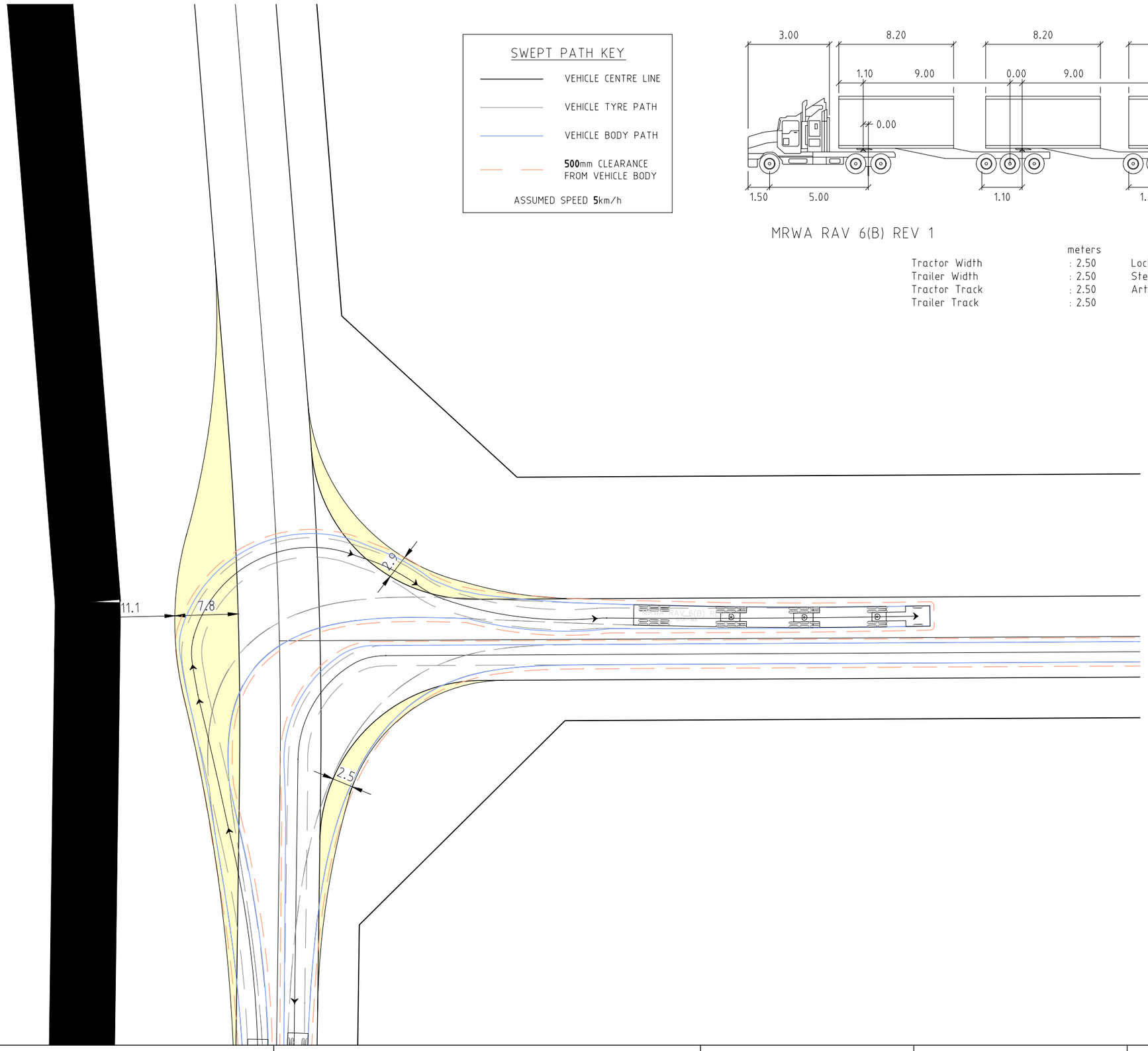
- VEHICLE CENTRE LINE
- VEHICLE TYRE PATH
- VEHICLE BODY PATH
- **500**mm CLEARANCE FROM VEHICLE BODY

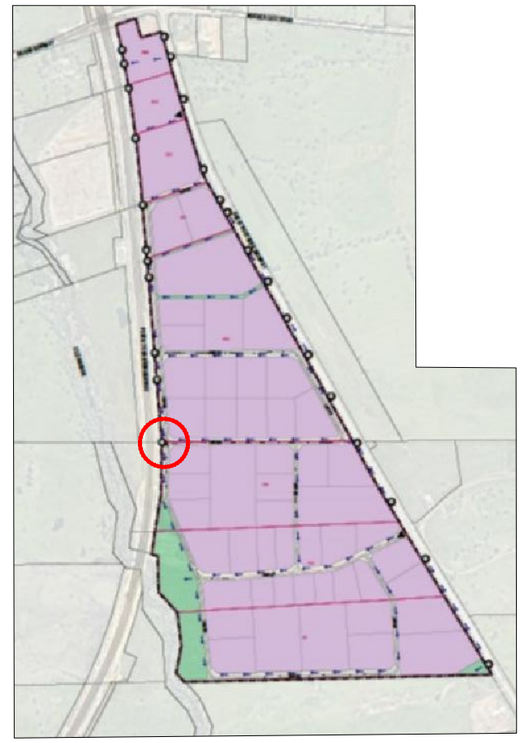
ASSUMED SPEED **5**km/h



MRWA RAV 6(B) REV 1

	meters		
Tractor Width	: 2.50	Lock to Lock Time	: 6.0
Trailer Width	: 2.50	Steering Angle	: 21.2
Tractor Track	: 2.50	Articulating Angle	: 70.0
Trailer Track	: 2.50		





GTA consultants
www.gta.com.au

Melbourne 03 9851 9600
Sydney 02 8448 1800
Brisbane 07 3113 5000
Adelaide 08 8334 3600
Perth 08 6169 1000

PRELIMINARY PLAN
FOR DISCUSSION PURPOSES ONLY
SUBJECT TO CHANGE WITHOUT NOTIFICATION

WARNING
BEWARE OF UNDERGROUND SERVICES
THE LOCATIONS OF UNDERGROUND SERVICES ARE APPROXIMATE ONLY AND THEIR EXACT POSITION SHOULD BE PROVEN ON SITE. NO GUARANTEE IS GIVEN THAT ALL EXISTING SERVICES ARE SHOWN.

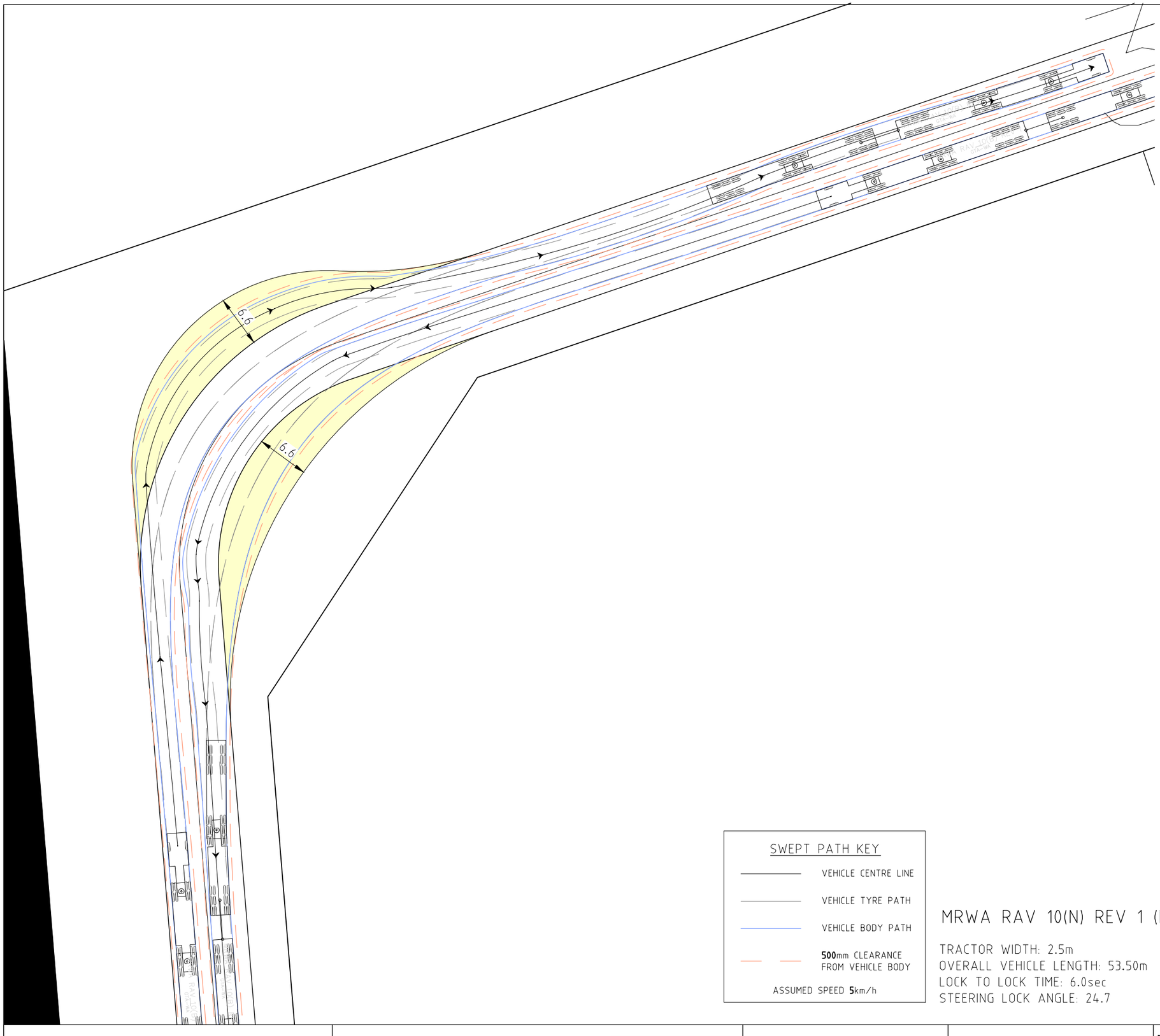
DESIGNED S. PEDRETTI
DESIGN CHECK R.DING
APPROVED BY R.DING
DATE ISSUED 01.10.2019

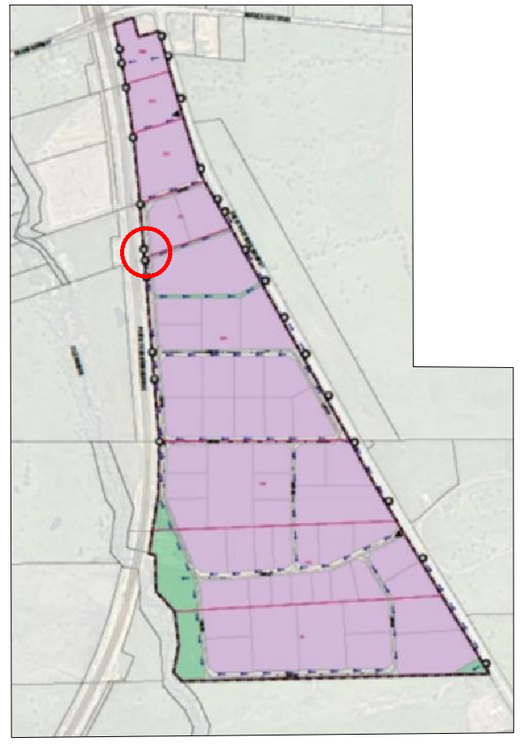
SCALE A3 0 2.5 5 10 1:500
CAD FILE NO. W150400-XC-DESN-3.DWG

MUCHEA EMPLOYMENT NODE
PRECINT 3
RAV 7
SWEPT PATH

DRAWING NO. W150400-SK05 SHEET 5 OF 6 ISSUE P2

T:\W15000-15999\W150400 MUCHEA EMPLOYMENT NODE STRUCTURE\CAD\W150400-XC-DESN-3.DWG PLOTTED BY SIMON PEDRETTI ON 01/10/2019 AT 15:21





N

SWEPT PATH KEY

- VEHICLE CENTRE LINE
- VEHICLE TYRE PATH
- VEHICLE BODY PATH
- **500**mm CLEARANCE FROM VEHICLE BODY

ASSUMED SPEED **5**km/h

MRWA RAV 10(N) REV 1 (No profile available)

TRACTOR WIDTH: 2.5m
OVERALL VEHICLE LENGTH: 53.50m
LOCK TO LOCK TIME: 6.0sec
STEERING LOCK ANGLE: 24.7

GTA consultants
www.gta.com.au

Melbourne 03 9851 9600
Sydney 02 8448 1800
Brisbane 07 3113 5000
Adelaide 08 8334 3600
Perth 08 6169 1000

PRELIMINARY PLAN
FOR DISCUSSION PURPOSES ONLY
SUBJECT TO CHANGE WITHOUT NOTIFICATION

WARNING
BEWARE OF UNDERGROUND SERVICES
THE LOCATIONS OF UNDERGROUND SERVICES ARE APPROXIMATE ONLY AND THEIR EXACT POSITION SHOULD BE PROVEN ON SITE. NO GUARANTEE IS GIVEN THAT ALL EXISTING SERVICES ARE SHOWN.

DESIGNED S. PEDRETTI	DESIGN CHECK R.DING
APPROVED BY R.DING	DATE ISSUED 01.10.2019

SCALE A3 0 2.5 5 10 1:500

CAD FILE NO. W150400-XC-DESN-3.DWG

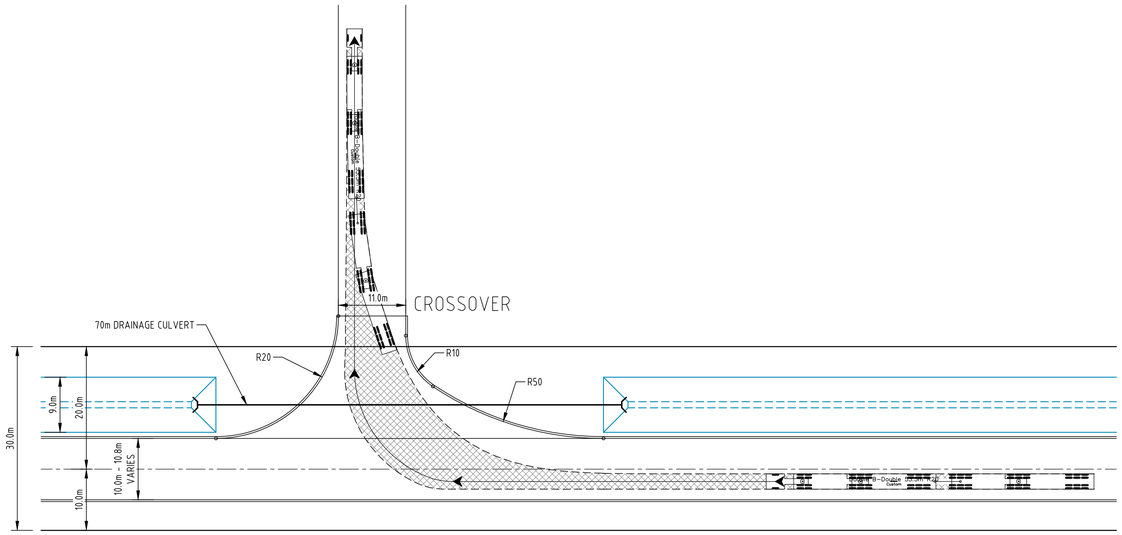
MUCHEA EMPLOYMENT NODE
PRECINT 3
RAV 10
SWEPT PATH

DRAWING NO. W150400-SK06 SHEET 6 OF 6 ISSUE P2

T:\W15000-15099\W15400 MUCHEA EMPLOYMENT NODE STRUCTURE\CAD\W150400-XC-DESN-3.DWG PLOTTED BY SIMON PEDRETTI ON 01/10/2019 AT 15:21

C. PORTER CONSULTING CROSS SECTIONS

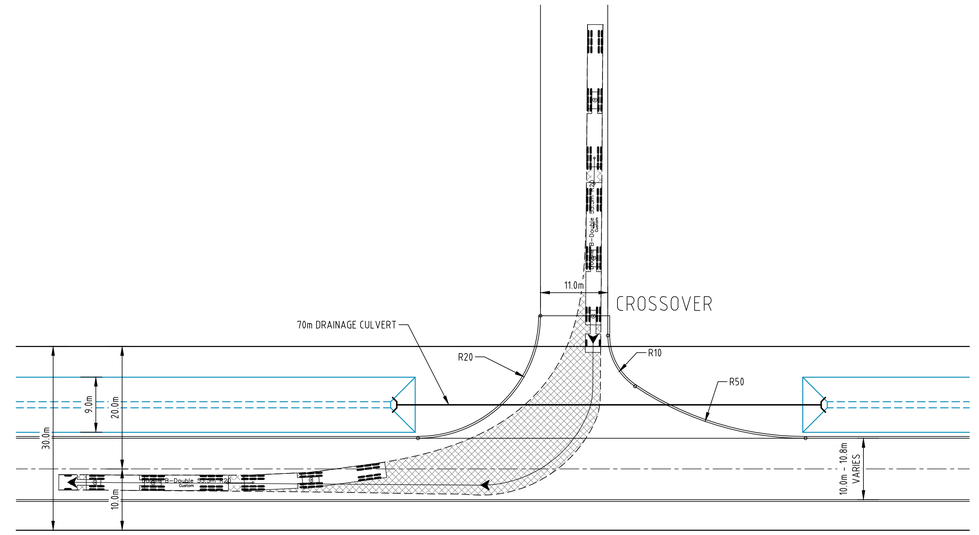
C



30m ROAD RESERVE - LOCAL ROAD (CARRIAGEWAY ON SOUTHERN SIDE)

CROSSOVER - RIGHT TURN ENTRY

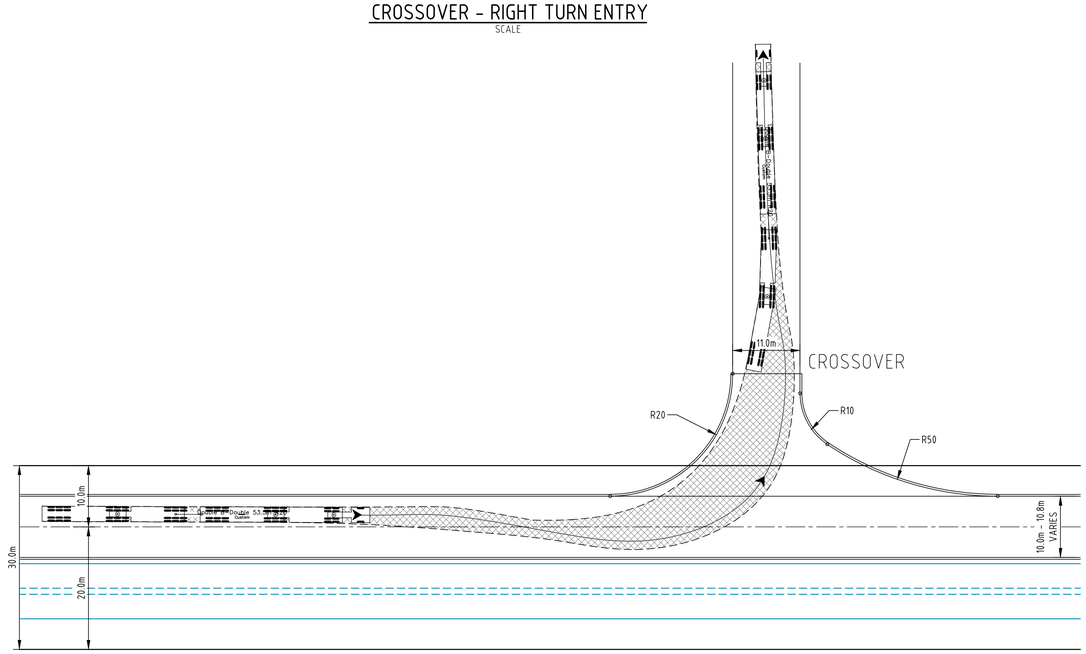
SCALE



30m ROAD RESERVE - LOCAL ROAD (CARRIAGEWAY ON SOUTHERN SIDE)

CROSSOVER - RIGHT TURN EXIT

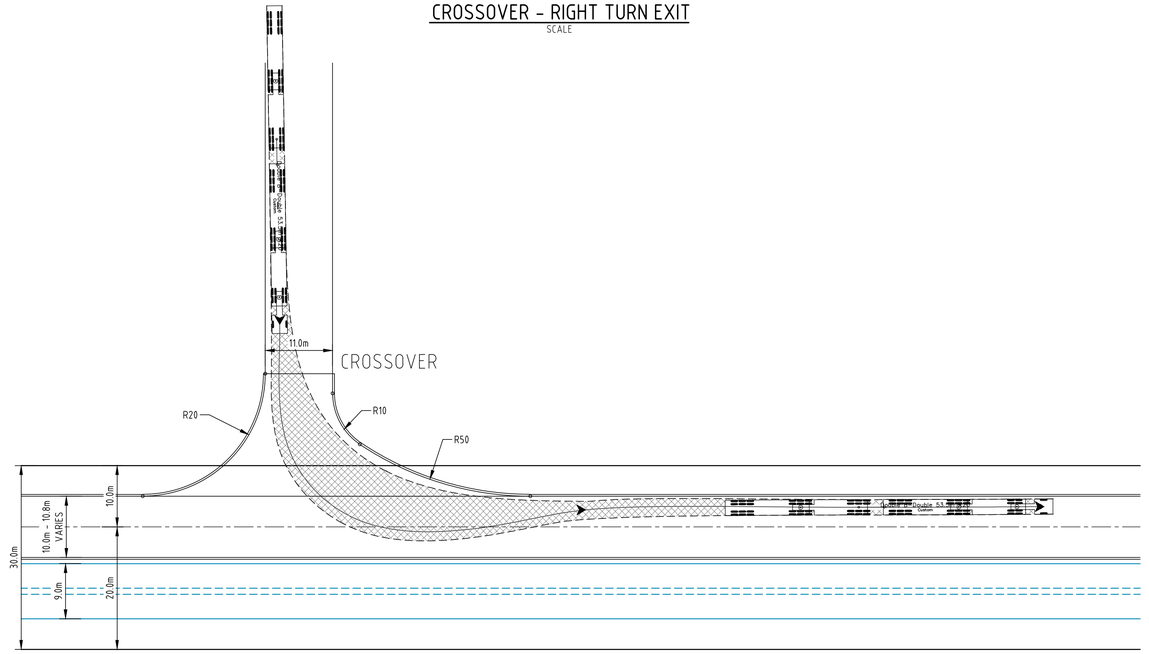
SCALE



30m ROAD RESERVE - LOCAL ROAD (CARRIAGEWAY ON NORTHERN SIDE)

CROSSOVER - LEFT TURN ENTRY

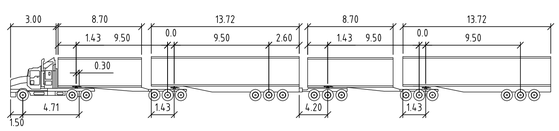
SCALE



30m ROAD RESERVE - LOCAL ROAD (CARRIAGEWAY ON NORTHERN SIDE)

CROSSOVER - LEFT TURN EXIT

SCALE

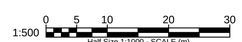


Tandem Drive Double B-Double 53.5m R20

meters

Tractor Width	:	2.50	Trailer Width	:	2.50
Tractor Track	:	2.50	Trailer Track	:	2.50
Lock to Lock Time	:	6.0	Articulating Angle	:	70.0
Steering Angle	:	14.5			





PROJECT:

MUCHEA EMPLOYMENT NODE

No	DATE	REVISION	BY
A	23-7-2018	PRELIMINARY PLOT FOR COMMENT	MJV

COPYRIGHT

COPYRIGHT IN THIS DRAWING IS THE PROPERTY OF THE CONSULTANT. THE CLIENT HAS LICENSE TO USE THIS DRAWING FOR THE PROJECT ONLY. THE USER SHALL BE RESPONSIBLE FOR "SITE CHECKING" ALL DIMENSIONS BEFORE COMMENCEMENT OF WORK. CAD DRAWING DO NOT MANUALLY ALTER

ONLY PLANS WITH NUMERICAL REVISION (REV '0' OR HIGHER) AND SIGNED AS APPROVED SHALL BE USED FOR CONSTRUCTION.

Porter Consulting Engineers

Level 2 Kishorn Court
58 Kishorn Road
Mt Pleasant 6153 WA

PO Box 1036
Canning Bridge 6153 WA

Tel (08) 9315 9955
Fax (08) 9315 9959
Email office@porterseng.com.au
www.porterseng.com.au

YUSHO Pty Ltd ACN 010 091 148 as trustee for the Consulting Engineering Unit Trust trading as Porter Consulting Engineers ABN 78 636 396 385

CLIENT:

SHIRE OF CHITTERING

DRAWING:

CROSSOVER SETOUT FOR RAV 10 VEHICLES

STATUS: **FOR APPROVAL**

SCALE	1:500
DATE	JULY 2018
DESIGN	JH
DRAWN	MJV
CHECK	
APP'D	

DRAWING No. 18-6-69/807

REV No. A

ORIGINAL DRAWING SIZE A1

FILE NAME S:\ACTIVE PROJECTS\18-06-069\ACAD\18669-807.dwg

D. TRAFFIC FLOWS

D

LEGEND

- PRECINCT 3 STRUCTURE PLAN AREA
- LIGHT INDUSTRIAL
- FORESHORE AND DRAINAGE
- EXISTING LOT BOUNDARIES
- C — EXISTING AND PROPOSED CULVERTS
- MAIN DRAINAGE FLOWS
- EXISTING LOT ACCESS POINT

BRAND HIGHWAY
MUCHEA EAST ROAD
GREAT NORTHERN HIGHWAY
PERTH TO DARWIN HIGHWAY
ELLENBROOK
30M RR
804
803
802
801
800
194
192
35
1400
600
5000
300
1000
200
3000
900
100

2031 Expected Daily Traffic Flows (Two Way, vpd)

Concept Plan

Muchea Employment Node - Precinct 3

DATA SOURCE
Landgate & Bayley Environmental

PROJECTION
MGA Zone 50

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

DISCLAIMER
Copyright by Urbis Pty. Ltd. This drawing or parts thereof may not be reproduced for any purpose or used for another project without the consent of Urbis. The plan must not be used for ordering, supply or installation and no relevance should be placed on this plan for any financial dealing of the land. This plan is conceptual and is for discussion purposes only and subject to further detail study, Council approval, engineering input, and survey. Cadastral boundaries, areas and dimensions are approximate only. Written figured dimensions shall take preference to scaled dimensions.

CLIENT
Tomahawk Property

1:5000 @ A1 | 1:10000 @ A3
50 100 150 200 250 m

PROJECT NO. P0002540
DATE 25.09.19
DRAWING NO. 02
REVISION f

E. SIDRA INTERSECTION OUTPUT



LANE SUMMARY

Site: 101 [Intersection N]

New Site
Giveway / Yield (Two-Way)

Lane Use and Performance

	Demand Flows Total veh/h	HV %	Cap. veh/h	Deg. Satn v/c	Lane Util. %	Average Delay sec	Level of Service	95% Back of Queue Veh	Dist m	Lane Config	Lane Length m	Cap. Adj. %	Prob. Block. %
South: GNH													
Lane 1	11	25.5	1233	0.009	100	6.9	LOS A	0.0	0.0	Short	120	0.0	NA
Lane 2	263	25.5	1319	0.199	100	3.7	LOS A	0.0	0.0	Full	500	0.0	0.0
Approach	274	25.5		0.199		3.8	NA	0.0	0.0				
North: GNH													
Lane 1	263	25.5	1319	0.199	100	3.7	LOS A	0.0	0.0	Full	500	0.0	0.0
Lane 2	21	25.5	751	0.028	100	9.1	LOS A	0.1	1.2	Short	120	0.0	NA
Approach	284	25.5		0.199		4.1	NA	0.1	1.2				
West: Northern Road													
Lane 1	79	25.5	907	0.087	100	5.5	LOS A	0.3	3.9	Short	60	0.0	NA
Lane 2	37	25.5	460	0.080	100	9.1	LOS A	0.3	2.9	Full	500	0.0	0.0
Approach	116	25.5		0.087		6.6	LOS A	0.3	3.9				
Intersection	674	25.5		0.199		4.4	NA	0.3	3.9				

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Lane LOS values are based on average delay per lane.
Minor Road Approach LOS values are based on average delay for all lanes.
NA: Intersection LOS and Major Road Approach LOS values are Not Applicable for two-way sign control since the average delay is not a good LOS measure due to zero delays associated with major road lanes.
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.
Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

LANE SUMMARY

Site: 101 [Intersection S]

New Site
Giveway / Yield (Two-Way)

Lane Use and Performance

	Demand Flows Total veh/h	HV %	Cap. veh/h	Deg. Satn v/c	Lane Util. %	Average Delay sec	Level of Service	95% Back of Queue Veh	Dist m	Lane Config	Lane Length m	Cap. Adj. %	Prob. Block. %
South: GNH													
Lane 1	21	25.5	1233	0.017	100	6.9	LOS A	0.0	0.0	Short	120	0.0	NA
Lane 2	263	25.5	1319	0.199	100	3.7	LOS A	0.0	0.0	Full	500	0.0	0.0
Approach	284	25.5		0.199		3.9	NA	0.0	0.0				
North: GNH													
Lane 1	263	25.5	1319	0.199	100	3.7	LOS A	0.0	0.0	Full	500	0.0	0.0
Lane 2	42	25.5	738	0.057	100	9.3	LOS A	0.2	2.5	Short	120	0.0	NA
Approach	305	25.5		0.199		4.5	NA	0.2	2.5				
West: Southern Road													
Lane 1	168	25.5	907	0.186	100	5.7	LOS A	0.8	8.9	Short	60	0.0	NA
Lane 2	84	25.5	445	0.189	100	9.9	LOS A	0.6	7.1	Full	500	0.0	0.0
Approach	253	25.5		0.189		7.1	LOS A	0.8	8.9				
Intersection	842	25.5		0.199		5.1	NA	0.8	8.9				

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Lane LOS values are based on average delay per lane.
Minor Road Approach LOS values are based on average delay for all lanes.
NA: Intersection LOS and Major Road Approach LOS values are Not Applicable for two-way sign control since the average delay is not a good LOS measure due to zero delays associated with major road lanes.
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.
Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

F. WAPC CHECKLIST



Transport Impact Assessment (Structure Plan) Checklist – Muchea Employment Node Precinct 3 LSP

Item	Provided	Comments/Proposals
Summary	Yes	Section 1
Introduction/Background	Yes	Section 1
Structure plan proposal	Yes	Section 2
regional context	Yes	Section 2.1
proposed land uses	Yes	Section 2.2
table of land uses and quantities	Yes	Section 2.2
major attractors/generators	Yes	Section 2.3
specific issues	Yes	Section 2.4
Existing situation	Yes	Section 3
existing land uses within structure plan	Yes	Section 3.1
existing land uses within 800 metres of structure plan area	Yes	Section 3.1
existing road network within structure plan area	N/A	No existing networks within structure plan area.
existing pedestrian/cycle networks within structure plan area	N/A	No existing networks within structure plan area.
existing public transport services within structure plan area	N/A	No existing networks within structure plan area.
existing road network within 2 (or 5) km of structure plan area	Yes	Section 3.2
traffic flows on roads within structure plan area (PM and/or AM peak hours)	N/A	No existing network within the structure plan area.
traffic flows on roads within 2 (or 5) km of structure plan area (AM and/ or PM peak hours)	Yes	Section 3.3
existing pedestrian/cycle networks within 800m of structure plan area	Yes	Section 3.2
existing public transport services within 800m of structure plan area	Yes	Section 3.2
Proposed internal transport networks	Yes	Yes 4
changes/additions to existing road network or proposed new road network	Yes	Section 4.1
road reservation widths	Yes	Sections 4.2 and 4.3
road cross-sections & speed limits	Yes	Section 4.3
intersection controls	Yes	Section 4.4
pedestrian/cycle networks and crossing facilities	Yes	Section 4.6
public transport routes	Yes	Section 4.8
Changes to external transport networks	Yes	Section 5
road network	Yes	Section 5.1
intersection controls	Yes	Section 5.1
pedestrian/cycle networks and crossing facilities	N/A	No changes to external network
public transport services	N/A	No changes to external network
Integration with surrounding area	Yes	Section 6

trip attractors/generators within 800 metres	Yes	Section 6.2
proposed changes to land uses within 800 metres	Yes	Section 6.3
travel desire lines from structure plan to these attractors/generators	Yes	Section 6.4
adequacy of external transport networks	Yes	Section 6.5
deficiencies in external transport networks	Yes	Section 6.5
remedial measures to address deficiencies	Yes	Section 6.6
Analysis of internal transport networks	Yes	Section 7
assessment year(s) and time period(s)	Yes	Section 7.1
structure plan generated traffic	Yes	Section 7.2
extraneous (through) traffic	Yes	Section 7.3
design traffic flows (that is, total traffic)	Yes	Section 7.4
road cross-sections	Yes	Section 7.5
intersection controls	Yes	Section 7.6
access strategy	Yes	Section 7.6
pedestrian/cycle networks	Yes	Section 7.7
safe routes to schools	Yes	NA as it is industrial
pedestrian permeability & efficiency	Yes	Section 7.8
access to public transport	Yes	Section 7.9
Analysis of external transport networks	Yes	Section 8
extent of analysis	Yes	Section 8.1
base flows for assessment year(s)	Yes	Section 8.2
total traffic flows	Yes	Section 8.2
road cross-sections	Yes	Section 8.3
intersection layouts & controls	Yes	Section 8.4
pedestrian/cycle networks	Yes	Section 8.5
Conclusions	Yes	Section 9

Proponent's Name: Tom Carmody

Company: Tomahawk Property Date: 11/12/2018

Transport Assessor's Name: Rodney Ding

Company: GTA Consultants (WA) Pty Ltd Date: 11/12/2018

GTAconsultants

www.gta.com.au

APPENDIX D ENGINEERING SERVICING REPORT

Cossill & Webley
CONSULTING ENGINEERS



Muchea Industrial Precinct 3 Engineering Servicing Report

Town Planning Scheme Amendment & Structure Plan

February 2019

Level 2, 431 Roberts Road,
Subiaco WA 6008.
PO Box 680 Subiaco, WA 6904

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

Contents

1. EXECUTIVE SUMMARY 1
2. INTRODUCTION 2
3. SITE DESCRIPTION 3
3.1 Site Vegetation 3
3.2 Existing Structures 3
3.3 Geology 4
3.4 Acid Sulfate Soils 5
3.5 Site Contours 6
4. SITEWORKS & EARTHWORKS 7
5. DRAINAGE AND GROUNDWATER MANAGEMENT 8
5.1 Groundwater 8
5.2 Regional Through-flow 9
5.3 Stormwater 9
6. ROADWORKS & FOOTPATHS 10
6.1 Great Northern Highway 10
6.2 Perth Darwin Highway 10
6.3 Brand Highway 10
6.4 Development Roads 10
7. WATER RETICULATION 11
8. SEWERAGE RETICULATION 12
9. POWER 13
10. GAS SUPPLY 14
11. TELECOMMUNICATIONS 14
12. CONCLUSION 14

Appendix A Typical Drainage Configuration
Appendix B Aqua Ferre Water Strategy Correspondence

1. EXECUTIVE SUMMARY

This report has been prepared by Cossill & Webley Pty Ltd (CW) for the Precinct 3 West Muchea Employment Node Town Planning Scheme Amendment (TPS) and Structure Plan (SP) preparation. It summarises the results of a review of the civil engineering issues which have influenced the form of the plan, as related to the future servicing of the developed land.

This report provides details for each major infrastructure type and a servicing strategy for implementation required for the development of the site. The level of detail is consistent with the requirements of a TPS Amendment and SP application and acknowledges further more detailed work will be required at the time of land subdivision.

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

The investigation has found the land is capable of development in accordance with the proposed TPS with logical progressive extension of infrastructure and base capacity.

The ground conditions and past uses will not limit the proposed industrial development.

The existing road access, via Great Northern Highway will provide good road access with the external arterial road system.

Sewer infrastructure will be provided via Aerobic Treatment Units (ATUs).

Water supply will be provided via an extension of the water supply provided by Aqua Ferre for the Harvis development north of the Site.

Electrical supply can be provided via extensions off the existing high voltage network in Great Northern Highway.

Communications are available from existing services in Great Northern Highway. We understand there is capacity in the existing network to service the proposed development.

The investigations and preparation of this report is largely based on preliminary advice from the various service authorities. The information is current as of February 2019.

2. INTRODUCTION

The following report has been prepared by Cossill & Webley Pty Ltd (CW) and summarises the results of a servicing assessment of the engineering aspects of the potential industrial development of Lots 35, 192, 194, 800- 804 Great Northern Highway, Muchea ("the Site"). The lots collectively form Precinct 3 West of the Muchea Employment Node and collectively cover approximately 185 hectares as presented below in **Error! Reference source not found.**.

This report covers the engineering infrastructure requirements (siteworks, roads, stormwater drainage and utility services) for the future development of the Site.

The investigations and preparation of the report are largely based on preliminary advice from the various service authorities and is current as of February 2019.

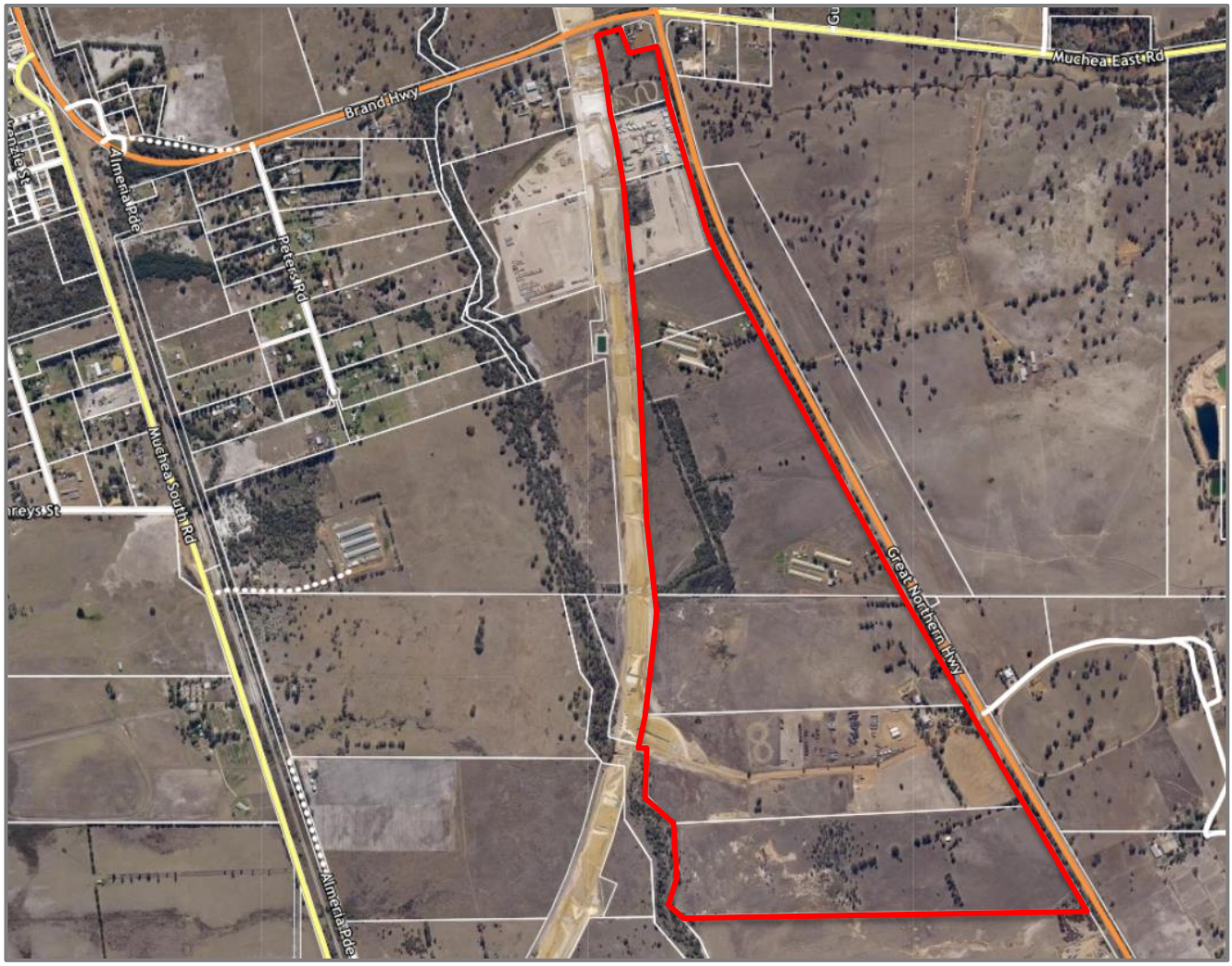


Figure 1: Existing Road Network (MNG, 2018)

The Site is bound by Northlink to the west, Great Northern Highway to the east, Brand Highway to the north and large undeveloped lots to the south. The Site is currently accessed from Great Northern Highway to the east as presented above in Figure 1.

The landholding is currently zoned Agricultural Resource under the Shire of Chittering Town Planning Scheme No. 6, but has been identified as future industrial land within the Muchea Employment Node Structure Plan.

3. SITE DESCRIPTION

3.1 Site Vegetation

The Site is predominantly cleared, with some small pockets of vegetation scattered across the Site. An environmental assessment accompanies this TPS and SP, prepared by Bayley Environmental.

3.2 Existing Structures

There are a number of existing structures and sheds across the Site as presented above in Figure 1. A number of the lots are also currently being used for lay down and storage. Lots 800 & 801 contain existing poultry farms, which typically attract 500 metre buffers for sensitive land uses (see Figure 2 below).

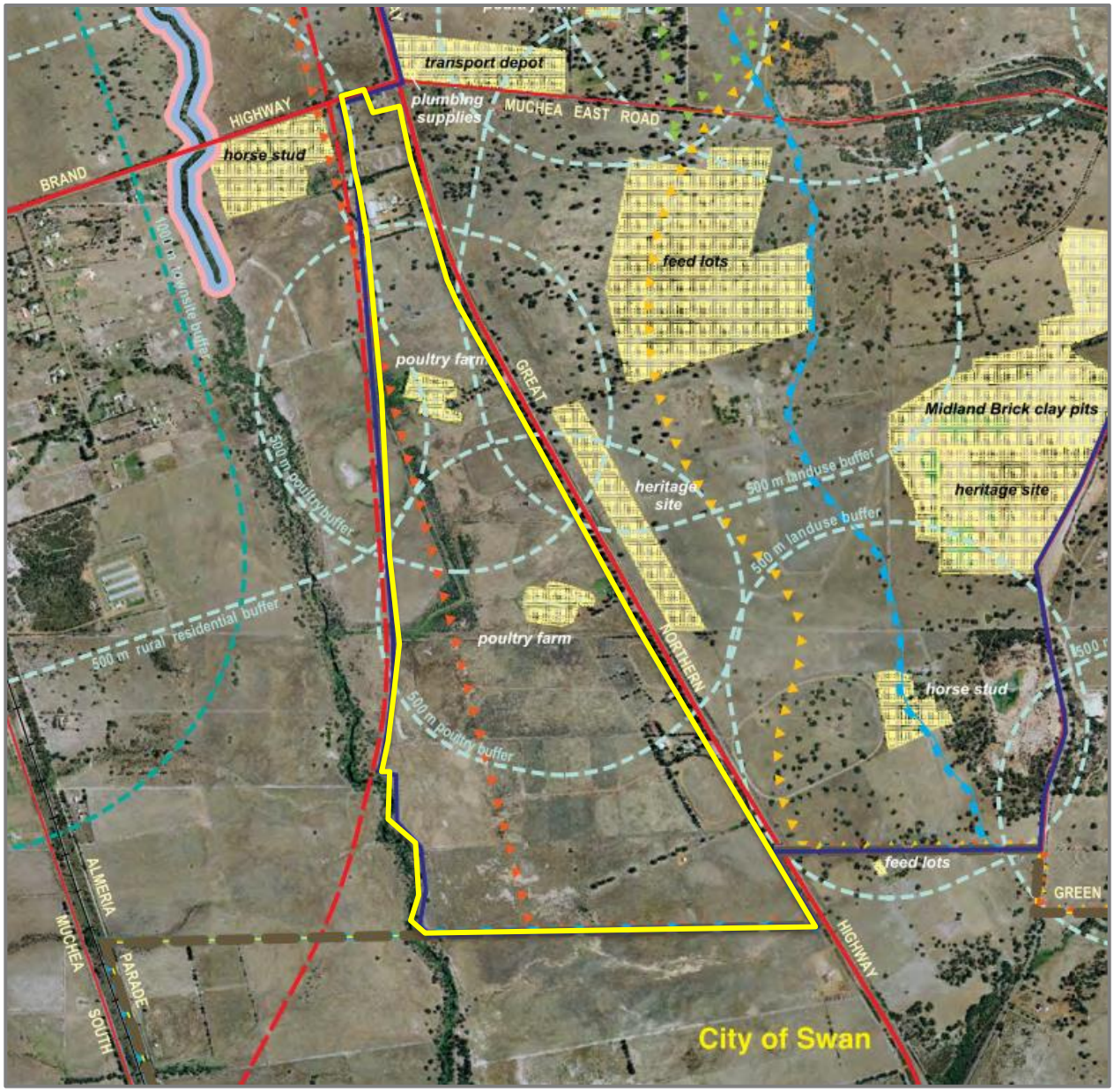


Figure 2: Land Use Planning and Poultry Farm Buffers (Muchea Employment Node Structure Plan, Shire of Chittering, 2011)

3.3 Geology

The Geological Survey of Western Australia Perth Metropolitan Region soils map for Muchea (part 2034I & 2134IV) indicates the majority of the Site is characterised by Pebbly Silt and Sand over Pebbly Silt, with a spine of Sand in the vicinity of the Ellen Brook (see below Figure 3). Pebbly Silt contains lower permeability material, and may increase the areas required for stormwater infiltration. They are also generally more reactive than sandy soils, resulting in greater movement with moisture changes, higher site classifications and resulting thicker foundations.

The soil conditions across the Site are consistent with the general Muchea area, and do not pose an impediment to industrial development.

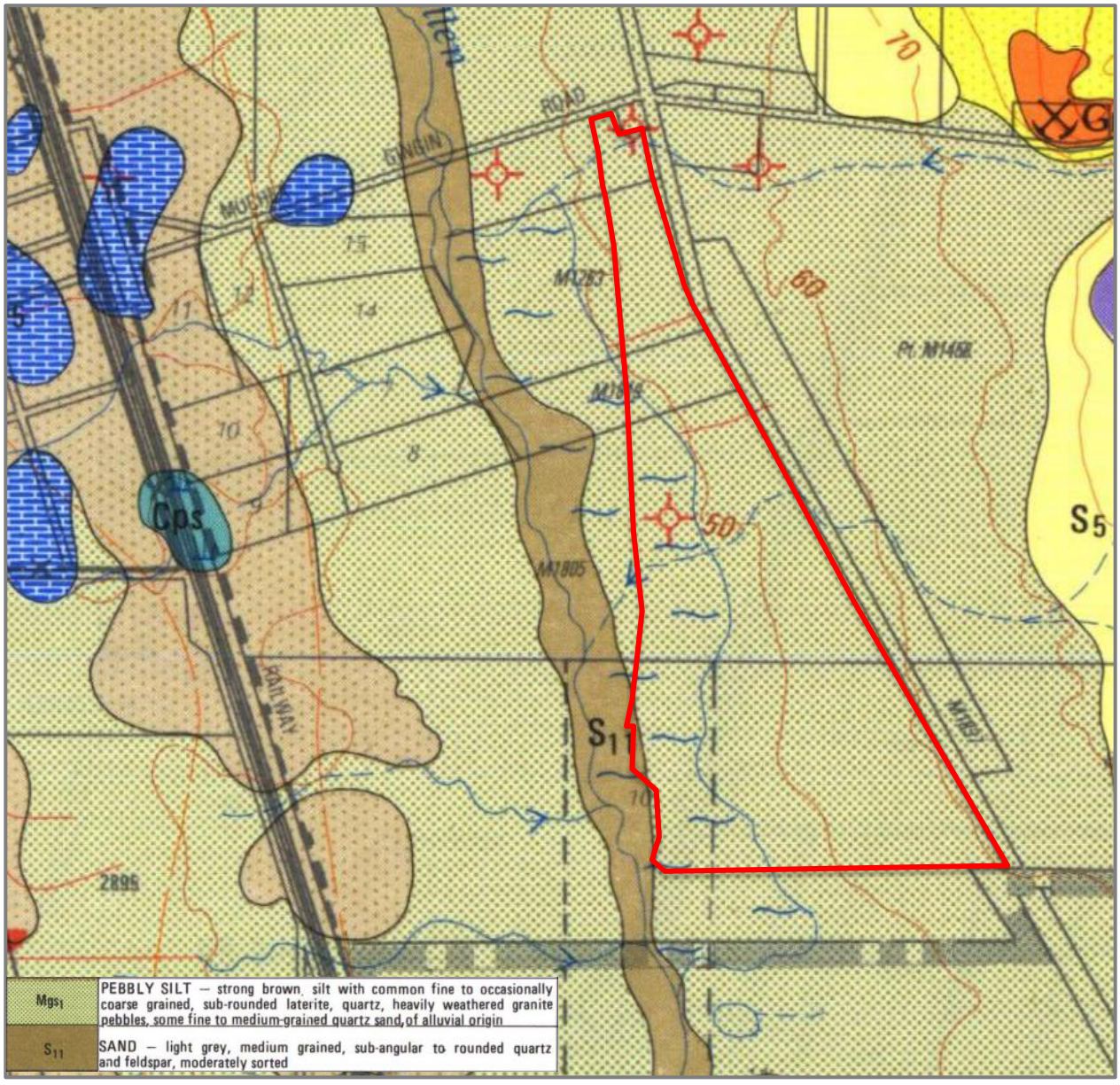


Figure 3: Geotechnical Information (Geological Survey of WA)

3.4 Acid Sulfate Soils

A desk top review of the ASS Risk Map for potential acid sulfate soils (ASS) indicates the Site is classed as having moderate to low risk of ASS occurring within 3m of the natural soil surface in the western and central portions of the site as depicted in Figure 4 below. The regions of varying ASS risk correspond to the different geologies across the Site, as presented in Figure 3 above.

Some treatment of acid sulfate soils or dewatering effluent may be required in the western portion of the Site, though this does not pose an impediment to future development.

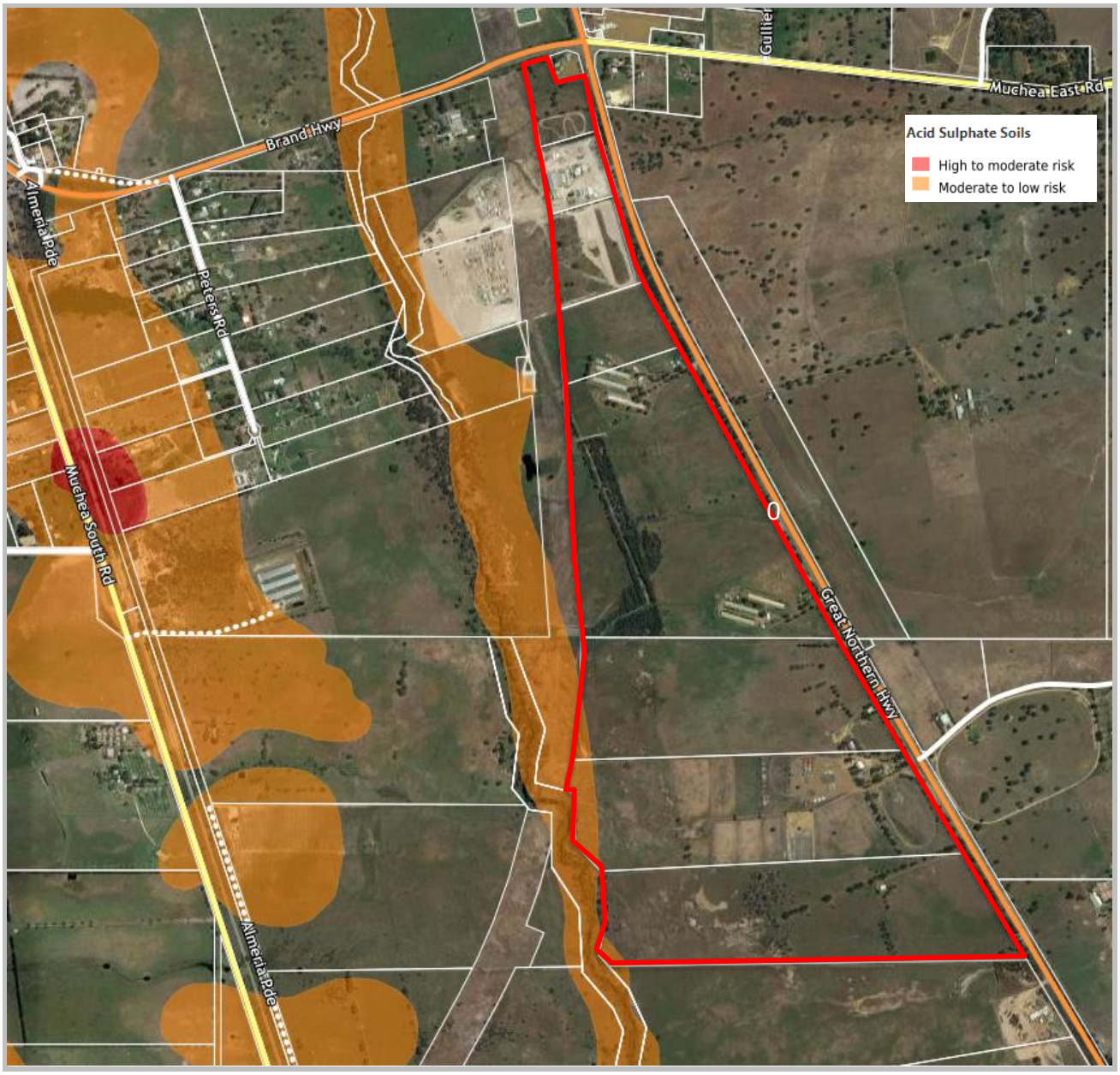


Figure 4: Acid Sulphate Soils Risk Mapping (Department of Environment and Conservation, 2017)

3.5 Site Contours

The Site ranges in elevation from RL59m AHD at the eastern boundary with Great Northern Highway to RL 42m AHD abutting Northlink as presented below in Figure 5.

The Site provides good grade for drainage purposes, though some regrading of the natural topography may be required for the proposed industrial land uses.

The planning layout provides good linkages in an east-west direction to convey runoff from west of the Site to the Ellen Brook.

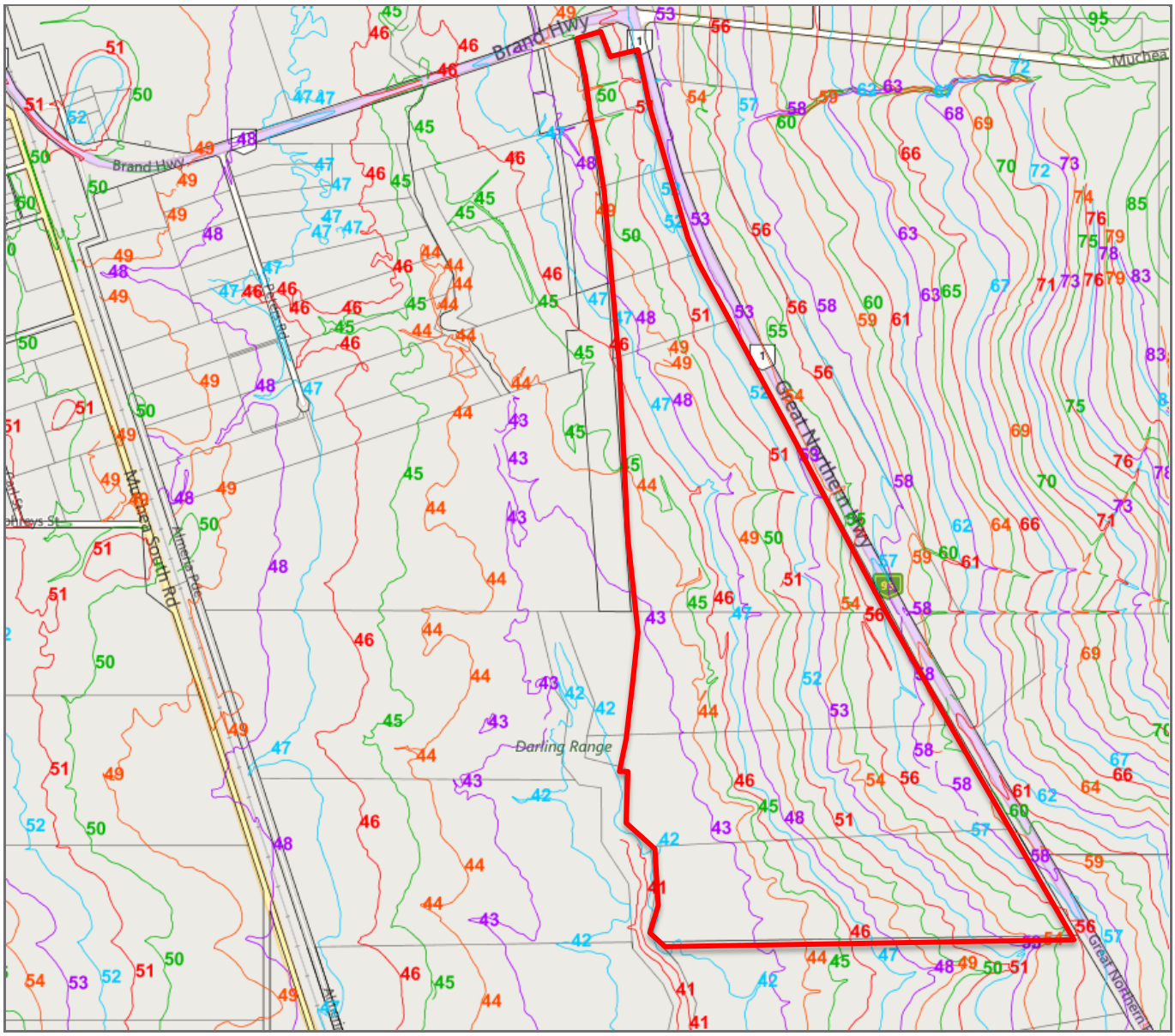


Figure 5: Existing Ground Contours of the Site (Water Corporation 2018)

4. SITEWORKS & EARTHWORKS

Siteworks for the proposed development will generally comprise clearing of existing vegetation and, where necessary, earthworking the existing ground to facilitate a required form of development.

Following clearing, topsoil is likely to be stripped, and if acid sulfate soils are present, this topsoil may require neutralisation treatment.

We note that the grades from east to west are generally about 2%, and typical industrial grades are preferred to be flatter, at approximately 1%. We anticipate the extent of siteworks and earthworks will be dictated by the proposed anticipated industrial usage, which may involve some filling of parts of the lot to provide flood protection from prevailing groundwater, level out grade across the lots and provide sufficient area for the effective disposal of treated effluent.

As a guide, the following earthworks are anticipated, which will be confirmed as part of the Subdivision Approval process, once further certainty on proposed land use, flood protection and effluent disposal requirements are known:

- Roads – we anticipate approximately 800mm separation between the finished road pavement and prevailing groundwater may be required to ensure the road pavement remains flood protected. This will be confirmed as part of the future detailed design, which will include the road pavement requirements and more accurately determine the depth to groundwater from the existing natural surface.
- Lots – the extent of fill is likely to vary across the lots depending on the sensitivity of the proposed land-use. We anticipate some fill may be provided to buildings areas (say 1 metre over the building pad), though this will be confirmed at the detailed design stage. Utilising the existing east/west grade across the site, there may be opportunity to minimise fill (to ensure adequate flood protection) by constructing cut-off diversion drains and grading the site to ensure any surface flows are directed away from proposed building pads.
- Effluent irrigation areas will be filled and sized to suit anticipated effluent disposal requirements.
- Subsoil drainage may be installed locally around existing building pads and effluent disposal areas to provide protection from prevailing groundwater.

A typical cross-section depicting a scenario for building pads and effluent irrigation areas is provided in Appendix A.

5. DRAINAGE AND GROUNDWATER MANAGEMENT

5.1 Groundwater

A review of groundwater levels across the Site has been undertaken by Bayley Environmental as part of this TPS & SP. Bayley Environmental has confirmed separation to groundwater varies from 0 at the south-western boundary to 0.8m at the eastern boundary. A plan depicting the Average Annual Maximum Groundwater Levels has been prepared by Bayley Environmental as part of the LWMS and is presented below in Figure 6.

At the detailed design stage, further consideration should be given to controlling groundwater through the incorporation of subsoil and cut-off drainage, or providing additional separation via the importation of fill. Further consideration could be given to providing a lower level of flood protection or only raising/protecting sensitive areas within each lot.

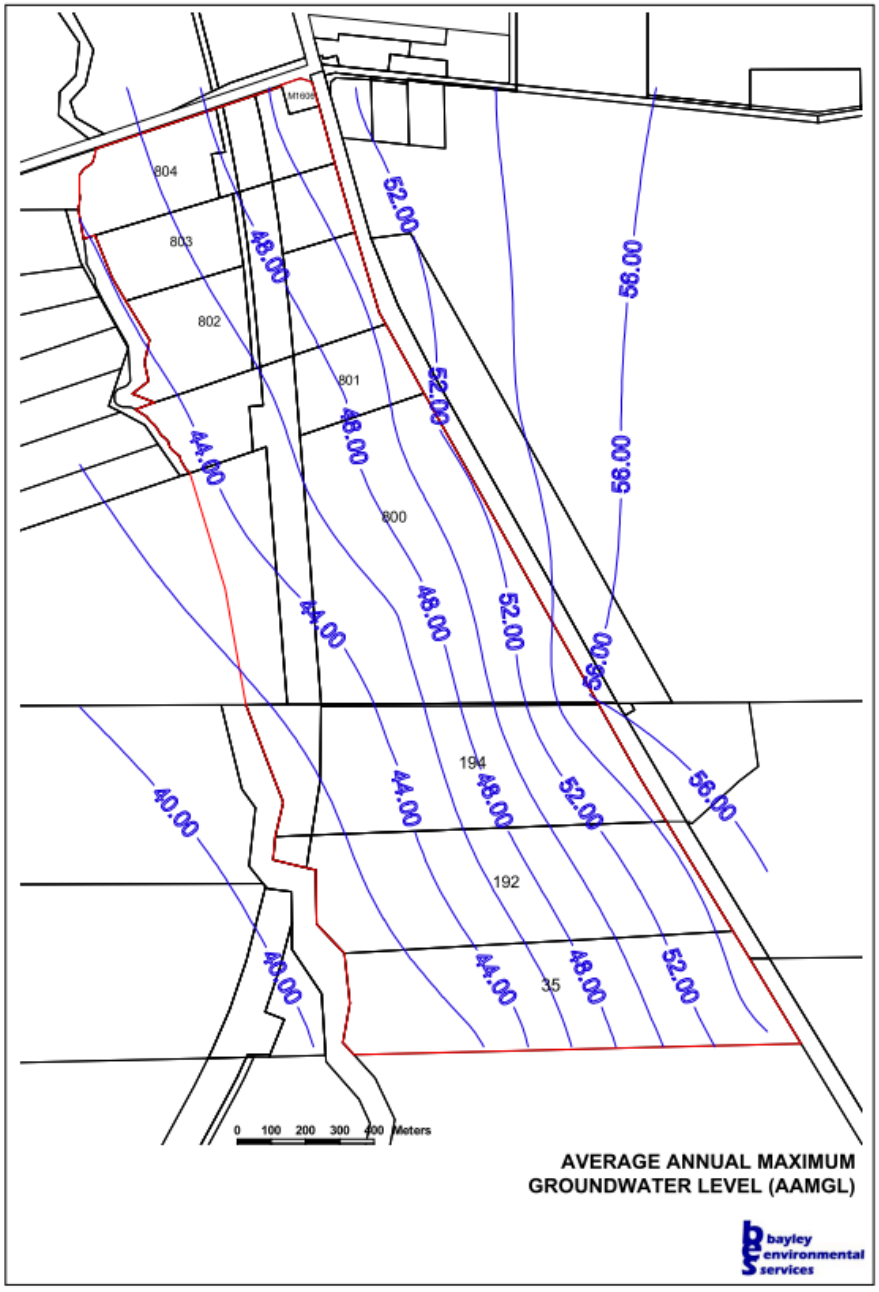


Figure 6: Groundwater Contours (Bayley Environmental, 2018)

5.2 Regional Through-flow

Bayley Environmental has confirmed there is regional through-flow from east of the Great Northern Highway through the Site, across Northlink to the Ellen Brook.

Drainage designs for the LSP have assumed this regional through-flow will be consolidated and diverted into roadside swales, which are sufficiently sized to convey local and external flows across the Site to the Ellen Brook.

Further details on the location of existing culverts under the Great Northern Highway abutting the Site and under Northlink are provided in the Local Water Management Strategy (LWMS).

The LWMS also confirms the anticipated external flows that will need to be conveyed through the Site as part of the development.

5.3 Stormwater

Ellen Brook is an ephemeral river which typically flows from May to December. The Site naturally grades towards Ellen Brook, hence it is anticipated discharge will be permitted from the Site at the pre-development flow rates as per the Local Water Management Strategy.

A typical plan and cross-section of the drainage strategy is presented in Sketch 1 in Appendix A for reference.

It is anticipated that stormwater runoff generated from the lots will be treated in swales at the front of the lots sized to retain the 1 hour 63.2% Average Exceedance Probability (AEP) storm event. Larger events will overtop to roadside drainage channels.

We anticipate all roads will include roadside treatment swales sized to treat the 1 hour 63.2% AEP storm event, with larger storm events from the roads and lots contained in the wider drainage swales within the road reserves, conveyed westward with the natural topography, towards the Ellenbrook. Road-side drainage swales will be sized to convey the critical 1% AEP event.

Some roadside swales will also be increased in size to cater for the regional through flow as outlined in the Local Water Management Strategy.

The drainage swales within the road reserves will be sized appropriately to convey the local runoff from roads and lots, as well as the external through-flows from east of the Site.

Some areas of piped drainage may be included where driveway cross-overs, or planning considerations do not support swale designs.

Flows to the Ellen Brook will be either via existing culverts constructed under Northlink, with any flow exceeding the culvert capacity diverted south to a detention basin at the southern area of the Site abutting Ellen Brook.

Further details of the proposed drainage strategy are provided in the Local Water Management Strategy prepared by Bayley Environmental.

6. ROADWORKS & FOOTPATHS

This Site is bound by Brand Highway to the north, Great Northern Highway to the east and the Perth Darwin Highway (Northlink) to the west as presented in Figure 1.

6.1 Great Northern Highway

Great Northern Highway is a Main Roads WA controlled Highway, which transitions from a four lane road at the south-eastern corner of the Site to a two lane road at the north-eastern corner. The pavement is in good condition and includes sealed shoulders and table drains both sides of the road.

There is an existing un-controlled T-intersection with passing lanes into Lot 192, with all other lots being accessed via standard driveway cross-overs.

6.2 Perth Darwin Highway

The Site is severed by an existing reserve for the future Perth-Darwin Highway (Northlink), which is currently under construction, due for completion mid-2019.

The proposed Highway will consist of a four-lane divided rural road, with an off-road Principle Shared Path (PSP) within the reserve to the east of the main road. Batters for the road and PSP are contained within the proposed reserve.

Construction of the Highway will sever access to a number of the parent lots within the development area, which Main Roads proposes to service with a slip road off Brand Highway.

There will be no access onto Northlink at Brand Highway, with the nearest interchange proposed an additional 1 kilometre north.

6.3 Brand Highway

The Brand Highway forms the northern boundary of the Site, and consists of a single carriageway two lane rural style unkerbed road. There is an existing intersection of Brand Highway and Great Northern Highway is controlled by traffic signals.

A fly-over of Northlink across Brand Highway is proposed as part of the Northlink construction, which will require reconstruction of a portion of the Brand Highway abutting the Site.

6.4 Development Roads

Road cross-sections will be designed to cater for utility services, on standard verge alignments, drainage requirements and on and off road pedestrian and cycle movements.

Further discussion on the RAV network and industrial road requirements is included in the Traffic Report accompanying the TPS and LSP.

The engineering design of roads will be carried out to comply with the Department of Planning, Lands & Heritage, and the Shire of Chittering.

Due to the proximity of the groundwater table, and the clay foundations of the Site, the inclusion of subsoil drainage adjacent to the road pavement may be required to protect the road base.

7. WATER RETICULATION

The Water Corporation has advised that the Site is not within a current water catchment, and there are no plans to extend the water catchment boundary at this stage.

A proposed water project for the Lower Chittering Valley is currently in development by Aqua Ferre, which includes construction of a water treatment facility on Lot 2 Reserve Road, Chittering capable of supplying potable water to residential and commercial properties in the Lower Chittering-Muchea area.

Aqua Ferre is in the process of applying for a Water Service Provider Licence from the Economic Regulation Authority.

The project proposes to draw water from the Leederville Aquifer, with treatment to meet drinking water quality guidelines. Aqua Ferre has confirmed they have capacity within their proposed licence to service the proposed industrial development of the Site with potable water, and have advised the most likely strategy would include an extension of the proposed Harvis network depicted below in Figure 7 to service the proposed development.

Provision to the Muchea Precinct 3 Employment Node is still subject to mutually agreeable commercial terms with Aqua Ferre, though from the structure plan perspective, we confirm the site can be serviced with water reticulation by a licensed provider, as required by the MENSP, and that there are no engineering impediments to the provision of water to the proposed development.

Further details pertaining to Aqua Ferre's strategy for the provision of water to the site is provided in Appendix B.

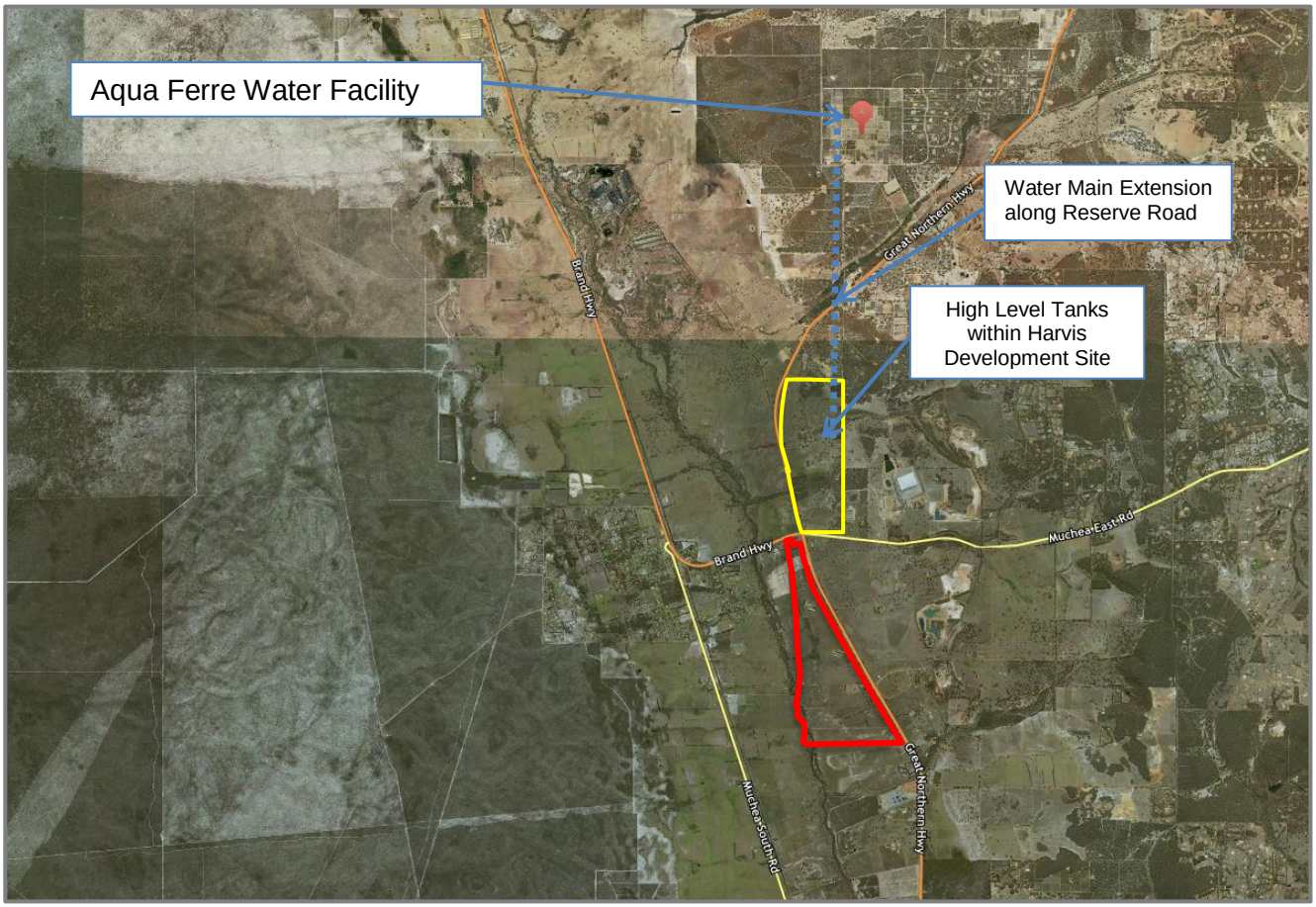


Figure 7: Aqua Ferre Water Strategy (Aqua Ferre, 2018)

8. SEWERAGE RETICULATION

The Water Corporation has advised that the Muchea LSP is not within a current wastewater catchment, and there is no proposal to extend the catchment boundary at this stage.

An alternative option proposed by the Precinct 3 West Muchea Employment Node is to manage general wastewater (wastewater from buildings/site offices) on an individual inter-allotment scale utilising Aerobic Treatment Units (ATUs). ATUs are small wastewater treatment plants, designed to treat wastewater to a quality suitable for irrigation. The individual lot must provide sufficient landscaped area to avoid inundation and surface runoff. A typical lot configuration showing the extent of landscaped area for the effective disposal of effluent is included in Appendix A.

- The ATUs must be maintained to ensure compliance with the Code of Practice for the Design, Manufacture, Installation and Operation of Aerobic Treatment Units
- Greater than or equal to 1.5m separation between the effluent discharge point (eg ATU drip lines) and the highest known groundwater level shall be provided;
- Wastewater disposal Site must be above 1:10 year flood level;
- Cannot discharge wastewater into the ground less than 30m from any water intended for human consumption;
- Cannot be located within 100m of a watercourse or wetland.

A land capability assessment (LCA) will be required prior to subdivision to determine the detailed design requirement for ATUs considering the underlying soil conditions, clearance to groundwater and environmental constraints specific to the lot.

Sewer reticulation and a centralised treatment system may be considered for parts of the Site where there are smaller industrial lots, which have reduced capacity for irrigation volumes, or lots with a requirement for a large volume of sewer treatment. There are alternatives for centralised treatment systems if required. These options have not been assessed, and will require the relevant approvals prior to any agreements with potential industrial developments.

Any wastewater produced on lots from industrial processes will be required to be treated appropriately on each lot, which is no different to industrial lots in areas with reticulated sewer. Where appropriate treatment is not achievable (due to the volumes or contaminants) industrial process wastewater will be captured and removed from site to an appropriate treatment facility.

9. POWER

There are existing overhead 22kV high voltage overhead power cables in the eastern verge of Great Northern Highway and southern verge of Brand Highway which are fed from the existing Muchea Zoned Sub-Station which are presented below in Figure 8.

The Western Power Network Capacity Mapping Tool was used to determine future forecast remaining capacity in the electricity network, which confirmed the network will have more than 30MVA remaining capacity in 2020. We anticipate this capacity will be sufficient to service the future power requirements of the development, though Western Power will need to confirm the connection locations and capacity of the existing system as part of a feasibility assessment at the next stage of the planning process.

A series of HV feeds, switch stations and transformers will be required throughout the development to meet individual site requirements.

Additional distribution mains from the Muchea Sub-Station may be required in the future to augment the existing supply network, depending on industrial uses proposed and likely power requirements.

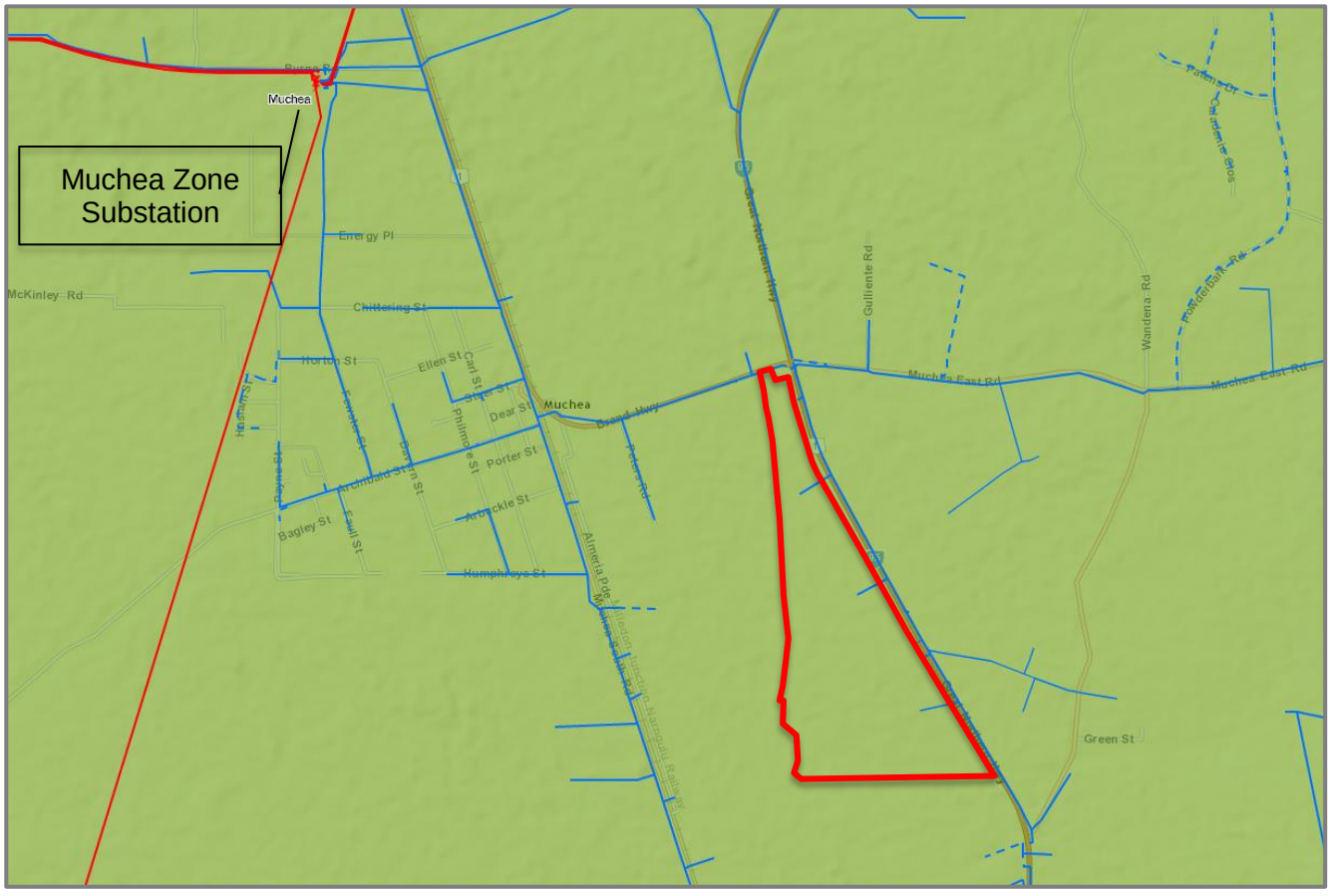


Figure 8: Existing Overhead Power Lines (Western Power, 2018)

10. GAS SUPPLY

There is no proposed gas distribution within the vicinity of the Site. The supply of a gas distribution network in the future is not ruled out, however it will depend on economics and likely demand of the broader Muchea area.

11. TELECOMMUNICATIONS

The Site has not yet been served with NBN, but there is existing Telstra communications in Great Northern Highway servicing the Site.

As per the New Developments Policy announced by the Minister for Communications & The Digital Economy in December 2010, new developments with 100 premises or more will be prioritised by NBN Co to have optic fibre infrastructure installed. This development falls short of this threshold, and may not be prioritised by NBN Co.

Using the NBN Co 'Check your address', the Site is planned to be connected to the NBN network in January-June 2020 with a fixed wireless connection (this date is an estimate and could change). Based on the anticipated connection date, it is likely the Site will be connected to the NBN network by the time development commences and no offsite upgrade by the developer would be applicable. A Fixed Wireless communications connection uses wireless technology rather than cables, data travels from a transmission tower located as much as 14 kilometres from the premises to a rooftop antenna that has been fitted by an approved NBN installer.

At the time of development negotiations with NBN, Telstra, or alternative telecommunications service providers will be required to negotiate for the provision of this service to the Site. If the Site isn't yet served with telecommunications from the preferred provider it is likely that contributions to backhaul or headworks upgrades may be sought by the relevant telecommunications service provider for the service.

12. CONCLUSION

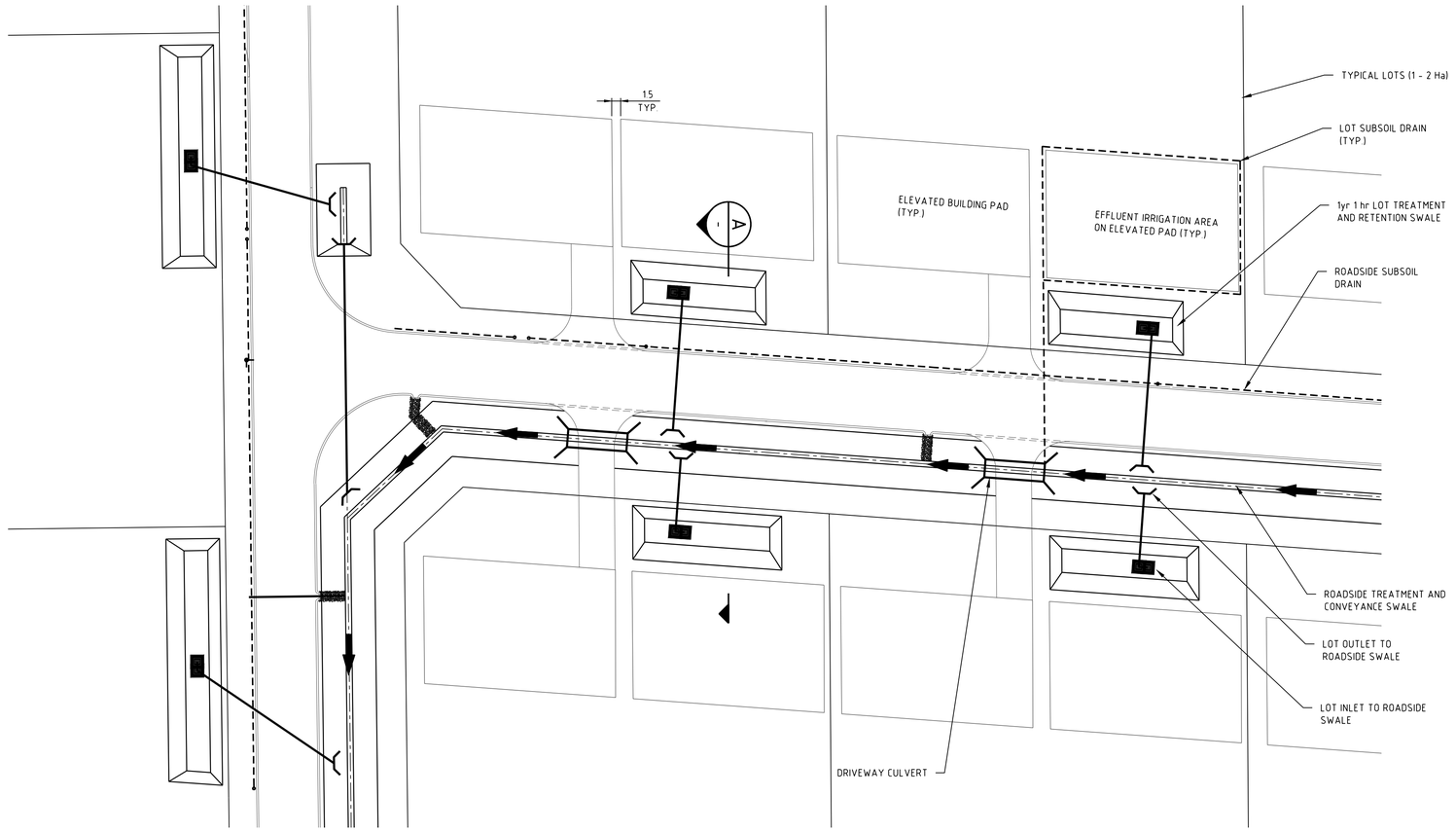
Precinct 3 West Muchea Employment Node has planned strategies for water and sewerage supply and other necessary public utility services are available or can easily be extended to service the proposed industrial area.

There are no engineering impediments to the development, though co-ordination and co-operation with the relevant Service Authorities will be required as the development progresses.

From an engineering perspective, the site is well suited to future development.

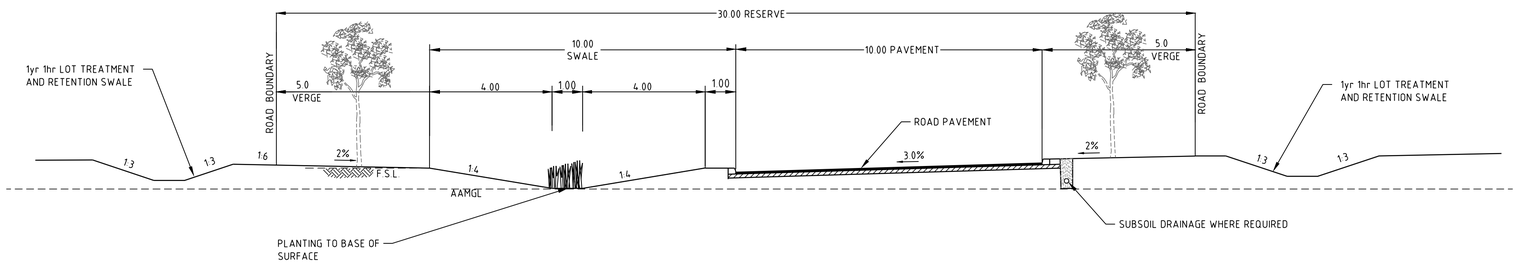
APPENDIX A

Typical Drainage & Lot Configuration



TYPICAL ROAD AND LOT CONFIGURATION

(SCALE 1:500)



TYPICAL CROSS SECTION OF LOCAL ROAD

SECTION A

(SCALE 1:100)

REV	DATE	DRN	CKD	APP	AMENDMENT
A	27.11.18	RG	AT		ISSUED FOR INFORMATION

COPYRIGHT
The concepts and information contained in this document are the Copyright of Cossill & Webley Pty Ltd. Use or copying of the document in whole or part without the written permission of Cossill & Webley Pty Ltd constitutes an infringement of copyright.

This plan is not to be used for construction unless issued as revision 0 or higher

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

CLIENT: TOMAHWAK PROPERTY

APPROVED

DESIGNED: AT

SCALE: AS SHOWN

PROJECT: MUCHEA EMPLOYMENT NODE - PRECINCT 3

TITLE: TYPICAL ROAD AND LOT CONFIGURATION

WAPC No.: WAPC No.

DRAWING No.: 6331-00-SK03

REVISION: A

ORIGINAL SIZE: A1

O:\6331 Ingham Muchea\6331-00\Acad\6331-00-SK03.dwg, 27/11/2018 4:51:33 PM, rajiang, Digital Signing PDF.pc3, 1:1, - CW Reference

APPENDIX B

Aqua Ferre Water Strategy Correspondence

AQUA FERRE PTY LTD

ACN 121 146 772
PO Box 1982 West Perth WA 6872
Level 1, 5 Ord Street West Perth WA 6005
Tel: 08 9282 5400
Fax: 08 9282 5484

29 January 2018

Tom Carmody
Director and Licensee
Tomahawk Property on behalf of the Muchea Employment Node Precinct 3 Landowner Group
8/355 Stirling Highway
Claremont WA 6010

Dear Mr Carmody

Muchea Employment Node Precinct 3 Landowner Group

I refer to your enquiries to Aqua Ferre Pty Ltd (Aqua Ferre) regarding the availability of water and the potential future supply of water, within the Muchea region.

You have advised that you represent a number of landowners with properties on Great Northern Highway and Brand Highway in Muchea (collectively described as the Muchea Employment Node Precinct 3 Landowner Group or more generally the landowner group).

On behalf of the landowner group you have requested information from Aqua Ferre in support of two planning documents:

- Shire of Chittering Town Planning Scheme No 6 Amendment No.67 - Rezoning Lots M1601, 800-804, 192, 194 and 35 Great Northern Highway, Muchea from 'Agricultural Resource' zone to 'Industrial Development' zone, and amending the Scheme Maps accordingly; and
- Precinct 3 Muchea Industrial Park Structure Plan.

In particular you have sought information regarding Aqua Ferre's water entitlements, the prospect that some of Aqua Ferre's water entitlement may be allocated to the landowner group properties, and whether the water can be practically supplied from Aqua Ferre's operations to the landowner group properties.

1 MEN & Precinct 3

The Muchea Employment Node Structure Plan (MENSP) was adopted by the WAPC in August 2011, and provides a 20-year planning framework for industrial development within the Shire of Chittering. We understand that the MENSP is currently under review and a revised document is expected to be released during 2019.

You have advised that the subject land is located within Precinct 3, which forms the eastern portion of the MENSP, to the west of Great Northern Highway (GNH).

Precinct 3 of the Muchea Employment Node (more recently referred to as the Muchea Industrial Park (MIP)) ('the Structure Plan area') is approximately 185ha in area and located to the south east of the

DRAFT

townsite of Muchea. Precinct 3 is triangular in shape and extends in a lineal pattern from Brand Highway in the north, along Great Northern Highway (GNH) in the east, to the southern boundary of the Shire of Chittering, and along the Perth-Darwin Highway (PDNH) to the west, which is currently under construction.

Figure 1 below shows the proposed Precinct 3 development boundaries (Urbis 2019, LPS Amendment, Muchea Employment Node, DWG-11).

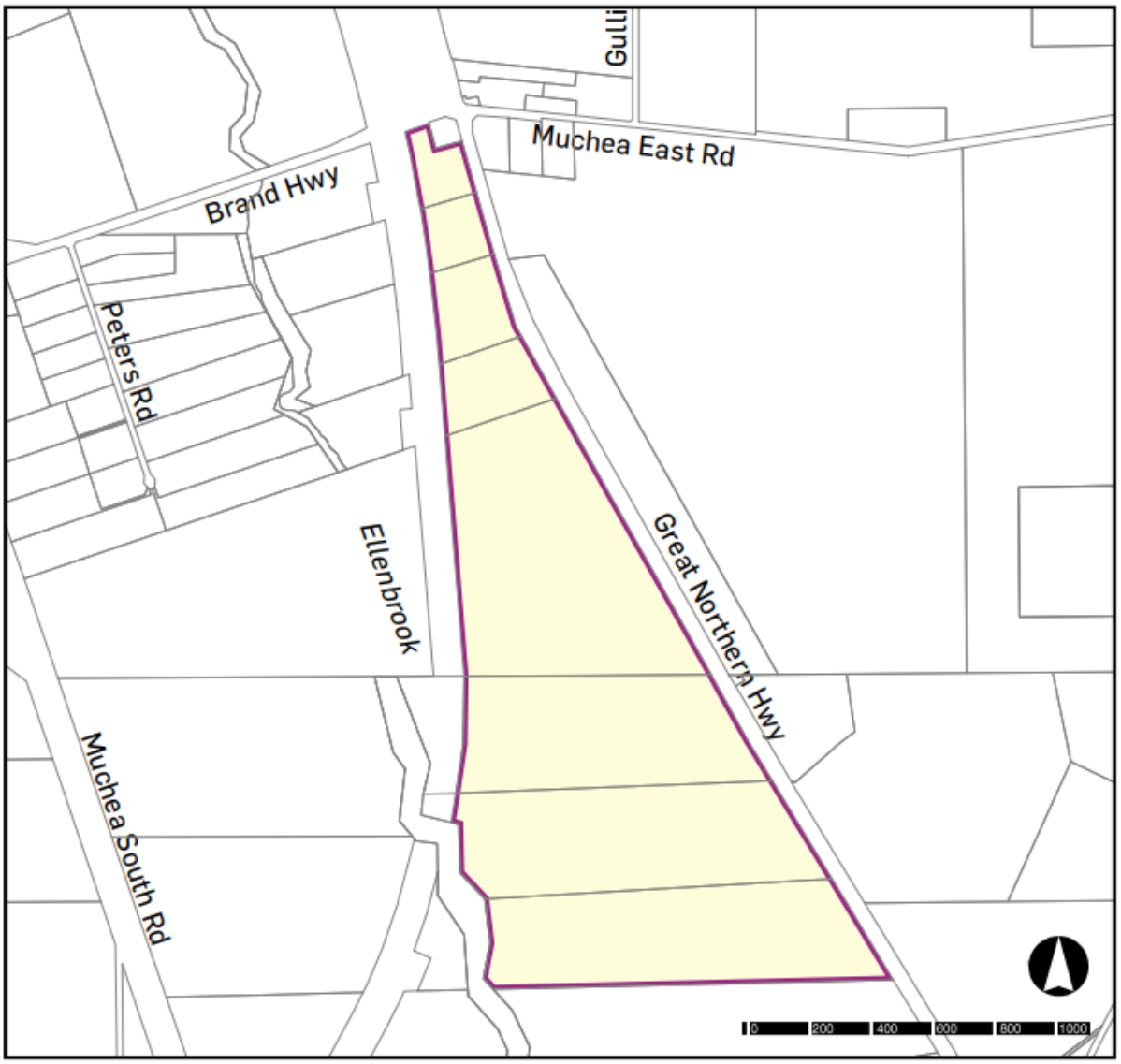


Figure 1 Proposed Precinct 3 development

Urbis[1] have indicated that the land has largely been historically cleared for agricultural purposes and contains stands of large, mature trees with degraded understorey, and a number of rural drainage lines.

[1] Urbis Pty Ltd 2019, Precinct 3, Muchea Industrial Park, Structure Plan, Draft January 2019

You have advised that the Structure Plan[2] will provide approximately 51 lots of approximately 1.3ha to 7.6ha providing flexibility for a range of industrial uses, expected to be primarily transport logistics related.

We understand that the Structure Plan is being progressed concurrently with Amendment No.67 to LPS6 which proposes to rezone the land from 'Agricultural Resource Zone' to the 'Industrial Development' zone, to introduce land use permissibility for Precinct 3; clarify requirements for the preparation of Management Plans, and introduce provisions relating to provision of reticulated water and construction of the loop road.

2 Aqua Ferre

Aqua Ferre was established to be an independent water service provider following approaches by property development groups seeking water services in the Chittering/Muchea region. Aqua Ferre is proposing to build and operate a potable water supply system at Reserve Road, Chittering (as shown in Figure 2).

The proposed water treatment plant (WTP) would be operated as a constant flow rate to promote a stable process with the intention of producing reliable potable water that meets the Australian Drinking Water Guidelines.

Figure 2 below broadly shows the Precinct 3 development (outlined in red) to the south of Harvis' proposed MEN (Phase 1) development (outlined in yellow) and Aqua Ferre's proposed water facility to the north.

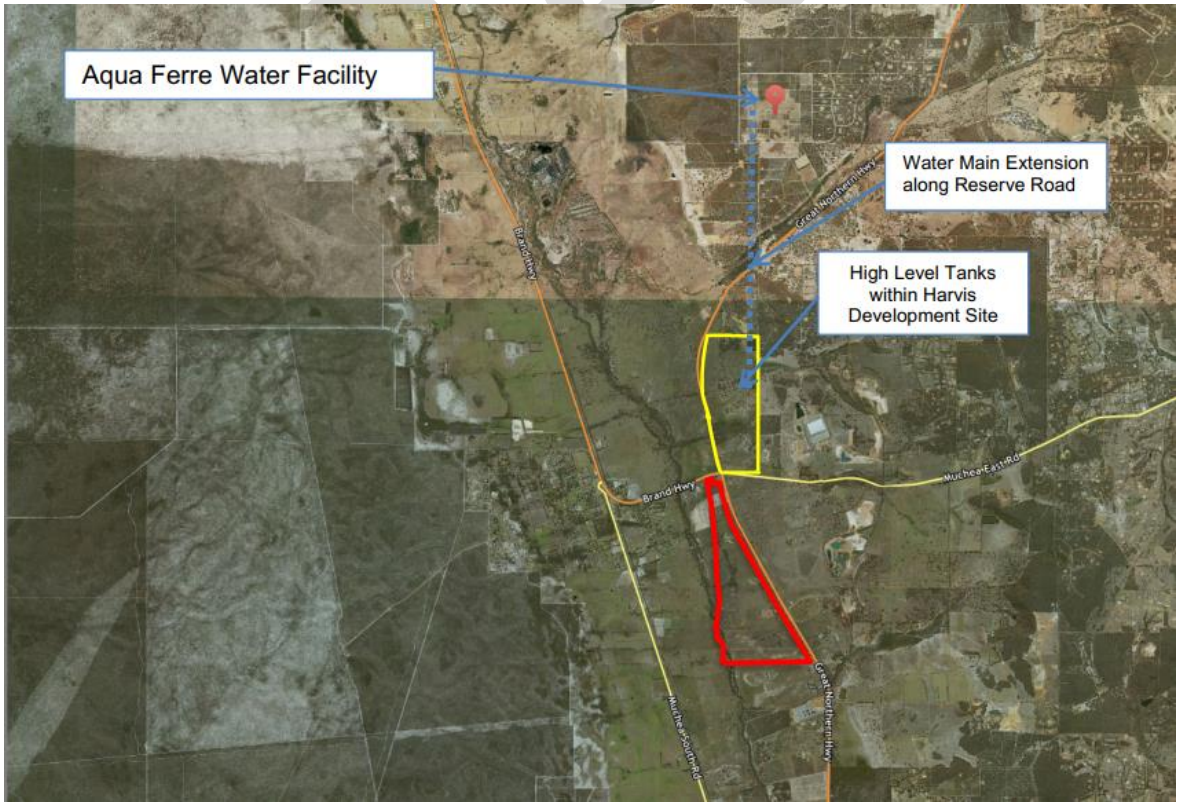


Figure 2 Development boundaries

[2] Urbis Pty Ltd 2019, Precinct 3, Muchea Industrial Park, Structure Plan, Draft January 2019

2.1 Water Entitlement

The Reserve Road (Chittering) property currently has a total water entitlement or allocation (licence to abstract water from an artesian aquifer) of 288,800 kL per annum. The developer of the Reserve Road residential development, Riverside, has transferred the Water Licence GWL 59907(3) to the Water Corporation to enable the licence to be changed from an agricultural extraction to public water supply. It is intended that this water entitlement will be transferred to Aqua Ferre when a water service licence has been granted.

Aqua Ferre has similar entitlement rights to a further 362,900 kL per annum licence, originally GWL 102502(4) which is now part of GWL 65011.

In total, it is intended that Aqua Ferre will have access to 651,700 kL of water per annum.

There is an existing production bore located within the proposed Reserve Road development that was previously used for wildflower irrigation, where the proposed potable WTP would be located.

2.2 Existing water supply commitments

Aqua Ferre intends supplying approximately 153 ML of treated potable water to the residential development at Reserve Road, Chittering, and to a commercial/industrial development at the adjacent MEN (northern Precinct 1 only). It is intended that a further 75 ML will be set aside for future demand across these two developments.

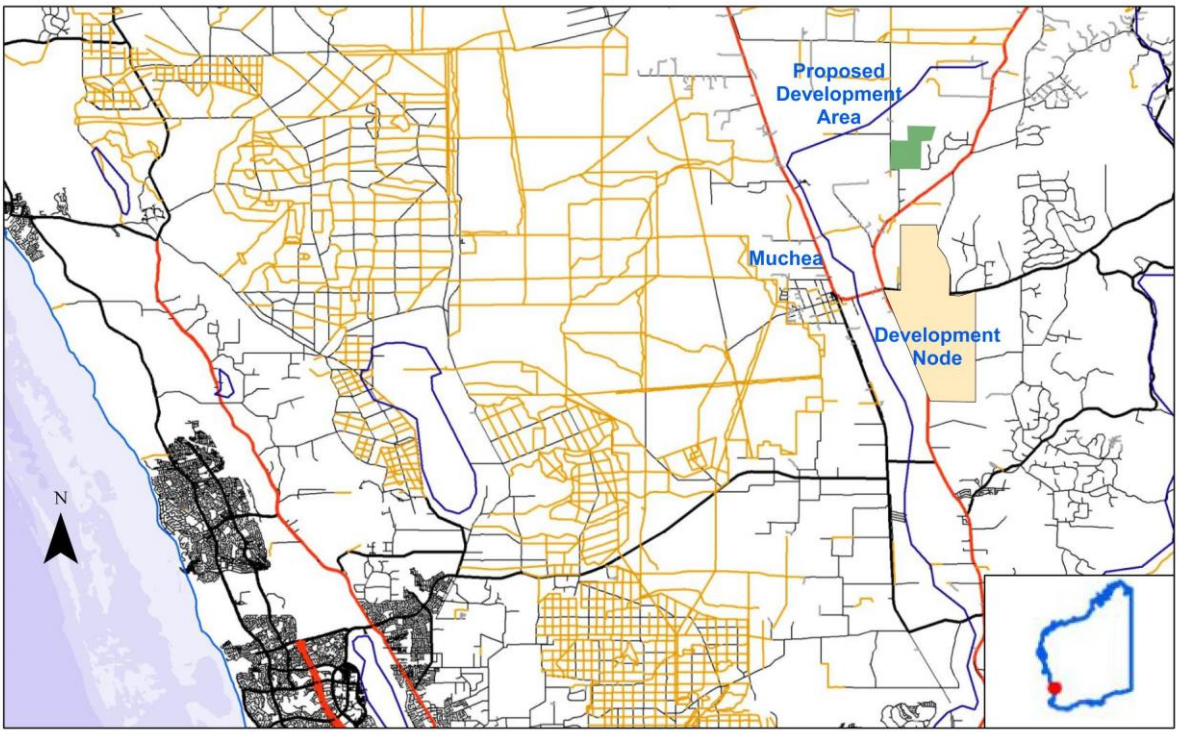


Figure 3 Location of Reserve Road residential development and MEN

The new Reserve Road rural living allotment development is located 8km north east of the Muchea town site and 80km north of the Perth central business district. It is also in close proximity (4km) to the

proposed MEN on the eastern side of Great Northern Highway. The development is in accordance with the Shire of Chittering's planning scheme (2004). The Reserve Road development covers an area of approximately 160 hectares and involves the creation of approximately 245 rural residential allotments in progressive stages. It is a requirement of the development approval that potable reticulated water is available.



Figure 4 Contour map (5m contour lines) of the Harvis MEN development showing ephemeral swale

Phase 1 of the MEN development is being undertaken by development group Harvis Capital Pty Ltd (Harvis). The Harvis development is located on the northern end of the proposed MEN. The site is slightly undulating with an ephemeral swale running through the development (Figure 4). The development is well placed and has been planned around the proposed Perth Darwin Highway.

It is the intention of the MEN development that these lots also have a reticulated water resource. Currently, the area does not have a public water supply scheme. Aqua Ferre is finalising documentation to allow the Economic Regulation Authority Western Australia to consider an application for a water services licence.

It is proposed that the water supply for the Harvis MEN development will have a standalone delivery and network system, to ensure that the demand of both systems can meet peak demand and firefighting requirements.

After treatment, it is intended that the water required for the Harvis MEN site will be delivered to a 500kL holding tank with aeration. Water would be reticulated to customers using a standard, continually pressurised water reticulation network. The piping would follow the general topography and alignment of the development streets and will have 600mm coverage.

3 Precinct 3 water requirement

You have advised that the intention is that the land the subject of the Structure Plan would be serviced with reticulated water provided by a licensed water provider.

The total area of supply is for an industrial development totalling approximately 185 hectares. No indication of staging of development has been provided at this point.

Estimated annual water usage has been provided (based on preliminary modelling by Cossill & Webley) as 203ML per annum on a net area of 139 hectares (after allowing for a 25% reduction in land area calculation to accommodate roads/drainage). The proposed system has been modelled at 4kL/day per hectare based on advice from Cossill & Webley of studies of similar industry types and uses. It is noted that this compares to the Water Corporation design standard for industrial land of approximately 17 kL/ha/day.

Based on your advice of estimated water usage, Aqua Ferre would have capacity under its entitlements to meet the demand of the subject land. This is not an undertaking to commit an allocation of water, or to supply water, to the Muchea Employment Node Precinct 3 Landowner Group. Any such arrangements would be the subject to future commercial negotiation, agreement on terms including pricing and remaining water availability under Aqua Ferre's entitlements.

4 Supply assessment

Aqua Ferre has conducted a preliminary desktop assessment of the potential supply route from its planned water treatment plant at Reserve Road to the proposed Precinct 3 development via Harvis' phase 1 MEN development. This represents a distance of approximately 3.5 kilometres.

The assessment did not highlight any major engineering impediments to the provision of water to the proposed development. (This is not to say, however, that any impediments would not become apparent on more detailed analysis.)

DRAFT

Any proposal for supply would be inclusive of the requirements of:

- Water Corporation Design Standard DS 63 – Water Reticulation Standard Design and Construction Requirements for Water Reticulation Systems or Water Reticulation Systems up to DN250
- DFES requirements for firefighting services
- Hydraulic modelling using EPANET 2 for system hydraulics.

Hydraulic modelling would require topographical mapping at 0.5m.

Additionally, there would be a requirement for a water reserve for tanks, pumps, sumps, generator and chlorination which would need to be met by the subject landowners' group.

5 Disclaimer

This report is dated 29 January 2019 and incorporates information available to Aqua Ferre up to that date only. It excludes consideration of any information arising, or event occurring, after that date which may impact opinions expressed or statements made by Aqua Ferre in this report.

Aqua Ferre has prepared this report on the instructions, and for the sole benefit, of Tomahawk Property (Instructing Party), for inclusion within a rezoning application and Structure Plan as described in paragraph 3 of this letter (Purpose) and not for any other purpose or use. To the extent permitted by applicable law, Aqua Ferre expressly disclaims all liability, whether direct or indirect:

- to the Instructing Party, which may arise in connection with any reliance or purported reliance on this report for any purpose other than the Purpose, and
- to any other person, which may arise in connection with any reliance or purported reliance on this report for any purpose whatsoever (including the Purpose).

All statements and opinions contained in or associated with this report are made on the basis of information supplied to Aqua Ferre as at the date of this report, and upon which Aqua Ferre has relied. To the extent permitted by applicable law, Aqua Ferre expressly disclaims any liability, whether direct or indirect, which may arise in connection with any errors or omissions in this report arising from information provided to Aqua Ferre by the Instructing Party or by any other person.

Achievement of any proposed or intended events or circumstances described in this report will depend, among other things, on the actions of others, over which Aqua Ferre has no control. To the extent permitted by applicable law, Aqua Ferre expressly disclaims any liability, whether direct or indirect, which may arise in connection with the delay in, or failure to occur of, any proposed or intended events or circumstances described in this report.

Yours sincerely

Peter Fogarty
Director

DRAFT

APPENDIX E GEOTECHNICAL REPORT

Doc GE2.2.1

GEOTECHNICAL INVESTIGATION

For: Tomahawk Property on behalf of Muchea Employment Node Precinct 3 Land Owners

Project Address: Muchea Employment Node - Precinct 3 - Muchea

Project Number: D206263

Job Number: J315642

Revision Number: 1

Author: David Harding

Date: 20/12/2018

Structerre Consulting Engineers
(+618) 9205 4500
1 Erindale Road, Balcatta WA 6021
wageotecheng@structerre.com.au
www.structerre.com.au

TABLE OF CONTENTS

1. PROJECT DETAILS 1
1.1. Introduction 1
1.2. Site Description & Proposed Development 1
1.3. Field Investigation – Scope of Works 2
2. DESK STUDY 2
2.1. Geological Setting 2
2.2. Ground Surface and Groundwater Level 2
2.3. Acid Sulphate Soils 2
2.4. Site History 3
3. RESULTS OF THE INVESTIGATION 3
3.1. Subsurface Soil Profile 3
3.2. Groundwater 4
3.3. Percolation Testing 4
3.4. Laboratory Test Results 5
3.4.1. Atterberg Limits 5
3.4.1. Phosphorus Retention Index 6
3.4.2. California Bearing Ratio (CBR) 7
4. GEOTECHNICAL CONSTRUCTION CONSIDERATIONS 8
4.1. Site Classification 8
4.2. Drainage 8
4.3. Seismic Site Subsoil Class 8
4.4. Earthworks 9
4.5. Geotechnical Design Parameters 10
4.6. Shallow Footings – Allowable Soil Bearing Capacities 11
5. CONCLUSIONS 13
6. LIMITATION OF FIELD INVESTIGATIONS 14
7. REFERENCES 15

1 Erindale Road, Balcatta, Western Australia 6021 | PO Box 792, Balcatta, Western Australia 6914
Phone (+618) 9205 4500 | Fax (+618) 9205 4501 | Email wageotecheng@structerre.com.au | Web www.structerre.com.au
ABN 71 349 772 837 Zemla Pty Ltd ACN 008 966 283 as trustee for the Young Purich and Higham Unit Trust trading as Structerre Consulting Engineers

TABLE 1 – HISTORICAL SITE INFORMATION 3
TABLE 2 – SUBSURFACE SOIL PROFILE 3
TABLE 3 – IN SITU PERCOLATION TEST RESULTS 4
TABLE 4 – ATTERBERG LIMIT TEST RESULTS 5
TABLE 5 – PHOSPHORUS RETENTION INDEX RESULTS 6
TABLE 6 – CBR RESULTS 7
TABLE 7 – SUMMARY OF SEISMIC PARAMETERS 8
TABLE 8 – COMPACTION REQUIREMENTS 9
TABLE 9 – SOIL PARAMETERS 10
TABLE 10 – ALLOWABLE BEARING CAPACITIES FOR PAD FOOTINGS 11
TABLE 11 – ALLOWABLE BEARING CAPACITIES FOR STRIP FOOTINGS 12

APPENDIX 1 – SITE LOCATION MAP 1
APPENDIX 2 – SITE PHOTOS 2
APPENDIX 3 – BORELOGS 3
APPENDIX 4 – LABORATORY TEST RESULTS 4
APPENDIX 5 – PRI TEST RESULTS 5
APPENDIX 6 – CBR RESULTS 6
APPENDIX 7 – BORELOG TERMINOLOGY 7

1 Erindale Road, Balcatta, Western Australia 6021 | PO Box 792, Balcatta, Western Australia 6914
Phone (+618) 9205 4500 | Fax (+618) 9205 4501 | Email wageotecheng@structerre.com.au | Web www.structerre.com.au
ABN 71 349 772 837 Zemla Pty Ltd ACN 008 966 283 as trustee for the Young Purich and Higham Unit Trust trading as Structerre Consulting Engineers

1. PROJECT DETAILS

1.1. Introduction

At the request of Tom Carmody of Tomahawk Property on behalf of Muchea Employment Node Precinct 3 Land Owners, Structerre Consulting Engineers (Structerre) have conducted a Geotechnical Investigation at Muchea Employment Node Precinct 3, Muchea, WA. The purpose of the investigation was to provide the following for industrial purposes:

- Desk top study including a summary of geology, groundwater, site history (obtained from historical photographs) and potential presence of Acid Sulfate Soils (ASS)
- Summary of encountered ground and groundwater conditions
- Site Classification in accordance with AS2870
- Earthquake site factor in accordance with AS1170.4
- Recommendations for stormwater drainage design
- Site preparation requirements (earthworks), including site traffic, excavation, reuse of materials and batter slopes
- Ground bearing capacity and estimated settlements for pad and strip footings founded at 0.5m and 1.0m
- Geotechnical design parameters for retaining structures and or deep foundations
- Preliminary pavement design parameter, indicative California Bearing Ratio (CBR) values determined from penetrometer results and ground conditions encountered

This report details the scope of the geotechnical investigation, presents an interpretation of ground conditions and material properties across the site, provides geotechnical design parameters for the design of the proposed infrastructure, and evaluates the suitability of materials for use in earthworks. Interpretation of site conditions is based on the subsurface lithology revealed during the investigation programme, visual assessments of the in situ materials and the results of in situ field tests.

Terms of reference for this investigation were presented in a Structerre Consulting Engineers proposal reference Q78062 (dated 21 November 2018), which was submitted to and accepted by Muchea Employment Node Precinct 3 Land Owners.

1.2. Site Description & Proposed Development

The site is located at Muchea Employment Node Precinct 3, Muchea, Shire of Chittering. Great Northern Highway lies to the east of the site, Brand Highway to the north, Perth To Darwin Highway to the west and rural properties to the south.

The site gently sloping towards the western section. At the time of the field investigation existing industrial/farm buildings occupied the site. The land is largely cleared farmland with some vegetation and trees existing.

We understand that the site is to be used for an industrial development.

1.3. Field Investigation – Scope of Works

The field investigation was carried out on 26 and 27 November 2018 and comprised:

- 37 x Sample Retrieval Probe boreholes (BH) to a depth of 2.5m over the site for material assessment and soil profiling;
- 7 x In situ percolation tests to determine the permeability of the materials within the upper 1.0m; and
- 37 x Dynamic Cone Penetrometer (DCP) tests in accordance with AS 1289.6.3.2 (1997) to a depth of 1.0m for evaluation of relative densities of the upper layers.

The borehole, percolation and DCP test locations are shown on the attached site plan in Appendix 1.

A suitability qualified geotechnical personnel from Structerre supervised the fieldwork and all fieldwork, interpretation and terminology used in this report are in accordance with the guidelines presented in AS1726-2017 Geotechnical Site Investigations.

2. DESK STUDY

2.1. Geological Setting

The Muchea sheet 1: 50,000 Environmental Geology Series (Sheet 2034 I and Part of 2134 IV, 1986) prepared by the Geological Survey of Western Australia indicates that the following geological layer underlies the site:

- Pebbly SILT (Mgs1) – strong brown silt with common, fine to occasionally coarse-grained, sub-rounded laterite quartz, heavily weathered granite pebble, some fine to medium-grained quartz sand, of alluvial origin (Guildford Formation Qpa)

2.2. Ground Surface and Groundwater Level

The Perth Groundwater Atlas (Waters & Rivers Commission) indicates the ground surface level at this site was approximately 58.0m at southeast to 41.0m at southwest.

Department of Water and Environment Regulation has published minimum groundwater levels for this site.

2.3. Acid Sulphate Soils

Information from publicly available Landgate website indicates that the site lies within a zone of no known risk of ASS occurring within 3m of natural surface.

2.4. Site History

Historical aerial photographs dating back to 1965 are publicly available through Landgate Map Viewer were assessed and a summary is presented in Table 1.

Table 1 – Historical Site Information

Date	Description
1965	The site is fully cleared
1977	Industrial/Farm buildings constructed
2012	A small portion of the site was cleared being Lot 802 & 803
2018	Construction started on the Perth To Darwin Highway to the west of the site
2018	Site remains relatively unchanged to the current day

3. RESULTS OF THE INVESTIGATION

3.1. Subsurface Soil Profile

The subsurface soil profile presented below was determined from the ground conditions encountered within the boreholes and through the interpretation of the DCP test results:

Table 2 – Subsurface Soil Profile

Depth to Base of Strata (m)	Material Description
0.1	TOPSOIL
0.2 – 1.0 (Ave. 0.5)	NATURAL: SAND/Gravelly SAND (fine to coarse grained), trace silt, loose to very dense
Not Penetrated (>2.5m)	NATURAL: Clayey SAND/Sandy CLAY/Clayey GRAVEL (medium to high plasticity), trace gravel, dense to very dense

The soils encountered are consistent with the expected site conditions as predicted from the Environmental Geology Map. It is important to note that there may be pockets of fill on site that are deeper than that encountered by the investigation boreholes. The subsurface soil conditions encountered are presented in the bore logs, within Appendix 3.

3.2. Groundwater

Groundwater was encountered in boreholes BH01, BH02, BH05 and BH12 at an approximate depth of 1.0m below the existing ground level. Groundwater is expected to perch above the impermeable materials.

3.3. Percolation Testing

Percolation testing of the in situ soils was undertaken in seven locations. Results of the testing are summarised below:

Table 3 – In Situ Percolation Test Results

Test Location	Testing Depth	Soil Type	Permeability
1	0 - 1.0m	SAND/Clayey SAND	0.6m/day
2	0 – 0.7m	SAND/Clayey SAND	0.5m/day
3	0 - 1.0m	SAND/Clayey SAND	0.3m/day
4	0 - 1.0m	SAND/Clayey SAND	0.7m/day
5	0 – 0.5m	SAND/Gravelly SAND	1.0m/day
6	0 - 1.0m	SAND/Clayey SAND	1.2m/day
7	0 – 0.6m	SAND/Clayey SAND	0.9m/day

3.4. Laboratory Test Results

Selected representative soil samples were tested by Structerre's in-house NATA accredited laboratory for Atterberg Limits, shrink-swell index, phosphate retention index and soil compaction. The results are attached in Appendix 4, 5 & 6.

3.4.1. Atterberg Limits

Atterberg Limits were tested by Structerre's in-house NATA accredited laboratory. Results of the testing are summarised below:

Table 4 – Atterberg Limit Test Results

Sample	Test Hole	Depth (m)	Soil Description	Liquid Limit % AS1289 3.1.2	Plastic Limit % AS1289 3.2.1	Plasticity Index % AS1289 3.3.1	Linear Shrinkage % AS1289 3.4.1
1	BH01	0.1-1.0	Sandy CLAY with gravel	52	20	32	9
2	BH07	0.7-1.0	Clayey GRAVEL with sand	36	17	19	6.5
3	BH12	0.7-1.3	Clayey GRAVEL with sand	34	14	20	7
4	BH20	0.4-0.9	Clayey SAND with gravel	37	15	22	9

Test results indicate that the natural clay has moderate shrink swell capacity or degree of expansion.

A copy of the results are presented in Appendix 4.

3.4.1. Phosphorus Retention Index

Six samples were submitted to CSBP Soil & Plant Analysis Laboratory for analysis of phosphate retention and calculation of Phosphorus Retention Index (PRI). The results are summarised below, with the certificate provided in Appendix 5.

Table 5 – Phosphorus Retention Index Results

Sample No.	Soil Type	PRI	Classification
BH02_ 0.1-0.4	SAND	4.5	Weakly
BH04_ 0.1-0.4	SAND	1.8	Very Weakly
BH05_ 0.1-0.4	Clayey SAND	185.8	Very Strongly
BH11_ 0.1-0.4	Sandy GRAVEL	6.4	Moderately
BH18_ 0.1-0.4	Sandy GRAVEL	445.7	Very Strongly
BH23_ 0.1-0.4	SAND	1.1	Very Weakly

The soil samples tested within the site areas indicate that the soil tested can be described as varying from very weakly to very strongly adsorbing (reference Method for Analysis of Phosphorus in Western Australia Soils, DG Allen & RC Jeffery, March 1990, Chemistry Centre, Agricultural Chemistry Laboratory).

3.4.2. California Bearing Ratio (CBR)

Representative samples were tested by Structerre's in-house NATA accredited laboratory in accordance with AS1289.5.2.1 (2003). The test certificates are presented in Appendix 6 and are summarised below.

Table 5 – CBR Results

Test Hole	Depth (m)	Soil Description	Optimum Moisture Content %	Maximum Dry Density t/m3	CBR @ 2.5mm Penetration (%)	CBR @ 5mm Penetration (%)
BH02	0.1 - 0.4	SAND	8.5	1.95	30	-
BH04	0.1 - 0.4	SAND	10.0	1.81	18	-
BH11	0.1 - 0.4	Sandy GRAVEL	7.0	2.20	-	50
BH05	0.2 - 0.6	SAND	12.0	1.73	30	-

Based on the above results a conservative soaked CBR of 18% would be recommended for design purposes.

4. GEOTECHNICAL CONSTRUCTION CONSIDERATIONS

4.1. Site Classification

AS 2870-2011 Residential Slabs and Footings provides guidance on site classification for residential slabs and footing design based on the expected ground surface movement and depth of expected moisture changes.

Although the proposed development falls outside the scope of AS 2870, site classification can be used to assist in the design of foundations. The foundation design should be undertaken by a Structural Engineer, taking into consideration ground bearing capacity and the acceptable total and differential settlements of the proposed foundation system.

Based on results of this investigation the building areas can be classified as an Class “S” provided that all unsuitable materials are removed and replaced with engineer-controlled sand fill materials in accordance with earthwork recommendations outlined in Section 4.3 in this report. The site in its current condition is classified as Class “P”.

4.2. Drainage

The existing ground conditions are not suitable for on-site disposal of stormwater runoff through the use of soakwells.

The design of the drainage system, is unknown at this time, but may include:

- Rainwater Tanks;
- Dams / Compensation basin;
- Overland flow paths; and
- Soakwells, if permeable cover and / or design are appropriate.

Sub soil drainage may be required to control groundwater perching in the upper soil layers within the building footprint.

4.3. Seismic Site Subsoil Class

The seismic subsoil site class has been assessed in accordance with AS 1170.4-2007, using the results of this investigation and published information.

Table 6 – Summary of Seismic Parameters

Hazard Factor	Site Sub-soil Class
0.1	Class Ce –shallow soil site

4.4. Earthworks

The building areas can be classified as Class "S", provided that the recommended earthworks are undertaken.

All earthworks shall be undertaken in accordance with AS 3798-2007 Guidelines on Earthworks For Commercial and Residential Developments and are to include the following:

- All unsuitable materials to be stripped and removed from the site. Unsuitable materials include topsoil, deleterious and organic materials.
- It is considered that the near surface loose sand materials require improvement. Therefore, it is proposed to excavate and stockpile the materials for reuse, provided it is dry, free from clay/silt (i.e. <5%), organic and deleterious materials. The depth of excavation may vary depending on conditions encountered (i.e. groundwater) and is subject to inspection.
- Excavations should not exceed 2.0m and / or undermine surrounding structures. A 1V:2H slope should be maintained for temporary excavations. If excavation is required closer than the 1V:2H slope would allow, it is recommended that this office be contacted for retaining design.
- Proof compact the exposed base. The compaction requirements are set out in the table below, as per AS 3798-2007:

Table 7 – Compaction Requirements

Item	Application	Minimum relative compaction, %	
		Minimum density ratio (Standard Compaction Effort) (Cohesive soils)	Minimum density index (Cohesionless soils)
1	Residential - lot, fill, house, sites	95	70
2	Commercial – fills to support minor loadings, including floor loading of up to 20kPa and isolated pad or strip footings to 100kPa	98	75
3	Fill to support pavements a) General fill b) Subgrade (to a depth of 0.3m)	 95 98	 70 75

- After excavation and proof compaction, the excavated base is to be inspected and approved by a representative from this office prior to backfilling. At this stage it can be

assessed whether any further materials need to be removed or whether further compaction of the base is required.

- The ground level should be built up to design levels with the stockpiled sand materials and imported fill. If required, the imported fill should consist of free draining sand with not more than 5% passing a 75µm sieve and be free of organic matter and other deleterious materials. The fill sand materials should be placed in layers not exceeding 300mm loose thickness and compacted to achieve the values stated in the table above. As a guide a minimum of 8 PSP blows over the interval 150 – 450mm, 9 PSP blows over the interval 450 – 750mm and 11 PSP blows over the interval 750 – 1050mm should be achieved, however its is recommended that this be verified with appropriate laboratory testing.
- A minimum of 0.6m of sand cover is required to be maintained above the reactive material in order to achieve a Class "S".
- After remedial earthworks have been completed, the earthworks should be inspected and approved by a representative from this office.

It is considered that standard small to medium sized earthmoving equipment would be appropriate for the proposed development. The near surface ground was generally competent and should not pose an issue to site traffic movements.

The material encountered on site can be deemed as 'easy' to excavate with medium sized earthwork equipment (i.e. a 20t excavator). Should excavations be required below groundwater level, dewatering will be necessary.

4.5. Geotechnical Design Parameters

Based on the on site observations and the DCP results, the interpreted geotechnical soil parameters of the encountered materials are presented in Table 9:

Table 8 – Soil Parameters

Soil Type	Depths (m)	Friction Angle Ø' (^{0})	Cohesion c' (kPa)	Density Y (t/m^3)	Elastic Modulus E (MPa)
FILL: SAND to silty SAND	0 – 0.6	32	0	1.85	15
Clayey SAND to Sandy CLAY	0.6 – 2.5	32	20	1.80	20

4.6. Shallow Footings – Allowable Soil Bearing Capacities

Based on the findings of the current preliminary geotechnical investigation, shallow pad and strip footings are considered appropriate for the proposed development. Allowable bearing capacities for shallow footings at the site have been calculated under the following assumptions:

- The site preparation procedures specified in Section 4.4 have been carried out;
- The specified level of compaction has been achieved below the base of each footing;
- Loads are vertical and not eccentric;
- Isolated footings (i.e. interaction of foundations has not been considered);
- The foundations are flexible;
- A factor of safety (FoS) of 3.0 against bearing capacity failure;
- Maximum allowable settlement of 20mm.

The tables below present the allowable bearing pressures for pad and strip footings of various dimensions, with embedment depths of 0.5m and 1.0m below finished surface levels.

Table 9 – Allowable Bearing Capacities for Pad Footings

Minimum Depth of Embedment (m)	Minimum Plan Dimension (m)	Allowable Bearing Capacities (kPa)	Settlement (mm)
0.5	0.5	140	< 20
	1.0	155	
	1.5	165	
	2.0	140	
1.0	0.5	245	< 20
	1.0	250	
	1.5	190	
	2.0	160	

* Note: it is recommended to limit these values to 250kPa.

Table 10 – Allowable Bearing Capacities for Strip Footings

Minimum Depth of Embedment (m)	Minimum Plan Dimension (m)	Allowable Bearing Capacities (kPa)	Settlement (mm)
0.5	0.5	115	< 20
	1.0	135	
	1.5	150	
1.0	0.5	160	< 20
	1.0	180	
	1.5	200	

The recommended allowable bearing capacities are dependent on the site being dry and well drained, so that the foundation material does not become saturated.

The actual allowable bearing capacity of a particular foundation will be dependent on its location, geometry and founding depth, as well as the founding horizon. Therefore, once specific foundation geometries have been determined and the earthworks completed, it is recommended that the allowable bearing capacity and associated settlements be verified.

Additionally, should undermining issue prevent the excavation of the near surface loose materials, it is recommended that the allowable bearing capacity be reviewed. However, this will likely result in lower allowable bearing capacities.

5. CONCLUSIONS

A site investigation was carried out at the proposed commercial development site to assess the geotechnical conditions. Parameter and design recommendations are incorporated in the body of the report. The following conclusions have been drawn from the site investigation:

- The subsurface soil profile encountered comprised of topsoil to 0.1m, loose to dense sand / gravelly sand / sandy gravel from the surface to 1.0m, underlain by clayey sand/sandy clay to the investigated depth of 2.5m.
- The water table was encountered at the approximately 1.0m below the existing surface in boreholes BH01, BH02, BH05 and BH12.
- The building areas can be classified as a Class “S” in accordance with AS 2870-2011 provided the recommended earthworks are undertaken.
- It is considered that the site is not suitable for on-site drainage.
- Recommended earthworks for the building areas, include stripping of fill sand and unsuitable materials, excavation of loose materials, proof compaction of the base, placement of engineered fill and compaction of final level.
- Allowable bearing capacity for pad footings range from 140kPa to 250kPa and from 115kPa to 200kPa for strip footings. The estimation of settlement of the footings is limited to 20mm.

6. LIMITATION OF FIELD INVESTIGATIONS

This report has been prepared in accordance with generally accepted consulting practice for Tomahawk Property on behalf of Muchea Employment Node Precinct 3 Land Owners using information supplied at the time and for the project specific requirements as understood by Structerre. To the best of our knowledge the information contained in this report is accurate at the date of issue, however it should be emphasised that any changes to ground conditions and/or the proposed structures may invalidate the recommendations given herein.

The conclusions and recommendations in this report are based on the site conditions revealed through selective point sampling, representing the conditions of the site in total, although the area investigated represents only a small portion of the site. The actual characteristics may vary significantly between successive test locations and sample intervals other than where observations, explorations and investigations have been made.

The materials and their geotechnical properties presented in this report may not represent the full range of materials and strengths that actually exist on site and the recommendations should be regarded as preliminary in nature. Allowances should be made for variability in ground conditions and any consequent impact on the development. Structerre accepts no responsibility and shall not be liable for any consequence of variations in ground conditions.

If ground conditions encountered during construction are different to that described in this report, this office should be notified immediately.

For and behalf of

STRUCTERRE CONSULTING ENGINEERS



Author: David Harding
Title: Geotechnical Supervisor



Checked By: Daniel Smith
Title: Geotechnical Engineer
Credentials: BEng Civil, MIEAust, AGS

Disclaimer
This report is at the request of the addressee and no liability is accepted by Structerre Consulting Engineers to any third person reading or relying upon the report, not withstanding any rule of law and/or equity to the contrary and that this report is strictly confidential and intended to be read and relied upon only be the addressee.

Job #	Revision	Authored	Checked	Authorised
J315642	0	DO	DAS	MEC
J315642	1	DO	DAS	MEC

7. REFERENCES

Department of Water – Perth Groundwater Atlas

Geological Survey of Western Australia 1:50,000 Environmental Geology Series

AS 1170.4-2007 Structural design actions – Earthquake actions in Australia

AS 1289.3.1.2-2009 Methods of testing soils for engineering purposes – Soil classification tests – Determination of the liquid limit of a soil

AS 1289.3.2.1-2009 Methods of testing soils for engineering purposes – Soil classification tests – Determination of the plastic limit of a soil

AS 1289.3.3.1-2009 Methods of testing soils for engineering purposes – Soil classification tests – Calculation of the plasticity index of a soil

AS 1289.3.4.1-2009 Methods of testing soils for engineering purposes – Soil classification tests – Determination of the linear shrinkage of a soil

AS 1289.5.2.1-2009 Soil compaction and density tests – Soil classification tests – Determination of the dry density/moisture content relation of a soil using modified compactive effort

AS 1289.6.1.1-2009 Soil strength and consolidation tests – Soil classification tests – Determination of the California Bearing Ratio of a soil

AS 1289.6.3.2-1997 Methods of testing soils for engineering purposes – Soil strength and consolidation tests – Determination of the penetration resistance of a soil – 9kg dynamic cone penetrometer test

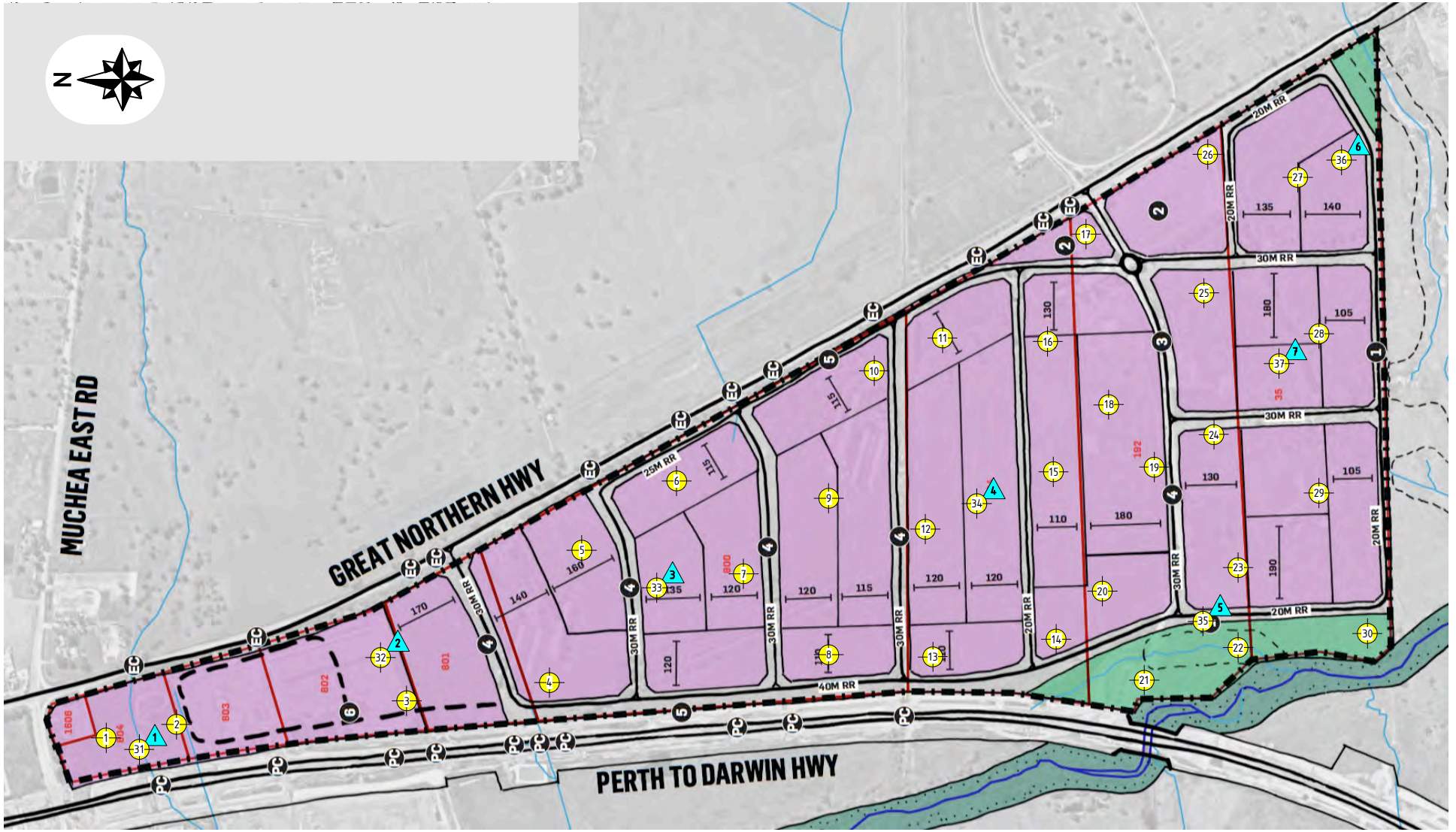
AS 1726-2017 Geotechnical site investigation

AS 2870-2011 Residential slabs and footings

AS 3798-2007 Guidelines on earthworks for commercial and residential developments

AS 4055-2012 Wind loads for housing

APPENDIX 1 – SITE LOCATION MAP



Note: Showing approximate test locations only

LEGEND

BH: Borehole

PERC: Percolation Test

STRUCterre consulting engineers

Zemla Pty Ltd (ABN 71 349 772 837) ATF the Young Purich and Higham Unit Trust trading as Structerre Consulting Engineers

1 ERINDALE ROAD, BALCATTA, WA 6021
TEL 9205 4500 FAX 9205 4501 EMAIL: wageotecheng@structerre.com.au

PROJECT:	Muchea Employment Node - Precinct 3 - Muchea
PROJECT #:	D206263
JOB #:	J315642
CLIENT:	**Muchea Employment Node Precinct 3 Land Owners**
SCALE:	NTS
TITLE:	Geotechnical Investigation Site Plan
DATE:	26 Nov '18
DRAWN BY:	MM
CHECKED BY:	DH

© COPYRIGHT STRUCTERRE CONSULTING GROUP - JUL'05

APPENDIX 2 – SITE PHOTOS



PHOTO 1



PHOTO 2

STRUCterre consulting engineers

Zemla Pty Ltd (ABN 71 349 772 837) ATF the Young Purich and Higham Unit Trust trading as Structerre Consulting Engineers

1 ERINDALE ROAD, BALCATTA, WA 6021
TEL 9205 4500 FAX 9205 4501 EMAIL: wageotecheng@structerre.com.au

PROJECT:	Muchea Employment Node - Precinct 3 - Muchea
PROJECT #:	D206263
JOB #:	J315642
CLIENT:	**Muchea Employment Node Precinct 3 Land Owners**
SCALE:	NTS
TITLE:	Site Photographs
DATE:	26 Nov '18
DRAWN BY:	MM
CHECKED BY:	DH

© COPYRIGHT STRUCTERRE CONSULTING GROUP - JUL'05



PHOTO 3 - Sample taken BH1



PHOTO 4 - Sample taken BH28

STRUCterre consulting engineers

Zemla Pty Ltd (ABN 71 349 772 837) ATF the Young Purich and Higham Unit Trust trading as Structerre Consulting Engineers

1 ERINDALE ROAD, BALCATTA, WA 6021
TEL 9205 4500 FAX 9205 4501 EMAIL: wageotecheng@structerre.com.au

PROJECT:	Muchea Employment Node - Precinct 3 - Muchea
PROJECT #:	D206263
JOB #:	J315642
CLIENT:	**Muchea Employment Node Precinct 3 Land Owners**
SCALE:	NTS
TITLE:	Site Photographs
DATE:	26 Nov '18
DRAWN BY:	MM
CHECKED BY:	DH

© COPYRIGHT STRUCTERRE CONSULTING GROUP - JUL'05

APPENDIX 3 – BORELOGS

STRUCterre consulting engineers

Project Muchea Employment Node - Precinct 3 - Muchea

Client Muchea Employment Node Precinct 3 Land Owners

Test No. **BH01**

Project No.	D206263	**Logged By**	Craig Pummell	**Machine**	Soil Retrieval Probe	**Easting**	404631
Job No.	J315642	**Date**	26/11/2018	**Hole Dia.**	65mm	**Northing**	6505901

Depth	Graphic	Stratum Description	Consistency	DCP Blows/150mm (5 10 15 20)	Samples Depth	Samples Type	Moisture	Water Level
		Topsoil:	MD		0.1 - 1.0	B	D to M	
		CH: Sandy CLAY: fine to medium grained, high plasticity, with gravel, grey (Guildford Formation)						
		mottled grey/brown	St-VSt				M	
1								
							S	
		trace gravel			1.8 - 2.3	B		
2								
		Terminated at 2.30 m						
3								

Remarks

1. Termination reason: Refusal - interpreted on stiff clay
2. Hole stability: Hole partially stable
3. Samples taken: As indicated
4. Co-ordinate system: WGS 84

1 Erindale Road, Balcatta, Western Australia 6021 | PO Box 792, Balcatta, Western Australia 6914
Phone (+618) 9205 4500 | Fax (+618) 9205 4501 | Email wageotecheng@structerre.com.au | Web www.structerre.com.au
ABN 71 349 772 837 Zemla Pty Ltd ACN 008 966 283 as trustee for the Young Purich and Higham Unit Trust trading as Structerre Consulting Engineers

STRUCterre consulting engineers

Project Muchea Employment Node - Precinct 3 - Muchea

Client Muchea Employment Node Precinct 3 Land Owners

Test No. **BH02**

Project No.	D206263	**Logged By**	Craig Pummell	**Machine**	Soil Retrieval Probe	**Easting**	404659
Job No.	J315642	**Date**	26/11/2018	**Hole Dia.**	65mm	**Northing**	6505814

Depth	Graphic	Stratum Description	Consistency	DCP Blows/150mm (5 10 15 20)	Samples Depth	Samples Type	Moisture	Water Level
		Topsoil:						
		SP: SAND: fine to medium grained, non-plastic, trace clay, grey/brown (Guildford Formation)	L				D to M	
			MD - D					
			L				M	▼
1		SC: Clayey SAND: fine to medium grained, low plasticity, with gravel, mottled grey/brown					S	
2		CH: Sandy CLAY: fine to medium grained, high plasticity, trace gravel, mottled grey/brown						
		Terminated at 2.50 m						
3								

Remarks

1. Termination reason: Target depth
2. Hole stability: Hole partially stable
3. Samples taken: None
4. Co-ordinate system: WGS 84

STRUCterre consulting engineers

Project Muchea Employment Node - Precinct 3 - Muchea

Client Muchea Employment Node Precinct 3 Land Owners

Test No. **BH03**

Project No.	D206263	**Logged By**	Craig Pummell	**Machine**	Soil Retrieval Probe	**Easting**	404781
Job No.	J315642	**Date**	26/11/2018	**Hole Dia.**	65mm	**Northing**	6505225

Depth	Graphic	Stratum Description	Consistency	DCP Blows/150mm (5 10 15 20)	Samples Depth	Samples Type	Moisture	Water Level
		Topsoil:					D to M	
		SP: SAND: fine to medium grained, non-plastic, grey (Guildford Formation)	L					
		SC: Clayey SAND: fine to medium grained, medium plasticity, with gravel, mottled grey/brown	MD					
			D - VD					
1							M	
		CH: Sandy CLAY: fine to medium grained, high plasticity, trace gravel, mottled grey/brown						
		Terminated at 1.90 m						
2								
3								

Remarks

1. Termination reason: Refusal - interpreted on stiff clay
2. Hole stability: Hole partially stable
3. Samples taken: None
4. Co-ordinate system: WGS 84

STRUCterre consulting engineers

Project Muchea Employment Node - Precinct 3 - Muchea

Client Muchea Employment Node Precinct 3 Land Owners

Test No. **BH04**

Project No.	D206263	**Logged By**	Craig Pummell	**Machine**	Soil Retrieval Probe	**Easting**	404762
Job No.	J315642	**Date**	26/11/2018	**Hole Dia.**	65mm	**Northing**	6504830

Depth	Graphic	Stratum Description	Consistency	DCP Blows/150mm (5 10 15 20)	Samples Depth	Samples Type	Moisture	Water Level
		Topsoil:	D				D to M	
		SP: SAND: fine to medium grained, non-plastic, grey (Guildford Formation)	L - MD					
		SP: Gravelly SAND: coarse grained, non-plastic, trace silt, mottled red/brown						
1		SC: Clayey SAND: fine to medium grained, medium plasticity, with gravel, mottled red/brown					M	
		CH: Sandy CLAY: fine to medium grained, high plasticity, trace gravel, mottled grey/brown						
		Terminated at 1.50 m						
2								
3								

Remarks

1. Termination reason: Refusal - interpreted on stiff clay
2. Hole stability: Hole partially stable
3. Samples taken: None
4. Co-ordinate system: WGS 84

WA | QLD | NSW | VIC

1 Erindale Road, Balcatta, Western Australia 6021 | PO Box 792, Balcatta, Western Australia 6914

Phone (+618) 9205 4500 | Fax (+618) 9205 4501 | Email wageotecheng@structerre.com.au | Web www.structerre.com.au

ABN 71 349 772 837 Zemla Pty Ltd ACN 008 966 283 as trustee for the Young Purich and Higham Unit Trust trading as Structerre Consulting Engineers

STRUCterre consulting engineers

Project Muchea Employment Node - Precinct 3 - Muchea

Client Muchea Employment Node Precinct 3 Land Owners

Test No. **BH05**

Project No.	D206263	**Logged By**	Craig Pummell	**Machine**	Soil Retrieval Probe	**Easting**	405086
Job No.	J315642	**Date**	26/11/2018	**Hole Dia.**	65mm	**Northing**	6504857

Depth	Graphic	Stratum Description	Consistency	DCP Blows/150mm (5 10 15 20)	Samples Depth	Samples Type	Moisture	Water Level
		Topsoil:			0.1 - 1.0	B	D to M	
		SC: Clayey SAND: fine to medium grained, medium plasticity, with gravel, grey (Guildford Formation)	L				M	
		brown						
1			D - VD				W	▼
		CH: Sandy CLAY: fine to medium grained, high plasticity, trace gravel, mottled grey/brown					S	
2								
		Terminated at 2.50 m						
3								

Remarks

1. Termination reason: Target depth
2. Hole stability: Hole partially stable
3. Samples taken: As indicated
4. Co-ordinate system: WGS 84

STRUCterre consulting engineers

Project Muchea Employment Node - Precinct 3 - Muchea

Client Muchea Employment Node Precinct 3 Land Owners

Test No. **BH06**

Project No.	D206263	**Logged By**	Craig Pummell	**Machine**	Soil Retrieval Probe	**Easting**	405259
Job No.	J315642	**Date**	26/11/2018	**Hole Dia.**	65mm	**Northing**	6504622

Depth	Graphic	Stratum Description	Consistency	DCP Blows/150mm (5 10 15 20)	Samples Depth	Samples Type	Moisture	Water Level
0		Topsoil:	D - VD				D to M	
		GP: Sandy GRAVEL: coarse grained, non-plastic, trace silt, grey/brown (Guildford Formation)						
		SC: Clayey SAND: fine to medium grained, medium plasticity, with gravel, brown						
1		Terminated at 1.30 m						
2								
3								

Remarks

1. Termination reason: Refusal - interpreted on stiff clay
2. Hole stability: Hole partially stable
3. Samples taken: None
4. Co-ordinate system: WGS 84

WA | QLD | NSW | VIC

1 Erindale Road, Balcatta, Western Australia 6021 | PO Box 792, Balcatta, Western Australia 6914

Phone (+618) 9205 4500 | Fax (+618) 9205 4501 | Email wageotecheng@structerre.com.au | Web www.structerre.com.au

ABN 71 349 772 837 Zemla Pty Ltd ACN 008 966 283 as trustee for the Young Purich and Higham Unit Trust trading as Structerre Consulting Engineers

STRUCterre consulting engineers

Project Muchea Employment Node - Precinct 3 - Muchea

Client Muchea Employment Node Precinct 3 Land Owners

Test No. **BH07**

Project No.	D206263	**Logged By**	Craig Pummell	**Machine**	Soil Retrieval Probe	**Easting**	404994
Job No.	J315642	**Date**	26/11/2018	**Hole Dia.**	65mm	**Northing**	6504472

Depth	Graphic	Stratum Description	Consistency	DCP Blows/150mm (5 10 15 20)	Samples Depth	Samples Type	Moisture	Water Level
		Topsoil:	D - VD		0.5 - 1.0	B	D to M	
		SP: Gravelly SAND: medium grained, non-plastic, trace silt, grey (Guildford Formation)						
		GP: Sandy GRAVEL: coarse grained, non-plastic, trace silt, grey/brown						
		GC: Clayey GRAVEL: medium to coarse grained, medium plasticity, with sand, mottled red/brown						
1		Terminated at 1.00 m						
2								
3								

Remarks

1. Termination reason: Refusal - interpreted on stiff clay
2. Hole stability: Hole partially stable
3. Samples taken: As indicated
4. Co-ordinate system: WGS 84

WA | QLD | NSW | VIC

1 Erindale Road, Balcatta, Western Australia 6021 | PO Box 792, Balcatta, Western Australia 6914

Phone (+618) 9205 4500 | Fax (+618) 9205 4501 | Email wageotecheng@structerre.com.au | Web www.structerre.com.au

ABN 71 349 772 837 Zemla Pty Ltd ACN 008 966 283 as trustee for the Young Purich and Higham Unit Trust trading as Structerre Consulting Engineers

STRUCterre consulting engineers

Project Muchea Employment Node - Precinct 3 - Muchea

Client Muchea Employment Node Precinct 3 Land Owners

Test No. **BH08**

Project No.	D206263	**Logged By**	Craig Pummell	**Machine**	Soil Retrieval Probe	**Easting**	404755
Job No.	J315642	**Date**	26/11/2018	**Hole Dia.**	65mm	**Northing**	6504337

Depth	Graphic	Stratum Description	Consistency	DCP Blows/150mm (5 10 15 20)	Samples Depth	Samples Type	Moisture	Water Level
		Topsoil:						
		SP: SAND: fine to medium grained, non-plastic, trace silt, pale grey (Guildford Formation)	L					
		GP: Sandy GRAVEL: coarse grained, low plasticity, with clay, red/brown	D - VD				D to M	
		SC: Clayey SAND: fine to medium grained, medium plasticity, with gravel, mottled grey/brown						
1		Terminated at 1.00 m						
2								
3								

Remarks

1. Termination reason: Refusal - interpreted on stiff clay
2. Hole stability: Hole partially stable
3. Samples taken: None
4. Co-ordinate system: WGS 84

WA | QLD | NSW | VIC

1 Erindale Road, Balcatta, Western Australia 6021 | PO Box 792, Balcatta, Western Australia 6914

Phone (+618) 9205 4500 | Fax (+618) 9205 4501 | Email wageotecheng@structerre.com.au | Web www.structerre.com.au

ABN 71 349 772 837 Zemla Pty Ltd ACN 008 966 283 as trustee for the Young Purich and Higham Unit Trust trading as Structerre Consulting Engineers

STRUCterre consulting engineers

Project Muchea Employment Node - Precinct 3 - Muchea

Client Muchea Employment Node Precinct 3 Land Owners

Test No. **BH09**

Project No.	D206263	**Logged By**	Craig Pummell	**Machine**	Soil Retrieval Probe	**Easting**	405126
Job No.	J315642	**Date**	26/11/2018	**Hole Dia.**	65mm	**Northing**	6504288

Depth	Graphic	Stratum Description	Consistency	DCP Blows/150mm (5 10 15 20)	Samples Depth	Samples Type	Moisture	Water Level
		Topsoil:	D - VD				D to M	
		SP: Gravelly SAND: medium grained, non-plastic, trace silt, grey (Guildford Formation)						
		GP: Sandy GRAVEL: coarse grained, medium plasticity, with clay, mottled grey/brown						
		SC: Clayey SAND: fine to medium grained, medium plasticity, with gravel, mottled grey/brown						
1		Terminated at 1.00 m						
2								
3								

Remarks

1. Termination reason: Refusal - interpreted on stiff clay
2. Hole stability: Hole partially stable
3. Samples taken: None
4. Co-ordinate system: WGS 84

WA | QLD | NSW | VIC

1 Erindale Road, Balcatta, Western Australia 6021 | PO Box 792, Balcatta, Western Australia 6914

Phone (+618) 9205 4500 | Fax (+618) 9205 4501 | Email wageotecheng@structerre.com.au | Web www.structerre.com.au

ABN 71 349 772 837 Zemla Pty Ltd ACN 008 966 283 as trustee for the Young Purich and Higham Unit Trust trading as Structerre Consulting Engineers

STRUCterre consulting engineers

Project Muchea Employment Node - Precinct 3 - Muchea

Client Muchea Employment Node Precinct 3 Land Owners

Test No. **BH10**

Project No.	D206263	**Logged By**	Craig Pummell	**Machine**	Soil Retrieval Probe	**Easting**	405415
Job No.	J315642	**Date**	26/11/2018	**Hole Dia.**	65mm	**Northing**	6504305

Depth	Graphic	Stratum Description	Consistency	DCP Blows/150mm (5 10 15 20)	Samples Depth	Samples Type	Moisture	Water Level
0		Topsoil:	L				D	
		SP: Gravelly SAND: medium grained, non-plastic, trace silt, grey (Guildford Formation)						
		GP: Sandy GRAVEL: coarse grained, non-plastic, trace silt, grey/brown	D - VD				D to M	
		SC: Clayey SAND: fine to medium grained, medium plasticity, with gravel, brown						
		Terminated at 0.70 m						
1								
2								
3								

Remarks

1. Termination reason: Refusal - interpreted on stiff clay
2. Hole stability: Hole partially stable
3. Samples taken: None
4. Co-ordinate system: WGS 84

1 Erindale Road, Balcatta, Western Australia 6021 | PO Box 792, Balcatta, Western Australia 6914
Phone (+618) 9205 4500 | Fax (+618) 9205 4501 | Email wageotecheng@structerre.com.au | Web www.structerre.com.au
ABN 71 349 772 837 Zemla Pty Ltd ACN 008 966 283 as trustee for the Young Purich and Higham Unit Trust trading as Structerre Consulting Engineers

STRUCterre consulting engineers

Project Muchea Employment Node - Precinct 3 - Muchea

Client Muchea Employment Node Precinct 3 Land Owners

Test No. **BH11**

Project No.	D206263	**Logged By**	Craig Pummell	**Machine**	Soil Retrieval Probe	**Easting**	405519
Job No.	J315642	**Date**	26/11/2018	**Hole Dia.**	65mm	**Northing**	6504153

Depth	Graphic	Stratum Description	Consistency	DCP Blows/150mm (5 10 15 20)	Samples Depth	Samples Type	Moisture	Water Level
0		Topsoil:	L				D	
		GP: Sandy GRAVEL: medium to coarse grained, non-plastic, trace silt, grey (Guildford Formation)	D - VD					
		brown						
		Terminated at 0.60 m						
1								
2								
3								

Remarks

1. Termination reason: Refusal - interpreted on dense gravel
2. Hole stability: Hole partially stable
3. Samples taken: None
4. Co-ordinate system: WGS 84

STRUCterre consulting engineers

Project Muchea Employment Node - Precinct 3 - Muchea

Client Muchea Employment Node Precinct 3 Land Owners

Test No. **BH12**

Project No.	D206263	**Logged By**	Craig Pummell	**Machine**	Soil Retrieval Probe	**Easting**	405023
Job No.	J315642	**Date**	26/11/2018	**Hole Dia.**	65mm	**Northing**	6504163

Depth	Graphic	Stratum Description	Consistency	DCP Blows/150mm (5 10 15 20)	Samples Depth	Samples Type	Moisture	Water Level
		Topsoil:						
		GP: Sandy GRAVEL: medium to coarse grained, non-plastic, trace silt, grey (Guildford Formation)	L - MD				D	
		brown						
		GC: Clayey GRAVEL: medium to coarse grained, low plasticity, with sand, brown	MD - D		0.7 - 1.3	B	D to M	▼
1							S	
		Terminated at 1.50 m						
2								
3								

Remarks

1. Termination reason: Refusal - interpreted on stiff clay
2. Hole stability: Hole partially stable
3. Samples taken: As indicated
4. Co-ordinate system: WGS 84

STRUCterre consulting engineers

Project Muchea Employment Node - Precinct 3 - Muchea

Client Muchea Employment Node Precinct 3 Land Owners

Test No. **BH13**

Project No.	D206263	**Logged By**	Craig Pummell	**Machine**	Soil Retrieval Probe	**Easting**	404781
Job No.	J315642	**Date**	26/11/2018	**Hole Dia.**	65mm	**Northing**	6504129

Depth	Graphic	Stratum Description	Consistency	DCP Blows/150mm (5 10 15 20)	Samples Depth	Samples Type	Moisture	Water Level
		Topsoil:	VL					
		SP: SAND: fine to medium grained, non-plastic, trace silt, pale grey (Guildford Formation)	MD				D to M	
			VD					
1		SC: Clayey SAND: fine to medium grained, medium plasticity, trace gravel, grey/brown					M	
		SM: Silty SAND: fine to medium grained, grey/brown						
		Terminated at 1.10 m						
2								
3								

Remarks

1. Termination reason: Refusal - interpreted on cemented ground
2. Hole stability: Hole partially stable
3. Samples taken: None
4. Co-ordinate system: WGS 84

STRUCterre consulting engineers

Project Muchea Employment Node - Precinct 3 - Muchea

Client Muchea Employment Node Precinct 3 Land Owners

Test No. **BH14**

Project No.	D206263	**Logged By**	Craig Pummell	**Machine**	Soil Retrieval Probe	**Easting**	404762
Job No.	J315642	**Date**	26/11/2018	**Hole Dia.**	65mm	**Northing**	6503876

Depth	Graphic	Stratum Description	Consistency	DCP Blows/150mm (5 10 15 20)	Samples Depth	Samples Type	Moisture	Water Level
		Topsoil:	L				D to M	
		SP: SAND: fine to medium grained, non-plastic, trace clay, grey (Guildford Formation)	D					
		SC: Clayey SAND: fine to medium grained, medium plasticity, grey/brown					M	
		SM: Silty SAND: fine to medium grained, grey/brown						
		Terminated at 0.60 m	VD					
1								
2								
3								

Remarks

1. Termination reason: Refusal - interpreted on cemented ground
2. Hole stability: Hole stable
3. Samples taken: None
4. Co-ordinate system: WGS 84

1 Erindale Road, Balcatta, Western Australia 6021 | PO Box 792, Balcatta, Western Australia 6914
Phone (+618) 9205 4500 | Fax (+618) 9205 4501 | Email wageotecheng@structerre.com.au | Web www.structerre.com.au
ABN 71 349 772 837 Zemla Pty Ltd ACN 008 966 283 as trustee for the Young Purich and Higham Unit Trust trading as Structerre Consulting Engineers

STRUCterre consulting engineers

Project Muchea Employment Node - Precinct 3 - Muchea

Client Muchea Employment Node Precinct 3 Land Owners

Test No. **BH15**

Project No.	D206263	**Logged By**	Craig Pummell	**Machine**	Soil Retrieval Probe	**Easting**	405114
Job No.	J315642	**Date**	26/11/2018	**Hole Dia.**	65mm	**Northing**	6503886

Depth	Graphic	Stratum Description	Consistency	DCP Blows/150mm (5 10 15 20)	Samples Depth	Samples Type	Moisture	Water Level
		Topsoil:	MD				D	
		GP: Sandy GRAVEL: coarse grained, non-plastic, trace silt, grey (Guildford Formation)	VD					
		brown						
		SC: Clayey SAND: fine to medium grained, medium plasticity, with gravel, brown					M	
1								
		Terminated at 1.50 m						
2								
3								

Remarks

1. Termination reason: Refusal - interpreted on stiff clay
2. Hole stability: Hole partially stable
3. Samples taken: None
4. Co-ordinate system: WGS 84

WA | QLD | NSW | VIC

1 Erindale Road, Balcatta, Western Australia 6021 | PO Box 792, Balcatta, Western Australia 6914

Phone (+618) 9205 4500 | Fax (+618) 9205 4501 | Email wageotecheng@structerre.com.au | Web www.structerre.com.au

ABN 71 349 772 837 Zemla Pty Ltd ACN 008 966 283 as trustee for the Young Purich and Higham Unit Trust trading as Structerre Consulting Engineers

STRUCterre consulting engineers

Project Muchea Employment Node - Precinct 3 - Muchea

Client Muchea Employment Node Precinct 3 Land Owners

Test No. **BH16**

Project No.	D206263	**Logged By**	Craig Pummell	**Machine**	Soil Retrieval Probe	**Easting**	405541
Job No.	J315642	**Date**	27/11/2018	**Hole Dia.**	65mm	**Northing**	6503958

Depth	Graphic	Stratum Description	Consistency	DCP Blows/150mm (5 10 15 20)	Samples Depth	Samples Type	Moisture	Water Level
		Topsoil:						
		GP: Sandy GRAVEL: coarse grained, non-plastic, trace silt, grey (Guildford Formation)	VD				D	
		SC: Clayey SAND: fine to medium grained, medium plasticity, with gravel, brown					M	
1		Terminated at 1.10 m						
2								
3								

Remarks

1. Termination reason: Refusal - interpreted on stiff clay
2. Hole stability: Hole partially stable
3. Samples taken: None
4. Co-ordinate system: WGS 84

1 Erindale Road, Balcatta, Western Australia 6021 | PO Box 792, Balcatta, Western Australia 6914
Phone (+618) 9205 4500 | Fax (+618) 9205 4501 | Email wageotecheng@structerre.com.au | Web www.structerre.com.au

ABN 71 349 772 837 Zemla Pty Ltd ACN 008 966 283 as trustee for the Young Purich and Higham Unit Trust trading as Structerre Consulting Engineers

STRUCterre consulting engineers

Project Muchea Employment Node - Precinct 3 - Muchea

Client Muchea Employment Node Precinct 3 Land Owners

Test No. **BH17**

Project No.	D206263	**Logged By**	Craig Pummell	**Machine**	Soil Retrieval Probe	**Easting**	405694
Job No.	J315642	**Date**	27/11/2018	**Hole Dia.**	65mm	**Northing**	6503838

Depth	Graphic	Stratum Description	Consistency	DCP Blows/150mm (5 10 15 20)	Samples Depth	Samples Type	Moisture	Water Level
		Topsoil:	MD					
		GP: Sandy GRAVEL: coarse grained, non-plastic, trace silt, grey (Guildford Formation)	VD				D	
		SC: Clayey SAND: fine to medium grained, medium plasticity, with gravel, brown					M	
1		Terminated at 1.00 m						
2								
3								

Remarks

1. Termination reason: Refusal - interpreted on stiff clay
2. Hole stability: Hole partially stable
3. Samples taken: None
4. Co-ordinate system: WGS 84

WA | QLD | NSW | VIC

1 Erindale Road, Balcatta, Western Australia 6021 | PO Box 792, Balcatta, Western Australia 6914

Phone (+618) 9205 4500 | Fax (+618) 9205 4501 | Email wageotecheng@structerre.com.au | Web www.structerre.com.au

ABN 71 349 772 837 Zemla Pty Ltd ACN 008 966 283 as trustee for the Young Purich and Higham Unit Trust trading as Structerre Consulting Engineers

STRUCterre consulting engineers

Project Muchea Employment Node - Precinct 3 - Muchea

Client Muchea Employment Node Precinct 3 Land Owners

Test No. **BH18**

Project No.	D206263	**Logged By**	Craig Pummell	**Machine**	Soil Retrieval Probe	**Easting**	405441
Job No.	J315642	**Date**	27/11/2018	**Hole Dia.**	65mm	**Northing**	6503828

Depth	Graphic	Stratum Description	Consistency	DCP Blows/150mm (5 10 15 20)	Samples Depth	Samples Type	Moisture	Water Level
		Topsoil:						
		GP: Sandy GRAVEL: coarse grained, non-plastic, trace silt, grey (Guildford Formation)	VD				D	
		SC: Clayey SAND: fine to medium grained, medium plasticity, with gravel, brown			0.5 - 1.0	B	M	
1		Terminated at 1.00 m						
2								
3								

Remarks

1. Termination reason: Refusal - interpreted on stiff clay
2. Hole stability: Hole partially stable
3. Samples taken: As indicated
4. Co-ordinate system: WGS 84

1 Erindale Road, Balcatta, Western Australia 6021 | PO Box 792, Balcatta, Western Australia 6914
Phone (+618) 9205 4500 | Fax (+618) 9205 4501 | Email wageotecheng@structerre.com.au | Web www.structerre.com.au

ABN 71 349 772 837 Zemla Pty Ltd ACN 008 966 283 as trustee for the Young Purich and Higham Unit Trust trading as Structerre Consulting Engineers

STRUCterre consulting engineers

Project Muchea Employment Node - Precinct 3 - Muchea

Client Muchea Employment Node Precinct 3 Land Owners

Test No. **BH19**

Project No.	D206263	**Logged By**	Craig Pummell	**Machine**	Soil Retrieval Probe	**Easting**	405139
Job No.	J315642	**Date**	27/11/2018	**Hole Dia.**	65mm	**Northing**	6503673

Depth	Graphic	Stratum Description	Consistency	DCP Blows/150mm (5 10 15 20)	Samples Depth	Samples Type	Moisture	Water Level
		Topsoil:	D - VD				D	
		GP: Sandy GRAVEL: coarse grained, non-plastic, trace silt, grey (Guildford Formation)						
		SC: Clayey SAND: fine to medium grained, medium plasticity, with gravel, brown					M	
1								
		Terminated at 1.20 m						
2								
3								

Remarks

1. Termination reason: Refusal - interpreted on stiff clay
2. Hole stability: Hole partially stable
3. Samples taken: None
4. Co-ordinate system: WGS 84

1 Erindale Road, Balcatta, Western Australia 6021 | PO Box 792, Balcatta, Western Australia 6914
Phone (+618) 9205 4500 | Fax (+618) 9205 4501 | Email wageotecheng@structerre.com.au | Web www.structerre.com.au
ABN 71 349 772 837 Zemla Pty Ltd ACN 008 966 283 as trustee for the Young Purich and Higham Unit Trust trading as Structerre Consulting Engineers

STRUCterre consulting engineers

Project Muchea Employment Node - Precinct 3 - Muchea

Client Muchea Employment Node Precinct 3 Land Owners

Test No. **BH20**

Project No.	D206263	**Logged By**	Craig Pummell	**Machine**	Soil Retrieval Probe	**Easting**	404895
Job No.	J315642	**Date**	27/11/2018	**Hole Dia.**	65mm	**Northing**	6503792

Depth	Graphic	Stratum Description	Consistency	DCP Blows/150mm (5 10 15 20)	Samples Depth	Samples Type	Moisture	Water Level
		Topsoil:						
		SP: SAND: fine to medium grained, non-plastic, trace silt, grey (Guildford Formation)					D to M	
		SC: Clayey SAND: fine to medium grained, medium plasticity, with gravel, grey	L - MD		0.4 - 0.9	B		
1		CH: Sandy CLAY: fine to medium grained, high plasticity, trace gravel, red/brown	St		0.9 - 1.4	B	M	
		Terminated at 1.40 m						
2								
3								

Remarks

1. Termination reason: Refusal - interpreted on stiff clay
2. Hole stability: Hole partially stable
3. Samples taken: As indicated
4. Co-ordinate system: WGS 84

1 Erindale Road, Balcatta, Western Australia 6021 | PO Box 792, Balcatta, Western Australia 6914
Phone (+618) 9205 4500 | Fax (+618) 9205 4501 | Email wageotecheng@structerre.com.au | Web www.structerre.com.au

ABN 71 349 772 837 Zemla Pty Ltd ACN 008 966 283 as trustee for the Young Purich and Higham Unit Trust trading as Structerre Consulting Engineers

STRUCterre consulting engineers

Project Muchea Employment Node - Precinct 3 - Muchea

Client Muchea Employment Node Precinct 3 Land Owners

Test No. **BH21**

Project No.	D206263	**Logged By**	Craig Pummell	**Machine**	Soil Retrieval Probe	**Easting**	404757
Job No.	J315642	**Date**	27/11/2018	**Hole Dia.**	65mm	**Northing**	6503652

Depth	Graphic	Stratum Description	Consistency	DCP Blows/150mm (5 10 15 20)	Samples Depth	Samples Type	Moisture	Water Level
		Topsoil:	VL				D to M	
		SP: SAND: fine to medium grained, non-plastic, trace silt, grey (Guildford Formation)	D					
		GP: Sandy GRAVEL: medium to coarse grained, non-plastic to low plasticity, with silt, trace clay, brown	VD				W	
		Terminated at 0.90 m						
1								
2								
3								

Remarks

1. Termination reason: Refusal - interpreted on dense gravel
2. Hole stability: Hole stable
3. Samples taken: None
4. Co-ordinate system: WGS 84

1 Erindale Road, Balcatta, Western Australia 6021 | PO Box 792, Balcatta, Western Australia 6914
Phone (+618) 9205 4500 | Fax (+618) 9205 4501 | Email wageotecheng@structerre.com.au | Web www.structerre.com.au
ABN 71 349 772 837 Zemla Pty Ltd ACN 008 966 283 as trustee for the Young Purich and Higham Unit Trust trading as Structerre Consulting Engineers

STRUCterre consulting engineers

Project Muchea Employment Node - Precinct 3 - Muchea

Client Muchea Employment Node Precinct 3 Land Owners

Test No. **BH22**

Project No.	D206263	**Logged By**	Craig Pummell	**Machine**	Soil Retrieval Probe	**Easting**	404782
Job No.	J315642	**Date**	27/11/2018	**Hole Dia.**	65mm	**Northing**	6503525

Depth	Graphic	Stratum Description	Consistency	DCP Blows/150mm (5 10 15 20)	Samples Depth	Samples Type	Moisture	Water Level
		Topsoil:	L				D to M	
		SP: SAND: fine to medium grained, non-plastic, trace silt, grey (Guildford Formation)	VD					
		GP: Sandy GRAVEL: medium to course grained, non-plastic, trace silt, dark brown						
		Terminated at 0.50 m						
1								
2								
3								

Remarks

1. Termination reason: Refusal - interpreted on dense gravel
2. Hole stability: Hole stable
3. Samples taken: None
4. Co-ordinate system: WGS 84

1 Erindale Road, Balcatta, Western Australia 6021 | PO Box 792, Balcatta, Western Australia 6914
Phone (+618) 9205 4500 | Fax (+618) 9205 4501 | Email wageotecheng@structerre.com.au | Web www.structerre.com.au

ABN 71 349 772 837 Zemla Pty Ltd ACN 008 966 283 as trustee for the Young Purich and Higham Unit Trust trading as Structerre Consulting Engineers

STRUCterre consulting engineers

Project Muchea Employment Node - Precinct 3 - Muchea

Client Muchea Employment Node Precinct 3 Land Owners

Test No. **BH23**

Project No.	D206263	**Logged By**	Craig Pummell	**Machine**	Soil Retrieval Probe	**Easting**	404883
Job No.	J315642	**Date**	27/11/2018	**Hole Dia.**	65mm	**Northing**	6503505

Depth	Graphic	Stratum Description	Consistency	DCP Blows/150mm (5 10 15 20)	Samples Depth	Samples Type	Moisture	Water Level
		Topsoil:						
		SP: SAND: fine to medium grained, non-plastic, trace silt, grey (Guildford Formation)	L - MD				D to M	
		pale brown						
		SC: Clayey SAND: fine to medium grained, medium plasticity, trace gravel, grey/brown	D - VD				M	
1		GP: Sandy GRAVEL: medium to course grained, low to medium plasticity, with clay, grey/brown						
		Terminated at 1.00 m						
2								
3								

Remarks

1. Termination reason: Refusal - interpreted on dense gravel
2. Hole stability: Hole stable
3. Samples taken: None
4. Co-ordinate system: WGS 84

1 Erindale Road, Balcatta, Western Australia 6021 | PO Box 792, Balcatta, Western Australia 6914
Phone (+618) 9205 4500 | Fax (+618) 9205 4501 | Email wageotecheng@structerre.com.au | Web www.structerre.com.au

ABN 71 349 772 837 Zemla Pty Ltd ACN 008 966 283 as trustee for the Young Purich and Higham Unit Trust trading as Structerre Consulting Engineers

STRUCterre consulting engineers

Project Muchea Employment Node - Precinct 3 - Muchea

Client Muchea Employment Node Precinct 3 Land Owners

Test No. **BH24**

Project No.	D206263	**Logged By**	Craig Pummell	**Machine**	Soil Retrieval Probe	**Easting**	405259
Job No.	J315642	**Date**	27/11/2018	**Hole Dia.**	65mm	**Northing**	6503609

Depth	Graphic	Stratum Description	Consistency	DCP Blows/150mm (5 10 15 20)	Samples Depth	Samples Type	Moisture	Water Level
		Topsoil:	D - VD				D	
		SP: Gravelly SAND: medium grained, non-plastic, trace silt, grey (Guildford Formation)						
		GP: Sandy GRAVEL: coarse grained, trace silt, pale brown						
		SC: Clayey SAND: fine to medium grained, medium plasticity, with gravel, mottled grey/brown					M	
1								
		Terminated at 1.50 m						
2								
3								

Remarks

1. Termination reason: Refusal - interpreted on stiff clay
2. Hole stability: Hole partially stable
3. Samples taken: None
4. Co-ordinate system: WGS 84

1 Erindale Road, Balcatta, Western Australia 6021 | PO Box 792, Balcatta, Western Australia 6914
Phone (+618) 9205 4500 | Fax (+618) 9205 4501 | Email wageotecheng@structerre.com.au | Web www.structerre.com.au
ABN 71 349 772 837 Zemla Pty Ltd ACN 008 966 283 as trustee for the Young Purich and Higham Unit Trust trading as Structerre Consulting Engineers

STRUCterre consulting engineers

Project Muchea Employment Node - Precinct 3 - Muchea

Client Muchea Employment Node Precinct 3 Land Owners

Test No. **BH25**

Project No.	D206263	**Logged By**	Craig Pummell	**Machine**	Soil Retrieval Probe	**Easting**	405659
Job No.	J315642	**Date**	27/11/2018	**Hole Dia.**	65mm	**Northing**	6503544

Depth	Graphic	Stratum Description	Consistency	DCP Blows/150mm (5 10 15 20)	Samples Depth	Samples Type	Moisture	Water Level
		Topsoil:						
		GP: Sandy GRAVEL: coarse grained, non-plastic, trace silt, grey (Guildford Formation)					D	
		mottled red/brown	VD					
		SC: Clayey SAND: fine to medium grained, medium plasticity, with gravel, brown					M	
1								
		Terminated at 1.20 m						
2								
3								

Remarks

1. Termination reason: Refusal - interpreted on stiff clay
2. Hole stability: Hole partially stable
3. Samples taken: None
4. Co-ordinate system: WGS 84

1 Erindale Road, Balcatta, Western Australia 6021 | PO Box 792, Balcatta, Western Australia 6914
Phone (+618) 9205 4500 | Fax (+618) 9205 4501 | Email wageotecheng@structerre.com.au | Web www.structerre.com.au
ABN 71 349 772 837 Zemla Pty Ltd ACN 008 966 283 as trustee for the Young Purich and Higham Unit Trust trading as Structerre Consulting Engineers

STRUCterre consulting engineers

Project Muchea Employment Node - Precinct 3 - Muchea

Client Muchea Employment Node Precinct 3 Land Owners

Test No. **BH26**

Project No.	D206263	**Logged By**	Craig Pummell	**Machine**	Soil Retrieval Probe	**Easting**	405858
Job No.	J315642	**Date**	27/11/2018	**Hole Dia.**	65mm	**Northing**	6503568

Depth	Graphic	Stratum Description	Consistency	DCP Blows/150mm (5 10 15 20)	Samples Depth	Samples Type	Moisture	Water Level
		Topsoil:					D	
		GP: Sandy GRAVEL: coarse grained, non-plastic, trace silt, mottled red/brown (Guildford Formation)	VD					
		trace clay,					D to M	
		Terminated at 0.70 m						
1								
2								
3								

Remarks

1. Termination reason: Refusal - interpreted on dense gravel
2. Hole stability: Hole partially stable
3. Samples taken: None
4. Co-ordinate system: WGS 84

1 Erindale Road, Balcatta, Western Australia 6021 | PO Box 792, Balcatta, Western Australia 6914
Phone (+618) 9205 4500 | Fax (+618) 9205 4501 | Email wageotecheng@structerre.com.au | Web www.structerre.com.au
ABN 71 349 772 837 Zemla Pty Ltd ACN 008 966 283 as trustee for the Young Purich and Higham Unit Trust trading as Structerre Consulting Engineers

STRUCterre consulting engineers

Project Muchea Employment Node - Precinct 3 - Muchea

Client Muchea Employment Node Precinct 3 Land Owners

Test No. **BH27**

Project No.	D206263	**Logged By**	Craig Pummell	**Machine**	Soil Retrieval Probe	**Easting**	405874
Job No.	J315642	**Date**	27/11/2018	**Hole Dia.**	65mm	**Northing**	6503343

Depth	Graphic	Stratum Description	Consistency	DCP Blows/150mm (5 10 15 20)	Samples Depth	Samples Type	Moisture	Water Level
		Topsoil:	MD				D	
		GP: Sandy GRAVEL: coarse grained, non-plastic, trace silt, grey (Guildford Formation)						
		trace clay, mottled grey/brown	VD					
		SC: Clayey SAND: fine to medium grained, medium plasticity, with gravel, brown					D to M	
1		CH: Sandy CLAY: fine to medium grained, high plasticity, with gravel, brown					M	
		Terminated at 1.50 m						
2								
3								

Remarks

1. Termination reason: Refusal - interpreted on stiff clay
2. Hole stability: Hole partially stable
3. Samples taken: None
4. Co-ordinate system: WGS 84

1 Erindale Road, Balcatta, Western Australia 6021 | PO Box 792, Balcatta, Western Australia 6914
Phone (+618) 9205 4500 | Fax (+618) 9205 4501 | Email wageotecheng@structerre.com.au | Web www.structerre.com.au

ABN 71 349 772 837 Zemla Pty Ltd ACN 008 966 283 as trustee for the Young Purich and Higham Unit Trust trading as Structerre Consulting Engineers

STRUCterre consulting engineers

Project Muchea Employment Node - Precinct 3 - Muchea

Client Muchea Employment Node Precinct 3 Land Owners

Test No. **BH28**

Project No.	D206263	**Logged By**	Craig Pummell	**Machine**	Soil Retrieval Probe	**Easting**	405419
Job No.	J315642	**Date**	27/11/2018	**Hole Dia.**	65mm	**Northing**	6503299

Depth	Graphic	Stratum Description	Consistency	DCP Blows/150mm (5 10 15 20)	Samples Depth	Samples Type	Moisture	Water Level
		Topsoil:	L				D	
		GP: Sandy GRAVEL: coarse grained, non-plastic, trace silt, grey (Guildford Formation)	VD					
		SC: Clayey SAND: fine to medium grained, medium plasticity, with gravel, pale brown						
		Terminated at 0.60 m						
1								
2								
3								

Remarks

1. Termination reason: Refusal - interpreted on dense gravel
2. Hole stability: Hole partially stable
3. Samples taken: None
4. Co-ordinate system: WGS 84

1 Erindale Road, Balcatta, Western Australia 6021 | PO Box 792, Balcatta, Western Australia 6914
Phone (+618) 9205 4500 | Fax (+618) 9205 4501 | Email wageotecheng@structerre.com.au | Web www.structerre.com.au

ABN 71 349 772 837 Zemla Pty Ltd ACN 008 966 283 as trustee for the Young Purich and Higham Unit Trust trading as Structerre Consulting Engineers

STRUCterre consulting engineers

Project Muchea Employment Node - Precinct 3 - Muchea

Client Muchea Employment Node Precinct 3 Land Owners

Test No. **BH29**

Project No.	D206263	**Logged By**	Craig Pummell	**Machine**	Soil Retrieval Probe	**Easting**	405018
Job No.	J315642	**Date**	27/11/2018	**Hole Dia.**	65mm	**Northing**	6503272

Depth	Graphic	Stratum Description	Consistency	DCP Blows/150mm (5 10 15 20)	Samples Depth	Samples Type	Moisture	Water Level
		Topsoil:						
		SP: SAND: fine to medium grained, non-plastic, trace silt, pale grey (Guildford Formation)	L - MD				D to M	
		SC: Clayey SAND: fine to medium grained, medium plasticity, grey	D - VD				M	
		SP: Silty SAND: fine to medium grained, grey/brown					D	
		Terminated at 0.80 m						
1								
2								
3								

Remarks

1. Termination reason: Refusal - interpreted on cemented ground
2. Hole stability: Hole partially stable
3. Samples taken: None
4. Co-ordinate system: WGS 84

1 Erindale Road, Balcatta, Western Australia 6021 | PO Box 792, Balcatta, Western Australia 6914
Phone (+618) 9205 4500 | Fax (+618) 9205 4501 | Email wageotecheng@structerre.com.au | Web www.structerre.com.au
ABN 71 349 772 837 Zemla Pty Ltd ACN 008 966 283 as trustee for the Young Purich and Higham Unit Trust trading as Structerre Consulting Engineers

STRUCterre consulting engineers

Project Muchea Employment Node - Precinct 3 - Muchea

Client Muchea Employment Node Precinct 3 Land Owners

Test No. **BH30**

Project No.	D206263	**Logged By**	Craig Pummell	**Machine**	Soil Retrieval Probe	**Easting**	404849
Job No.	J315642	**Date**	27/11/2018	**Hole Dia.**	65mm	**Northing**	6503206

Depth	Graphic	Stratum Description	Consistency	DCP Blows/150mm (5 10 15 20)	Samples Depth	Samples Type	Moisture	Water Level
		Topsoil:	L					
		SP: SAND: fine to medium grained, non-plastic, trace silt, pale grey (Guildford Formation)	D		0.6 - 1.0	B	D to M	
		SC: Clayey SAND: fine to medium grained, medium plasticity, grey	MD					
			VD				M	
1		Terminated at 1.00 m						
2								
3								

Remarks

1. Termination reason: Refusal - interpreted on dense gravel
2. Hole stability: Hole partially stable
3. Samples taken: As indicated
4. Co-ordinate system: WGS 84

WA | QLD | NSW | VIC

1 Erindale Road, Balcatta, Western Australia 6021 | PO Box 792, Balcatta, Western Australia 6914

Phone (+618) 9205 4500 | Fax (+618) 9205 4501 | Email wageotecheng@structerre.com.au | Web www.structerre.com.au

ABN 71 349 772 837 Zemla Pty Ltd ACN 008 966 283 as trustee for the Young Purich and Higham Unit Trust trading as Structerre Consulting Engineers

STRUCterre consulting engineers

Project Muchea Employment Node - Precinct 3 - Muchea

Client Muchea Employment Node Precinct 3 Land Owners

Test No. **BH31**

Project No.	D206263	**Logged By**	Craig Pummell	**Machine**	Hand Auger	**Easting**	
Job No.	J315642	**Date**	27/11/2018	**Hole Dia.**	65mm	**Northing**	

Depth	Graphic	Stratum Description	Consistency	DCP Blows/150mm (5 10 15 20)	Samples Depth	Samples Type	Moisture	Water Level
		Topsoil:						
		SP: SAND: fine to medium grained, non-plastic, with silt, trace gravel, brown (Guildford Formation)	MD - D				D to M	
		SC: Clayey SAND: fine to medium grained, low plasticity, trace gravel, yellow/brown	L - MD				D to M	
1		Terminated at 1.00 m	D					
2								
3								

Remarks

1. Termination reason: Target depth - permeability test
2. Hole stability: Hole stable
3. Samples taken: None
4. Co-ordinate system: WGS 84

STRUCterre consulting engineers

Project Muchea Employment Node - Precinct 3 - Muchea

Client Muchea Employment Node Precinct 3 Land Owners

Test No. **BH32**

Project No.	D206263	**Logged By**	Craig Pummell	**Machine**	Hand Auger	**Easting**	
Job No.	J315642	**Date**	27/11/2018	**Hole Dia.**	65mm	**Northing**	

Depth	Graphic	Stratum Description	Consistency	DCP Blows/150mm (5 10 15 20)	Samples Depth	Samples Type	Moisture	Water Level
		Topsoil:	MD - D				D to M	
		SP: SAND: fine to medium grained, non-plastic, trace gravel, trace organic material (fine roots), grey/brown (Guildford Formation)						
		SC: Clayey SAND: fine to medium grained, low plasticity, trace gravel, yellow/brown						
		Terminated at 0.70 m	VD					
1								
2								
3								

Remarks

1. Termination reason: Refusal - interpreted on dense gravel
2. Hole stability: Hole stable
3. Samples taken: None
4. Co-ordinate system: WGS 84

1 Erindale Road, Balcatta, Western Australia 6021 | PO Box 792, Balcatta, Western Australia 6914
Phone (+618) 9205 4500 | Fax (+618) 9205 4501 | Email wageotecheng@structerre.com.au | Web www.structerre.com.au
ABN 71 349 772 837 Zemla Pty Ltd ACN 008 966 283 as trustee for the Young Purich and Higham Unit Trust trading as Structerre Consulting Engineers

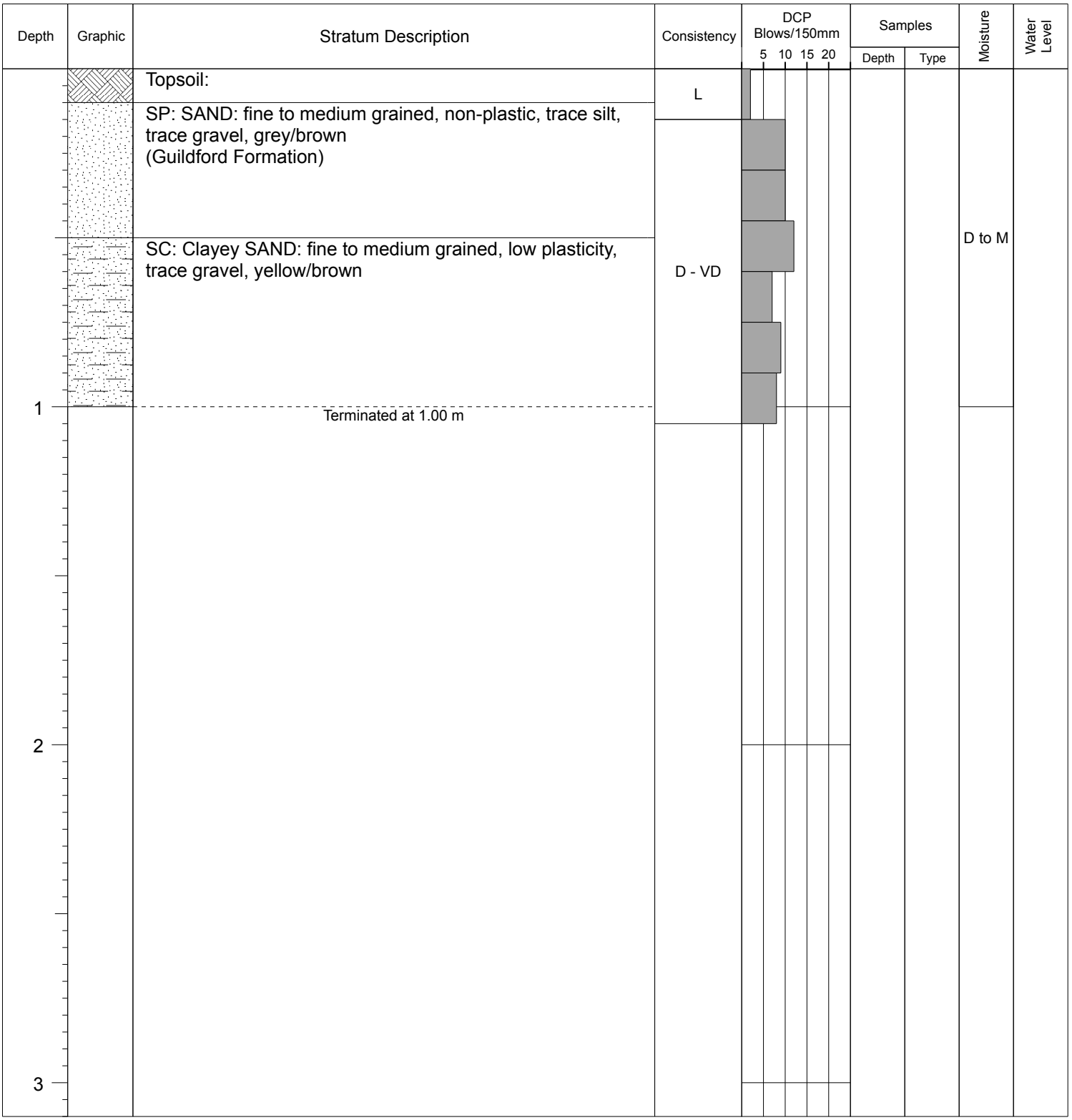
STRUCterre consulting engineers

Project Muchea Employment Node - Precinct 3 - Muchea

Client Muchea Employment Node Precinct 3 Land Owners

Test No. **BH33**

Project No.	D206263	**Logged By**	Craig Pummell	**Machine**	Hand Auger	**Easting**	
Job No.	J315642	**Date**	27/11/2018	**Hole Dia.**	65mm	**Northing**	



Remarks

1. Termination reason: Target depth - permeability test
2. Hole stability: Hole stable
3. Samples taken: None
4. Co-ordinate system: WGS 84

WA | QLD | NSW | VIC

1 Erindale Road, Balcatta, Western Australia 6021 | PO Box 792, Balcatta, Western Australia 6914

Phone (+618) 9205 4500 | Fax (+618) 9205 4501 | Email wageotecheng@structerre.com.au | Web www.structerre.com.au

ABN 71 349 772 837 Zemla Pty Ltd ACN 008 966 283 as trustee for the Young Purich and Higham Unit Trust trading as Structerre Consulting Engineers

STRUCterre consulting engineers

Project Muchea Employment Node - Precinct 3 - Muchea

Client Muchea Employment Node Precinct 3 Land Owners

Test No. **BH34**

Project No.	D206263	**Logged By**	Craig Pummell	**Machine**	Soil Retrieval Probe	**Easting**	
Job No.	J315642	**Date**	27/11/2018	**Hole Dia.**	65mm	**Northing**	

Depth	Graphic	Stratum Description	Consistency	DCP Blows/150mm (5 10 15 20)	Samples Depth	Samples Type	Moisture	Water Level
		Topsoil:						
		SP: Gravelly SAND: fine to medium grained, non-plastic, with silt, grey/brown (Guildford Formation)	VD				D	
		SC: Clayey SAND: fine to medium grained, low plasticity, with gravel, mottled grey/brown					D to M	
1		Terminated at 1.00 m						
2								
3								

Remarks

1. Termination reason: Target depth - permeability test
2. Hole stability: Hole partially stable
3. Samples taken: None
4. Co-ordinate system: WGS 84

1 Erindale Road, Balcatta, Western Australia 6021 | PO Box 792, Balcatta, Western Australia 6914
Phone (+618) 9205 4500 | Fax (+618) 9205 4501 | Email wageotecheng@structerre.com.au | Web www.structerre.com.au
ABN 71 349 772 837 Zemla Pty Ltd ACN 008 966 283 as trustee for the Young Purich and Higham Unit Trust trading as Structerre Consulting Engineers

STRUCterre consulting engineers

Project Muchea Employment Node - Precinct 3 - Muchea

Client Muchea Employment Node Precinct 3 Land Owners

Test No. **BH35**

Project No.	D206263	**Logged By**	Craig Pummell	**Machine**	Soil Retrieval Probe	**Easting**	
Job No.	J315642	**Date**	27/11/2018	**Hole Dia.**	65mm	**Northing**	

Depth	Graphic	Stratum Description	Consistency	DCP Blows/150mm (5 10 15 20)	Samples Depth	Samples Type	Moisture	Water Level
		Topsoil:	L				D to M	
		SP: SAND: fine to medium grained, non-plastic, trace silt, grey (Guildford Formation)	VD					
		GP: Sandy GRAVEL: medium to course grained, non-plastic, trace silt, dark brown						
		Terminated at 0.50 m						
1								
2								
3								

Remarks

1. Termination reason: Refusal - interpreted on stiff clay
2. Hole stability: Hole partially stable
3. Samples taken: None
4. Co-ordinate system: WGS 84

1 Erindale Road, Balcatta, Western Australia 6021 | PO Box 792, Balcatta, Western Australia 6914
Phone (+618) 9205 4500 | Fax (+618) 9205 4501 | Email wageotecheng@structerre.com.au | Web www.structerre.com.au

ABN 71 349 772 837 Zemla Pty Ltd ACN 008 966 283 as trustee for the Young Purich and Higham Unit Trust trading as Structerre Consulting Engineers

STRUCterre consulting engineers

Project Muchea Employment Node - Precinct 3 - Muchea

Client Muchea Employment Node Precinct 3 Land Owners

Test No. **BH36**

Project No.	D206263	**Logged By**	Craig Pummell	**Machine**	Soil Retrieval Probe	**Easting**	
Job No.	J315642	**Date**	27/11/2018	**Hole Dia.**	65mm	**Northing**	

Depth	Graphic	Stratum Description	Consistency	DCP Blows/150mm (5 10 15 20)	Samples Depth	Samples Type	Moisture	Water Level
		Topsoil:	MD					
		SP: Gravelly SAND: fine to medium grained, non-plastic, with silt, pale grey/brown (Guildford Formation)	VD				D	
		SC: Clayey SAND: fine to medium grained, low plasticity, trace gravel, brown					D to M	
1		Terminated at 1.00 m						
2								
3								

Remarks

1. Termination reason: Target depth - permeability test
2. Hole stability: Hole partially stable
3. Samples taken: None
4. Co-ordinate system: WGS 84

1 Erindale Road, Balcatta, Western Australia 6021 | PO Box 792, Balcatta, Western Australia 6914
Phone (+618) 9205 4500 | Fax (+618) 9205 4501 | Email wageotecheng@structerre.com.au | Web www.structerre.com.au
ABN 71 349 772 837 Zemla Pty Ltd ACN 008 966 283 as trustee for the Young Purich and Higham Unit Trust trading as Structerre Consulting Engineers

STRUCterre consulting engineers

Project Muchea Employment Node - Precinct 3 - Muchea

Client Muchea Employment Node Precinct 3 Land Owners

Test No. **BH37**

Project No.	D206263	**Logged By**	Craig Pummell	**Machine**	Soil Retrieval Probe	**Easting**	
Job No.	J315642	**Date**	27/11/2018	**Hole Dia.**	65mm	**Northing**	

Depth	Graphic	Stratum Description	Consistency	DCP Blows/150mm (5 10 15 20)	Samples Depth	Samples Type	Moisture	Water Level
		Topsoil:	L				D	
		GP: Sandy GRAVEL: coarse grained, non-plastic, trace silt, grey (Guildford Formation)	VD					
		SC: Clayey SAND: fine to medium grained, medium plasticity, with gravel, pale brown						
		Terminated at 0.60 m						
1								
2								
3								

Remarks

1. Termination reason: Refusal - interpreted on stiff clay
2. Hole stability: Hole partially stable
3. Samples taken: None
4. Co-ordinate system: WGS 84

1 Erindale Road, Balcatta, Western Australia 6021 | PO Box 792, Balcatta, Western Australia 6914
Phone (+618) 9205 4500 | Fax (+618) 9205 4501 | Email wageotecheng@structerre.com.au | Web www.structerre.com.au
ABN 71 349 772 837 Zemla Pty Ltd ACN 008 966 283 as trustee for the Young Purich and Higham Unit Trust trading as Structerre Consulting Engineers

APPENDIX 4 – LABORATORY TEST RESULTS

Sample No.	**32126**	**Client**	Geotechnical
Job No.	J315642	**Project**	Muchea Employment Node - Precinct 3, Muchea

Laboratory testing carried out at Balcatta Laboratory 1 Erindale Rd, Balcatta WA 6021

SAMPLE DETAILS

BH No. / Depth : 1 0.1-1m
Sample History : 50°C Oven Dried

Sampling Method Client
Sample Preparation AS 1289 1.1

ATTERBERG LIMITS

Description	Method	Result (%)
Liquid Limit	AS 1289.3.1.2	52
Plastic Limit	AS 1289.3.2.1	20
Plasticity Index	AS 1289.3.3.1	32
Linear Shrinkage	AS 1289.3.4.1	9
Nature of Shrinkage		Flat

PARTICLE SIZE DISTRIBUTION

Method: AS 1289.3.6.1
Description: Particle size distribution by sieve analysis

Sieve Size (mm)	% Passing
19.0	98
2.36	73
0.425	59
0.075	42

AS 1726:2017 Clause 6.1
Material Description: Sandy CLAY with gravel
AS Group Symbol: CH or OH

Accredited for compliance with ISO/IEC 17025

NATA
WORLD RECOGNISED ACCREDITATION
STRUCTERRE CONSULTING ENGINEERS BALCATTA LABORATORY
ACCREDITATION NUMBER 18742

Wayne Rozmianiec
Laboratory Manager

Date: 07-Dec-18

Soils Analysis Workbook V 3.15 22-Nov-18

AS 1289.3.6.1 Report Feb 18

1 Erindale Road, Balcatta, Western Australia 6021 | PO Box 792, Balcatta, Western Australia 6914
Phone (+618) 9205 4500 | Fax (+618) 9205 4501 | Email wageotechlab@structerre.com.au | Web www.structerre.com.au
ABN 71 349 772 837 Zemla Pty Ltd ACN 008 966 283 as trustee for the Young Purich and Higham Unit Trust trading as Structerre Consulting Engineers

Sample No.	**32127**	**Client**	Geotechnical
Job No.	J315642	**Project**	Muchea Employment Node - Precinct 3

Laboratory testing carried out at Balcatta Laboratory 1 Erindale Rd, Balcatta WA 6021

SAMPLE DETAILS

BH No. / Depth : 7 0.7-1m
Sample History : 50°C Oven Dried

Sampling Method Client
Sample Preparation AS 1289 1.1

ATTERBERG LIMITS

Description	Method	Result (%)
Liquid Limit	AS 1289.3.1.2	36
Plastic Limit	AS 1289.3.2.1	17
Plasticity Index	AS 1289.3.3.1	19
Linear Shrinkage	AS 1289.3.4.1	6.5
Nature of Shrinkage		Flat

PARTICLE SIZE DISTRIBUTION

Method: AS 1289.3.6.1
Description: Particle size distribution by sieve analysis

Sieve Size (mm)	% Passing
19.0	88
2.36	59
0.425	52
0.075	33

AS 1726:2017 Clause 6.1
Material Description: Clayey GRAVEL with sand
AS Group Symbol: GC

Accredited for compliance with ISO/IEC 17025
NATA
WORLD RECOGNISED ACCREDITATION
STRUCTERRE CONSULTING ENGINEERS BALCATTA LABORATORY ACCREDITATION NUMBER 18742

Wayne Rozmianiec
Laboratory Manager

Date: 07-Dec-18

Soils Analysis Workbook V 3.15 22-Nov-18

AS 1289.3.6.1 Report Feb 18

1 Erindale Road, Balcatta, Western Australia 6021 | PO Box 792, Balcatta, Western Australia 6914
Phone (+618) 9205 4500 | Fax (+618) 9205 4501 | Email wageotechlab@structerre.com.au | Web www.structerre.com.au
ABN 71 349 772 837 Zemla Pty Ltd ACN 008 966 283 as trustee for the Young Purich and Higham Unit Trust trading as Structerre Consulting Engineers

Sample No.	**32128**	**Client**	Geotechnical
Job No.	J315642	**Project**	Muchea Employment Node - Precinct 3

Laboratory testing carried out at Balcatta Laboratory 1 Erindale Rd, Balcatta WA 6021

SAMPLE DETAILS

BH No. / Depth : 12 0.7-1.3m
Sample History : 50°C Oven Dried

Sampling Method Client
Sample Preparation AS 1289 1.1

ATTERBERG LIMITS

Description	Method	Result (%)
Liquid Limit	AS 1289.3.1.2	34
Plastic Limit	AS 1289.3.2.1	14
Plasticity Index	AS 1289.3.3.1	20
Linear Shrinkage	AS 1289.3.4.1	7
Nature of Shrinkage		Flat

PARTICLE SIZE DISTRIBUTION

Method: AS 1289.3.6.1
Description: Particle size distribution by sieve analysis

Sieve Size (mm)	% Passing
19.0	100
2.36	56
0.425	50
0.075	33

AS 1726:2017 Clause 6.1
Material Description: Clayey GRAVEL with sand
AS Group Symbol: GC

Accredited for compliance with ISO/IEC 17025

NATA
WORLD RECOGNISED ACCREDITATION
STRUCTERRE CONSULTING ENGINEERS BALCATTA LABORATORY
ACCREDITATION NUMBER 18742

Wayne Rozmianiec
Laboratory Manager

Date: 10-Dec-18

WA | QLD | NSW | VIC
1 Erindale Road, Balcatta, Western Australia 6021 | PO Box 792, Balcatta, Western Australia 6914
Phone (+618) 9205 4500 | Fax (+618) 9205 4501 | Email wageotechlab@structerre.com.au | Web www.structerre.com.au
ABN 71 349 772 837 Zemla Pty Ltd ACN 008 966 283 as trustee for the Young Purich and Higham Unit Trust trading as Structerre Consulting Engineers

Sample No.	**32129**	**Client**	Geotechnical
Job No.	J315642	**Project**	Muchea Employment Node - Precinct 3

Laboratory testing carried out at Balcatta Laboratory 1 Erindale Rd, Balcatta WA 6021

SAMPLE DETAILS

BH No. / Depth : 20 0.4-0.9m
Sample History : 50°C Oven Dried

Sampling Method Client
Sample Preparation AS 1289 1.1

ATTERBERG LIMITS

Description	Method	Result (%)
Liquid Limit	AS 1289.3.1.2	37
Plastic Limit	AS 1289.3.2.1	15
Plasticity Index	AS 1289.3.3.1	22
Linear Shrinkage	AS 1289.3.4.1	9
Nature of Shrinkage		Cracked

PARTICLE SIZE DISTRIBUTION

Method: AS 1289.3.6.1
Description: Particle size distribution by sieve analysis

Sieve Size (mm)	% Passing
19.0	100
2.36	71
0.425	62
0.075	33

AS 1726:2017 Clause 6.1
Material Description: Clayey SAND with gravel
AS Group Symbol: SC

Accredited for compliance with ISO/IEC 17025
NATA
WORLD RECOGNISED ACCREDITATION
STRUCTERRE CONSULTING ENGINEERS BALCATTA LABORATORY ACCREDITATION NUMBER 18742

Wayne Rozmianiec
Laboratory Manager

Date: 10-Dec-18

WA | QLD | NSW | VIC
1 Erindale Road, Balcatta, Western Australia 6021 | PO Box 792, Balcatta, Western Australia 6914
Phone (+618) 9205 4500 | Fax (+618) 9205 4501 | Email wageotechlab@structerre.com.au | Web www.structerre.com.au
ABN 71 349 772 837 Zemla Pty Ltd ACN 008 966 283 as trustee for the Young Purich and Higham Unit Trust trading as Structerre Consulting Engineers

APPENDIX 5 – PRI TEST RESULTS

Analysis Results

CSBP Soil and Plant Laboratory

88282
Structerre Consulting Engineers

Lab No	5IS18042	5IS18043	5IS18044	5IS18045	5IS18046	5IS18047
Name	BH2_0.1-0.4M	BH4_0.1-0.4M	BH5_0.1-0.4M	BH11_0.1-0.4M	BH18_0.1-0.4M	BH23_0.1-0.4M
Code	J315642	J315642	J315642	J315642	J315642	J315642
Customer	Structerre	Structerre	Structerre	Structerre	Structerre	Structerre
Depth	0-10	0-10	0-10	0-10	0-10	0-10
Phosphorus Retention Index	4.5	1.8	185.8	6.4	445.7	1.1

CSBP Lab. Extract Value.

APPENDIX 6 – CBR RESULTS

Material Test Certificate

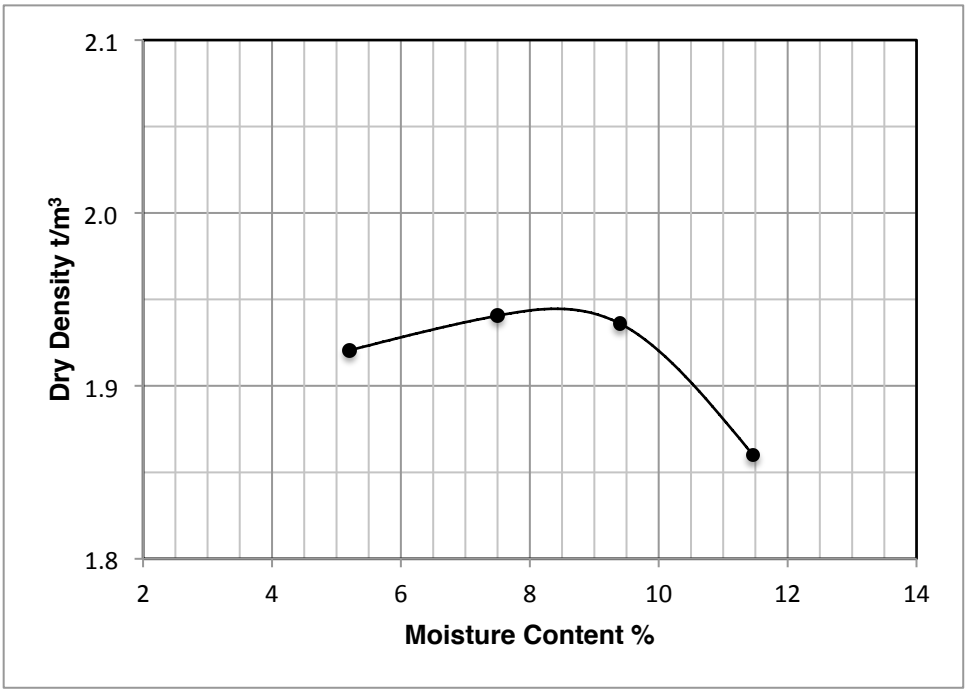
AS 1289.5.2.1 Determination of the dry density/moisture content relation of a soil using modified compactive effort

Client:	INHAM RURAL PROPERTY GROUP PTY LTD	**Job Number:**	S905648
Project:	Muchea Employment Node Precinct 3 - GREAT NORTHERN HWY MUCHEA	**Issue Number:**	1
Report Number:	S905648-A	**Page:**	1 of 1

Laboratory testing carried out at Balcatta Laboratory 1 Erindale Rd Balcatta WA 6021

Sample ID:	BH2_0.1-0.4m	**Date Tested:**	29 Nov 2018
Proposed Use:	-	**Laboratory Number:**	S905648-A-1
Material Type:	Sand	**Depth of Test:**	- mm
		Layer Thickness:	- mm
Sampling Method :	Client	**Site Selection Method:**	Client

Maximum Dry Density t/m³	1.94	**Optimum Moisture Content %**	8.5
% Retained 19mm Sieve	0	**% Retained 37.5mm Sieve**	0
Curing Time hrs	24	**Method used to determine LL**	Visual/Tactile



Notes:

Accredited for compliance with ISO/IEC 17025 – Testing
NATA
WORLD RECOGNISED ACCREDITATION
STRUCTERRE CONSULTING ENGINEERS BALCATTA LABORATORY ACCREDITATION NUMBER 18742

Approved Signatory: Laboratory Manager Wayne Rozmianiec Date: 5 Dec 2018

WA | QLD | NSW | VIC
1 Erindale Road, Balcatta, Western Australia 6021 | PO Box 792, Balcatta, Western Australia 6914
Phone (+618) 9205 4500 | Fax (+618) 9205 4501 | Email wageotechlab@structerre.com.au | Web www.structerre.com.au
ABN 71 349 772 837 Zemla Pty Ltd ACN 008 966 283 as trustee for the Young Purich and Higham Unit Trust trading as Structerre Consulting Engineers

Material Test Certificate

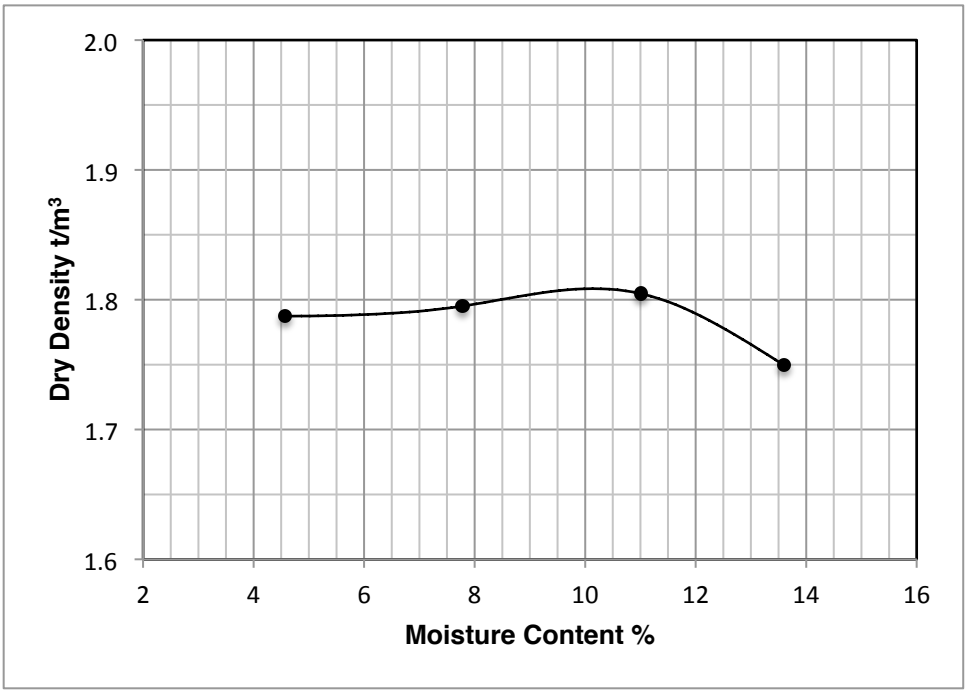
AS 1289.5.2.1 Determination of the dry density/moisture content relation of a soil using modified compactive effort

Client:	INHAM RURAL PROPERTY GROUP PTY LTD	**Job Number:**	S905648
Project:	Muchea Employment Node Precinct 3 - GREAT NORTHERN HWY MUCHEA	**Issue Number:**	1
Report Number:	S905648-A	**Page:**	1 of 1

Laboratory testing carried out at Balcatta Laboratory 1 Erindale Rd Balcatta WA 6021

Sample ID:	BH4_0.1-0.4m	**Date Tested:**	29 Nov 2018
Proposed Use:	-	**Laboratory Number:**	S905648-A-2
Material Type:	Sand	**Depth of Test:**	- mm
		Layer Thickness:	- mm
Sampling Method :	Client	**Site Selection Method:**	Client

Maximum Dry Density t/m³	1.81	**Optimum Moisture Content %**	10.0
% Retained 19mm Sieve	0	**% Retained 37.5mm Sieve**	0
Curing Time hrs	24	**Method used to determine LL**	Visual/Tactile



Notes:

NATA Accredited for compliance with ISO/IEC 17025 – Testing
WORLD RECOGNISED ACCREDITATION
STRUCTERRE CONSULTING ENGINEERS BALCATTA LABORATORY ACCREDITATION NUMBER 18742

Approved Signatory: Laboratory Manager Wayne Rozmianiec Date: 5 Dec 2018

WA | QLD | NSW | VIC
1 Erindale Road, Balcatta, Western Australia 6021 | PO Box 792, Balcatta, Western Australia 6914
Phone (+618) 9205 4500 | Fax (+618) 9205 4501 | Email wageotechlab@structerre.com.au | Web www.structerre.com.au
ABN 71 349 772 837 Zemla Pty Ltd ACN 008 966 283 as trustee for the Young Purich and Higham Unit Trust trading as Structerre Consulting Engineers

Material Test Certificate

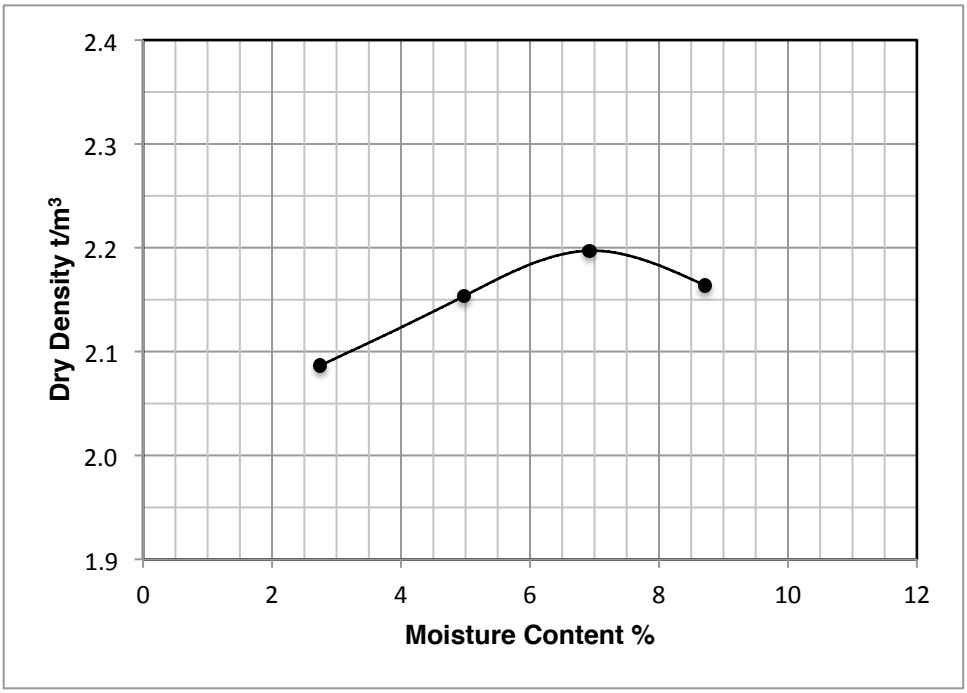
AS 1289.5.2.1 Determination of the dry density/moisture content relation of a soil using modified compactive effort

Client:	INHAM RURAL PROPERTY GROUP PTY LTD	**Job Number:**	S905648
Project:	Muchea Employment Node Precinct 3 - GREAT NORTHERN HWY MUCHEA	**Issue Number:**	1
Report Number:	S905648-A	**Page:**	1 of 1

Laboratory testing carried out at Balcatta Laboratory 1 Erindale Rd Balcatta WA 6021

Sample ID:	BH11_0.1-0.4	**Date Tested:**	29 Nov 2018
Proposed Use:	-	**Laboratory Number:**	S905648-A-3
Material Type:	Sand	**Depth of Test:**	- mm
		Layer Thickness:	- mm
Sampling Method :	Client	**Site Selection Method:**	Client

Maximum Dry Density t/m³	2.20	**Optimum Moisture Content %**	7.0
% Retained 19mm Sieve	1	**% Retained 37.5mm Sieve**	0
Curing Time hrs	24	**Method used to determine LL**	Visual/Tactile



Notes:

NATA Accredited for compliance with ISO/IEC 17025 – Testing
WORLD RECOGNISED ACCREDITATION
STRUCTERRE CONSULTING ENGINEERS BALCATTA LABORATORY ACCREDITATION NUMBER 18742

Approved Signatory:
Laboratory Manager Wayne Rozmianiec Date: 5 Dec 2018

WA | QLD | NSW | VIC
1 Erindale Road, Balcatta, Western Australia 6021 | PO Box 792, Balcatta, Western Australia 6914
Phone (+618) 9205 4500 | Fax (+618) 9205 4501 | Email wageotechlab@structerre.com.au | Web www.structerre.com.au
ABN 71 349 772 837 Zemla Pty Ltd ACN 008 966 283 as trustee for the Young Purich and Higham Unit Trust trading as Structerre Consulting Engineers

Material Test Certificate

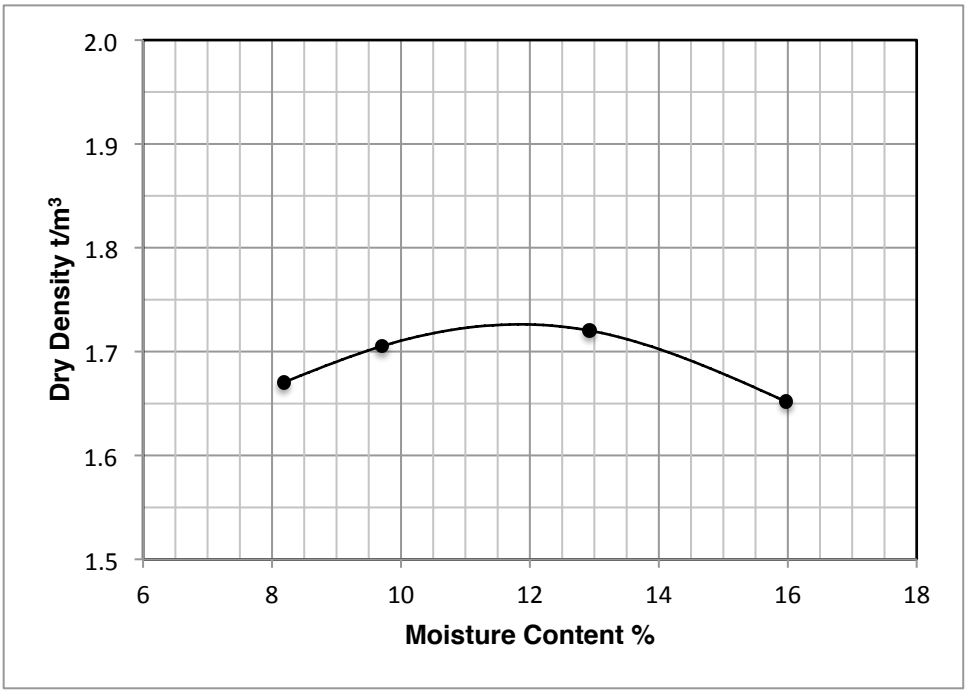
AS 1289.5.2.1 Determination of the dry density/moisture content relation of a soil using modified compactive effort

Client:	INHAM RURAL PROPERTY GROUP PTY LTD	**Job Number:**	S905648
Project:	Muchea Employment Node Precinct 3 - GREAT NORTHERN HWY MUCHEA	**Issue Number:**	1
Report Number:	S905648-A	**Page:**	1 of 1

Laboratory testing carried out at Balcatta Laboratory 1 Erindale Rd Balcatta WA 6021

Sample ID:	BH23_0.1-0.4m	**Date Tested:**	29 Nov 2018
Proposed Use:	-	**Laboratory Number:**	S905648-A-4
Material Type:	Sand	**Depth of Test:**	- mm
		Layer Thickness:	- mm
Sampling Method :	Client	**Site Selection Method:**	Client

Maximum Dry Density t/m³	1.73	**Optimum Moisture Content %**	12.0
% Retained 19mm Sieve	0	**% Retained 37.5mm Sieve**	0
Curing Time hrs	24	**Method used to determine LL**	Visual/Tactile



Notes:

Accredited for compliance with ISO/IEC 17025 – Testing
NATA
WORLD RECOGNISED ACCREDITATION
STRUCTERRE CONSULTING ENGINEERS BALCATTA LABORATORY ACCREDITATION NUMBER 18742

Approved Signatory:
Laboratory Manager

Wayne Rozmianiec

Date: 5 Dec 2018

WA | QLD | NSW | VIC

1 Erindale Road, Balcatta, Western Australia 6021 | PO Box 792, Balcatta, Western Australia 6914

Phone (+618) 9205 4500 | Fax (+618) 9205 4501 | Email wageotechlab@structerre.com.au | Web www.structerre.com.au

ABN 71 349 772 837 Zemla Pty Ltd ACN 008 966 283 as trustee for the Young Purich and Higham Unit Trust trading as Structerre Consulting Engineers

Material Test Certificate

AS 1289.6.1.1 Determination of the California Bearing Ratio of a soil - Standard laboratory method for a remoulded specimen

Client:	INHAM RURAL PROPERTY GROUP PTY LTD	**Job Number:**	S905648
Project:	Muchea Employment Node Precinct 3 - GREAT NORTHERN HWY MUCHEA	**Issue Number:**	1
Report Number:	S905648-A	**Page:**	1 of 1

Laboratory testing carried out at Balcatta Laboratory 1 Erindale Rd Balcatta WA 6021

Sample ID:	BH2_0.1-0.4m	**Date Tested:**	30 Nov 2018
Proposed Use:	Subgrade	**Laboratory Number**	S905648-A-1
Material Type:	Sand	**Depth of Test:**	- mm
Moisture content method	AS 1289.2.1.1	**Layer Thickness:**	- mm
Sampling Method :	Client	**Site Selection Method:**	Client

Compaction

Maximum dry density	t/m^3	1.95
Optimum moisture content	%	8.5
Moisture content at compaction	%	8.0
Laboratory density ratio	%	95.0
Laboratory moisture ratio	%	95.0
Curing time	hrs	2
Method used to determine LL:		Visual/Tactile
Percent retained on 19 mm	%	0
Excluded from compaction or retained		Excluded
Hammer		AS 1289.5.2.1

Soaking

Moisture condition		Soaked
Period of soaking	days	4
Surcharge	kg	4.50
Swell	%	0.0
Dry density after soaking	t/m^3	1.85

Penetration

Moisture content top 30 mm	%	12.1
Moisture content of remainder	%	11.7
California Bearing Ratio	%	30
Penetration	mm	2.5

Notes:

Approved Signatory:
Laboratory Manager Wayne Rozmianiec Date: 19-Jan-18

WA | QLD | NSW | VIC

1 Erindale Road, Balcatta, Western Australia 6021 | PO Box 792, Balcatta, Western Australia 6914
Phone (+618) 9205 4500 | Fax (+618) 9205 4501 | Email wageotechlab@structerre.com.au | Web www.structerre.com.au
ABN 71 349 772 837 Zemla Pty Ltd ACN 008 966 283 as trustee for the Young Purich and Higham Unit Trust trading as Structerre Consulting Engineers

Material Test Certificate

AS 1289.6.1.1 Determination of the California Bearing Ratio of a soil - Standard laboratory method for a remoulded specimen

Client:	INHAM RURAL PROPERTY GROUP PTY LTD	**Job Number:**	S905648
Project:	Muchea Employment Node Precinct 3 - GREAT NORTHERN HWY MUCHEA	**Issue Number:**	1
Report Number:	S905648-A	**Page:**	1 of 1

Laboratory testing carried out at Balcatta Lab 1 Erindale Rd Balcatta WA 6021

Sample ID:	BH4_0.1-0.4m	**Date Tested:**	30 Nov 2018
Proposed Use:	Subgrade	**Laboratory Number**	S905648-A-2
Material Type:	Sand	**Depth of Test:**	- mm
Moisture content method	AS 1289.2.1.1	**Layer Thickness:**	- mm
Sampling Method :	Client	**Site Selection Method:**	Client

Compaction

Maximum dry density	t/m^3	1.81
Optimum moisture content	%	10.0
Moisture content at compaction	%	9.7
Laboratory density ratio	%	95.5
Laboratory moisture ratio	%	96.0
Curing time	hrs	2
Method used to determine LL:		Visual/Tactile
Percent retained on 19 mm	%	0
Excluded from compaction or retained		Excluded
Hammer		AS 1289.5.2.1

Soaking

Moisture condition		Soaked
Period of soaking	days	4
Surcharge	kg	4.50
Swell	%	0.0
Dry density after soaking	t/m^3	1.73

Moisture content top 30 mm	%	15.3
Moisture content of remainder	%	34.0
California Bearing Ratio	%	18
Penetration	mm	2.5

Notes:

Approved Signatory:
Laboratory Manager Wayne Rozmianiec Date: 19-Jan-18

WA | QLD | NSW | VIC

1 Erindale Road, Balcatta, Western Australia 6021 | PO Box 792, Balcatta, Western Australia 6914
Phone (+618) 9205 4500 | Fax (+618) 9205 4501 | Email wageotechlab@structerre.com.au | Web www.structerre.com.au
ABN 71 349 772 837 Zemla Pty Ltd ACN 008 966 283 as trustee for the Young Purich and Higham Unit Trust trading as Structerre Consulting Engineers

Material Test Certificate

AS 1289.6.1.1 Determination of the California Bearing Ratio of a soil - Standard laboratory method for a remoulded specimen

Client:	INHAM RURAL PROPERTY GROUP PTY LTD	**Job Number:**	S905648
Project:	Muchea Employment Node Precinct 3 - GREAT NORTHERN HWY MUCHEA	**Issue Number:**	1
Report Number:	S905648-A	**Page:**	1 of 1

Laboratory testing carried out at Balcatta Lab 1 Erindale Rd Balcatta WA 6021

Sample ID:	BH11_0.1-0.4m	**Date Tested:**	30-Nov-18
Proposed Use:	Subgrade	**Laboratory Number**	S905648-A-3
Material Type:	Sandy Gravel	**Depth of Test:**	- mm
Moisture content method	AS 1289.2.1.1	**Layer Thickness:**	- mm
Sampling Method :	Client	**Site Selection Method:**	Client

Compaction

Maximum dry density	t/m^3	2.20
Optimum moisture content	%	7.0
Moisture content at compaction	%	6.8
Laboratory density ratio	%	94.5
Laboratory moisture ratio	%	97.5
Curing time	hrs	2
Method used to determine LL:		Visual/Tactile
Percent retained on 19 mm	%	1
Excluded from compaction or retained		Excluded
Hammer		AS 1289.5.2.1

Soaking

Moisture condition		Soaked
Period of soaking	days	4
Surcharge	kg	4.50
Swell	%	0.0
Dry density after soaking	t/m^3	2.08

Moisture content top 30 mm	%	10.3
Moisture content of remainder	%	9.8
California Bearing Ratio	%	50
Penetration	mm	5.0

Notes:

Approved Signatory:
Laboratory Manager — Wayne Rozmianiec — Date: 19-Jan-18

WA | QLD | NSW | VIC

1 Erindale Road, Balcatta, Western Australia 6021 | PO Box 792, Balcatta, Western Australia 6914
Phone (+618) 9205 4500 | Fax (+618) 9205 4501 | Email wageotechlab@structerre.com.au | Web www.structerre.com.au
ABN 71 349 772 837 Zemla Pty Ltd ACN 008 966 283 as trustee for the Young Purich and Higham Unit Trust trading as Structerre Consulting Engineers

Material Test Certificate

AS 1289.6.1.1 Determination of the California Bearing Ratio of a soil - Standard laboratory method for a remoulded specimen

Client:	INHAM RURAL PROPERTY GROUP PTY LTD	**Job Number:**	S905648
Project:	Muchea Employment Node Precinct 3 - GREAT NORTHERN HWY MUCHEA	**Issue Number:**	1
Report Number:	S905648-A	**Page:**	1 of 1

Laboratory testing carried out at Balcatta Lab 1 Erindale Rd Balcatta WA 6021

Sample ID:	BH23_0.1-0.4m	**Date Tested:**	30 Nov 2018
Proposed Use:	Subgrade	**Laboratory Number**	S905648-A-4
Material Type:	Sandy Gravel	**Depth of Test:**	- mm
Moisture content method	AS 1289.2.1.1	**Layer Thickness:**	- mm
Sampling Method :	Client	**Site Selection Method:**	Client

Compaction

Maximum dry density	t/m^3	1.73
Optimum moisture content	%	12.0
Moisture content at compaction	%	11.7
Laboratory density ratio	%	95.0
Laboratory moisture ratio	%	98.5
Curing time	hrs	2
Method used to determine LL:		Visual/Tactile
Percent retained on 19 mm	%	0
Excluded from compaction or retained		Excluded
Hammer		AS 1289.5.2.1

Soaking

Moisture condition		Soaked
Period of soaking	days	4
Surcharge	kg	4.50
Swell	%	0.0
Dry density after soaking	t/m^3	1.64

Moisture content top 30 mm	%	18.7
Moisture content of remainder	%	18.0
California Bearing Ratio	%	30
Penetration	mm	2.5

Notes:

Approved Signatory:
Laboratory Manager — Wayne Rozmianiec — Date: 19-Jan-18

WA | QLD | NSW | VIC

1 Erindale Road, Balcatta, Western Australia 6021 | PO Box 792, Balcatta, Western Australia 6914
Phone (+618) 9205 4500 | Fax (+618) 9205 4501 | Email wageotechlab@structerre.com.au | Web www.structerre.com.au
ABN 71 349 772 837 Zemla Pty Ltd ACN 008 966 283 as trustee for the Young Purich and Higham Unit Trust trading as Structerre Consulting Engineers

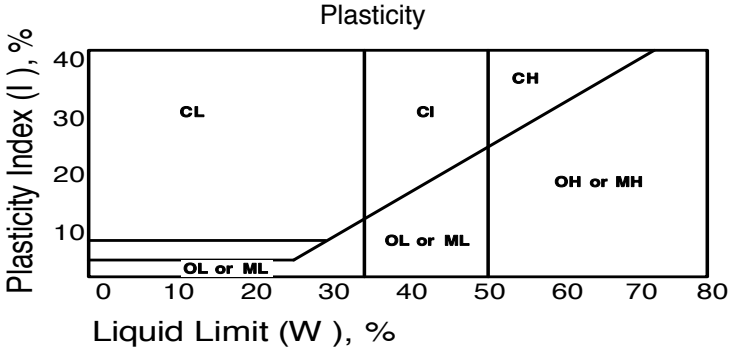
APPENDIX 7 – BORELOG TERMINOLOGY

BOREHOLE TERMINOLOGY

Particle Size Distribution

Major Division	Subdivision	Size
Boulders		>200mm
Cobbles		200 - 63mm
Gravel	Coarse	63 - 20mm
	Medium	20- 6mm
	Fine	6 - 2.36mm
Sand	Coarse	2.36 - 0.6mm
	Medium	0.6 - 0.2mm
	Fine	0.2 - 0.075mm

Plasticity



Consistency of Cohesive Soils

Term	Undrained Strength Su (kPa)	Field Guide
Very Soft	< 12	Exudes between the fingers when squeezed in hand
Soft	12 - 25	Can be moulded by light finger pressure
Firm	25 - 50	Can be moulded by strong finger pressure
Stiff	50 - 100	Cannot be moulded by Fingers. Can be indented by thumb.
Very Stiff	100 - 200	Can be indented by thumb nail
Hard	> 200	Can be indented with difficulty by thumb nail.
Friable	-	Crumbles or powders when scraped by thumbnail

Consistency/Density of Non-Cohesive Soils

Term	Density Index (%)	SPT "N" Value Comparison
Very Loose	< 15	0 - 4
Loose	15 - 35	4 - 10
Medium Dense	35 - 65	10 - 30
Dense	65 - 85	30 - 50
Very Dense	> 85	> 50

Moisture Content

D	Dry
M	Moist
W	Wet
S	Saturated

Minor Components

Term	Assessment Guide	Proportion of Minor Component In:
Trace	Presence just detectable by feel or eye, but soil properties little or no different to general properties of primary component	Coarse grained soils: < 5 % Fine grained soils: <15%
With	Presence easily detected by feel or eye, soil properties little different to general properties of primary component	Coarse grained soils: 5 - 12 % Fine grained soils: 15 - 30%

Soil Legend

FILL	CLAY	GRAVEL	CONCRETE
TOPSOIL	SILT	LIMESTONE	COMBINATIONS
PEAT	SAND	BEDROCK	eg: Clay, Silty, Sandy

USCS

GW	Well graded gravel	SC	Clayey sand	OL	Organic low plasticity silt	CL	Low plasticity clay
GP	Poorly graded gravel	SM	Silty sand	ML	Low plasticity silt	CI	Intermediate plasticity clay
SW	Well graded sand			MH	High plasticity silt	CH	High plasticity clay
SP	Poorly graded sand			OH	Organic high plasticity silt	PT	Peat

DOC:GE:3.003

WA | QLD | NSW | VIC

1 Erindale Road, Balcatta, Western Australia 6021 | PO Box 792, Balcatta, Western Australia 6914

Phone (+618) 9205 4500 | Fax (+618) 9205 4501 | Email wageotecheng@structerre.com.au | Web www.structerre.com.au

ABN 71 349 772 837 Zemla Pty Ltd ACN 008 966 283 as trustee for the Young Purich and Higham Unit Trust trading as Structerre Consulting Engineers

APPENDIX F ELLEN BROOK FLOOD MODELLING

MEMORANDUM

Project:	Muchea Employment Node P3 Waterways		Project No:	P18311
To:	Copy:	Name:	Organisation:	Facsimile:
☒	☐	Phil Bayley	Bayley Environmental Services	
☒	☐	Tom Carmody	Tomahawk Property	
☐	☐			
From:	Brett Stinton		Date: 25 January 2019	Total Pages: 9

Subject:	Muchea Employment Node P3 – Floodway Definition

If you do not receive all pages, or some are unclear, please advise immediately

BG&E Pty Limited (BG&E) has been engaged by the Muchea Employment Node Precinct 3 Landowners Group to carry out a waterways assessment for Ellen Brook to inform the development of the Muchea Employment Node Precinct 3.

As part of the Northlink Stage 3 project, BG&E prepared a TUFLOW hydraulic model for the new Perth to Darwin National Highway (PDNH) bridge which crosses Ellen Brook. This model has been utilised and updated to incorporate the boundary of the concept plan for the Muchea Employment Node Precinct prepared by Urbis. The southern section of the development layout is directly adjacent to the Ellen Brook floodplain where public open space and drainage reserve areas are proposed.

SCOPE

The following scope of works was carried out:

1. Review modelling assumptions in accordance with 2016 edition of Australian Rainfall and Runoff
2. Simulate 1 in 100 annual exceedance probability (AEP) event under current day scenario (including new PDNH)
3. Preliminary definition of floodway based on review of hydraulic model results (depths, velocities etc)
4. Meet with representatives from DWER and Main Roads WA to discuss the project and agree on allowable backwater criteria
5. Update hydraulic model to include earthworks up to the preliminary floodway and review 1 in 100 AEP backwater
6. Refine the floodway and update the hydraulic model with revised earthworks extents to achieve suitable backwater (up to 5 post-development iterations have been assumed)
7. Prepare a memo report summarising the methodology and findings of the project, including polygons for floodway and flood fringe areas similar to those provided by DWER for other areas within Ellen Brook.

The scope of works is limited to the Ellen Brook waterway and does not consider local catchment flows which occur throughout the site from the east via existing culverts beneath Great Eastern Highway. It is expected suitable drainage reserves and infrastructure would be required to manage local catchment flows which would need to be identified as part of a separate study.

TUFLOW MODEL

The TUFLOW 2D hydraulic has been updated to include the outline of the proposed development that lies within the flood extents of the Ellen Brook flood plain and other scenarios where the boundary encroaches further toward the main Ellen Brook channel.

MEETING WITH MAIN ROADS AND DWER

A meeting was held on 15th January 2019 with Simon Rodgers (Supervising Engineer - Floodplain Management) from the Department of Water and Environmental Regulation (DWER) and Eric Cheung (Senior Waterways Engineer) from Main Roads WA, to discuss any potential impacts the development may have. Preliminary results showing the impact on flood levels were tabled. The DWER representative indicated that the impacts were not of concern from a DWER perspective. The Main Roads WA representative was concerned of any potential impacts to the recently constructed PDNH alignment that passes adjacent to the proposed development.

FLOODWAY DEFINITION

The Department of Water and Environmental Regulation (DWER) define the Floodway as *"the river channel and a portion of the floodplain where a significant flow or storage of water occurs during floods. If the floodway is even partially blocked then the natural flooding regime of the area may be detrimentally impacted with flood levels being raised and affecting areas which may not have been previously affected"*.

The following items were considered when defining the floodway:

- 1% AEP pre-development velocity and depth mapping (attached) used to identify areas where higher depths and velocities occur which provide an indication of flood conveyance
- The presence of existing flowpaths within the floodplain which includes the main channel and breakout channel downstream of the PDNH culvert crossing to the north of the bridge. These flowpaths should be maintained to avoid redistribution of flow
- Potential impacts to flood levels as a result of partially blocking the floodplain, based on the hydraulic model results
- The floodway extent adopted by DWER for Ellen Brook to the south of the site. Shapefiles were provided by DWER which show the floodway extending to the edge of the floodplain in some areas. Flood behaviour in the northern section of the dataset is expected to be similar to that within the project site (Figure 1).

Refer to attached plots for 1% AEP pre-development and post-development flood extents. These include the proposed floodway and flood fringe extents. The proposed development footprint is close to but does not encroach into the floodway. The results indicate a maximum increase in flood level of approximately 30 mm near the proposed road, reducing to approximately 10mm at the PDNH PSP.

Scenarios where the earthworks footprint encroaches further into the floodway with offsets ranging from 20m to 80m were also simulated in the hydraulic model to assess potential impacts on the adjacent PDNH. The results indicate an increase in flood levels along the PDNH alignment varying between 40mm for a 40m offset to 90mm for an 80m offset.



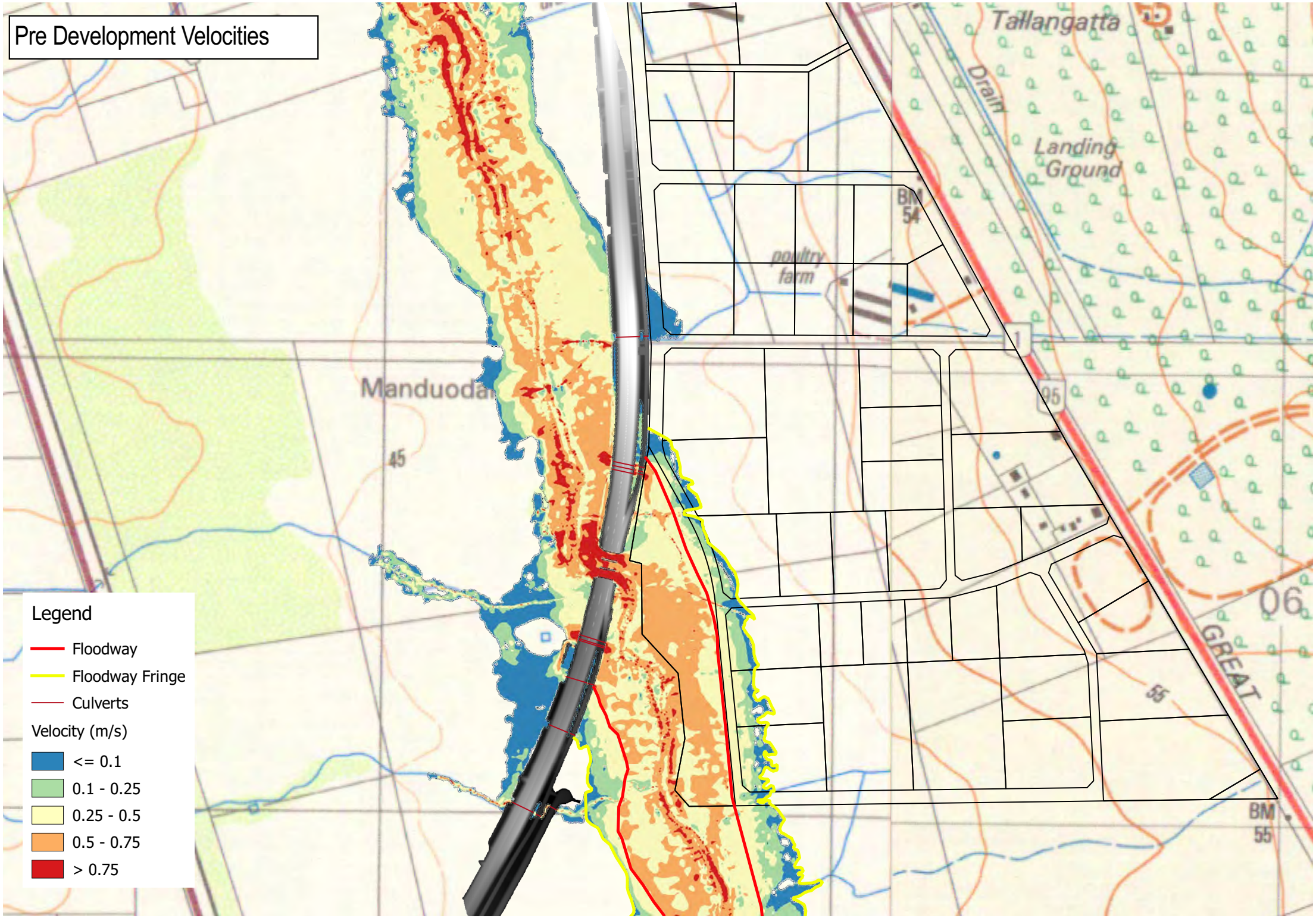
Figure 1 – Downstream floodway definition by DWER

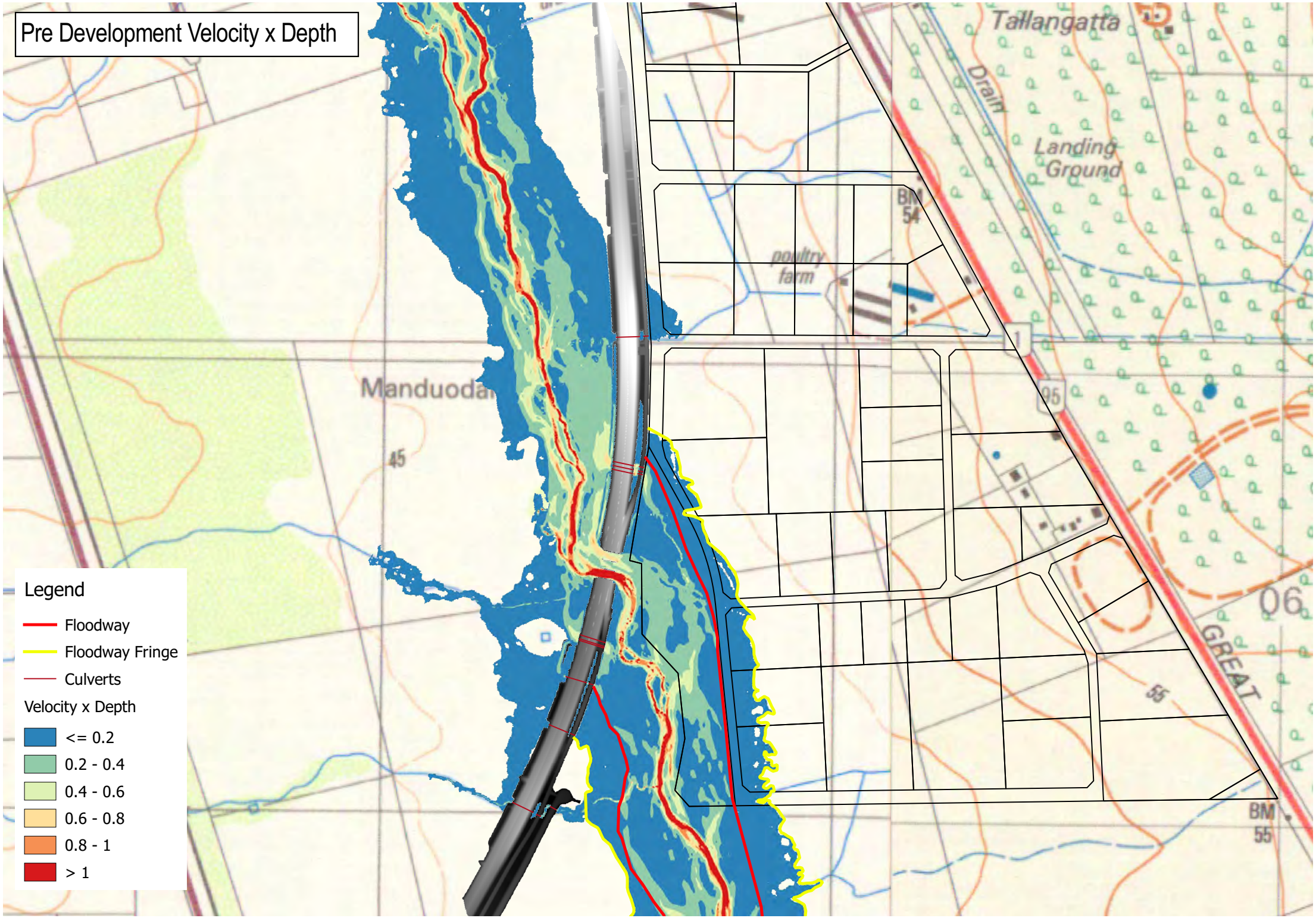
LIMITATIONS

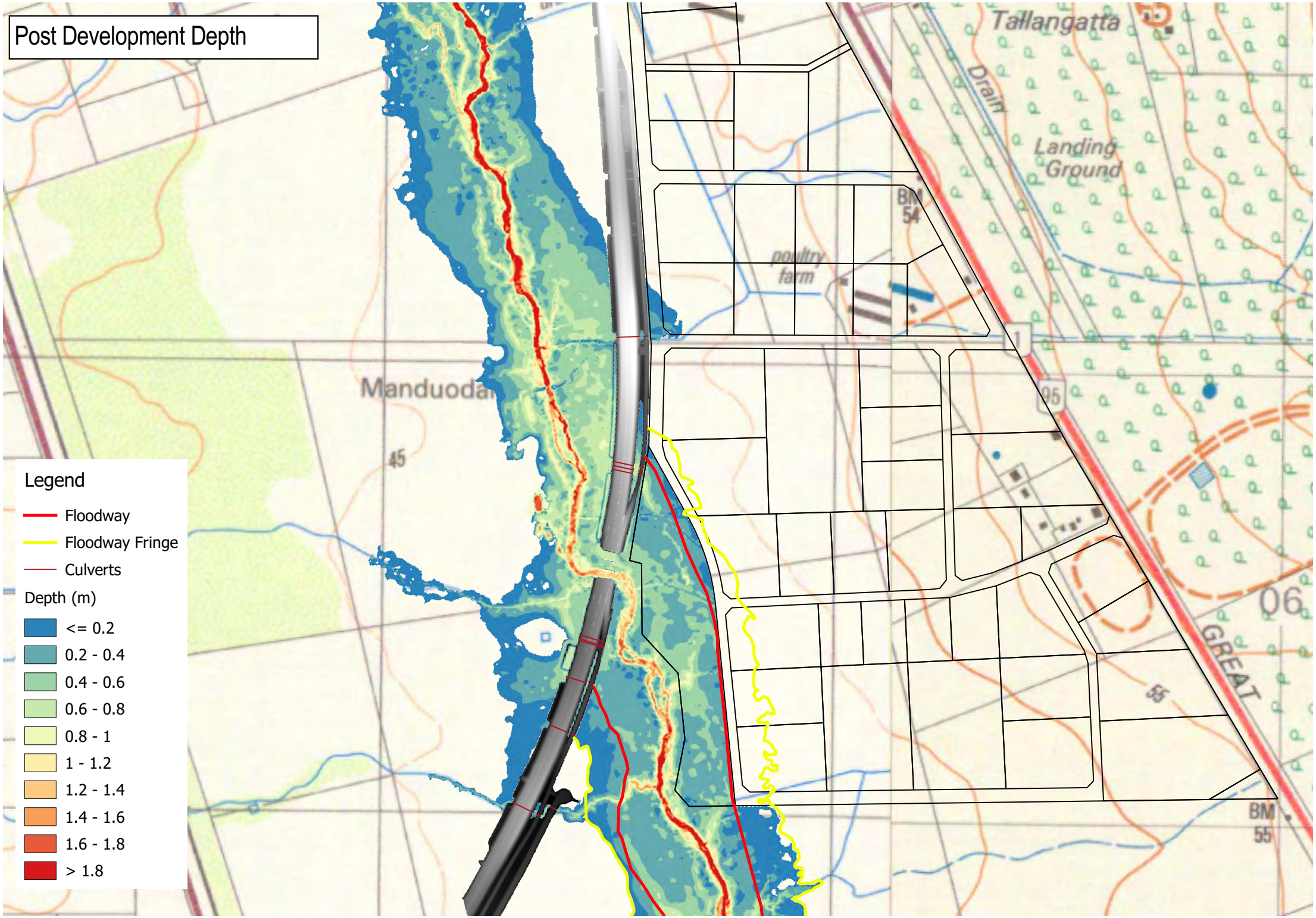
The findings of this study are subject to the following limitations:

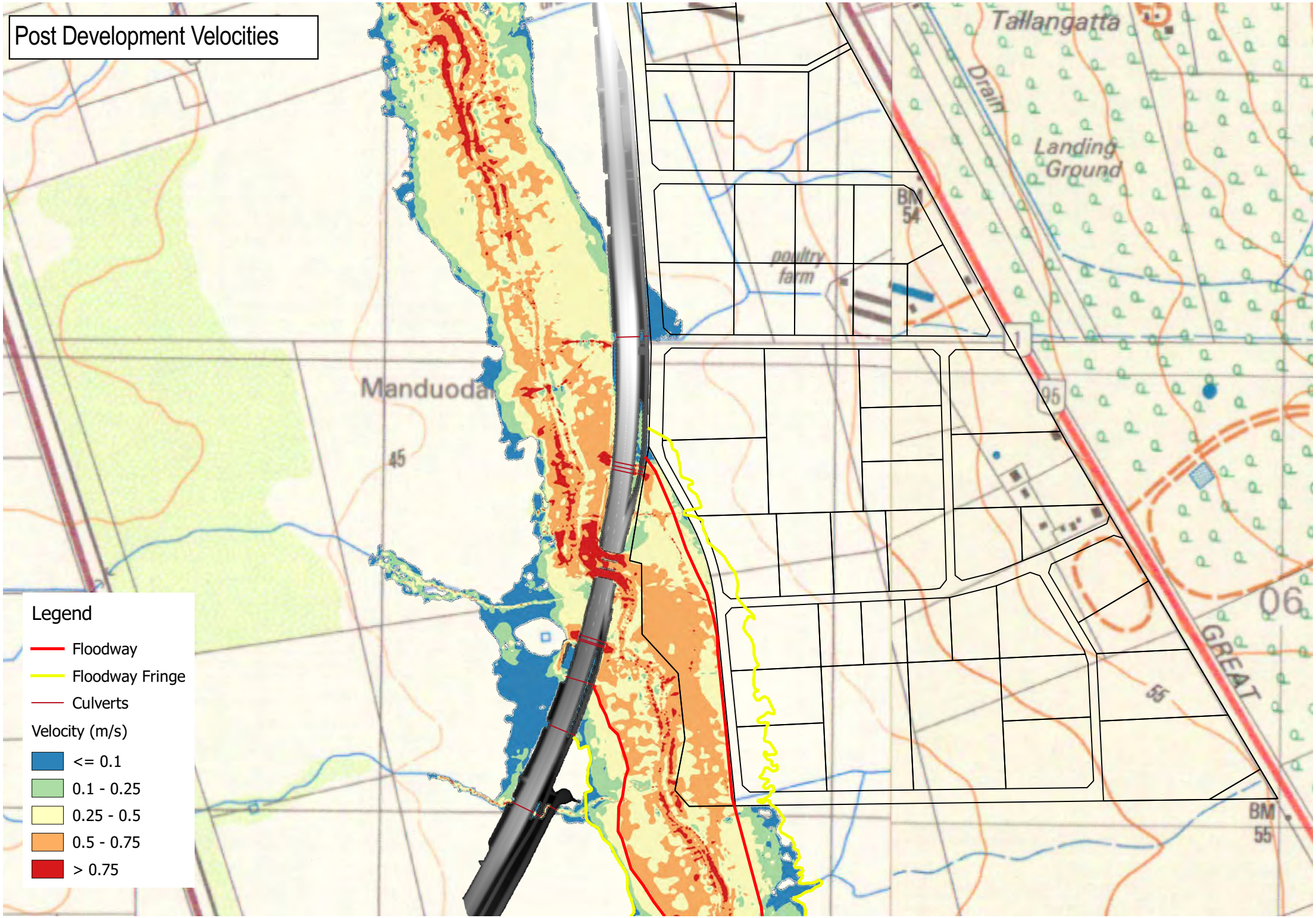
- The scope of works is limited to the Ellen Brook waterway and does not consider local catchment flows which occur throughout the site from the east via existing culverts beneath Great Eastern Highway. It is expected suitable drainage reserves and infrastructure would be required to manage local catchment flows which would need to be identified as part of a separate study.
- No allowance has been made for blockage of drainage infrastructure or increasing flows due to climate change.

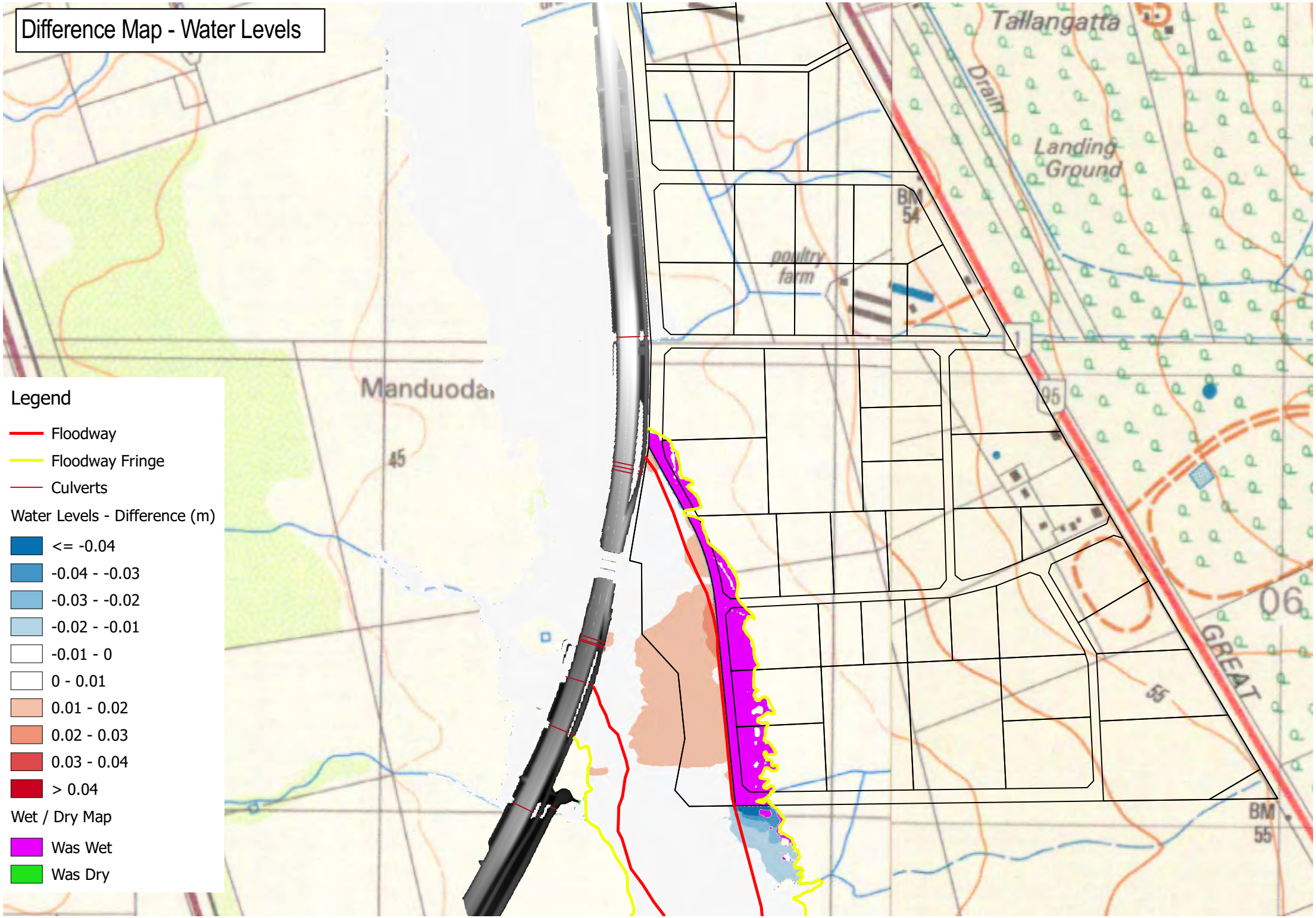

Pre Development Depth
Tallangatta
Drain
Landing Ground
poultry farm
BM 54
Manduoda
45
95
06
GREAT
55
BM 55
Legend
Floodway
Floodway Fringe
Culverts
Depth (m)
<= 0.2
0.2 - 0.4
0.4 - 0.6
0.6 - 0.8
0.8 - 1
1 - 1.2
1.2 - 1.4
1.4 - 1.6
1.6 - 1.8
> 1.8


Pre Development Velocities
Tallangatta
Drain
Landing Ground
poultry farm
BM 54
Manduoda
45
95
06
GREAT
55
BM 55
Legend
Floodway
Floodway Fringe
Culverts
Velocity (m/s)
<= 0.1
0.1 - 0.25
0.25 - 0.5
0.5 - 0.75
> 0.75


Pre Development Velocity x Depth
Tallangatta
Drain
Landing Ground
poultry farm
BM 54
Manduoda
45
95
06
GREAT
55
BM 55
Legend
Floodway
Floodway Fringe
Culverts
Velocity x Depth
<= 0.2
0.2 - 0.4
0.4 - 0.6
0.6 - 0.8
0.8 - 1
> 1


Post Development Depth
Tallangatta
Drain
Landing Ground
poultry farm
BM 54
Manduoda
45
95
06
55
GREAT
BM 55
Legend
Floodway
Floodway Fringe
Culverts
Depth (m)
<= 0.2
0.2 - 0.4
0.4 - 0.6
0.6 - 0.8
0.8 - 1
1 - 1.2
1.2 - 1.4
1.4 - 1.6
1.6 - 1.8
> 1.8


Post Development Velocities
Tallangatta
Drain
Landing Ground
poultry farm
BM 54
Manduoda
45
95
06
GREAT
55
BM 55
Legend
Floodway
Floodway Fringe
Culverts
Velocity (m/s)
<= 0.1
0.1 - 0.25
0.25 - 0.5
0.5 - 0.75
> 0.75


Difference Map - Water Levels
Tallangatta
Drain
Landing Ground
poultry farm
BM 54
Manduoda
45
95
06
55
GREAT
BM 55
Legend
Floodway
Floodway Fringe
Culverts
Water Levels - Difference (m)
<= -0.04
-0.04 - -0.03
-0.03 - -0.02
-0.02 - -0.01
-0.01 - 0
0 - 0.01
0.01 - 0.02
0.02 - 0.03
0.03 - 0.04
> 0.04
Wet / Dry Map
Was Wet
Was Dry

APPENDIX G BUSH FIRE MANAGEMENT PLAN

Bushfire Management Plan

Lots 35, 192, 194, 800, 801, 802, 803 and 804 Great Northern Hwy, Muchea

Prepared for
Muchea Employment Node Precinct 3 Landowner Group, c/- Tomahawk Properties

02 October 2019







DOCUMENT TRACKING

Item	Detail
Project Name	Bushfire Management Plan, Lots 35, 192, 194, 800, 801, 802, 803 and 804 Great Northern
Project Number	18PER-10856
Project Manager	Daniel Panickar Level 1, 235 St Georges Terrace Perth WA 6000
Prepared by	James Leonard
Reviewed by	Daniel Panickar (BPAD37802-L2)
Approved by	Daniel Panickar (BPAD37802-L2)
Status	FINAL
Version Number	V3
Last saved on	2 October 2019

This report should be cited as 'Eco Logical Australia, November 2018. *Bushfire Management Plan, Lots 35, 192, 194, 800, 801, 802, 803 and 804 Great Northern Hwy, Muchea*. Prepared for Muchea Employment Node Precinct 3 Landowner Group, c/-Tomahawk Properties.'

Disclaimer

This document may only be used for the purpose for which it was commissioned and in accordance with the contract between Eco Logical Australia Pty Ltd and Tomahawk Properties. The scope of services was defined in consultation with Tomahawk Properties, by time and budgetary constraints imposed by the client, and the availability of reports and other data on the subject area. Changes to available information, legislation and schedules are made on an ongoing basis and readers should obtain up to date information.

Eco Logical Australia Pty Ltd accepts no liability or responsibility whatsoever for or in respect of any use of or reliance upon this report and its supporting material by any third party. Information provided is not intended to be a substitute for site specific assessment or legal advice in relation to any matter. Unauthorised use of this report in any form is prohibited.

Template 29/9/2015

Contents

1 Introduction 5
1.1 Proposal details 5
1.2 Purpose and application of the plan 5
1.3 Environmental Considerations 5

2 Bushfire Assessment Results 8
2.1 Assessment inputs 8
2.1.1 General 8
2.1.2 Vegetation classification 8
2.1.3 Topography and slope under vegetation 8
2.2 Assessment outputs 10
2.2.1 Bushfire Hazard Level (BHL) assessment 10

3 Identification of Bushfire Hazard issues 13

4 Assessment against the Bushfire Protection Criteria 14
4.1 Compliance 14
4.2 Additional management strategies 15

5 Responsibilities for Implementation and Management of Bushfire Measures 17

6 Conclusion 18

References 19

Appendix A Plates 20

Appendix B Standards for Asset Protection Zones 29

Appendix C Vehicular access technical requirements (WAPC 2017) 31

© ECO LOGICAL AUSTRALIA PTY LTD

List of figures

Figure 1: Site overview 6
Figure 2: Map of Bushfire Prone Areas for the subject site 7
Figure 3: Pre-development vegetation classification and effective slope 9
Figure 4: Pre- development BHL assessment 11
Figure 5: Post-development BHL assessment 12
Figure 6: Spatial representation of bushfire management strategies 16
Figure 7: Illustrated tree canopy cover projection (WAPC 2017) 29

List of tables

Table 1: Bushfire Hazard Level (BHL) Assessment 10
Table 2: Summary of solutions used to achieve bushfire performance criteria 14

© ECO LOGICAL AUSTRALIA PTY LTD

1 Introduction

1.1 Proposal details

Eco Logical Australia (ELA) was commissioned by Bayley Environmental Services on behalf of Tomahawk Properties to prepare a Bushfire Management Plan (BMP) to support a Structure Plan amendment for Lots 35, 192, 194, 800, 801, 802, 803 and 804 Great Northern Hwy, Muchea (hereafter referred to as the subject site; **Figure 1**). The subject site is identified for industrial development in Precinct 3 of the Muchea Employment Node (WAPC 2011). It is also zoned as 'Agricultural Resource' in the Shire of Chittering Town Planning Scheme 6 and is proposed to be rezoned to 'Light Industrial'.

The entirety of the subject site is within a designated bushfire prone area as per the *Western Australia State Map of Bush Fire Prone Areas* (DFES 2018; **Figure 2**), which triggers bushfire planning requirements under *State Planning Policy 3.7 Planning in Bushfire Prone Areas* (SPP 3.7; WAPC 2015) and reporting to accompany submission of the Structure Plan in accordance with the associated *Guidelines for Planning in Bushfire Prone Areas v 1.3* (the Guidelines; WAPC 2017). The south- eastern area of the 150 m assessment area is not designated as bushfire prone.

This assessment has been prepared by ELA Bushfire Consultant, James Leonard and quality assurance undertaken by ELA Senior Bushfire Consultant, Daniel Panickar (FPAA BPAD Level 2 Certified Practitioner No. BPAD37802-L2).

1.2 Purpose and application of the plan

The primary purpose of this BMP is to act as a technical supporting document to inform planning assessment.

This BMP is also designed to provide guidance on how to plan for and manage the bushfire risk to the subject site through implementation of a range of bushfire management measures in accordance with the Guidelines.

1.3 Environmental Considerations

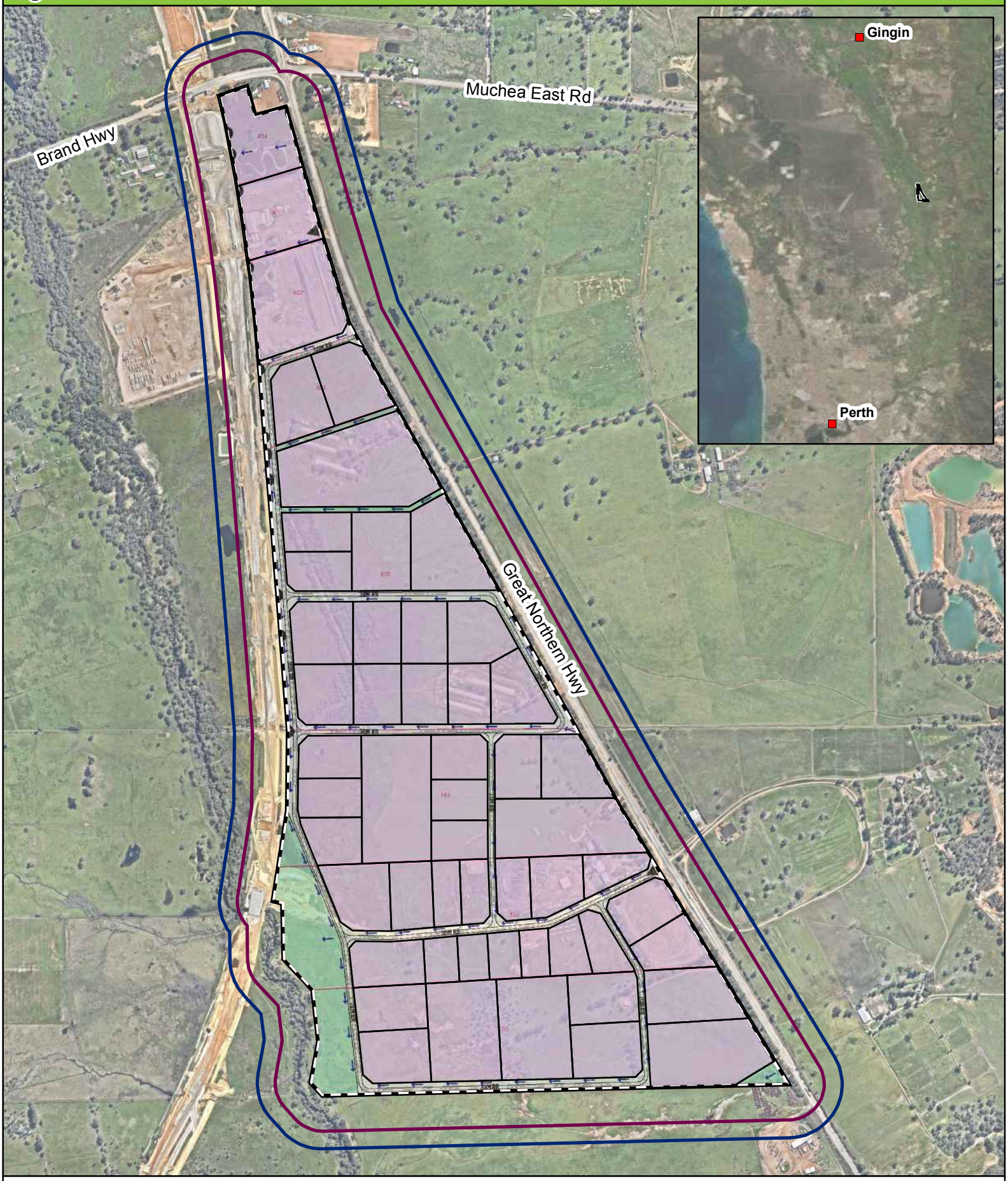
Some bushfire prone areas also have high biodiversity values. SPP 3.7 policy objective 5.4 recognises the need to consider bushfire risk management measures alongside environmental, biodiversity and conservation values.

Environmental approvals for the development are currently in the process of being obtained. This BMP is not expected to trigger any additional requirements.

No revegetation is proposed within the subject site, however if this changes, it will be addressed in future BMPs.

© ECO LOGICAL AUSTRALIA PTY LTD

Figure 1: Site Overview



Legend

- Subject site
- 100m assessment area
- 150m assessment area
- Proposed Structure Plan

0 112.5 225 450
Metres
Datum/Projection:
GDA 1994 MGA Zone 50

N

ecological AUSTRALIA
www.ecoaus.com.au

Prepared by: JL Date:02/10/2019

Figure 2: Bushfire Prone Areas for the subject site



Legend

- Subject site
- 100m assessment area
- 150m assessment area
- Bushfire Prone Mapping (DFES 2018)

0 112.5 225 450

Metres

Datum/Projection:
GDA 1994 MGA Zone 50

N

ecological AUSTRALIA

www.ecoaus.com.au

Prepared by: JL Date:28/11/2018

2 Bushfire Assessment Results

2.1 Assessment inputs

The following section is a consideration of spatial bushfire risk and has been used to inform the bushfire assessment in this report.

2.1.1 General

The subject site is located in the Shire of Chittering, and is bound by:

- Brand Hwy and agricultural lots in the north;
- Great Northern Hwy to the east,
- Private lots to the south; and
- The Northlink infrastructure corridor to the west.

Visual assessment of the surrounding vegetation within the assessment area did not identify any recent fire scars and fire history was not able to be determined. Accumulation of vegetative matter over time, combined with the moderate to high risk of ignition associated with high levels of public access and proximity to urban areas would potentially facilitate a bushfire occurrence in this area.

2.1.2 Vegetation classification

Vegetation within the subject site and surrounding 150 m (the assessment area) was assessed in accordance with the Guidelines and AS 3959-2009 *Construction of Buildings in Bushfire Prone Areas* (SA 2009) with regard given to the *Visual guide for bushfire risk assessment in Western Australia* (DoP 2016). The site inspection was undertaken on 26 November 2018.

The following vegetation classes and exclusions were identified within the assessment area as depicted in and listed below:

- Class B woodland;
- Class G grassland; and
- Exclusions as per clause 2.2.3.2 (e) and (f) (i.e. non-vegetated areas and low-threat vegetation).

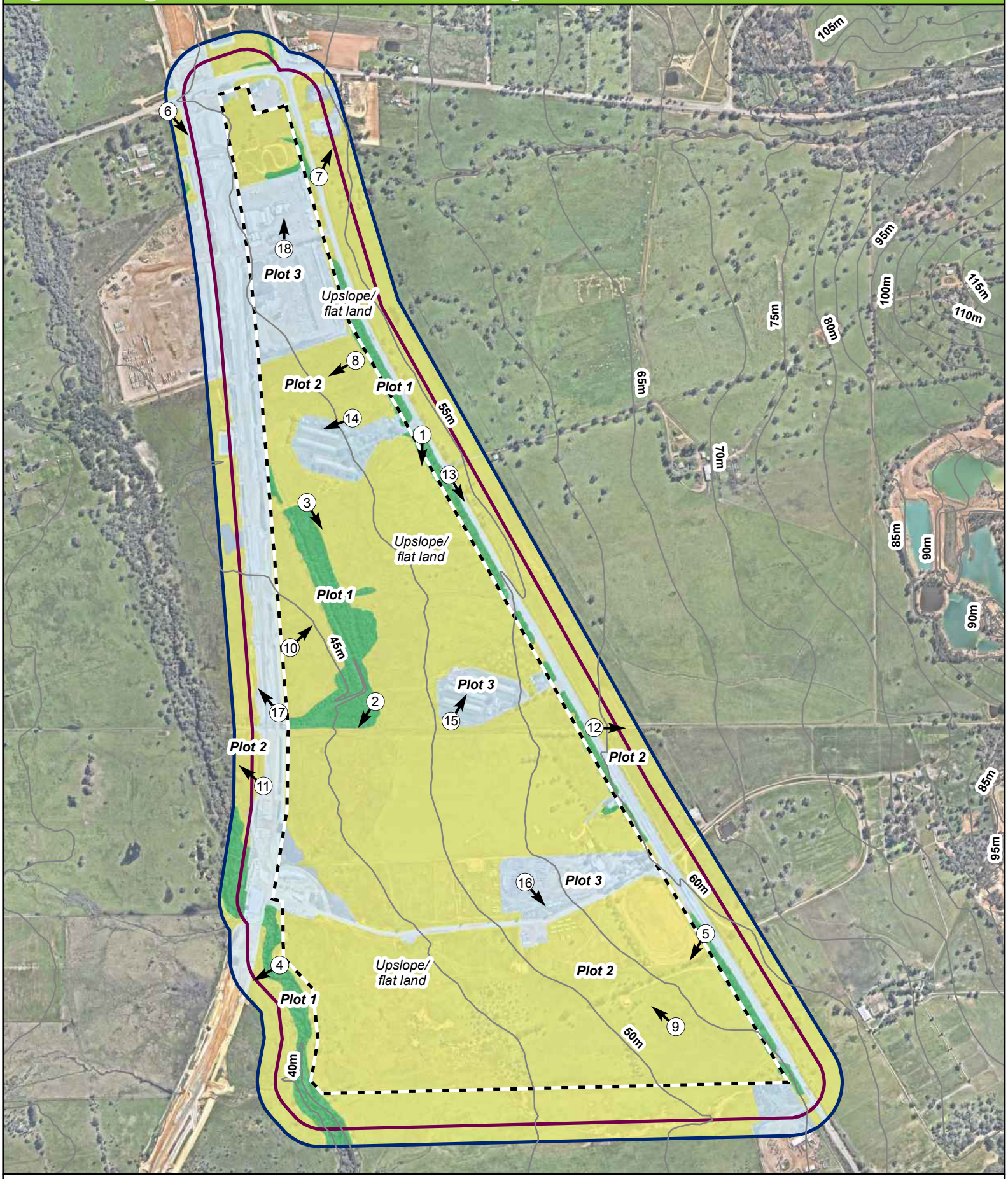
Photographs relating to each vegetation type are included in **Appendix A.**

2.1.3 Topography and slope under vegetation

Effective slope under vegetation was assessed for a distance of 150 m from the subject site in accordance with the Guidelines and AS 3959-2009. Visual assessment on site determined that slope under classified vegetation in all directions was assessed as upslope/flat land (**Figure 3**).

© ECO LOGICAL AUSTRALIA PTY LTD

Figure 3: Vegetation classification of the subject site



Legend

- Subject site
- 100m assessment area
- 150m assessment area
- Contours 5m Intervals (Statewide)
- Photo_location

Vegetation classification

- Class B woodland
- Class G grassland
- Excluded under 2.2.3.2 (e) and (f)

0 112.5 225 450
Metres
Datum/Projection:
GDA 1994 MGA Zone 50

N

eco logical AUSTRALIA
www.ecoaus.com.au

Prepared by: JL Date:28/11/2018

2.2 Assessment outputs

A BHL assessment has been undertaken in accordance with SPP 3.7, the Guidelines and the bushfire assessment inputs in **Section 2.1**.

2.2.1 Bushfire Hazard Level (BHL) assessment

A BHL assessment is required for all land located within 150 m of the subject site in accordance with the Guidelines.

Pre-development BHLs have been assessed for the subject site in accordance with the methodology contained within the Guidelines and incorporates the following factors:

- Vegetation class; and
- Slope under classified vegetation.

Table 1 contains a summary of the BHL assessment for each vegetation class or exclusion. All land within 100 m of Extreme and Moderate BHLs has also been mapped as a Moderate hazard as per the Guidelines, and the final result is depicted in **Figure 4**.

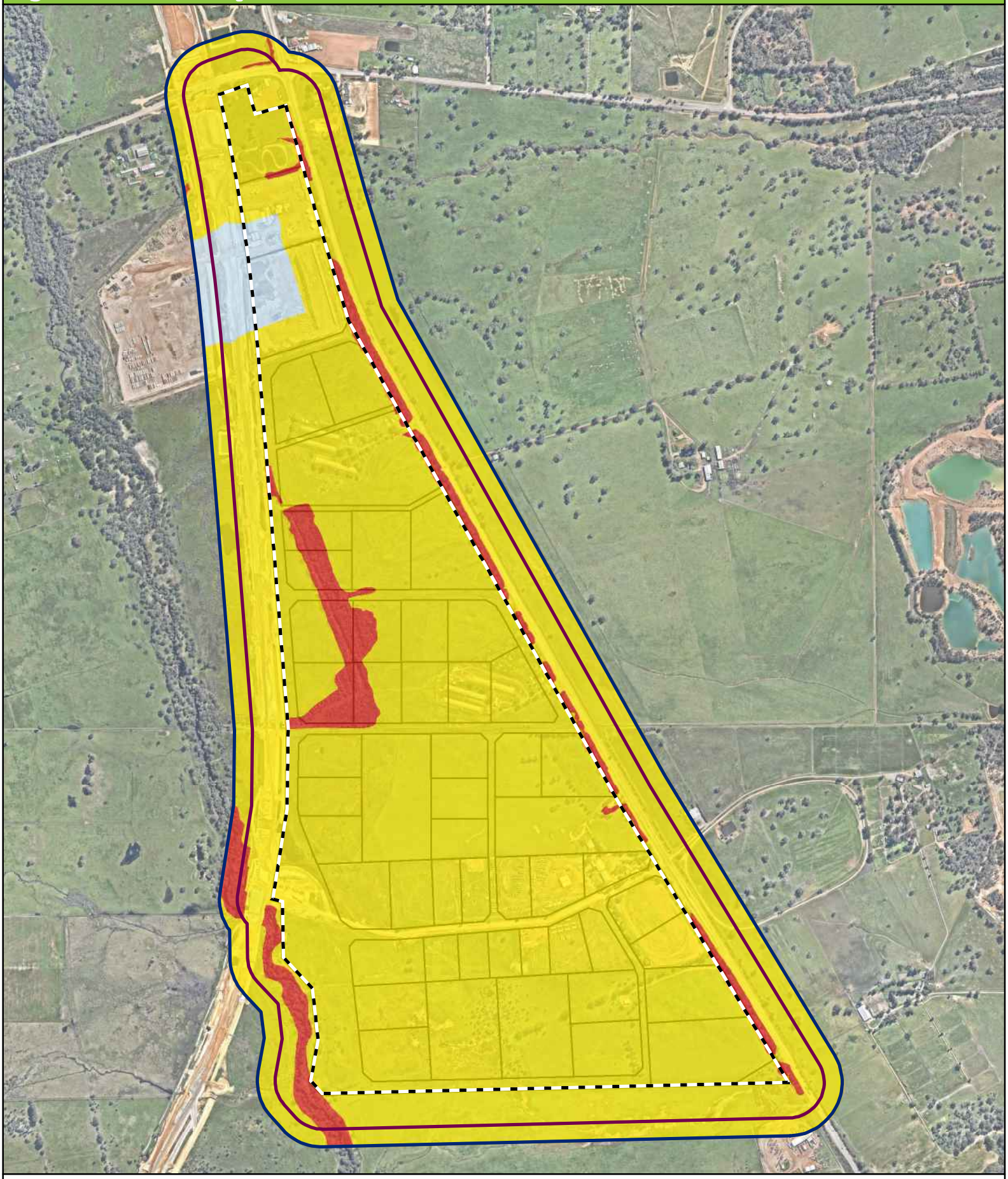
Table 1: Bushfire Hazard Level (BHL) Assessment

Plot	Vegetation Classification	Effective Slope	Bushfire Hazard Level
1	Class B Woodland	Upslope/flat	Extreme
2	Class G Grassland	Upslope/flat	Moderate
3	Excluded as per clause 2.2.3.2 (e) & (f)	N/A	Low

Clearing and revegetation will be undertaken within the subject site for development purposes, and consequently the pre-development BHLs are subject to change. A post-development BHL assessment is provided in **Figure 5** based on expected changes to vegetation within the subject site.

© ECO LOGICAL AUSTRALIA PTY LTD

Figure 4: Pre-development Bushfire Hazard Assessment



Legend

- Subject site
- 100m assessment area
- 150m assessment area
- Proposed Structure Plan

Bushfire Hazard Level

- Extreme
- Moderate
- Low

0 112.5 225 450

Metres

Datum/Projection:
GDA 1994 MGA Zone 50

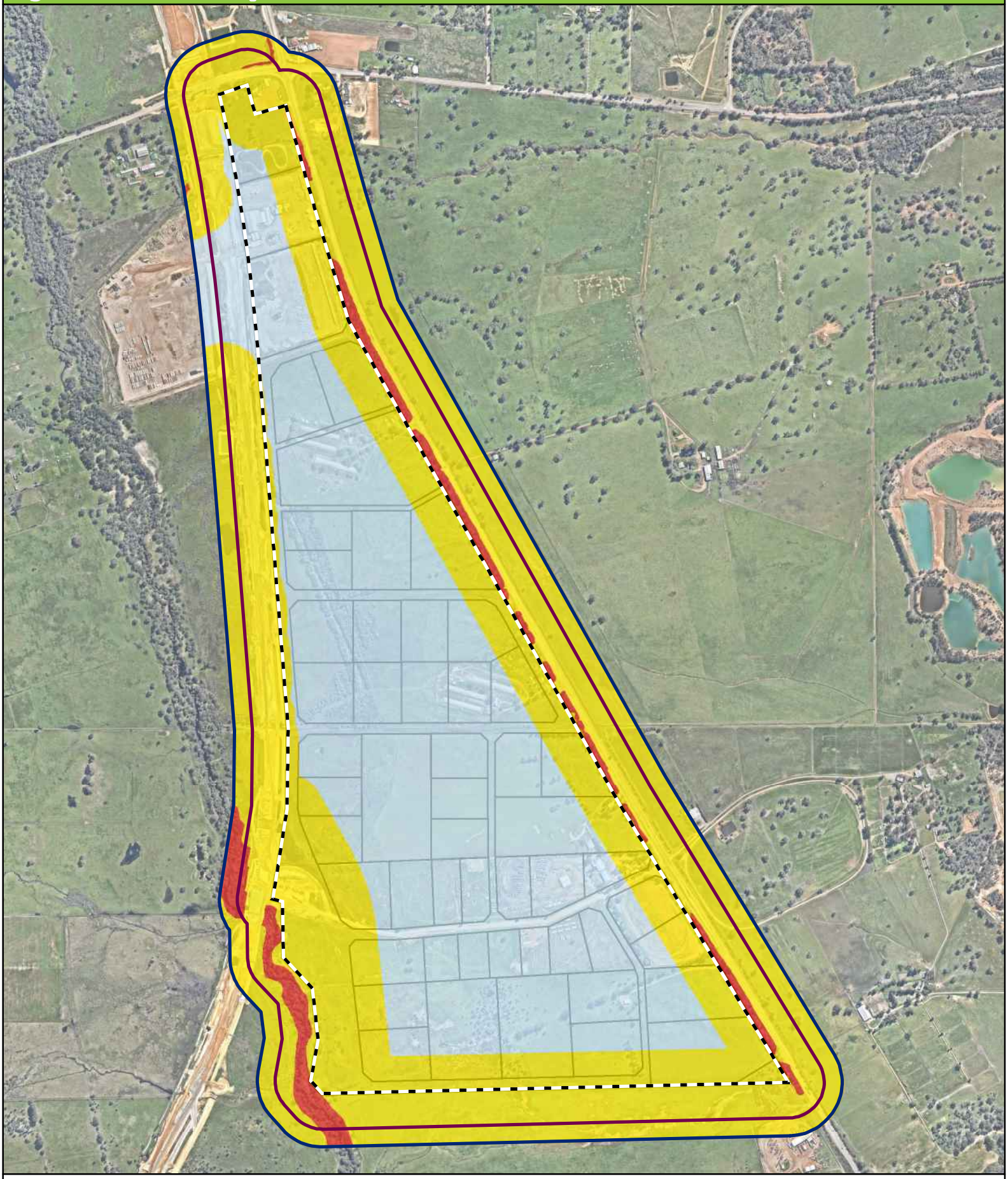
N

ecological AUSTRALIA

www.ecoaus.com.au

Prepared by: JL Date:02/10/2019

Figure 5: Post-development Bushfire Hazard Level Assessment



Legend

- Subject site
- 100m assessment area
- 150m assessment area
- Proposed Structure Plan

Bushfire Hazard Level

- Extreme
- Moderate
- Low

0 112.5 225 450

Metres

Datum/Projection:
GDA 1994 MGA Zone 50

N

ecological AUSTRALIA

www.ecoaus.com.au

Prepared by: JL Date:02/10/2019

3 Identification of Bushfire Hazard issues

The on-site vegetation extent is proposed to be cleared to enable development of a significant industrial development. Therefore, for the purposes of strategic level planning, ELA does not consider the current on-site vegetation extent to be a bushfire hazard issue post-development, since these hazards are to be cleared for development, can be managed through a staged clearing process, adequate separation of future built assets from classified vegetation, and ongoing fuel management that can be undertaken in and around individual development stages.

On the basis of the above information, ELA considers that the bushfire hazards within and adjacent to the subject site and the associated bushfire risk is readily manageable through standard management responses and compliance with acceptable solutions outlined in the Guidelines and AS 3959-2009. These management measures will need to be factored into the development design as early as possible to ensure a suitable, compliant and effective bushfire management outcome is achieved to ensure protection of future life and property assets.

Demonstration of compliance with the relevant requirements of SPP 3.7, the Guidelines and AS 3959-2009 at future planning stages will also depend on the developer's ability to coordinate the timing and staging of clearing and development works within the subject site with those developments proposed on adjacent landholdings in the aim of avoiding bushfire impacts from temporary retained vegetation.

© ECO LOGICAL AUSTRALIA PTY LTD

4 Assessment against the Bushfire Protection Criteria

4.1 Compliance

The proposed Structure Plan is required to comply with policy measures 6.2 and 6.3 of SPP 3.7 and the Guidelines. Implementation of this BMP is expected to meet objectives 5.1 - 5.4 of SPP 3.7.

Bushfire management measures have been devised for the proposed development in accordance with Guideline acceptable solutions to meet compliance with bushfire protection criteria.

The 'acceptable solutions assessment' is provided below to assess the proposed bushfire management measures against each bushfire protection criteria in accordance with the Guidelines. The assessment demonstrates that the proposed measures meet the intent of each element of the bushfire protection criteria. **Figure 6** depicts bushfire management strategies where necessary.

Table 2: Summary of solutions used to achieve bushfire performance criteria

Bushfire Performance Criteria	AS	PS	N/A	Proposed bushfire management strategies
Element 1: Location A1.1 Development location	☒	☐	☐	Post-development, all buildings within the subject site will be situated in areas subject to BHLs of moderate or low (refer to **Figure 6**). The proposed development is considered to be compliant with A1.1.
Element 2: Siting and design of development A2.1 Asset Protection Zone (APZ)	☒	☐	☐	APZs can be accommodated between all future buildings and classified vegetation within the proposed subject site (refer to **Figure 6**). Future development would result in the majority of the proposed area being cleared of vegetation and APZs may not be required. This is to be assessed during future stages of planning. The proposed development is considered to be compliant A2.1.
Element 3: Vehicular access A3.1 Two access routes	☒	☐	☐	There are currently two vehicular access points within the proposed subject site that join onto Great Northern Highway (refer to **Figure 6**). This is a major highway and provides two-way access to different destinations. The proposed development is considered to be compliant with A3.1.
Element 3: Vehicular access A3.2 Public Road	☒	☐	☐	All public roads will comply with vehicular access requirements (refer to **Appendix C**). The proposed development is considered to be compliant with A3.2.

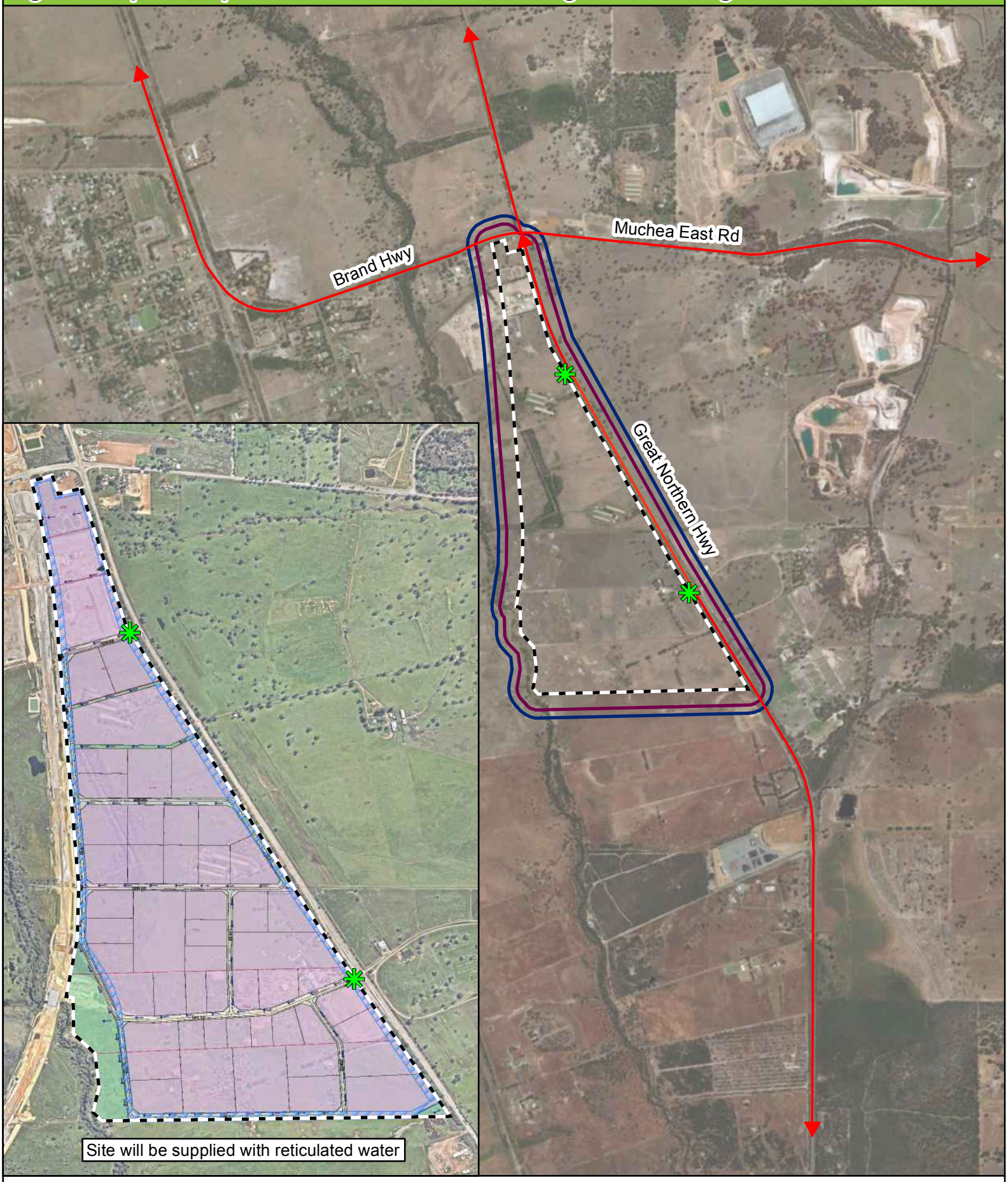
Bushfire Performance Criteria	AS	PS	N/A	Proposed bushfire management strategies
Element 3: Vehicular access A3.3 Cul-de-sac	☐	☐	☒	No cul-de-sacs are proposed as part of the development.
Element 3: Vehicular access A3.4 Battle-axe	☐	☐	☒	No battle-axe lots are proposed as part of the development.
Element 3: Vehicular access A3.5 Private Driveway longer than 50 m	☐	☐	☒	No private driveways longer than 50 m are proposed as part of the development.
Element 3: Vehicular access A3.6 Emergency Access way	☐	☐	☒	No emergency access way routes are proposed or required as part of the development.
Element 3: Vehicular access A3.7 Fire-service access route	☐	☐	☒	No fire service access routes are proposed or required as part of the development.
Element 3: Vehicular access A3.8 Firebreak width	☒	☐	☐	There are currently 3 m wide firebreaks around the perimeter of the existing lots within the subject site that comply with the current Shire of Chittering Fire Control Notice. Future BMPs, to support subsequent planning applications, will address this requirement in greater detail. The proposed development is considered to be compliant with A3.8.
Element 4: Water A4.1 Reticulated areas	☒	☐	☐	The subject site will be connected to a reticulated water supply. The proposed development is considered to be compliant with A4.1. A4.2 and A4.3 are not applicable to this proposed development.

4.2 Additional management strategies

Future demonstration of compliance with the relevant requirements of SPP 3.7, the Guidelines and AS 3959-2009 will depend on the developer's ability to coordinate the timing of development works within the subject site. Updated BMPs will be prepared to support subsequent planning applications where relevant and will contain re-assessments of bushfire risk including Bushfire Attack Level assessments etc.

© ECO LOGICAL AUSTRALIA PTY LTD

Figure 6: Spatial representation of bushfire management strategies



Legend

- Subject site
- 100m assessment area
- 150m assessment area
- Access Route
- Access/ egress points
- Indicative Asset Protection Zone (APZ)

0 250 500 1,000
Metres
Datum/Projection:
GDA 1994 MGA Zone 50

N

eco logical AUSTRALIA
www.ecoaus.com.au

Prepared by: JL Date:02/10/2019

5 Responsibilities for Implementation and Management of Bushfire Measures

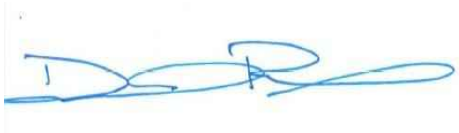
Implementation of the BMP applies to Tomahawk Properties, on behalf of the Muchea Employment Node Precinct 3 Landowner Group, the Shire of Chittering, and future landowners to ensure bushfire management measures are adopted and implemented on an ongoing basis. This BMP has been prepared as a strategic guide to demonstrate how development compliance will be delivered at future planning stages in accordance with the Guidelines. In this respect, management measures documented in **Section 4**, where applicable, will be incorporated into development design as early as possible and confirmed through subdivision design. Therefore, aside from the revision of this BMP or preparation of a BMP addendum to accompany future subdivision applications, there are no further items to implement, enforce or review at this stage of the planning process.

The revised BMP or addendum to this BMP is required to meet the relevant commitments outlined in this strategic level BMP, address the relevant requirements of SPP 3.7 (i.e. Policy Measure 6.4) and demonstrate in detail how the proposed development will incorporate the relevant acceptable solutions to meet the performance requirements of the Guidelines.

© ECO LOGICAL AUSTRALIA PTY LTD

6 Conclusion

In the author's professional opinion, the bushfire protection requirements listed in this assessment provide an adequate standard of bushfire protection for the proposed development. As such, the proposed development is consistent with the aim and objectives of SPP 3.7 and associated guidelines and is recommended for approval.



Daniel Panickar
Senior Bushfire Consultant
FPAA BPAD Certified Practitioner
No. BPAD37802-L2

References

Department of Fire and Emergency Services (DFES). 2018. *Map of Bush Fire Prone Areas*, [Online], Government of Western Australia, available from: http://www.dfes.wa.gov.au/regulationandcompliance/bushfireproneareas/Pages/default.aspx

Department of Planning (DoP). 2016. *Visual guide for bushfire risk assessment in Western Australia.* DoP, Perth.

Standards Australia. 2009. *Construction of buildings in bushfire-prone areas, AS 3959-2009*. SAI Global, Sydney.

Western Australian Planning Commission (WAPC). 2011. *Muchea Employment Node Structure Plan.* WAPC, Perth.

Western Australian Planning Commission (WAPC). 2015. *State Planning Policy 3.7 Planning in Bushfire Prone Areas*. WAPC, Perth.

Western Australian Planning Commission (WAPC). 2017. *Guidelines for Planning in Bushfire Prone Areas Version 1.3 (including appendices).* WAPC, Perth.

© ECO LOGICAL AUSTRALIA PTY LTD

Appendix A Plates

Plot	Photo ID	Photo and vegetation class
1	1	 **Class B Woodland**
1	2	 **Class B Woodland -** Classified vegetation within this plot is comprised of trees between 10 to 30 m tall with approximately 20 to 30% foliage cover. There is limited surface litter. Some grass is present at the base of the trees. Slope under vegetation was assessed as upslope/flat land.

© ECO LOGICAL AUSTRALIA PTY LTD

Plot	Photo ID	Photo and vegetation class
1	3	 **Class B Woodland**
1	4	 **Class B Woodland**

Plot	Photo ID	Photo and vegetation class
1	5	 **Class B Woodland**
2	6	 **Class G Grassland**

Plot	Photo ID	Photo and vegetation class
2	7	 **Class G Grassland**
2	8	 **Class G Grassland**

Plot	Photo ID	Photo and vegetation class
2	9	 **Class G Grassland**
2	10	 **Class G Grassland**

Plot	Photo ID	Photo and vegetation class
2	11	 **Class G Grassland**
2	12	 **Class G Grassland**

Plot	Photo ID	Photo and vegetation class
3	13	 **Excluded under Clause 2.2.3.2 (e) and (f)**
3	14	 **Excluded under Clause 2.2.3.2 (e) and (f) (Background)**

Plot	Photo ID	Photo and vegetation class
3	15	 **Excluded under Clause 2.2.3.2 (e) and (f)**
3	16	 **Excluded under Clause 2.2.3.2 (e) and (f) (Background)**

Plot	Photo ID	Photo and vegetation class
3	17	 **Excluded under Clause 2.2.3.2 (e) and (f)**
3	18	 **Excluded under Clause 2.2.3.2 (e) and (f) (Background)**

Appendix B Standards for Asset Protection Zones

The following standards have been extracted from the *Guidelines for Planning in Bushfire Prone Areas v 1.3* (WAPC 2017).

Every habitable building is to be surrounded by, and every proposed lot can achieve, an APZ depicted on submitted plans, which meets the following requirements:

a. Width: Measured from any external wall or supporting post or column of the proposed building, and of sufficient size to ensure the potential radiant heat impact of a fire does not exceed 29kW/m² (BAL 29) in all circumstances.

b. Location: the APZ should be contained solely within the boundaries of the lot on which a building is situated, except in instances where the neighbouring lot or lots will be managed in a low-fuel state on an ongoing basis, in perpetuity (see explanatory notes).

c. Management: the APZ is managed in accordance with the requirements of '*Standards for Asset Protection Zones*' (below):

- Fences: within the APZ are constructed from non-combustible materials (e.g. iron, brick, limestone, metal post and wire). It is recommended that solid or slatted non-combustible perimeter fences are used
- Objects: within 10 metres of a building, combustible objects must not be located close to the vulnerable parts of the building i.e. windows and doors
- Fine Fuel load: combustible dead vegetation matter less than 6 millimetres in thickness reduced to and maintained at an average of two tonnes per hectare
- Trees (> 5 metres in height): trunks at maturity should be a minimum distance of 6 metres from all elevations of the building, branches at maturity should not touch or overhang the building, lower branches should be removed to a height of 2 metres above the ground and or surface vegetation, canopy cover should be less than 15% with tree canopies at maturity well spread to at least 5 metres apart as to not form a continuous canopy (**Figure 7**).

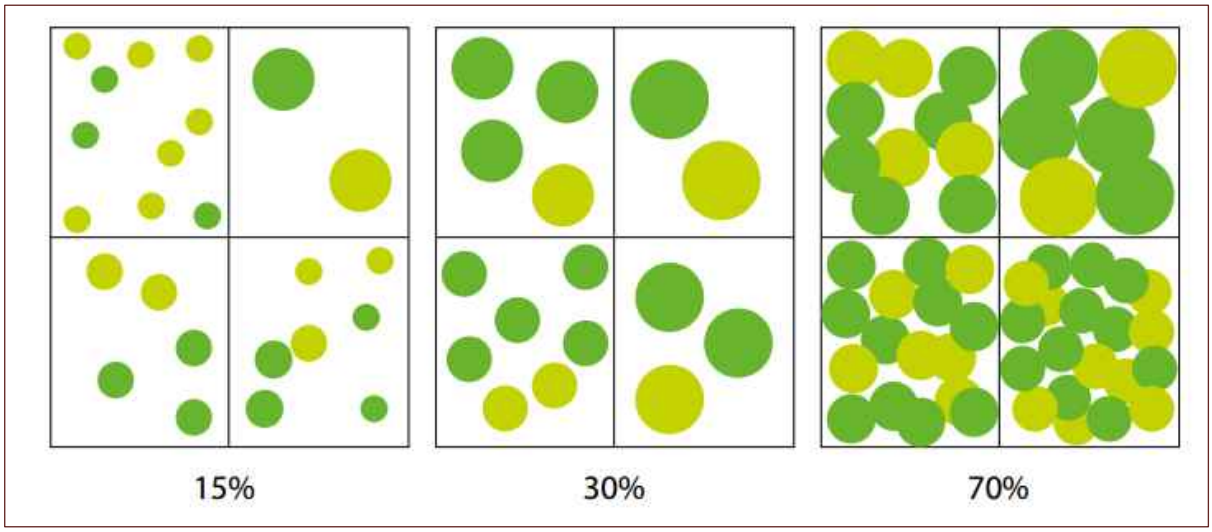


Figure 7: Illustrated tree canopy cover projection (WAPC 2017)

- **Shrubs (0.5 metres to 5 metres in height):** should not be located under trees or within 3 metres of buildings, should not be planted in clumps greater than 5m2 in area, clumps of shrubs should be separated from each other and any exposed window or door by at least 10 metres. Shrubs greater than 5 metres in height are to be treated as trees
- **Ground covers (<0.5 metres in height):** can be planted under trees but must be properly maintained to remove dead plant material and any parts within 2 metres of a structure, but 3 metres from windows or doors if greater than 100 millimetres in height. Ground covers greater than 0.5 metres in height are to be treated as shrubs
- **Grass:** should be managed to maintain a height of 100 millimetres or less.

Additional notes

The Asset Protection Zone (APZ) is an area surrounding a building that is managed to reduce the bushfire hazard to an acceptable level. Hazard separation in the form of using subdivision design elements or excluded and low threat vegetation adjacent to the lot may be used to reduce the dimensions of the APZ within the lot.

The APZ should be contained solely within the boundaries of the lot on which the building is situated, except in instances where the neighbouring lot or lots will be managed in a low-fuel state on an ongoing basis, in perpetuity. The APZ may include public roads, waterways, footpaths, buildings, rocky outcrops, golf courses, maintained parkland as well as cultivated gardens in an urban context, but does not include grassland or vegetation on a neighbouring rural lot, farmland, wetland reserves and unmanaged public reserves.

© ECO LOGICAL AUSTRALIA PTY LTD

Appendix C Vehicular access technical requirements (WAPC 2017)

Technical requirements	Public road	Cul-de-sac	Private driveway	Emergency access way	Fire service access route
Minimum trafficable surface (m)	6*	6	4	6*	6*
Horizontal distance (m)	6	6	6	6	6
Vertical clearance (m)	4.5	N/A	4.5	4.5	4.5
Maximum grade <50 m	1 in 10	1 in 10	1 in 10	1 in 10	1 in 10
Minimum weight capacity (t)	15	15	15	15	15
Maximum crossfall	1 in 33	1 in 33	1 in 33	1 in 33	1 in 33
Curves minimum inner radius	8.5	8.5	8.5	8.5	8.5

* Refer to E3.2 Public roads: Trafficable surface

© ECO LOGICAL AUSTRALIA PTY LTD

ecological AUSTRALIA

ISO 14001 Environmental Management

AS/NZS 4801:2001 Occupational Health and Safety Management

ISO 9001 Quality Management

HEAD OFFICE
Suite 2, Level 3
668-672 Old Princes Highway
Sutherland NSW 2232
T 02 8536 8600
F 02 9542 5622

CANBERRA
Level 2
11 London Circuit
Canberra ACT 2601
T 02 6103 0145
F 02 9542 5622

COFFS HARBOUR
22 Ray McCarthy Drive
Coffs Harbour NSW 2450
T 02 6651 5484
F 02 6651 6890

PERTH
Level 1, Bishop's See
235 St Georges Terrace
Perth WA 6000
T 08 9227 1070
F 02 9542 5622

MELBOURNE
Level 1, 436 Johnston St
Abbotsford, VIC 3076
T 1300 646 131

SYDNEY
Suite 1, Level 1
101 Sussex Street
Sydney NSW 2000
T 02 8536 8650
F 02 9542 5622

NEWCASTLE
Suites 28 & 29, Level 7
19 Bolton Street
Newcastle NSW 2300
T 02 4910 0125
F 02 9542 5622

ARMIDALE
92 Taylor Street
Armidale NSW 2350
T 02 8081 2685
F 02 9542 5622

WOLLONGONG
Suite 204, Level 2
62 Moore Street
Austinmer NSW 2515
T 02 4201 2200
F 02 9542 5622

BRISBANE
Suite 1, Level 3
471 Adelaide Street
Brisbane QLD 4000
T 07 3503 7192

HUSKISSON
Unit 1, 51 Owen Street
Huskisson NSW 2540
T 02 4201 2264
F 02 9542 5622

NAROOMA
5/20 Canty Street
Narooma NSW 2546
T 02 4302 1266
F 02 9542 5622

MUDGEE
Unit 1, Level 1
79 Market Street
Mudgee NSW 2850
T 02 4302 1234
F 02 6372 9230

GOSFORD
Suite 5, Baker One
1-5 Baker Street
Gosford NSW 2250
T 02 4302 1221
F 02 9542 5622

ADELAIDE
2, 70 Pirie Street
Adelaide SA 5000
T 08 8470 6650
F 02 9542 5622

1300 646 131
www.ecoaus.com.au

APPENDIX H LOCAL WATER MANAGEMENT STRATEGY

MUCHEA EMPLOYMENT NODE
PRECINCT 3

LOCAL WATER MANAGEMENT STRATEGY

Prepared for

Muchea Employment Node
Precinct 3 Landowner Group
c/- Tomahawk Property
8/355 Stirling Hwy
CLAREMONT WA 6010

Report No. J18015b
23 January 2020

BAYLEY ENVIRONMENTAL SERVICES
30 Thomas Street
SOUTH FREMANTLE WA 6162

Sundowner Nominees Pty Ltd as trustee for the Bayley Cook Family Trust ABN 20 822 598 897
trading as Bayley Environmental Services

TABLE OF CONTENTS

Page

1.0 INTRODUCTION 1
1.1 Background 1
1.2 Previous Studies 1
1.2.1 Water Management Strategy – Muchea Employment Node 1
1.2.2 Regional Water Management Strategy – Muchea 2
1.3 Relevant Guidelines and Policies 3
1.3.1 State Planning Policy 2.9 3
1.3.2 Better Urban Water Management 3
1.3.3 Shire of Chittering Town Planning Scheme No. 6 4
1.3.4 Government Sewerage Policy 6
1.3.5 DoW Operational Policy 4.3: Identifying and Establishing Waterways Foreshore Areas 6
1.3.6 DoW Interim Guideline: Developing a Local Water Management Strategy 7
1.4 Scope of the LWMS 7
1.5 Design Objectives 7

2.0 EXISTING ENVIRONMENT 9
2.1 Rainfall 9
2.2 Physiography 10
2.2.1 Topography 10
2.2.2 Geology, Landforms and Soils 10
2.2.3 Soil Permeability 11
2.2.4 Acid Sulphate Soils 11
2.2.5 Phosphorus Retention Index 12
2.3 Hydrology 12
2.3.1 Groundwater 12
2.3.2 Surface Drainage 13
2.3.3 Foreshore Definition 14
2.3.4 Water Resources 15
2.4 Water Quality 16
2.4.1 Groundwater 16
2.4.2 Surface Water 16
2.5 Vegetation 23
2.5.1 Vegetation Type and Condition 23
2.5.2 Vegetation Complexes 24
2.6 Land Uses and Potential Contamination 24

3.0 WATER USE SUSTAINABILITY 25
3.1 Water Supply 25
3.2 Water Efficiency Measures 25

4.0 LAND CAPABILITY FOR ON-SITE EFFLUENT DISPOSAL 27
4.1 Published Land Capability Ratings and Constraints 27
4.2 Soil Permeability 27
4.3 Phosphorus Retention Index 27
4.4 Depth to Groundwater 28
4.5 Slope 28
4.6 Watercourse Setbacks 28
4.7 System Selection and Location 29
4.8 Subsoil Drainage 29

5.0 STORMWATER MANAGEMENT STRATEGY 31
5.1 Principles and Objectives 31
5.2 Drainage Management System 31
5.2.1 Through Drainage 31
5.2.2 Internal Drainage 32
5.2.3 Major Storm Drainage 33
5.3 Ellen Brook Floodplain 35
5.4 Surface Water Quality Management 35
5.5 Maintenance 35

6.0 GROUNDWATER MANAGEMENT STRATEGY 37
6.1 Groundwater Levels 37
6.2 Subsoil Drainage 37
6.3 Groundwater Quality 37

7.0 LANDSCAPING STRATEGY 39

8.0 MONITORING 40

9.0 IMPLEMENTATION AND FURTHER MANAGEMENT PLANS 41

10.0 REFERENCES 42

LIST OF TABLES

Table	Title	Page
1.1	Design Objectives	8
2.1	Rainfall Intensity for Muchea	10
2.2	Groundwater Depths and Levels 22 August 2018	13
2.3	Groundwater Licences	15
2.4	Groundwater Quality 22/8/2018	17
2.5	Upstream Surface Water Quality 22/8/2018	19
2.6	Downstream Surface Water Quality 22/8/2018	21
5.1	100-year ARI Flows	34

LIST OF FIGURES

Figure	Title
1	Muchea Employment Node Structure Plan
2	The Site and Surroundings
3	Proposed Plan of Subdivision
4	Pearce RAAF Mean Rainfall (p. 9 of document)
5	Physiography
6	Hydrology Overview
7	Groundwater
8	DWER Bore Hydrographs
9	Surface Hydrology
10	Groundwater Licences
11	Vegetation
12	Drainage Concept
13	Swale Profiles
14	Landscape Master Plan

LIST OF APPENDICES

Appendix	Title
A	DWER LWMS Checklist
B	Soil Logs
C	BES Permeability Test Results
D	Geotechnical Report
E	Floodway Modelling Report
F	Foreshore Definition Report
G	Letter from Aqua Ferre Pty Ltd
H	Runoff Calculations

1.0 INTRODUCTION

1.1 Background

The owners of Lots 35, 192, 194 and 800-804 Great Northern Highway, Muchea (the subject site) have applied to the WAPC for the lots to be rezoned from Agricultural Resource to Light Industrial. The Muchea Employment Node Structure Plan (MENSP) was adopted by the WAPC in August 2011 and provides a twenty-year planning framework for industrial development within the Shire of Chittering. The subject site forms Precinct 3 of the MENSP, bordered on the east by Great Northern Highway and on the west by the new Perth-Darwin National Highway (PDNH) and Ellen Brook. Figure 1 shows the location of the site within the Muchea Employment Node.

The total area of the rezoning is approximately 185 hectares. Figure 2 shows an aerial view of the site and surroundings. The Structure Plan proposes approximately 51 Light Industrial lots within Precinct 3, with lot sizes nominally ranging from 1.3ha to 7.6ha.

The MENSP concept for Precinct 3 is for low water-use industries, with effluent disposed on-site using aerobic treatment units. This recognises the site constraints posed by the land's low elevation and high winter water table. Figure 3 shows a preliminary conceptual plan of subdivision for the site.

The Local Structure Plan for Precinct 3 has been submitted to the Department of Planning, Lands & Heritage and the Shire of Chittering, and is currently being considered by these agencies.

1.2 Previous Studies

1.2.1 Water Management Strategy – Muchea Employment Node

A Water Management Strategy (WMS) was prepared by Connell Wagner in 2008 in support of the District Structure Plan for the Muchea Employment Node. The WMS documented the existing environment of the MEN in broad terms, including soils and geology, topography, hydrology, vegetation and land uses. The WMS examined:

- the possible impacts of development on surface water and groundwater
- water demand and supply options;
- wastewater treatment and disposal, including leach drains, evaporation ponds and reuse.

The WMS recommended, among other things:

- Geotechnical investigations should be undertaken in the western part (Precinct 3) to determine soil permeability and phosphorus retention index for the purposes of on-site effluent disposal.

- Groundwater monitoring over at least two winter seasons should be undertaken to provide information on groundwater levels and quality.

- The preferred method of effluent disposal, based on desktop studies, was treatment by Aerobic Treatment Units (ATU) followed by disposal in evaporation ponds.

- Flood modelling of Ellen Brook should be undertaken to establish the boundaries of the 100-year ARI floodway and flood fringe.

- Development should be set back from waterways in accordance with Water and Rivers Commission Note 23: *Determining Foreshore Reserves* (2001), with a default minimum setback of 30m.

- Stormwater runoff from lots and roads should be managed by infiltration and detention so that the runoff from a 1-year 1-hour storm is retained and infiltrated, and that peak flows from critical storms up to 100-year ARI are limited to pre-development rates.

- Water sensitive urban design measures should be implemented to meet catchment water quality targets as set out in the Swan-Canning Water Quality Improvement Plan (2009).

1.2.2 Regional Water Management Strategy – Muchea

The Muchea Regional Water Management Strategy (RWMS) was prepared by Emerge Associates for the Department of Planning, Lands & Heritage in 2019. The RWMS deals with the entire Muchea Employment Node, covering an area of 6,580 hectares.

The RWMS identifies environmental values, documents the hydrological regime and identifies requirements for wastewater management. The RWMS recommends furhter assessments prior to development including geotechnical, flora and fauna, wetlands, waterways, land capability and flooding.

The draft RWMS was completed in June 2019, after the draft LWMS for Precinct 3 had been submitted. The final RWMS was completed in November 2019. This LWMS pre-empts many of the recommendations of the RWMS in examining the environmental factors at a greater level of detail than undertaken in the RWMS.

1.3 Relevant Guidelines and Policies

1.3.1 State Planning Policy 2.9

State Planning Policy 2.9: *Water Resources* (WAPC, 2006) lists the following key principles for total water cycle management:

- Consideration of all water sources (including wastewater) in water planning, maximising the value of water resources.
- Integration of water and land use planning.
- Sustainable and equitable use of all water sources, having consideration of the needs of all water users including the community, industry and the environment.
- Integration of water use and natural water processes.
- A whole-of-catchment integration of natural resource use and management.

SPP 2.9 also lists the following general objectives for water-sensitive urban design:

- to manage a water regime;
- to maintain and, where possible, enhance water quality;
- to encourage water conservation;
- to enhance water-related environmental values; and
- to enhance water-related recreational and cultural values.

Element 5 of *Liveable Neighbourhoods* Edition 3 (WAPC, 2004) identifies specific objectives and requirements for Urban Water Management. These are based on Best Planning Practices which are defined as the best practical approach for achieving water resource management objectives within an urban framework.

1.3.2 Better Urban Water Management

Better Urban Water Management (WAPC, 2008) sets out the following objectives for water sensitive urban design:

Water Conservation

- Consumption of 100kL/p/yr including less than 40-60 kL/p/yr scheme water.

Water Quantity

- Ecological Protection – Maintain pre-development flow rates and volumes for the 1 year ARI event. Maintain or restore desirable environmental flows and/or hydrological cycles.

- Flood Management – Maintain pre-development flow rates and volumes for the 100 year ARI event.

Water Quality

- Maintain pre-development nutrient outputs (if known) or meet relevant water quality guidelines (e.g. ANZECC & ARMCANZ, 2000).

- Treat all runoff in the drainage network prior to discharge consistent with the Stormwater Management Manual.

- As compared to a development that does not actively manage stormwater quality, achieve:

  - at least 80% reduction of 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.

Mosquitoes and Midges

- Design detention structures so that, between the months of November and May, stormwater is fully infiltrated within 96 hours.

- Design permanent water bodies (where accepted by DWER) to maximise predation of mosquito larvae by native fauna.

1.3.3 Shire of Chittering Town Planning Scheme No. 6

"The following development requirements shall apply to the development and subdivision of land within industrial zones and to industrial land uses –

(a) the effect on the environment by means of discharge of pollutants or contaminants into the air, ground and water be avoided, or managed within acceptable limits;

(b) where an on-site wastewater disposal system is proposed –

  i. land capability assessment may be required to demonstrate the capability of the site to manage wastewater and the suitability of the proposed system;
  ii. the use of fill and drains to achieve the required separation from groundwater is to be limited; and

iii. a suitable and unencumbered land application area is to be set aside to distribute treated sewage, where required;

(c) within sewerage sensitive areas secondary treatment systems with nutrient removal are to be utilised;

(d) notwithstanding any other provisions of this scheme, industrial development not connected to reticulated sewerage (for treatment on-site or off-site) is to be restricted to 'dry industry' being land uses that intend to dispose of wastewater on site to the environment of a kind and volume ordinarily discharged from a habitable building at a daily volume of less than 540 litres per 1,000m^2 of the site area [R10 equivalent];

(e) where trade waste is to be managed and/or disposed of on-site or off-site the associated risks must be identified and addressed, including the vulnerability of the receiving environment where relevant."

The Scheme shows Precinct 3 and its surroundings as part of a Water Prone Area (Ellen Brook Palusplain), within which the following special provisions apply:

"5.3.3 Planning Requirements

The local government will impose conditions on any Development approval relating to -

a) the construction and occupation of any dwelling or outbuilding;

b) the type of effluent disposal system used in this area shall be high performance with bacterial and nutrient stripping capabilities to the specifications of local government and the Health Department and shall be located in a position determined by local government.;

c) minimum floor levels for any building above the highest known water levels;

d) any land use that may contribute to the degradation of the surface or sub-surface water quality.

e) no development other than for conservation purposes will be permitted within 30 metres of any natural water body; AMD 21 GG 3/4/09

f) damming, draining or other developments which may alter the natural flow of surface water will not be permitted unless such works are part of an approved Catchment Management Plan."

Schedule 11 of the Scheme contains the following provisions that apply to the Muchea Employment Node:

"2.2 Environmental Management Plans

The following Environmental Management Plans shall be prepared and used to inform the design and proposed subdivision and development within the Structure Plan area. They shall be submitted as an additional detail of a Structure Plan unless otherwise determined by the Western Australian Planning Commission.

2.2.1 Local Water Management Strategy

The developer shall submit to the Local Authority a Local Water Management Strategy (LWMS) for approval as an additional detail of a Structure Plan pursuant to clause 5.19 in order to ensure that surface and ground waters are managed with the aim of maintaining the natural water balance. The Local Authority must notify and consult with the authority responsible for water and the environment on the proposed strategy in advertising the Local Structure Plan(s) pursuant to Part 4 of the deemed provisions.

The LWMS shall be prepared in accordance with Better Urban Water Management or its successor document.

The Structure Plan design shall respond to the LWMS required by 2.2.1 and shall be implemented to the satisfaction of the Local Authority, having regard to any advice from the Department of Water."

1.3.4 Government Sewerage Policy

The Government Sewerage Policy (2019) requires that all new subdivision and development should be deep-sewered unless it is exempt for one of several reasons. For exempt developments, the policy establishes minimum site capability requirements and, where appropriate, density limits. In these cases, on-site effluent disposal may be approved where the responsible authority is satisfied that:

- each lot is capable of accommodating on-site sewage disposal without endangering public health or the environment; and
- the minimum site requirements for on-site sewage disposal as set out in the Policy can be met.

1.3.5 DoW Operational Policy 4.3: Identifying and Establishing Waterways Foreshore Areas

DoW Operational Policy 4.3 was published in 2012 and sets out the Department of Water's policy on defining and protecting foreshore reserves. It is intended to apply to all waterways within development areas. The policy sets out procedures for identifying, delineating and protecting foreshore areas.

The procedure may vary depending on the size and nature of the waterway and the nature of the proposed adjacent development. The policy provides for standard or nominal

foreshore widths to be employed in some cases, such as small subdivisions and/or minor tributary creeks where the waterway is adequately protected and the proposed development poses an insignificant additional risk to the waterway.

1.3.6 DoW Interim Guideline: Developing a Local Water Management Strategy

The DoW LWMS guideline was published in 2008 and sets out the DoW's preferred format and content for LWMS documents. The guideline expands on the LWMS guidance provided in *Better Urban Water Management* (2008).

This LWMS has been prepared in accordance with the principles set out in the DoW guideline. Appendix A shows a completed checklist from the DWER guideline.

1.4 Scope of the LWMS

The scope of this LWMS is to:

- Document the existing environment on the site, in relation to soils, drainage, erosion, watercourses, groundwater and water-dependent ecosystems.
- Briefly describe the proposed development in relation to water management.
- Examine the capability of the site for on-site effluent disposal.
- Address relevant regulatory requirements and design criteria for water harvesting, setbacks to watercourses, groundwater management and drainage.
- Describe the strategies to be implemented for water conservation, watercourse protection, groundwater management and stormwater drainage.
- Outline the proposed monitoring program.
- Outline what is to be addressed in future Urban Water Management Plans.

1.5 Design Objectives

Table 1.1 summarises the water-related design objectives for Precinct 3 and the means by which they will be achieved in the LWMS and subsequent management plans.

Table 1.1 Design Objectives

Design Aspect	*Design Objective*	*How Objective is to be Achieved*
Water Conservation	Ensure efficient and sustainable use of water resources	Only low water use industries permitted in precinct. Use water efficient fixtures. Limit wastewater generation to 5.4 KL/ha/day. Use non-potable water for irrigation. Purchase groundwater licence(s) from existing holders within or outside Precinct 3. Use water-efficient native species for landscaping. Irrigate landscape plantings only for 2 years.
Groundwater Management	Minimise impacts on groundwater level and flows Minimise impacts on groundwater quality	Subsoil drains set at or above pre-existing AAMGL, with fill used to provide additional clearance if required. Finished floor levels of habitable buildings set at least 0.5m above controlled groundwater level. Treat runoff from minor storms in bioretention swales. Minimise fertiliser and chemical use in landscaping areas. Use nutrient-removing alternative treatment systems for effluent disposal.
Surface Water Management	Minimise impacts on surface water flow rates, volumes and quality	Retain and infiltrate runoff from 1-year ARI 1-hour storms in bioretention swales. Detain runoff from larger storms and control release from lots and overall site to pre-development flow rates. Convey existing flows through the site in roadside swales at pre-development rates. Set effluent disposal facilities at least 100m back from natural waterways. Sweep streets regularly to remove accumulated contaminants.
Floodplain Management	Minimise impacts of development on flows in Ellen Brook. Protect developed lots and structures from flooding.	Protect all of 100-year floodway in foreshore reserve. Finished floor levels of habitable buildings in flood fringe set at least 0.5m above 100-year flood level.

2.0 EXISTING ENVIRONMENT

2.1 Rainfall

Muchea, like the rest of the greater Perth region, has a strongly seasonal rainfall, with most of the annual rain falling between May and September in association with winter cold fronts. Occasional heavy falls may occur from summer thunderstorms. The long-term average annual rainfall for Pearce RAAF Base (located 13.6km south of the site) is 679.7mm, of which 77% falls between the months of May and September.

Figure 4 shows a rainfall occurrence chart for Pearce. Table 2.1 shows rainfall intensity, frequency and duration for Muchea.

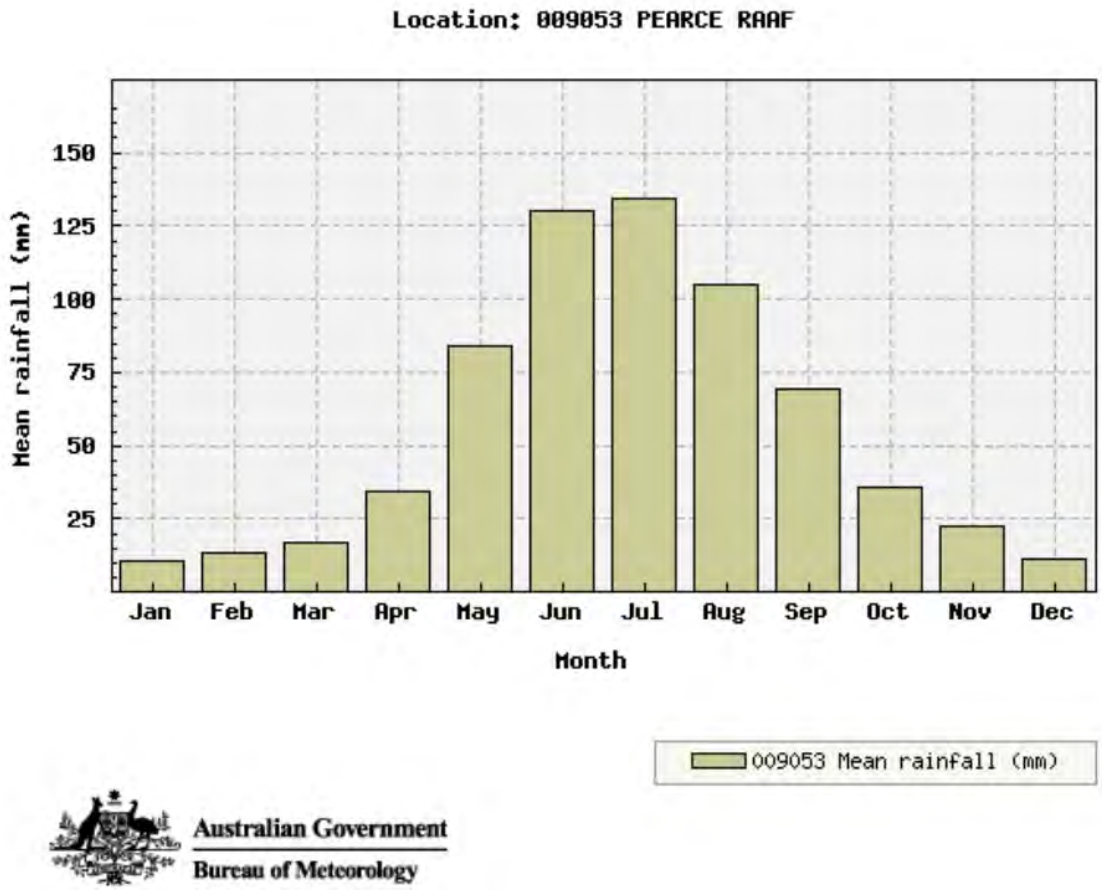


Figure 4 Pearce RAAF Mean Rainfall

IFD Design Rainfall Depth (mm) Issued: 31 October 2018

Rainfall depth for Durations, Exceedance per Year (EY), and Annual Exceedance Probabilities (AEP).
FAQ for New ARR probability terminology

	Annual Exceedance Probability (AEP)						
Duration	**63.2%**	**50%#**	**20%***	**10%**	**5%**	**2%**	**1%**
1 min	1.51	1.68	2.26	2.69	3.14	3.77	4.29
2 min	2.61	2.89	3.82	4.49	5.18	6.18	7.00
3 min	3.52	3.90	5.17	6.11	7.07	8.47	9.62
4 min	4.28	4.75	6.34	7.50	8.72	10.5	11.9
5 min	4.92	5.48	7.34	8.71	10.1	12.2	13.9
10 min	7.23	8.07	10.9	13.0	15.2	18.2	20.8
15 min	8.75	9.76	13.2	15.7	18.3	22.0	25.1
20 min	9.90	11.0	14.9	17.7	20.6	24.8	28.2
25 min	10.8	12.1	16.2	19.3	22.5	27.0	30.7
30 min	11.6	13.0	17.4	20.7	24.0	28.8	32.8
45 min	13.6	15.1	20.1	23.9	27.7	33.3	37.9
1 hour	15.1	16.7	22.2	26.4	30.7	36.9	42.1
1.5 hour	17.4	19.3	25.6	30.4	35.4	42.8	49.1
2 hour	19.3	21.3	28.3	33.6	39.4	47.8	55.1
3 hour	22.3	24.6	32.7	39.0	45.9	56.3	65.2
4.5 hour	25.8	28.5	37.9	45.4	53.8	66.4	77.6
6 hour	28.7	31.6	42.1	50.6	60.1	74.7	87.7
9 hour	33.1	36.5	48.7	58.7	70.0	87.5	103
12 hour	36.6	40.3	53.9	65.0	77.5	96.9	114
18 hour	42.0	46.3	61.7	74.2	88.1	110	129
24 hour	46.1	50.8	67.5	80.8	95.3	118	138
30 hour	49.5	54.5	72.1	85.8	101	124	143
36 hour	52.4	57.7	75.9	89.8	105	128	147
48 hour	57.2	62.9	82.1	96.1	111	133	152
72 hour	64.9	71.2	91.5	106	120	141	158
96 hour	71.4	78.2	99.4	114	128	148	164
120 hour	77.4	84.6	107	122	136	157	173
144 hour	83.4	91.0	115	131	146	168	185
168 hour	89.4	97.3	123	140	157	181	200

Note:
The 50% AEP IFD **does not** correspond to the 2 year Average Recurrence Interval (ARI) IFD. Rather it corresponds to the 1.44 ARI.
* The 20% AEP IFD **does not** correspond to the 5 year Average Recurrence Interval (ARI) IFD. Rather it corresponds to the 4.48 ARI.

Table 2.1 Rainfall Intensity for Muchea

2.2 Physiography

2.2.1 Topography

The site lies on a very gently sloping plain on the eastern side of Ellen Brook. The site slopes gently to the west-southwest at gradients of up to 2.5%, decreasing to less than 0.4% near Ellen Brook. Figure 5 shows the topography of the site.

2.2.2 Geology, Landforms and Soils

Precinct 3 is located on the Pinjarra Plain, with soils of pebbly silt belonging to the Guildford Formation. These soils originated as alluvial deposits washed from the Dandaragan Plateau by rivers and streams.

The Guildford Formation soils are described by the Geological Survey of Western Australia (Gozzard, 1982) as "Strong brown silt with common fine to occasionally coarse grained, sub-rounded quartz, heavily weathered granite pebbles, some fine to medium-grained quartz sand, of alluvial origin".

Drilling at six sites across the project area for this LWMS found silty soils containing varying proportions of clay, with the clay content increasing with depth. The low-lying western parts of the site are underlain in places by an ironstone (laterite) hardpan at depths of around one metre. Bore logs from the drilling are attached in Appendix B.

At the western edge of the site the alluvial deposits are overlain by a thin veneer of grey sand transported by floods in Ellen Brook. Figure 5 shows the site geology.

2.2.3 Soil Permeability

The permeability of the site soils is variable, depending on the clay content. Test pumping during sampling of the on-site bores indicated hydraulic conductivities in the top few metres ranging from about 1 m/day to over 5 m/day.

Constant-head permeability tests in accordance with the method set out in Australian Standard AS1547:2012: – *On-site Domestic Wastewater Management* were undertaken by BES at six sites at depths of 0.5m to 1m in November 2018. The tests returned saturated hydraulic conductivity values ranging from 0.25m/day to 4.2m/day with a mean of 1.8m/day. Details of the BES permeability tests are attached in Appendix C.

Structerre Consulting Engineers carried out falling-head permeability tests at depths of up to 1m at seven sites in November 2018. The falling-head tests returned hydraulic conductivity values ranging from 0.3m/day to 1.2m/day with a mean of 0.7m/day. Details of the Structerre permeability tests are shown in the Geotechnical Report (Appendix D).

Figure 5 shows the locations of the BES and Structerre permeability tests

The ironstone hardpan in low-lying areas would impede vertical groundwater movement but its restricted extent means that its effect would be localised. In the east of the site, the clay subsoils impede rainfall infiltration and cause a perched surface water table to develop in winter.

The presence of a water table at the ground surface in winter across much of the site (see Section 2.3.2) means that all infiltration of drainage and effluent will be in fill, so the permeability of the natural soils is of reduced importance.

2.2.4 Acid Sulphate Soils

The DBCA maps most of the site as Low to Nil risk of Acid Sulphate Soils (ASS). Areas within 50-250m of Ellen Brook (corresponding to the alluvial sand S11 and ironstone) are

mapped as Low to Moderate risk. The nearest mapped High ASS risks are an area of palusplain about 850m to the south-east and a sumpland about 900m to the west of the site. Bore sampling in August 2018 found no indications of potential or actual ASS in the groundwater. No further investigation of ASS is considered to be necessary, although monitoring should be undertaken during any dewatering activities, with lime dosing of water and/or soil if required.

2.2.5 Phosphorus Retention Index

Previous experience has shown that the gravelly and silty soils of the Guildford Formation generally have moderate to high PRI.

PRI is a measure of the ability of a soil to adsorb and retain phosphorus from solution. A high PRI indicates that a soil is unlikely to leach phosphorus to the water table. Typical ranges for PRI values in soils are as follows:

PRI Range	*Rating*	*Typical soils*
0 – 0.5	Very Low	Bassendean Sand
2 – 4	Low – Moderate	Karrakatta Sands
5 – 12	Moderate – High	Cottesloe Sands
12 – 20	High	Crushed Limestone, Limesand
20 – 1000+	Very High	Clay

The DWER recommends a minimum PRI of 15 for soils beneath infiltration basins. The Health Department's draft *Code of Practice for Onsite Sewage Management* (2001) recommends a PRI of at least 20 for soils beneath effluent irrigation areas.

Soil samples collected from eight boreholes and infiltration test holes on the site (Figure 5) at depths of 0.5m to 1m returned PRI values of 39.3 to 338.1, with an average of 146.8. This shows that the soils of the site have a very high capacity to bind phosphorus.

2.3 Hydrology

The hydrology of the project area is complex, with soils of varying permeability, shallow and deep groundwater, runoff and surface discharge. Figure 6 depicts the overall hydrology of the site.

2.3.1 Groundwater

Groundwater occurs at shallow depth across the site. The DWER maps minimum groundwater levels at 39-48m AHD (2-7m below ground), flowing south-west towards Ellen Brook.

In winter, the groundwater rises to the ground surface across the lower western parts of the site and creates surface discharge to creeks, drainage lines and Ellen Brook. In the higher

eastern parts of the site, rainfall infiltration is impeded by the low-permeability subsoils, creating a perched water table which flows downslope and discharges as surface flow on the lower parts of the site. The net result of these two processes is that groundwater is at or near the ground surface over much of the site in winter.

Bores installed and measured in August 2018 (Figure 7), during a wetter than average winter, gave water depths and levels shown in Table 2.2. Simultaneous measurements of DWER bores located 480m south-east (Swan GWA 2-98) and 580m north-east (Gnangara Monitoring GD20) enabled Average Annual Maximum (AAMGL) and Maximum (MGL) groundwater levels at the site to be calculated. Figure 7 shows the calculated AAMGL and depth to AAMGL contours across the site. Figure 8 shows hydrographs for the DWER bores.

Table 2.2 shows that the groundwater levels measured on 22 August 2018 were slightly above the AAMGL. The table also shows that the estimated MGL is above the ground surface over much of the site. This does not take into account the effects of existing drains and surface runoff, which would generally limit the groundwater levels to at or just below the ground surface.

Table 2.2 Groundwater Depths and Levels 22 August 2018

Bore	*Depth (mbgl)*	*Level (m AHD)*	*AAMGL (m AHD)*	*MGL (m AHD)*	*Depth to AAMGL (m)*	*Depth to MGL (m)*
MB1	0.2	51.39	51.14	51.72	0.45	-0.13
MB2	0.34	45.29	45.04	45.62	0.59	0.01
MB3	0.21	52.37	52.12	52.70	0.46	-0.12
MB4	0.02	42.58	42.33	42.91	0.27	-0.31
MB5	0.69	56.1	55.85	56.43	0.94	0.36
MB6	-0.08	42.98	42.73	43.31	0.17	-0.41
MB7	0.32	55.19	54.94	55.52	0.57	-0.01
MB8	0.23	42.64	42.39	42.97	0.48	-0.10
399	0.02	48.42	48.17	48.75	0.27	-0.31
GD20	0.12	61.36	59.85	61.35	1.63	0.13
2-98	1.44	56.85	56.6	57.18	1.69	1.11

2.3.2 Surface Drainage

The high water tables and low permeability subsoils result in surface flow in channels and sheet flow across the ground surface during wet winters.

Several natural and artificial drainage lines cross the site from fifteen culverts beneath Great Northern Highway. The largest of these is a creek at the northern end, which has a catchment of 384ha east of Great Northern Highway. Historical Landgate aerial photography shows that between 1965 and 1977 this creek was diverted within the project area to run along a fenceline drain within Lot 804.

Two other drainage lines enter on the mid eastern boundary, draining catchments of 67ha and 121ha east of Great Northern Highway. Historical Landgate aerial photography shows that the southern and larger of these two drainage lines was constructed between 1965 and 1974. The smaller northern drainage line has been modified and cleared over the years so that it now retains no natural attributes.

Several other culverts beneath the highway drain into minor drainage lines within the site. Other small drainage lines rise within the site and flow west. Figure 9 shows the drainage within the site.

All drainage from the site flows into Ellen Brook, the major drainage feature of the region. The Ellen Brook catchment is the largest sub-catchment of the Swan-Canning River system, contributing 6% of the total annual flow in the system, and is the largest single contributor of nutrients to the system (WA Govt, 2011).

Ellen Brook has a surface catchment of 715 km^2 (WRC, 2012). The Brook rises as Chandala Brook about 20km north-northwest of the site. The Brook is seasonal, flowing generally between May and November with an annual flow ranging from 2.1 to 48.6 GL (SRT, 2009).

Flows in Ellen Brook are normally confined to the defined channel of the Brook, although high flows can cause inundation of adjacent land. BG&E Pty Ltd modelled the 100-year ARI floodplain of Ellen Brook for the Perth-Darwin National Highway (PDNH) project on behalf of Main Roads Western Australia (MRWA) in 2018. Figure 9 shows the 100-year ARI floodplain as modelled by BG&E.

Emerge (2019) modelled combined flows in Ellen Brook and the minor drainages across the site for the Muchea Regional Water Management Strategy. The boundary of the floodplain modelled by Emerge (2019) agrees closely with the floodplain boundary modelled by BG&E for MRWA.

Further flood modelling was carried out by BG&E for this project, in order to map the 100-year floodway of the Brook for the purposes of defining the foreshore reserve. The floodway modelling was confined to the part of Ellen Brook south of the PDNH crossing, where the Structure Plan area adjoins the Brook. The BG&E floodway modelling report is attached in Appendix E. Figure 9 shows the floodway as mapped by BG&E, which falls within the foreshore and drainage/landscape reserve.

2.3.3 Foreshore Definition

The Muchea Employment Node Structure Plan (WA Govt, 2011) designated a nominal 15-40m foreshore reserve east of Ellen Brook. The Structure Plan noted that the reserve could be modified at the Urban Water Management Plan stage in accordance with DoW Foreshore Protection Policy No. 1 – *Identifying the Foreshore Area* and Water Note 23 – *Determining Foreshore Reserves*.

A Foreshore Definition Study was undertaken for this LWMS in accordance with the above DoW policies to better define the foreshore reserve of Ellen Brook in the light of detailed flood modelling in 2018. The Foreshore Definition report is attached in Appendix F.

The Foreshore Definition Study found that a foreshore setback of between 120m and 204m east of Ellen Brook was necessary to accommodate the 100-year ARI floodway. This foreshore setback is reflected in the Local Structure Plan.

The foreshore setback will be reserved for public open space and drainage under the Scheme. The reserve will be densely revegetated with local native species and used for landscaping, passive recreation and overflow drainage management.

2.3.4 Water Resources

The project area is within the Lake Mungala sub-area of the Gingin Groundwater Area for the superficial and semi-confined (Mirrabooka) aquifers, and the SA 3 South sub-area for the confined Leederville and Yarragadee aquifers. Groundwater allocations within the Lake Mungala and SA 3 South sub-areas are managed under the Gnangara Groundwater Areas Allocation Plan. Under the plan, all of the aquifers within the Lake Mungala and SA 3 South sub-areas are fully or over allocated, and no new allocations are available. The DWER advised in 2018 that it intended to release a new Gnangara Groundwater Allocation Plan in late 2018 (G. Chandler, 2018 pers. comm.). However, in January 2020 the DWER indicated that the draft was not expected to be released until 2021. The revised allocation plan is likely to further reduce allocation limits within the plan area.

The DWER Water Register (https://maps.water.wa.gov.au/#/webmap/register) shows a number of licensed bores within the project area, abstracting water from the superficial and Leederville aquifers. The total licensed allocations within the project area are 81,500 KL/a from the Leederville and 35,000 KL/a from the superficial aquifer. A Leederville allocation of 180,000 KL/a is licensed to CPB Contractors for the construction of the Perth-Darwin National Highway (PDNH). This allocation is expected to be surrendered when the PDNH construction is completed. Figure 10 shows the existing groundwater licences in Precinct 3. Table 2.3 shows the owners and licensed volumes.

Table 2.3 Groundwater Licences

Licence No.	*Lot No.*	*Owner*	*Aquifer*	*Allocation (KL/yr)*
53081	804	A. Quince	Leederville	30,000
59401	803	Karratha Enterprises Pty Ltd	Leederville	1,500
53084	801	Inghams Enterprises Pty Ltd	Superficial	35,000
53083	800	Inghams Enterprises Pty Ltd	Leederville	50,000

2.4 Water Quality

2.4.1 Groundwater

Groundwater samples were collected from eight bores within the project area (Figure 7) on 22 August 2018, when groundwater levels were at or near their peak for the year. The results of the analysis are shown in Table 2.3 and summarised below.

Groundwater quality within the project area is moderate, which is to be expected given the soil types and the history of agriculture. Nitrogen and phosphorus concentrations are generally moderate with the exception of a notably high reading for total phosphorus in Bore MB2, in the north-west of the project area. This bore is downstream of a heavily-stocked special rural lot and also has sandy surface soils. The high Total Phosphorus concentration is not reflected in the dissolved (reactive) phosphorus concentration.

The groundwater shows low acidity and sulphate levels, indicating that there is no evidence of acid sulphate soils. Dissolved metals concentrations are low except for aluminium and zinc, which are slightly elevated across much of the site.

2.4.2 Surface Water

Surface water samples were collected on 22 August 2018 from ten drainage lines flowing into the project area from culverts beneath Great Northern Highway (Figure 9). A further six samples were collected from drains flowing out of the project area into Ellen Brook. Samples were also collected from Ellen Brook immediately upstream and downstream of the project area, and from two small dams in the south of the project area (Figure 9). The results of the analysis are shown in Tables 2.4 and 2.5 and summarised below.

Surface water quality upstream of the project area is variable, with total phosphorus in ten drains and creeklines flowing into the site (Figure 9) ranging from 0.04mg/L to 0.31mg/L (the ANZECC target for freshwater ecosystems is 0.065mg/L). Total nitrogen in these watercourses ranged from 0.6mg/L to 2.1mg/L, against an ANZECC target of 1.2mg/L.

Water quality downstream of the project area was generally poorer, with six outflowing drains (Figure 9) having total phosphorus of 0.07 - 1.8 mg/L and total nitrogen of 1.3 - 3.0 mg/L.

The most notable feature of surface water quality is Ellen Brook itself, which showed total phosphorus of 0.59mg/L upstream of the project area and 0.54mg/L downstream. Coupled with the high flow at the time, this emphasises the primary role of Ellen Brook in the water quality issues facing the Swan-Canning River system.

Suspended sediment levels in surface water upstream and downstream were generally low except at Site 369 (Figure 9) in Ellen Brook immediately downstream of the confluence of a small drain carrying sediment-laden water from the PDNH roadworks. The effect of this drain was not apparent in samples further down Ellen Brook.

The two dams sampled in the south of the project area, which held a blend of surface and ground water, gave mixed water quality results, with low phosphorus but elevated nitrogen levels.

Table 2.4 Groundwater Quality 22/8/2018

(see Figure 7 for bore locations)

	Parameter	Unit	Aquatic Ecosystems[a]	Irrigation Water[b]	*MB1*	*MB2*	*MB3*	*MB4*	*MB5*	*MB7*	*MB8*
Nutrients	Total Nitrogen	mg/L	1.2	5	**1.7**	**4.3**	**3**	<0.2	**2**	1.2	0.5
	NOx	mg/L	0.15	ng	**1.5**	**2.5**	**3**	<0.01	**2**	**0.21**	0.07
	Total Kjeldahl Nitrogen	mg/L	ng	ng	0.2	1.8	<0.2	<0.2	<0.2	1	0.4
	Total Phosphorus	mg/L	0.065	0.05	0.04	**0.99**	0.03	**0.15**	**0.2**	**0.2**	**0.25**
	Reactive Phosphorus	mg/L	0.04	ng	<0.01	0.01	<0.01	0.02	<0.01	0.02	0.03
Physical	pH		6.5-8.0	6-8.5	6.5	6.9	6.7	**4.7**	6.6	**6.3**	**5.5**
	Conductivity	mS/cm	0.12-0.3	1.3	**4.8**	**1.6**	**0.82**	**2.8**	0.25	**3.5**	**4.4**
	Salinity (from EC)	mg/L	72-180	780	**2880**	**960**	**492**	**1680**	150	**2100**	**2640**
	Acidity	mg/L	40[c]	ng	15	20	9	**63**	15	**77**	**67**
	Alkalinity	mg/L	ng	ng	29	70	22	<5	27	65	<5
	Acidity:Alkalinity Ratio		1[c]	ng	0.52	0.11	0.18	0.57	0.29	0.45	0.37
	Hardness	mg/L	ng	60-350	140	190	51	110	52	170	180
	Sulphate	mg/L	ng	ng	240	130	13	120	12	130	120
	Chloride	mg/L	ng	350	1400	400	230	850	44	1100	1400
	SO_4:Cl Ratio		0.5	ng	0.17	0.33	0.06	0.14	0.27	0.12	0.09
Major Ions	Calcium	mg/L	ng	ng	54	44	20	23	17	54	32
	Sodium	mg/L	ng	230	820	300	110	420	29	630	710
	Potassium	mg/L	ng	ng	1.7	19	0.3	13	2.3	8	24
	Magnesium	mg/L	ng	ng	160	28	23	83	8.8	67	140
	Iron	mg/L	ng	10	0.16	0.19	0.08	0.39	0.08	4.3	18

Notes

ng denotes "no guideline". na denotes "not analysed"

a. ANZECC (2000) Aquatic Ecosystem trigger values (Nutrient, pH and Conductivity are for lowland rivers; Dissolved Metals are for freshwater ecosystems 90% species protection)

b. ANZECC (2000) Irrigation trigger values (long-term irrigation up to 100 years)

c. DEC(20__) oxidation indicator triggers for ASS-affected groundwater.

d. ANZECC (2000) Irrigation trigger values for pasture and fodder for grazing animals except pigs and dairy animals.

Dissolved Metals	Aluminium	mg/L	0.08	5	**0.2**	<0.1	**0.2**	**0.2**	**0.1**	**0.2**	**0.2**	
	Arsenic (III & V)	mg/L	0.136	0.1	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	0.006	
	Cadmium	mg/L	0.0004	0.01	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	
	Chromium (VI)	mg/L	0.006	0.1	<0.002	<0.002	<0.002	<0.002	<0.002	0.003	<0.002	
	Copper	mg/L	0.0018	0.2	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	
	Mercury	mg/L	0.0019	0.002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	
	Nickel	mg/L	0.013	0.2	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	<0.01	
	Lead	mg/L	0.0056	2	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	
	Zinc	mg/L	0.015	2	<0.01	0.01	0.01	**0.06**	<0.01	**0.07**	**0.02**	

Table 2.5 Upstream Surface Water Quality 22/8/2018

(see Figure 9 for sample locations)

	Parameter	Unit	Aquatic Ecosystems[a]	Irrigation Water[b]	*Ellen Brook Upstream*	*407*	*405*	*395*	*393*	*392*	*391*	*410*	*409*	*415*
Nutrients	Total Nitrogen	mg/L	1.2	5	**3**	0.7	**2.1**	1.2	**1.7**	0.6	0.6	**1.7**	**1.7**	**1.7**
	NOx	mg/L	0.15	ng	0.01	0.06	<0.01	0.02	0.12	<0.01	0.01	**0.45**	**0.32**	<0.01
	Total Kjeldahl Nitrogen	mg/L	ng	ng	3	0.6	2.1	1.2	1.6	0.6	0.6	1.2	1.4	1.7
	Total Phosphorus	mg/L	0.065	0.05	**0.59**	**0.11**	**0.27**	**0.08**	**0.09**	0.04	0.04	0.05	**0.24**	**0.31**
	Reactive Phosphorus	mg/L	0.04	ng	**0.47**	<0.01	**0.13**	0.01	0.01	<0.01	<0.01	<0.01	**0.18**	**0.22**
Physical	pH		6.5-8.0	6-8.5	7.2									
	Conductivity	mS/cm	0.12-0.3	1.3	**1.7**									
	Salinity (from EC)	mg/L	72-180	780	**1020**									
	Acidity	mg/L	40[c]	ng	8									
	Alkalinity	mg/L	ng	ng	62									
	Acidity:Alkalinity Ratio		1[c]	ng	0.04									
	Hardness	mg/L	ng	60-350	180									
	TSS	mg/L	ng	ng	7	6	14	<5	<5	<5	<5	<5	<5	<5
	Sulphate	mg/L	ng	ng	49									
	Chloride	mg/L	ng	350	470									
	SO_4:Cl Ratio		0.5	ng	0.10									
Major Ions	Calcium	mg/L	ng	ng	56									
	Sodium	mg/L	ng	230	220									
	Potassium	mg/L	ng	ng	10									
	Magnesium	mg/L	ng	ng	53									
	Iron	mg/L	ng	10	2.8									

Notes

ng denotes "no guideline", na denotes "not analysed"
a. ANZECC (2000) Aquatic Ecosystem trigger values (Nutrient, pH and Conductivity are for lowland rivers; Dissolved Metals are for freshwater ecosystems 90% species protection)
b. ANZECC (2000) Irrigation trigger values (long-term irrigation up to 100 years)
c. DEC(20__) oxidation indicator triggers for ASS-affected groundwater.
d. ANZECC (2000) Irrigation trigger values for pasture and fodder for grazing animals except pigs and dairy animals.

Dissolved Metals	Aluminium	mg/L	0.08	5	**0.2**									
	Arsenic (III & V)	mg/L	0.136	0.1	<0.002									
	Cadmium	mg/L	0.0004	0.01	<0.002									
	Chromium (VI)	mg/L	0.006	0.1	<0.002									
	Copper	mg/L	0.0018	0.2	<0.01									
	Mercury	mg/L	0.0019	0.002	<0.0002									
	Nickel	mg/L	0.013	0.2	<0.01									
	Lead	mg/L	0.0056	2	<0.01									
	Zinc	mg/L	0.015	2	**0.03**									

Table 2.6 Downstream Surface Water Quality 22/8/2018

(see Figure 9 for sample locations)

	Parameter	Unit	Aquatic Ecosystems[a]	Irrigation Water[b]	*Ellen Brook Down -stream*	*AMS1*	*Ingham1*	*Ingham2*	*MD*	*369*	*362*	*Dam1*	*Dam2*	Notes
Nutrients	Total Nitrogen	mg/L	1.2	5	**2.6**	**1.5**	**2.3**	**1.7**	**1.6**	**3**	**1.3**	**3.2**	**2.9**	ng denotes "no guideline", na denotes "not analysed"
	NOx	mg/L	0.15	ng	0.02	**0.23**	<0.01	<0.01	<0.01	**0.34**	<0.01	**2.4**	**2.9**	a. ANZECC (2000) Aquatic Ecosystem trigger values (Nutrient, pH and Conductivity are for lowland rivers; Dissolved Metals are for freshwater ecosystems 90% species protection)
	Total Kjeldahl Nitrogen	mg/L	ng	ng	2.6	1.3	2.3	1.7	1.6	2.7	1.3	0.8	<0.2	b. ANZECC (2000) Irrigation trigger values (long-term irrigation up to 100 years)
	Total Phosphorus	mg/L	0.065	0.05	**0.54**	**0.12**	**0.14**	**0.07**	**0.16**	**0.18**	**0.12**	0.05	0.04	c. DEC(20__) oxidation indicator triggers for ASS-affected groundwater.
	Reactive Phosphorus	mg/L	0.04	ng	**0.45**	<0.01	0.04	<0.01	0.02	0.04	0.02	<0.01	<0.01	d. ANZECC (2000) Irrigation trigger values for pasture and fodder for grazing animals except pigs and dairy animals.
Physical	pH		6.5-8.0	6-8.5	7.3									
	Conductivity	mS/cm	0.12-0.3	1.3	**1.7**									
	Salinity (from EC)	mg/L	72-180	780	**1020**									
	Acidity	mg/L	40[c]	ng	7									
	Alkalinity	mg/L	ng	ng	65									
	Acidity:Alkalinity Ratio		1[c]	ng	0.04									
	Hardness	mg/L	ng	60-350	200									
	TSS	mg/L	ng	ng	<5	7	10	<5	7	51	<5	<5	<5	
	Sulphate	mg/L	ng	ng	51									
	Chloride	mg/L	ng	350	480									
	SO_4:Cl Ratio		0.5	ng	0.11									
Major Ions	Calcium	mg/L	ng	ng	64									
	Sodium	mg/L	ng	230	220									
	Potassium	mg/L	ng	ng	10									
	Magnesium	mg/L	ng	ng	53									
	Iron	mg/L	ng	10	2.9									

Dissolved Metals	Aluminium	mg/L	0.08	5	**0.2**									
	Arsenic (III & V)	mg/L	0.136	0.1	<0.002									
	Cadmium	mg/L	0.0004	0.01	<0.002									
	Chromium (VI)	mg/L	0.006	0.1	<0.002									
	Copper	mg/L	0.0018	0.2	<0.01									
	Mercury	mg/L	0.0019	0.002	<0.0002									
	Nickel	mg/L	0.013	0.2	<0.01									
	Lead	mg/L	0.0056	2	<0.01									
	Zinc	mg/L	0.015	2	<0.01									

2.5 Vegetation

2.5.1 Vegetation Type and Condition

The project area is mostly cleared of native vegetation, consisting of current and former farm paddocks and industrial sites. Figure 11 shows the vegetation of the project area.

Remnant native vegetation consists of a few mature paddock trees (Marri, Flooded Gum and Wandoo), including several very large Marri trees that have been retained within the AMS site (Lots 802 & 803) and a few large Wandoo trees in Lot 804.

Native regrowth is present near the large drain on Lot 800 in the form of a small (0.5ha) thicket of species including *Allocasuarina fraseriana, Melaleuca preissiana, Eucalyptus rudis, Astartea fascicularis* and *Acacia ?rostellifera* over grasses. Nearby is a smaller thicket on a drainage line with regrowth of *Juncus ?kraussii*, *M. preissiana, A. fascicularis* and *E. rudis*.

The area around the large drain on Lot 800 has been planted densely with native tree species including *E. rudis, A. fraseriana, M. preissiana, M. cuticularis* and *Corymbia calophylla.* The drain itself contains a heavy growth of sedges, Bulrush (*Typha orientalis*) and Kikuyu and Couch grasses.

Other areas near the large drain and in other low-lying parts of the site contain dense growths of Cape Tulip (*Moraea flaccida*), Spiny Rush (*Juncus acutus*) and Narrow-leaf Cotton Bush (*Gomphocarpus fruticosus*), all of which are declared pests in Western Australia (www.agric.wa.gov.au/pests-weeds-diseases/weeds/declared-plants). The native rush *Juncus kraussii* occurs along with the introduced *J. acutus* in some areas.

In the west of Lot 35 in the south of the project area are a few large isolated Flooded Gums. In the central south of the site (Lot 35) is a 2.5ha patch of open woodland of young *E. rudis* regrowth over grass.

Elsewhere on the site there are lines and clumps of planted trees, mostly Flooded Gums, Bluegums (*Eucalyptus globulus*), River Red Gums (*E. camaldulensis*) and other non-local eucalypts. There is also scattered regrowth of sedges (*Juncus* ?*kraussii*) and isolated shrubs.

Overall the condition of the vegetation within the project area is classed as Cleared to Completely Degraded. There is no vegetation in Good or better condition.

Adjacent to Ellen Brook there is a sparse to dense woodland of *Eucalyptus rudis, Allocasuarina fraseriana, Melaleuca preissiana, M. rhaphiophylla, Astartea affinis, Jacksonia furcellata and Acacia saligna.* This woodland thins rapidly with distance from the Brook and is mostly outside of the project area. The ground cover over most of this area consists of a heavy growth of pasture grasses and weeds, which extend into the waterway itself.

The condition of the Brook vegetation is mostly Degraded to Completely Degraded, with a few areas of Good condition. The central part (Lots 800 & 801) is accessible to cattle and is in poorer condition than the rest due to grazing. In the northern part (Lots 802-804) there is a dense growth of *Watsonia meriana* var. *bulbillifera* in areas not accessed by cattle.

2.5.2 Vegetation Complexes

The vegetation of the site is mapped as Yanga Complex, described by Heddle *et al.* (1980) as a low open-forest of *Casuarina obesa*, *Actinostrobus* (now *Callitris*) *pyramidalis, Melaleuca* spp. (including *M. lateritia, M. hamulosa*, *M. preissiana and M. rhaphiophylla*) and *Eucalyptus rudis* in the lower-lying areas, with *Banksia* spp., *Eucalyptus todtiana* and *Corymbia calophylla* open-woodland in the higher areas.

2.6 Land Uses and Potential Contamination

Historic Landgate aerial photography shows that the project area has been largely cleared and used for farming since at least 1965.

The DWER Contaminated Sites Database (https://dow.maps.arcgis.com/apps/webappviewer/index.html?id=c2ecb74291ae4da2ac32c441819c6d47) shows no record of any contaminated sites in the project area. The nearest mapped contaminated site is a service station in Muchea, 700m west of the northern end of the project area and on the other side of Ellen Brook. There is no potential for this contamination to directly affect the project area.

The DWER (DoE, 2004) considers intensive agriculture such as the poultry farming operation on Lots 800 and 801 to be a potentially contaminating land use, with potential contaminants including organochlorine, organophosphate and carbamate pesticides, herbicides, metals, salinity and nutrients. Residual soil contamination is most likely to be present around the poultry sheds. Groundwater contamination by nutrients and salinity may be present downgradient of the sheds but would diminish and eventually clear once the sheds were removed. There is no visual or olfactory evidence of soil or groundwater contamination at the poultry farm.

Given the proposed use of the land for industry, and assuming the poultry farm has been operating in according with its licence, there should be no need for a site contamination assessment before the land is redeveloped.

There is no visual evidence of other potentially contaminating activities such as piggeries, hydrocarbon storage or landfill.

3.0 WATER USE SUSTAINABILITY

3.1 Water Supply

Water will be required for both potable and non-potable purposes. The Leederville aquifer is likely to be the preferred source for potable supply due to its generally higher quality and lower risk of contamination. Non-potable groundwater demand is likely to be limited to landscape irrigation, as industries within the Precinct will be restricted to those with low water usage.

Potable water will be supplied to the Precinct by a licensed water provider. A proposed water project for the Lower Chittering Valley is currently in development by Aqua Ferre Pty Ltd, which includes construction of a water treatment facility on Lot 2 Reserve Rd, Chittering. Aqua Ferre is in the process of applying for a Water Service Provider's Licence from the Economic Regulation Authority (ERA). Aqua Ferre has confirmed that it has the capacity within its proposed licence to supply Precinct 3 with potable water. Discussions with Aqua Ferre are ongoing. A letter from Aqua Ferre confirming this understanding is attached in Appendix G.

For non-potable uses, purchase of water entitlements from existing licensed users within or outside of the Precinct is likely to be necessary. The landowners group will negotiate with existing licence holders within and outside of the Precinct with a view to purchasing an existing groundwater allocation, and will submit a groundwater licence application to the DWER in due course.

3.2 Water Efficiency Measures

Precinct 3 will be designed as a low water-use precinct. Only industries with low water consumption will be permitted. This is driven largely by the hydrology of the site and its proximity to Ellen Brook, which demands that wastewater disposal be minimised.

Potable water use within the Precinct will be limited to consumption for domestic use in toilets, bathrooms and kitchens. The Shire of Chittering Town Planning Scheme No. 6 limits wastewater generation in industrial zones to 5,400 litres per hectare per day. If it is assumed that all potable water used will ultimately become wastewater, it can be calculated that the maximum allowable potable water demand for the 185ha precinct will be approximately 1,000 KL per day.

Cossill & Webley (2018) estimated total potable water demand for the Precinct at 228.6 ML per year, based on a study by GHD (20__) for a similar industrial estate in Karratha.

Groundwater will be used mainly for irrigation of landscape plantings and swales. These areas will be irrigated only during the establishment stage (one or two years).

The Landscape Master Plan estimates total plantings of 31.5ha of sedges, shrubs and trees within the precinct.

The water demand for irrigation in a given year will depend on the staging of subdivision and development. If the precinct were developed over ten years, the demand for irrigation water (at the DWER's default rate of 4,500 KL/ha/yr) over that ten year period would be in the order of 14 – 20 ML/yr, decreasing in subsequent years.

4.0 LAND CAPABILITY FOR ON-SITE EFFLUENT DISPOSAL

4.1 Published Land Capability Ratings and Constraints

The proposed lots are located on land mapped mostly as Guildford Formation (Gozzard, 1982). King & Wells (1990) rated the capability of the more elevated parts of the Guildford Formation as Fair to High, while the lower-lying parts were rated as Low to Very Low. The main constraints to effluent disposal in the lower areas are high water tables and poor drainage.

The Government Sewerage Policy maps the project area as being within a Sewage Sensitive Area (SSA) due to its location within the catchment of the Swan-Canning Estuary. The Policy places additional site requirements in terms of groundwater clearance and lot density on effluent disposal within SSAs.

4.2 Soil Permeability

Australian Standard AS1947:2012 recommends a minimum hydraulic conductivity of 0.06m/day for on-site effluent disposal without special design. The testing method set out in the *Health (Treatment of Sewage and Disposal of Effluent and Liquid Waste) Regulations 1974* implies a minimum conductivity of 0.11m/day without specific approval by the Director-General of Public Health. Permeabilities of this order are generally found in weakly structured or massive clays.

Constant-head permeability tests in accordance with the method set out in Australian Standard AS1547:2012: – *On-site Domestic Wastewater Management* were undertaken at 0.5m depth at five sites (Figure 5) in November 2018. The tests returned saturated hydraulic conductivity values ranging from 0.5 m/day to 4.2 m/day. Details of the permeability tests are attached in Appendix C.

4.3 Phosphorus Retention Index

The Health Department's draft *Code of Practice for Onsite Sewage Management* (2012) recommends a PRI of at least 20 for soils beneath effluent irrigation areas.

Soil samples collected from eight boreholes and infiltration test holes on the site (Figure 5) at depths of 0.5m to 1m returned PRI values of 39.3 to 338.1, with an average of 146.8. This shows that the soils of the site have a very high capacity to bind phosphorus.

Fill used in effluent disposal areas will have a PRI of at least 20, in line with the Health Department's draft Code of Practice (2012).

4.4 Depth to Groundwater

The Government Sewerage Policy (GSP) (WA Govt, 2019) requires that land used for effluent disposal in sewage sensitive areas must have a minimum clearance of 1.5m from the effluent discharge point (e.g. base of leach drain or ATU drip lines) to the highest groundwater level. Under the Policy, the required clearance can be achieved by filling but not by drainage.

The groundwater measurements carried out in August 2018 indicate that the average annual maximum groundwater level (AAMGL) is within 1.5m of the ground surface over the entire project area, and effectively at the ground surface in lower-lying areas (Figure 7). This means that up to 1.5m of fill will be required in effluent disposal areas.

Where filling is used to achieve the necessary groundwater clearance, subsoil drains will be installed at the AAMGL to minimise groundwater rise into the fill. Because drainage is not being used to create the required clearance, this is believed to comply with the GSP.

4.5 Slope

The Government Sewerage Policy prohibits on-site effluent disposal on land with a slope of more than 1 in 5 (20%), in order to prevent runoff of effluent.

The slope of the subject land does not exceed 2.5% (Figure 5). Therefore effluent disposal on the site is not constrained by slope.

4.6 Watercourse Setbacks

The Department of Water & Environmental Regulation (DWER, 2016) recommends that effluent disposal systems should be located at least 100m from waterways and wetlands. The Government Sewerage Policy requires a 100m setback from waterways, significant wetlands and drains discharging directly into waterways or significant wetlands without treatment.

For the purposes of these requirements, “waterway” is defined as a natural watercourse. Ellen Brook is a waterway under this definition. Based on site inspections and historical aerial photography, the minor drainages crossing the project area are regarded as drains, being either wholly artificial in origin or having been so modified over decades of farming that they retain no natural attributes.

The Government Sewerage Policy provides that reduced setbacks from drains may be allowed where it can be demonstrated that the reduced setbacks will not have a significant impact on the environment or public health. In this case, a reduced setback of 6m from subsoil drains is considered necessary and justified because:

- the subsoil drains will be located upslope of the effluent disposal fields (Section 4.8) and will drain only clean groundwater that has been filtered through the soil profile;
- all effluent disposal will be by means of alternative effluent disposal systems with nutrient removal capability (Section 4.7);
- the drained water will be treated by infiltration and vegetation uptake within the roadside swales before being released to Ellen Brook (Section 5.5.2);
- a greater separation would reduce the effectiveness of the subsoil drains in limiting groundwater rise within the effluent disposal areas; and
- the clayey soils and high PRI of the site (Section 2.2.5) mean that the drained water will be of high quality.

It is therefore concluded that the proposed system of effluent disposal in Precinct 3 will meet all setback requirements set out in current government policies.

4.7 System Selection and Location

All effluent generated within the subdivision will be treated and disposed by means of individual on-site effluent disposal systems. All lots will be required to employ nutrient-attenuating alternative systems such as aerobic treatment units (ATUs) with high-PRI irrigation areas or modified leach drain systems (e.g. Filtrex).

ATU irrigation areas will be filled to approximately 2m above the AAMGL (Figure 7) in order to provide 1.5m clearance from the AAMGL to the effluent drip lines as required under the Government Sewerage Policy (2019), allowing for 0.3m groundwater mounding and 0.2m soil cover over the drip lines. The effluent irrigation areas will be filled with soil either sourced from on site or imported. The soil will be tested to confirm a PRI of at least 20.

The ATU irrigation area on each lot will be sized to suit the expected population of the lot. As a rough rule of thumb, each full-time employee on site will require approximately $23m^2$ of effluent irrigation area. Alternatively, the treated ATU effluent may be disposed of via leach drains, which may reduce the area required for disposal by up to two thirds at the cost of a greater height of fill (2.3m total above the AAMGL).

The effluent disposal requirements of each lot will vary depending on the soil profile, groundwater depth, risk of saturation and expected site population. Site testing on each lot prior to development will be required to determine the location and type of effluent disposal system.

4.8 Subsoil Drainage

Where fill is used to raise pads for effluent disposal, subsoil drains will be placed upslope of the filled pad to prevent groundwater rise into the fill. The drains will be placed at least 6m upslope from the drip lines or leach drains. The drains will be set

with their inverts at or above the AAMGL and will discharge via free-draining outlets into the roadside swales, where the water will be further treated by infiltration and vegetation uptake within the swales. Because the water will be draining from high-PRI soil (see Section 2.2.5), it will be of high quality.

5.0 STORMWATER MANAGEMENT STRATEGY

5.1 Principles and Objectives

The stormwater management strategy aims to comply with the principles and objectives for stormwater management identified in the *Stormwater Management Manual for WA* (DoW, 2004) and *Better Urban Water Management* (WAPC, 2008).

Nutrient concentrations and loads in water leaving the site will be managed to comply with the targets of the draft *Swan Canning Water Quality Improvement Plan* (SRT, 2009) for the Ellen Brook catchment, as follows:

- Winter median TP concentration: 0.1 mg/L
- Winter median TN concentration: 1.0 mg/L
- Annual TP yield: 0.03 kg/ha
- Annual TN yield: 0.31 kg/ha.

5.2 Drainage Management System

The drainage system will be designed to maintain surface flow rates and volumes within and from the developed site at their pre-development levels. The drainage design presented here is conceptual and will be refined in the detailed subdivision designs.

The priorities for managing the various sizes of storm event will be:

- 1 year ARI Infiltrate all flows as close to the source as possible. Maintain pre-development flow rates and volumes. Minimise export of nutrients and sediments.

- 5 year ARI Detain water prior to discharge. Maintain pre-development flow rates and volumes. Maintain amenity and serviceability. Prevent scouring and damage.

- 100 year ARI Maintain pre-development flow rates and volumes. Prevent flooding and damage.

5.2.1 Through Drainage

Water enters the project area from external catchments to the east via fifteen culverts beneath Great Northern Highway. Some of these flow directly into defined drainage lines across the site, while others dissipate within the site and become part of the general overland and subsurface flow. Figure 9 shows the existing drainage across the site.

If and when the land to the east (some of which is within Precinct 2 of the Muchea Employment Node) becomes subdivided and developed, it is expected that runoff from storms up to 1-year ARI 1-hour will be retained within each subdivision, and runoff from larger storms up to 100-year ARI will be suitably detained so that the flow rates into the project area will be no greater than the current rates.

The existing drainage lines will be either preserved within easements or realigned and consolidated in vegetated swales within road reserves, which will be wider than normal to accommodate the swales. Figure 12 shows the proposed through-drainage at full development of the site. Figure 13 shows a conceptual profile of the swales.

The swales will be sized to accommodate the flow from a 100-year ARI critical storm from the upstream and internal catchments. A series of low weirs within the swales will capture and infiltrate road runoff from storms up to 1-year ARI 1-hour. The inverts of the swales will be at or above the AAMGL.

The swales will be configured as living streams and densely planted with sedges and shrubs to slow the water flow and help to remove sediments and nutrients from the water.

5.2.2 Internal Drainage

Runoff from roofs, paved surfaces and hardstand areas within private lots from storms up to 1-year ARI 1-hour duration (about 15mm) will be retained and infiltrated within each lot in soakwells, swales and/or landscaping areas. These will be subject to detailed design on individual lots. Lot runoff from larger storms will overflow via pipes into the roadside swales. The overflow pipes will be sized to regulate the flow to pre-development rates.

Runoff from public roads from up to the 1-year ARI 1-hour storm will be retained and infiltrated in roadside swales. The inverts of the swales will be at or above the AAMGL.

The swales will be constructed with low internal weirs set at a height that captures the 1-year 1-hour storm. In road reserves that also include a through-drainage swale, the weirs may incorporate underdrains to promote infiltration of the 1-year flows. Alternatively, the 1-year ARI swale may be formed in the bank of the through-swale to create a double swale. Figure 13 shows conceptual profiles of the alternative swale layouts.

The configuration of the swales and internal weirs will be subject to detailed design including:

- the height of the swale inverts at or above the AAMGL;
- the width and composition of the swale floors, designed to maximise nutrient uptake;
- planting of the swales with dense sedges and shrubs to maximise nutrient uptake;

- the possible inclusion of underdrains within the swales to promote infiltration of 1-year ARI flows; and
- the possible inclusion of secondary swales within throughflow swales to accommodate the 1-year ARI road runoff.

5.2.3 Major Storm Drainage

Road runoff from larger storms will overtop the weirs and flow along the swales to the western boundary, where eleven culverts beneath the PDNH embankment will carry it across to Ellen Brook. Because the PDNH was designed in the context of a rural setting, the culverts are not large enough to carry the full flow from upstream in a 100-year storm event. The drainage design therefore incorporates a swale running adjacent to the southern part of the PDNH embankment. During a 100-year storm, flows that exceed the capacity of the PDNH culverts will be carried south within this swale to the next culvert or into the drainage/landscape reserve, where it will slowly make its way overland through dense vegetation to Ellen Brook.

Figure 12 shows the overall drainage layout and the 100-year ARI flow paths. Table 5.1 summarises the 100-year flows in the swales and PDNH culverts. The flow calculations are detailed in Appendix H.

Table 5.1 100-year ARI Flows

Culvert No. (Figure 12)	*Culvert Dimensions*	*Culvert Invert (mAHD)*	*Culvert Slope*	*Pre Development*			*Post Development*		
				100-yr ARI Inflow (m^3/s) [1]	*Flow Through Culvert (m^3/s) [2]*	*Bypass Flow (m^3/s)*	*100-yr ARI Inflow (m^3/s) [1]*	*Flow Through Culvert (m^3/s) [2]*	*Bypass Flow (m^3/s)*
2.20	1 x 0.45m Circular	49.00	.0085	2.23	0.26	1.97	2.23	0.26	1.97
2.28	2 x 2.4x0.6m Rectangular	48.92	.0105	8.87	8.87	0.00	15.48	14.57	0.91
2.39	1 x 0.9x0.375m Rectangular	49.00	.0186	0.92	0.92	0.00	1.82	1.45	0.36
2.60	5 x 1.2x0.45m Rectangular	48.89	.0066	1.12	1.12	0.00	1.50	1.50	0.00
2.89	1 x 1.2x0.375m Rectangular	47.28	.0119	1.92	1.68	0.24	1.96	1.68	0.28
3.11	1 x 0.9x0.375m Rectangular	46.22	.0095	2.61	1.04	1.57	2.96	1.04	1.92
3.14	1 x 1.2x0.375m Rectangular	45.47	.0083	1.78	1.40	0.38	2.02	1.40	0.62
3.20	1 x 0.9x0.375m Rectangular	45.70	.0078	0.00	0.00	0.00	1.06	0.94	0.12
3.52	1 x 0.9x0.375m Rectangular	44.40	.0047	0.39	0.39	0.00	4.88	0.73	4.15
3.64	3 x 1.2x0.375m Rectangular	43.69	.0014	0.45	0.45	0.00	8.21	1.73	6.49
3.89	4 x 1.2x0.45m Rectangular	42.30	.0019	14.76	3.46	11.30	12.50	3.46	9.04
Ellen Brook	Brook Inflow			18.86	18.86	0.00	17.54	17.54	0.00
South	Offsite Flow			8.38	8.38	0.00	8.59	8.59	0.00

1 Inflow includes any excess (bypass) flow from culvert above.

2. Culvert flows are calculated as follows:
   - Rectangular culverts: Manning's open channel formula (http://www.eng.auburn.edu/~xzf0001/Handbook/Channels.html)
   - Circular culverts: Hazen-Williams formula for full-pipe flow (http://www.calctool.org/CALC/eng/civil/hazen-williams_g)

5.3 Ellen Brook Floodplain

The 100-year ARI floodplain of Ellen Brook was modelled by BG&E in 2017 on behalf of MRWA for the Northlink (PDNH) project. The modelling mapped only the floodplain extent, and not the floodway. Figure 9 shows the 100-year floodplain mapped by BGE.

BG&E revisited the modelling in 2018 for this project to define the 100-year floodway of Ellen Brook. The modelling focussed only on the part of Ellen Brook south of the PDNH crossing and adjacent to the project area. The modelling was carried out in consultation with DWER and MRWA. Figure 9 shows the floodway modelled by BG&E.

The floodway is defined by the DWER as the area within which filling or development would cause an unacceptable rise in river levels (afflux) upstream during a 100-year ARI flood. The floodway is therefore taken as the minimum setback of development or filling (including roads) from the waterway.

The floodplain is the area expected to be inundated by a 100-year ARI flood. Development within the floodplain but outside the floodway is permitted provided that roads and other infrastructure are not damaged by floodwaters and all habitable buildings have a floor level at least 0.5m above the 100-year flood level.

5.4 Surface Water Quality Management

The drainage system will be designed to maximise on-site retention of nitrogen and phosphorus. This will be achieved by:

- Retaining and infiltrating all lot runoff from storms up to 1-year ARI within the lots.
- Infiltrating all road runoff from storms up to 1-year ARI 1-hour duration (estimated by the DWER to carry more than 99% of total flows and nutrients) in vegetated bioretention swales with a minimum soil PRI of 15.
- Conveying all runoff from storms between 1-year and 100-year ARI in densely vegetated bioretention swales to allow suspended particles to be filtered out.

5.5 Maintenance

The drainage system has been designed to require minimal maintenance. The following will be required to ensure that the system continues to function as designed:

- Regular (possibly annual) cleaning of side entry and junction pits, inlet pits and small culverts. More frequent cleaning may be required during the construction phase.

- Tending and maintenance of swales and other vegetated drainage features to remove litter, control weeds and encourage the growth of native species.

- Pruning, mulching or removal of vegetation in swales as necessary to maintain ground fuel loads below 8 tonnes/ha.

6.0 GROUNDWATER MANAGEMENT STRATEGY

6.1 Groundwater Levels

The average annual groundwater level (AAMGL) is at or near the ground surface over much of the site (Figure 7). In the west of the site, groundwater rise in winter is limited by intersecting the ground surface, giving rise to surface runoff.

The drainage system for the site is designed to minimise changes to the existing groundwater regime. Roadside swales and subsoil drains will be set with their inverts at or above the AAMGL. Subsoil drainage within lots will be limited to filled areas used for buildings or effluent disposal.

6.2 Subsoil Drainage

Subsoil drainage will be employed within lots to maintain existing maximum groundwater levels beneath building pads and effluent disposal areas. The subsoil drains will discharge into roadside swales via free-draining outlets.

Subsoil drains may also be employed within road reserves to prevent groundwater rise from damaging the road base and pavement.

All subsoil drains will be set with their invert at or above the AAMGL. Therefore, changes to the groundwater hydrology of the site will be minimal.

6.3 Groundwater Quality

The sampling undertaken to date indicates that the groundwater beneath the site contains low to moderate concentrations of nitrogen and phosphorus. This is to be expected given the nature of the soils and the land use history of the site.

The relationship between nutrient inputs and exports is complex, especially in the case of phosphorus, which travels through the soil profile as a “front” in a complex series of adsorption and desorption reactions. Nitrogen is subject to denitrification and mineralisation in the soil and groundwater. As a result, nutrient exports from the site at present will be a reflection of nutrient inputs over the last several decades, modified by soil hydrology and nutrient retention capacity.

The aim of nutrient management will be to limit nutrient inputs to the site so that nutrient outputs are minimised. As an industrial precinct, the area of fertilised gardens and lawns will be small. Landscaping areas including street trees, swales and vegetation buffers will be established with minimal fertilisers and irrigation.

Measures available to minimise nutrient inputs and exports in the development will include:

- regular street sweeping to remove accumulated contaminants; and
- selection of native species with low water and fertiliser requirements for public open space and landscape areas.

7.0 LANDSCAPING STRATEGY

Landscaping of the site will focus on the use of species with low water demand. Plantings will include bioretention swales and basins, landscape buffers (to a minimum of 10% of the area of each lot) and street trees. The plantings will not be irrigated after the establishment phase. No turf grass will be planted.

Fertiliser use will be minimal. New tube stock plantings will be fertilised with slow-release nitrogen and phosphorus tablets on establishment and thereafter will be unfertilised.

The bioretention basins and swales will be densely planted with inundation-tolerant species including sedges and low shrubs in order to stabilise the basins and maximise their ability to take up nitrogen from the water.

The immediate surrounds of Ellen Brook (extending up to 30m from the watercourse) and the drainage/landscape reserve will be densely planted with wetland-tolerant native sedges, low shrubs and other understorey species in order to slow and filter runoff that is not captured by the road drainage system.

The total area to be planted is approximately 31.5 hectares. If all of this area were planted simultaneously during the establishment phase, approximately 142 ML of water would be required to irrigate the new plantings for the first year. As the project area is likely to be developed in a number of stages, the requirement for irrigation water is likely to be spread out over a number of years, with only a small part of the total demand being required in any one year.

The density of planting will be controlled to keep flammable ground fuel loads below 8 tonnes/ha, in accordance with the Bushfire Management Plan (eco logical Australia, 2018).

Figure 14 shows the conceptual landscaping strategy.

8.0 MONITORING

Baseline water quality results for the site are shown in Tables 2.3, 2.4 and 2.5. Groundwater levels and quality will continue to be monitored and compared against baseline levels and relevant guidelines. Water quality in the creeklines and Ellen Brook will be monitored upstream and downstream of the project area to determine what (if any) impacts the development may be having on the watercourses.

Water quality sampling will be conducted nominally once a year in late winter. Detailed water monitoring and response procedures will be developed as part of the Urban Water Management Plans to be prepared for each stage of subdivision.

9.0 IMPLEMENTATION AND FURTHER MANAGEMENT PLANS

Further planning and subdivision of the subject land will be carried out in accordance with the general water management principles set out in this LWMS. Subdivision of lots in the structure plan area may be carried out by individual owners as they see fit, in accordance with the framework of the LWMS.

An Urban Water Management Plan (UWMP) will be prepared as a condition of subdivision approval for each stage of subdivision. The UWMP will present the detailed design of the stormwater drainage system within that stage.

The developer of each stage of subdivision will maintain the drainage system, landscaped areas and water monitoring program within that stage until two years after that stage of subdivision is completed. At the end of that time the responsibility for monitoring and management will be handed over to the Shire of Chittering.

10.0 REFERENCES

ANZECC & ARMCANZ (2000). *National Water Quality Management Strategy*. Australian and New Zealand Environment and Conservation Council, Canberra.

BoM (2017). *Climate Statistics for Australian Locations.* http://www.bom.gov.au/climate/averages/tables/ca_wa_names.shtml#name_n Accessed 17/4/2017. Bureau of Meteorology, Perth.

Connell Wagner (2007). Contaminated Sites Desktop Study. Cited in: WA Govt (2011). *Muchea Employment Node Structure Plan.* Western Australian Planning Commission, Perth.

CSIRO (2009). *Surface Water Yields in South-West Western Australia*. CSIRO, Perth.

DoE (2004). *Potentially Contaminating Activities, Industries and Landuses.* Contaminated Sites Management Series No. 8. Department of Environment, Perth.

DWER (2004). *Potentially Contaminating Activities and Land Uses.* Contaminated Sites Management Series No. 8. Department of Environmental Regulation, Perth.

DWER (2004). *Stormwater Management Manual for WA*. Department of Water & Environmental Regulation, Perth.

DWER (2015). *Gingin Groundwater Allocation Plan*. Water resource allocation and planning report series no. 53. Department of Water, Perth.

DWER (2016). *Water Quality Protection Note 70: Wastewater treatment and disposal - domestic systems*. DWER, Perth.

Emerge Associates (2015). *Environmental Assessment and Management Strategy: Muchea Employment Node Local Structure Plan 1.* Sirona Capital Management Pty Ltd, Perth.

EPA (2015). *Draft Environmental Assessment Guideline for separation distances between industrial and sensitive land uses.* Environmental Protection Authority, Perth.

Fang X. (2000). *Open Channel Flow Calculator.* https://www.eng.auburn.edu/~xzf0001/Handbook/Channels.html Accessed 17/4/2017. Lamar University, USA.

Government of Western Australia (2019). *Government Sewerage Policy.* Dept of Planning, Lands & Heritage, Perth.

Gozzard J.R. (1982). *Muchea Sheet 2034 I and part 2134 IV, Perth Metropolitan Region.* Environmental Geology Series. Geological Survey of Western Australia, Perth.

Health Department (2012). *Draft Code of Practice for On-Site Sewage Management.* Consultation Draft – November 2012. Health Department, Perth.

Institute of Engineers, Australia (1987). *Australian Rainfall and Runoff: A Guide to Flood Estimation.* Institute of Engineers, Australia, Barton, ACT.

King P.D. and Wells M.R. (1990). *Darling Range Rural Land Capability Study.* Land Resources Series No. 3. Department of Agriculture, South Perth.

Standards Australia (2012). *Australian/New Zealand Standard 1547:2012 – On-site Domestic Wastewater Management.*

Summers R. & Weaver D. (2008). *Agricultural Nutrients: Presentation to the CSIRO Urban Drainage Workshop*. CSIRO, Perth.

Swan River Trust (2009). *Swan Canning Water Quality Improvement Plan.* Swan River Trust, Perth.

WAPC (2004). *Liveable Neighbourhoods Edition 3.* Western Australian Planning Commission, Perth.

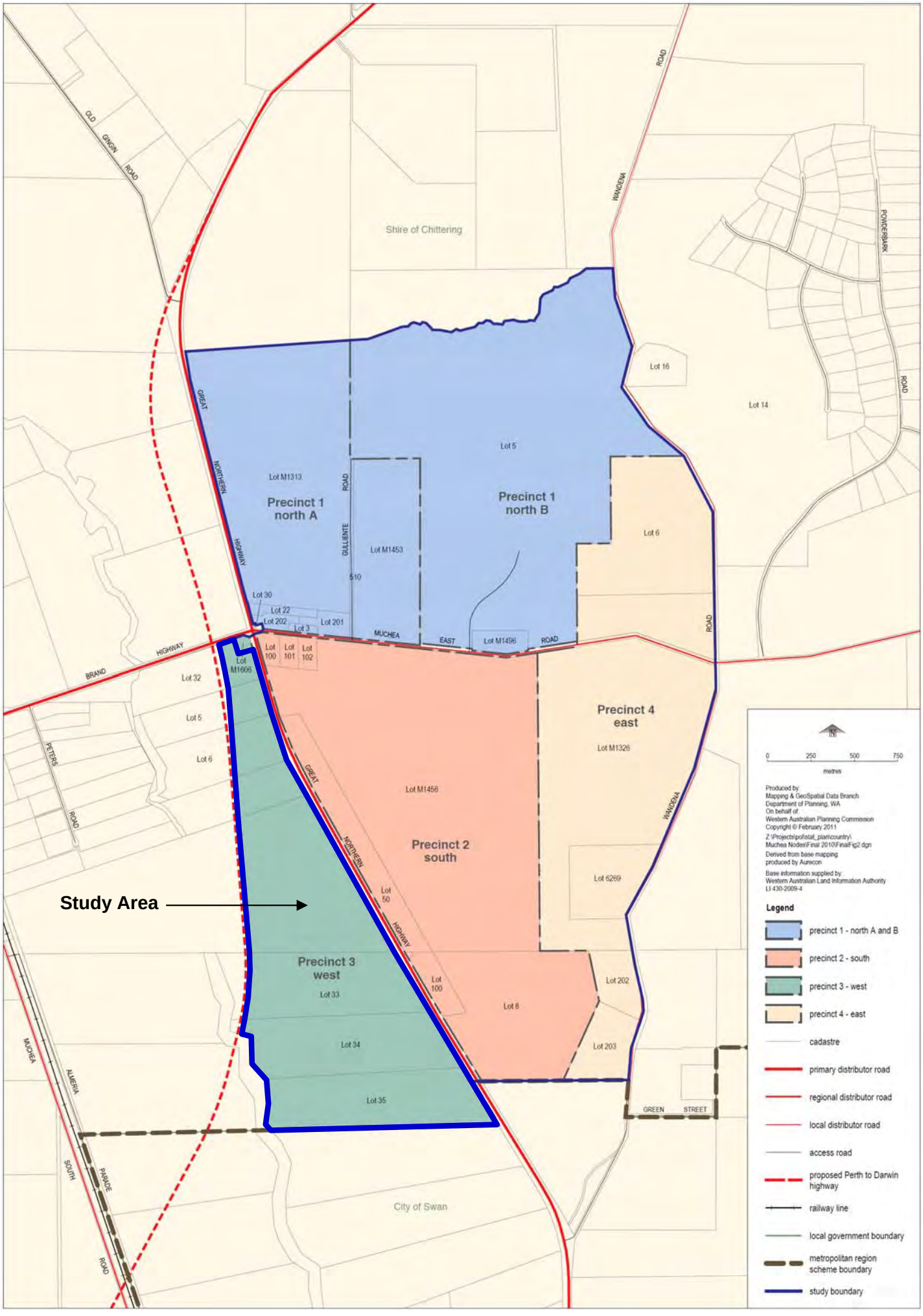
WAPC (2006). State Planning Policy 2.9: Water Resources. WAPC, Perth.

WAPC (2008). *Better Urban Water Management.* WAPC, Perth.

WA Govt (2011). *Muchea Employment Node Structure Plan.* WAPC, Perth.

–

Figures



Source: WAPC, 2011

Figure 1

MUCHEA EMPLOYMENT NODE STRUCTURE PLAN

bayley environmental services



Figure 2

THE SITE AND SURROUNDINGS

Image: Google Earth

bayley environmental services

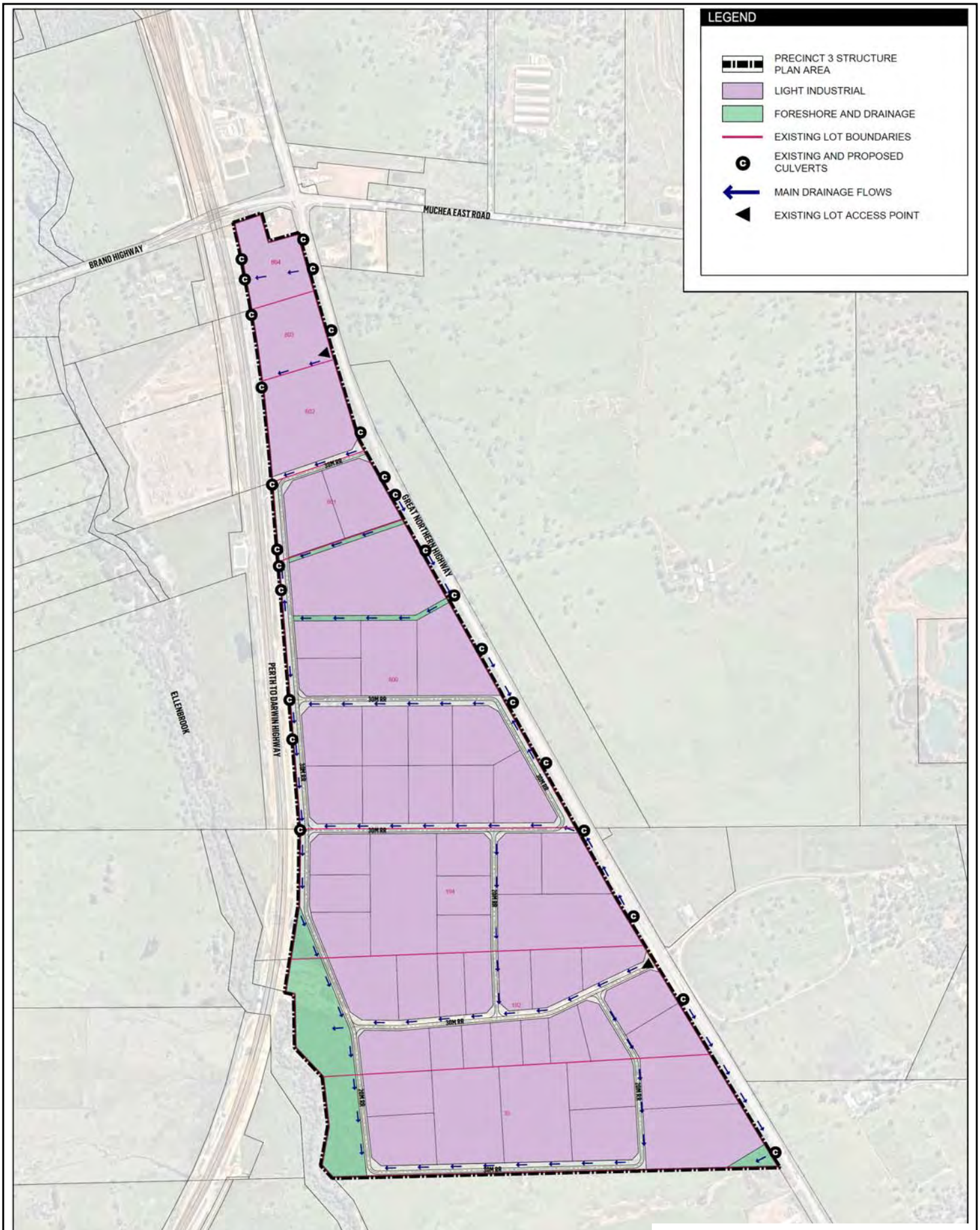


Figure 3

SUBDIVISION CONCEPT

URBIS

bayley environmental services

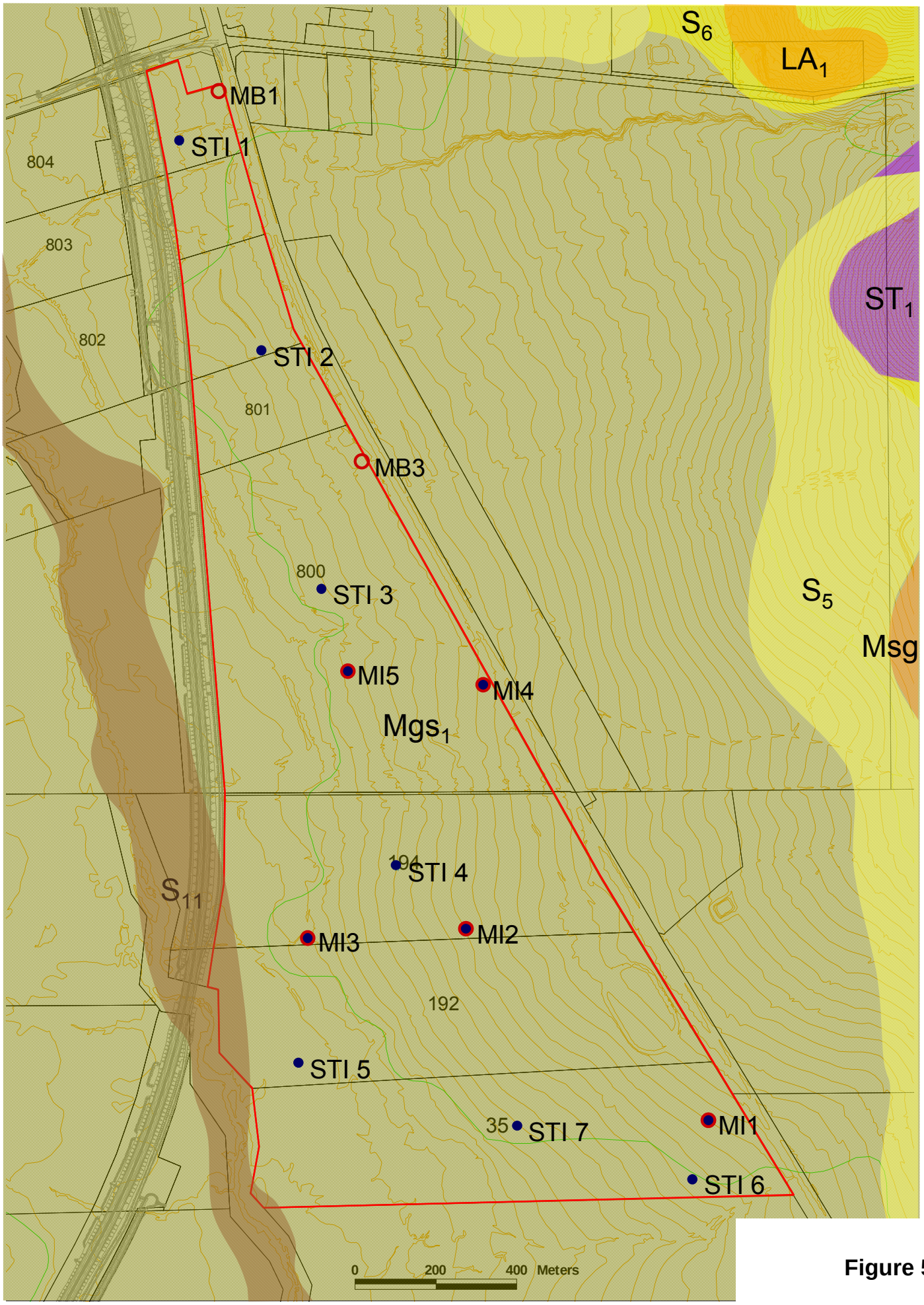


Figure 5

PHYSIOGRAPHY

bayley environmental services

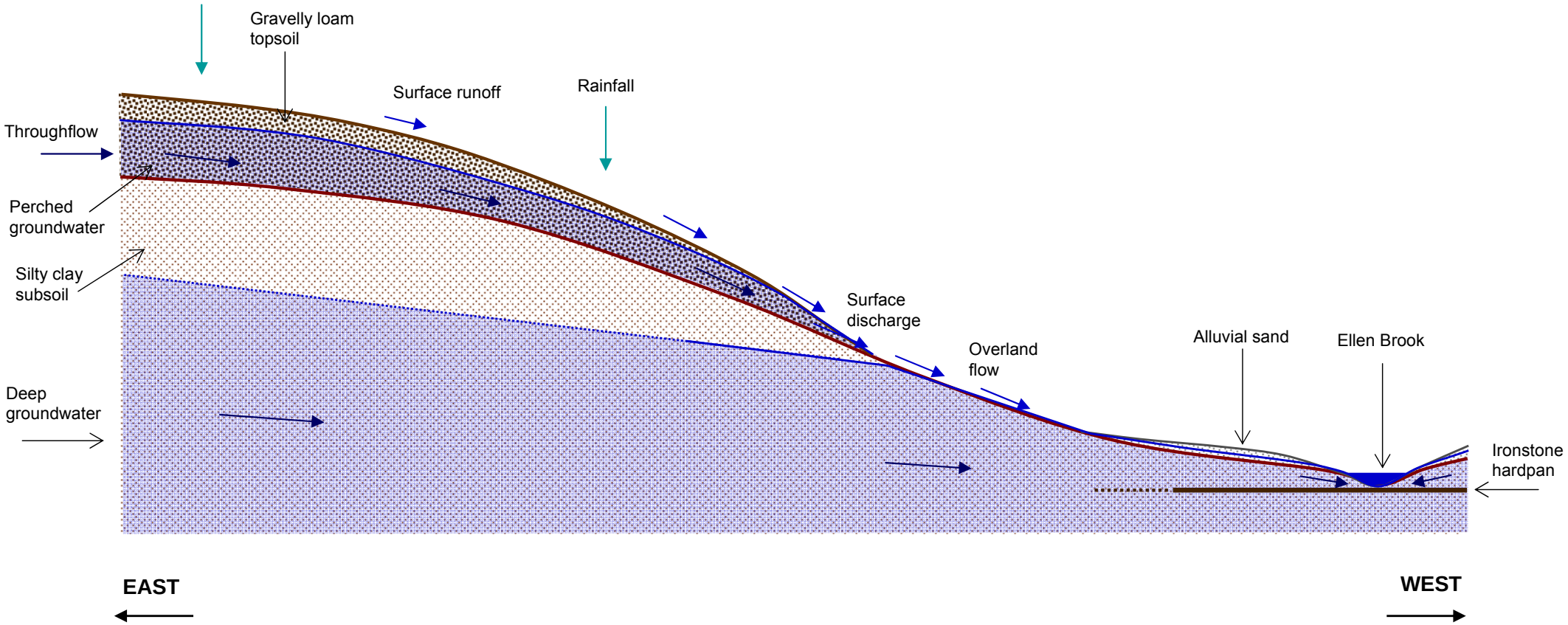
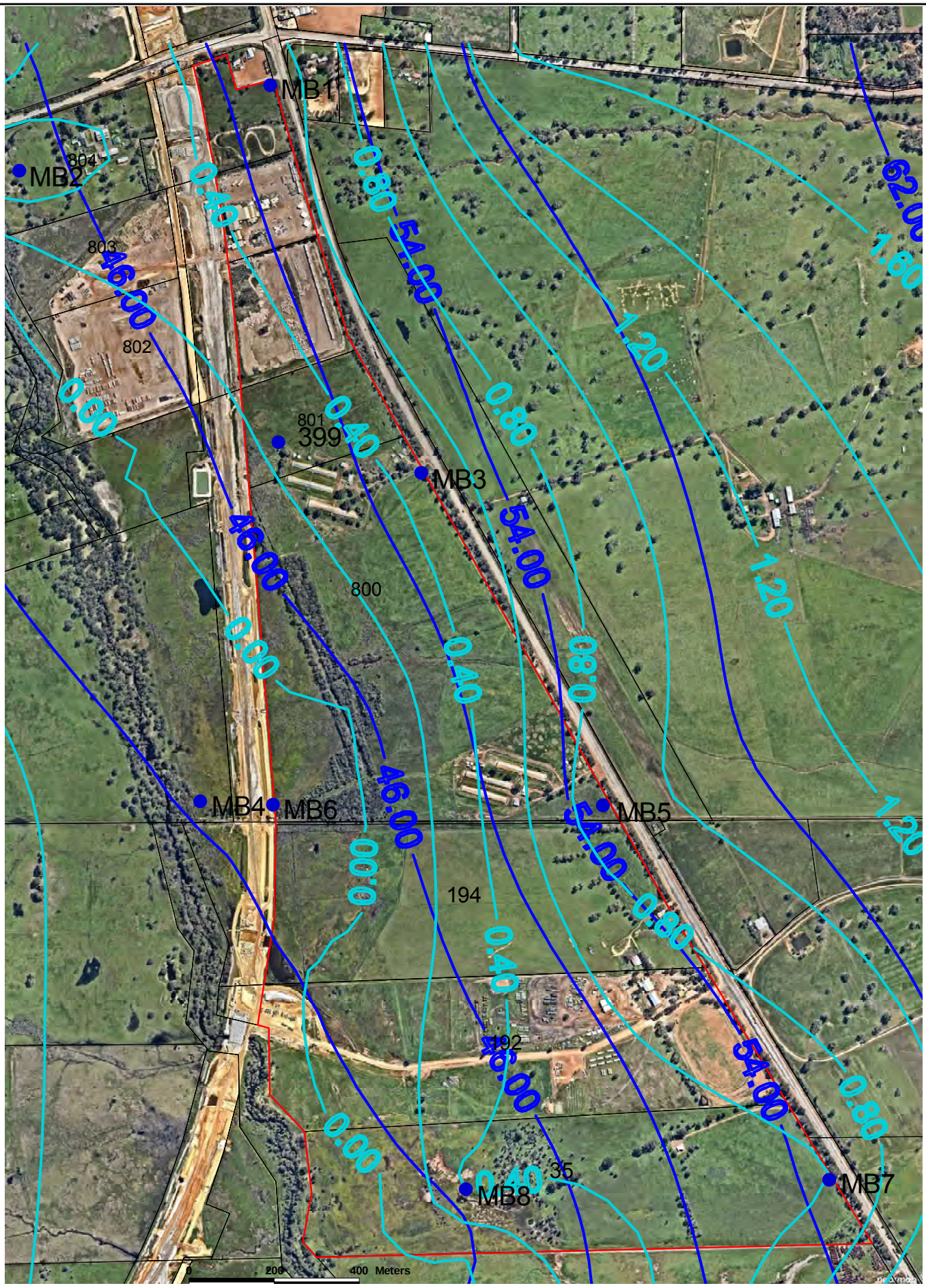


Figure 6

HYDROLOGY OVERVIEW

Not to scale

bayley environmental services

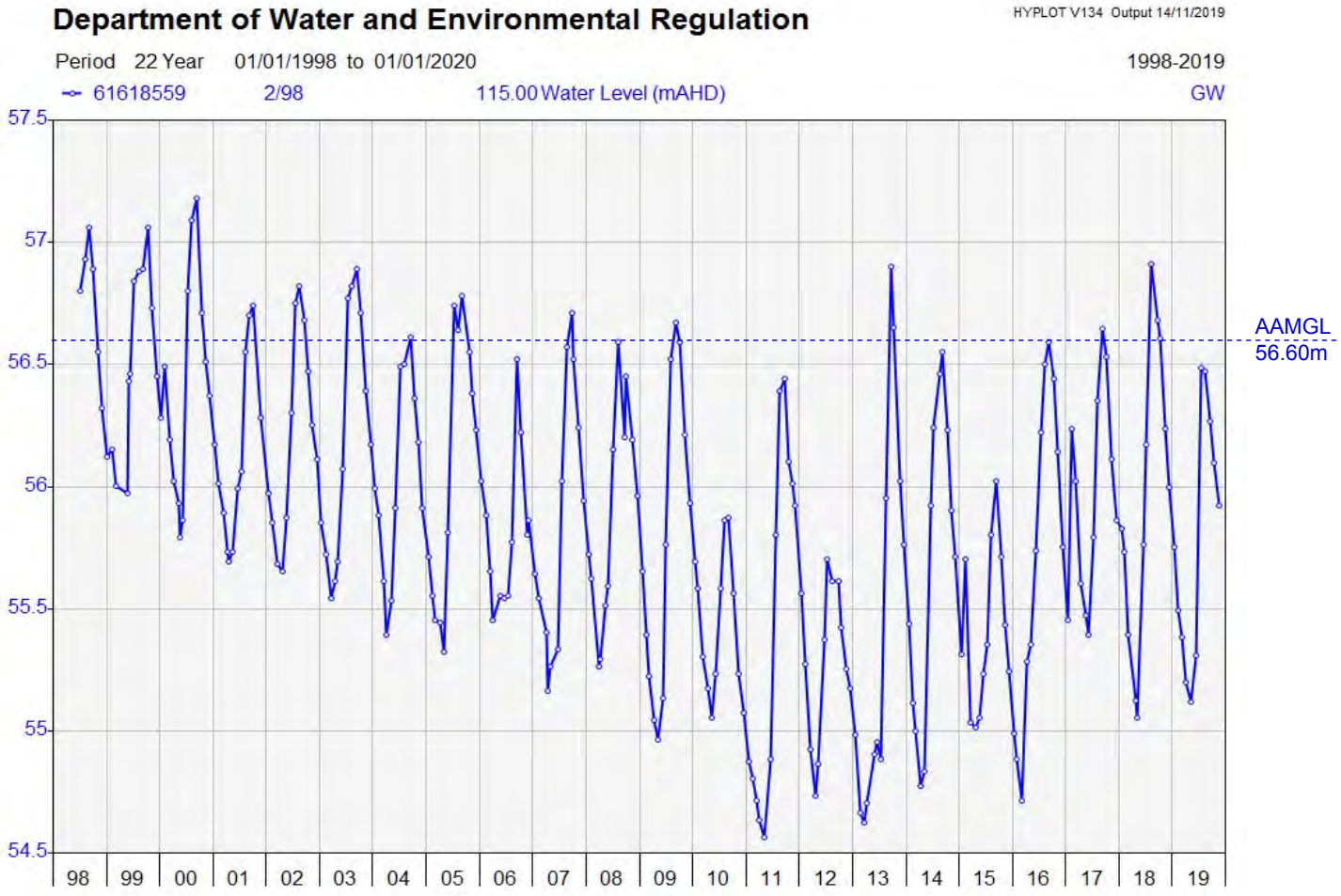


AAMGL Contour
Depth to AAMGL Contour
Bore

Figure 7

GROUNDWATER

bayley environmental services



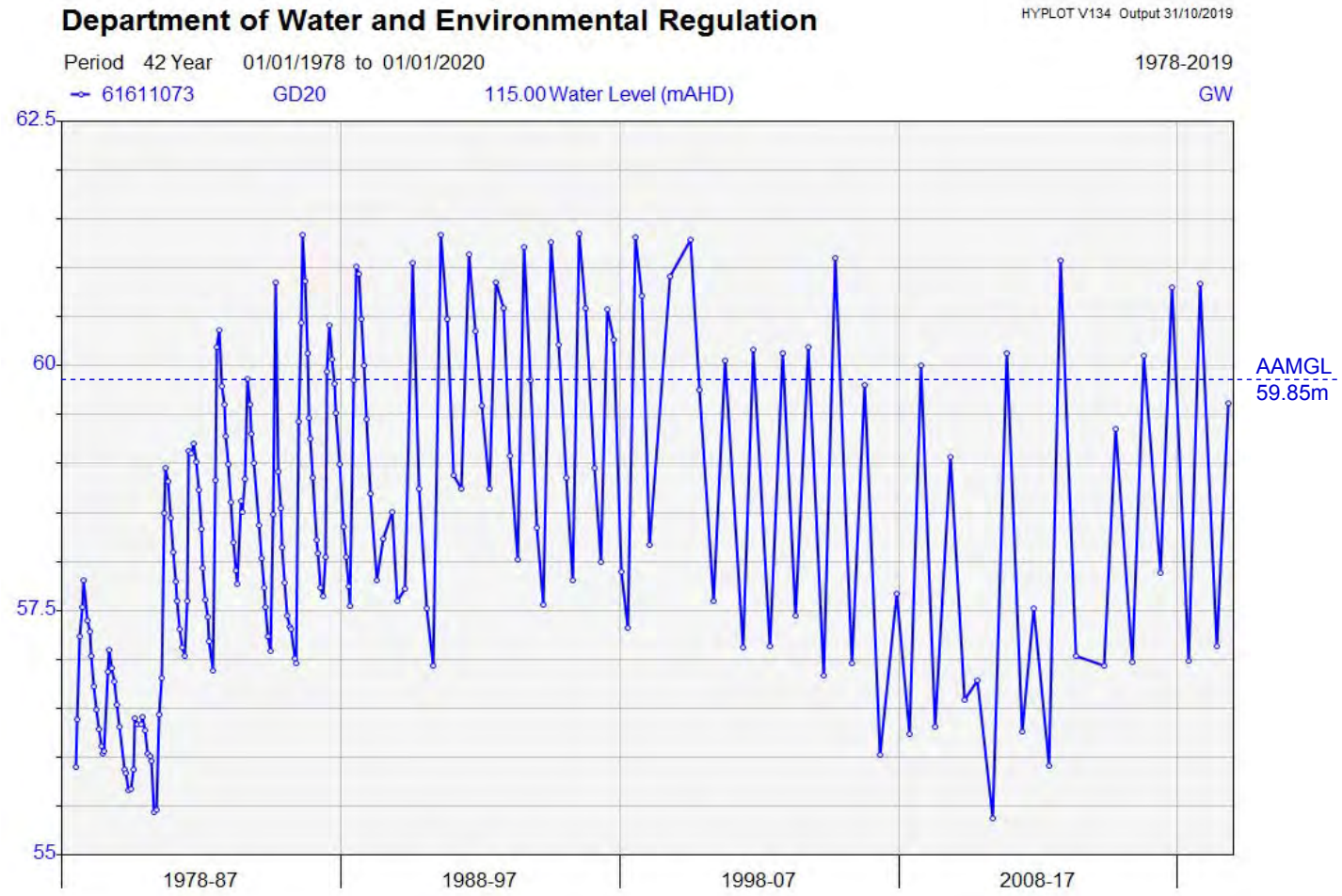


Figure 8

DWER BORE HYDROGRAPHS

bayley environmental services

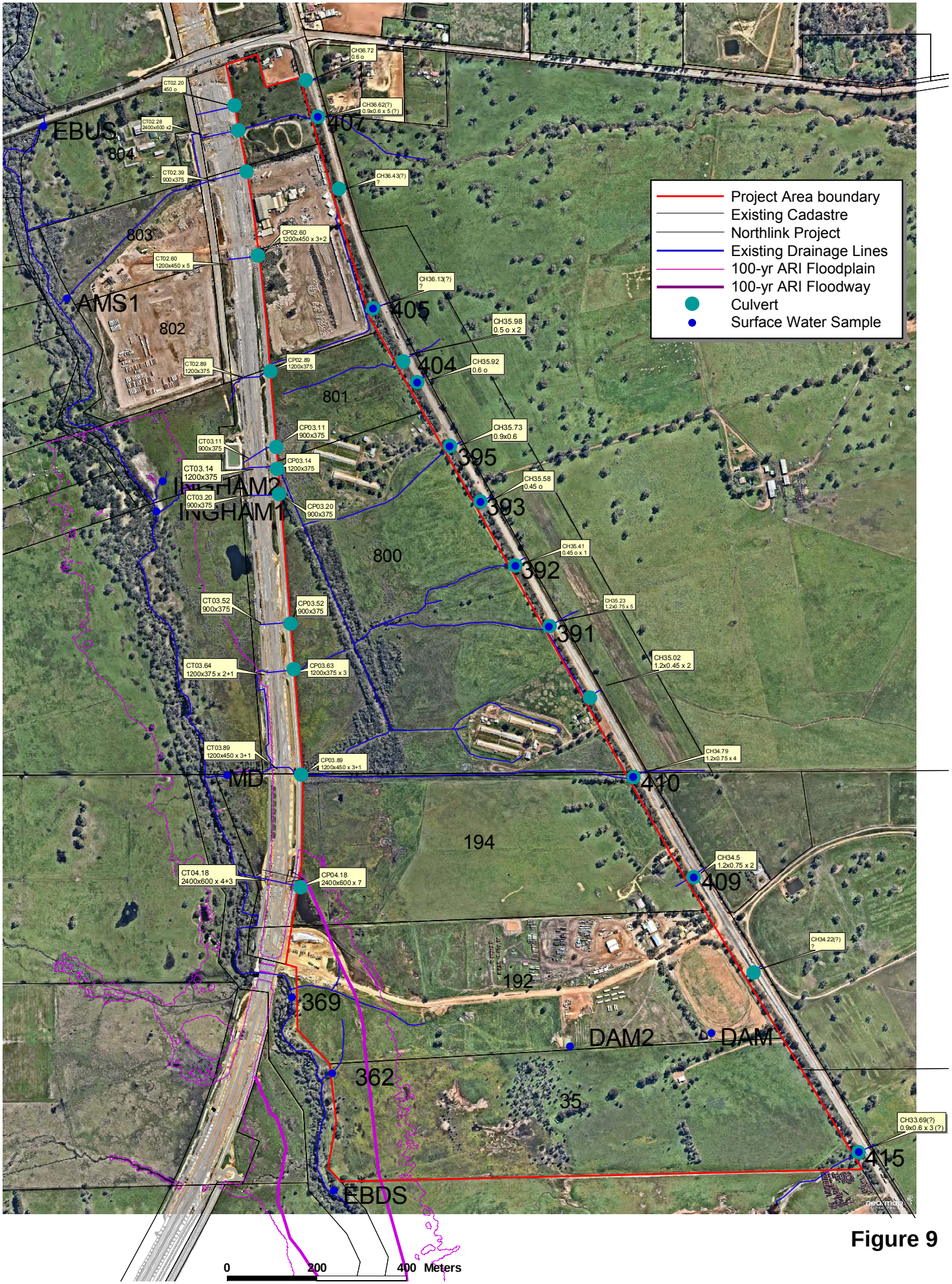


Figure 9

SURFACE HYDROLOGY

bayley environmental services

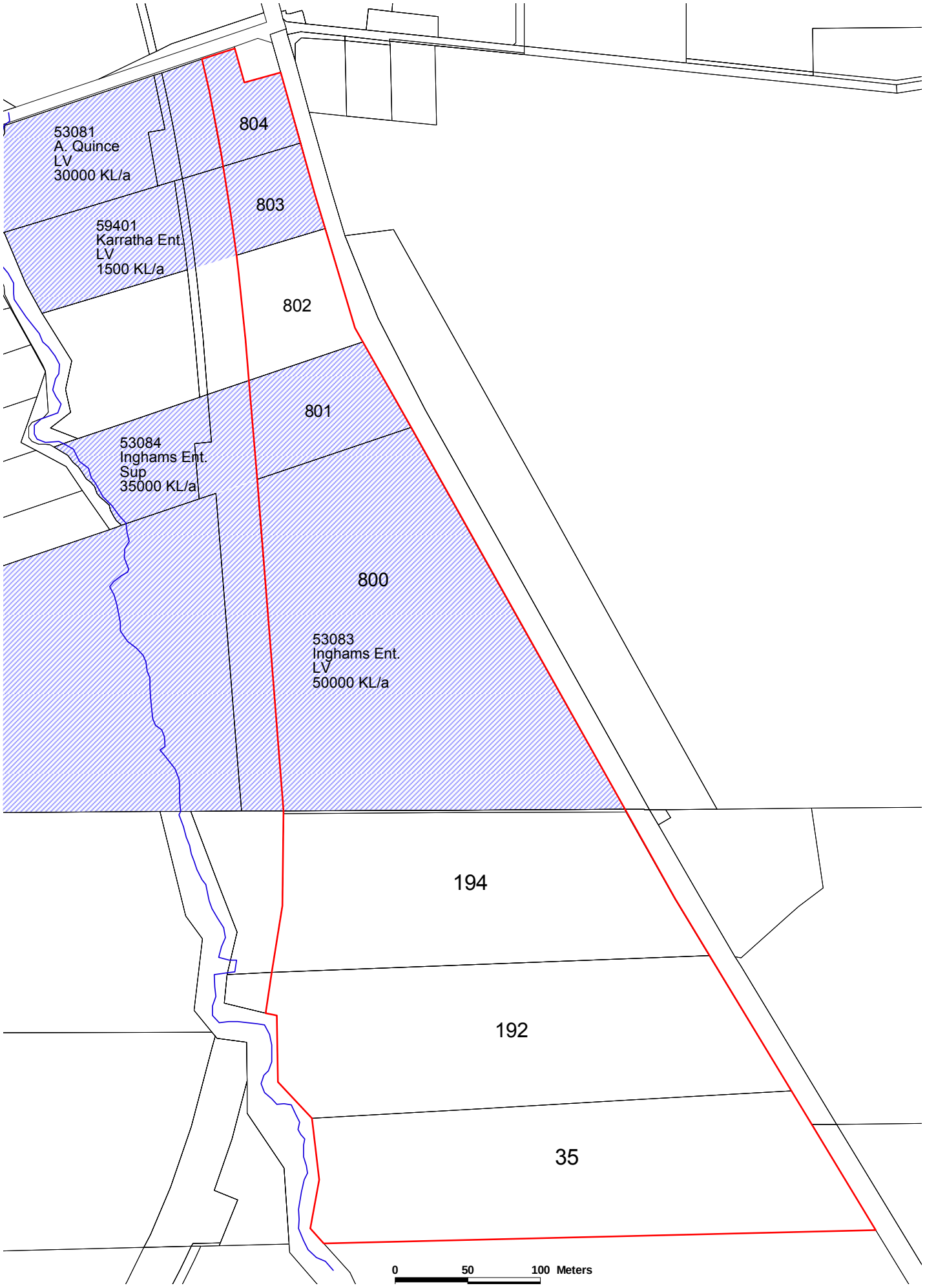


Figure 10

GROUNDWATER LICENCES

bayley environmental services

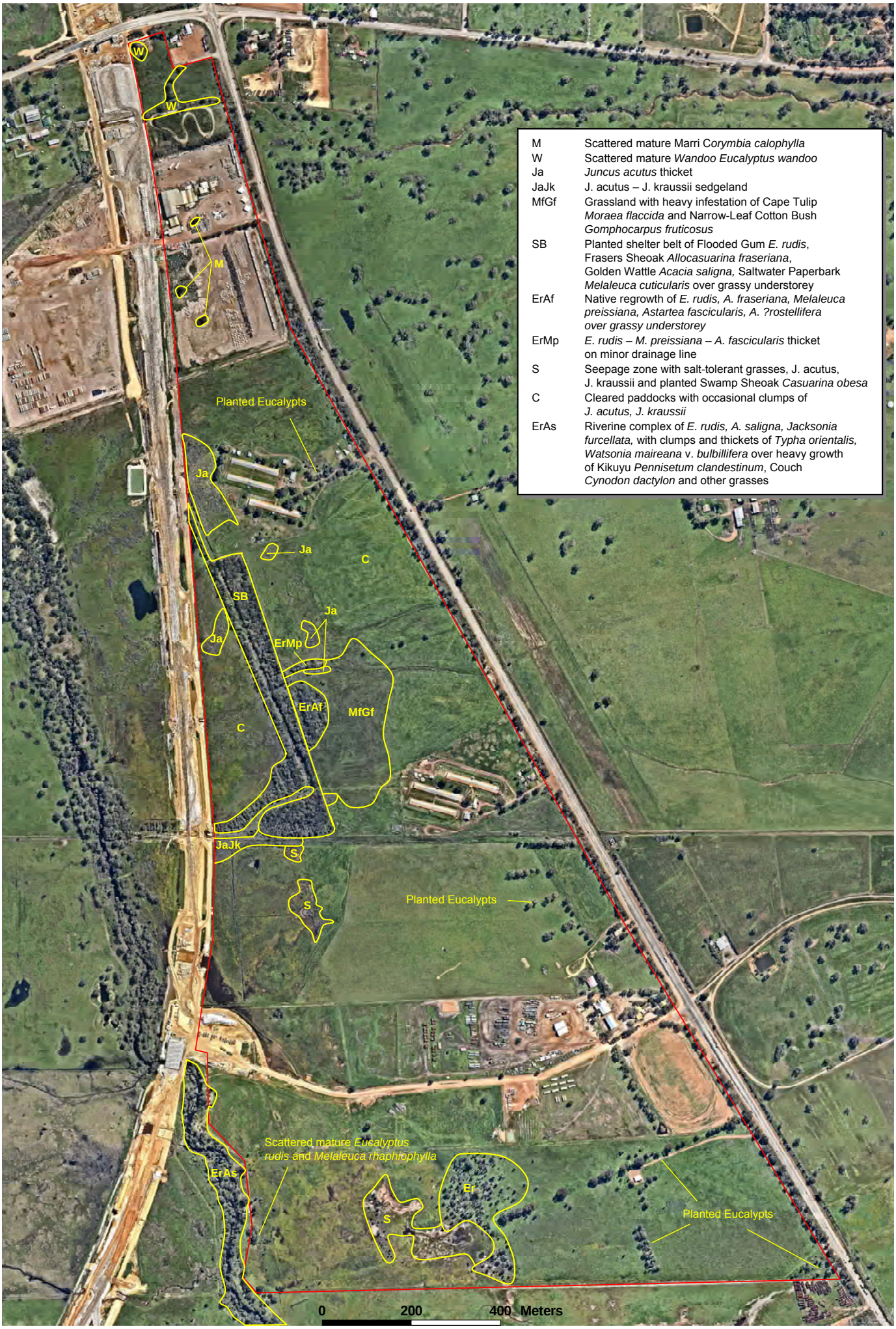


Figure 11

VEGETATION

bayley environmental services

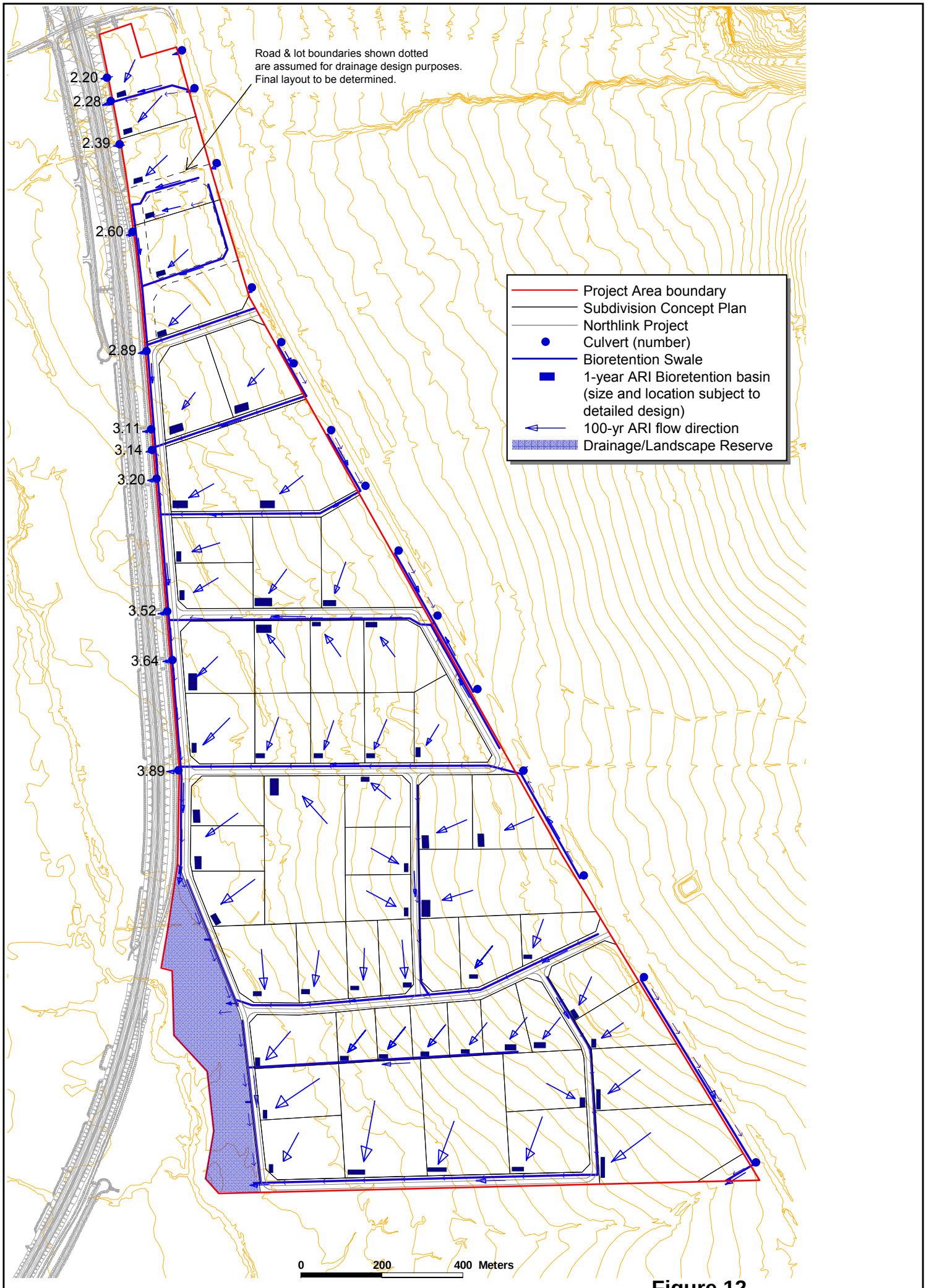


Figure 12

DRAINAGE CONCEPT

bayley environmental services

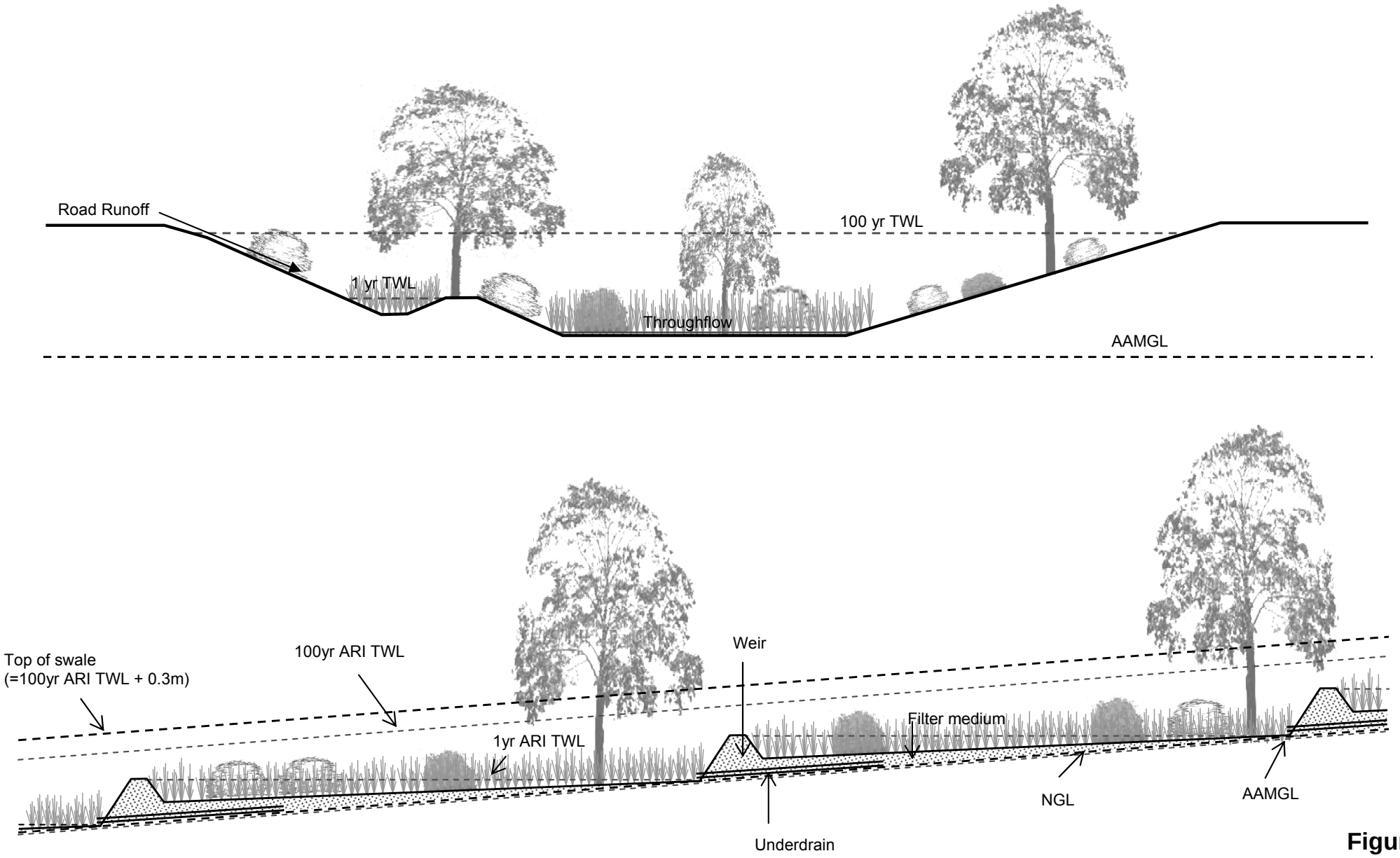


Figure 13

SWALE OPTIONS

bayley environmental services

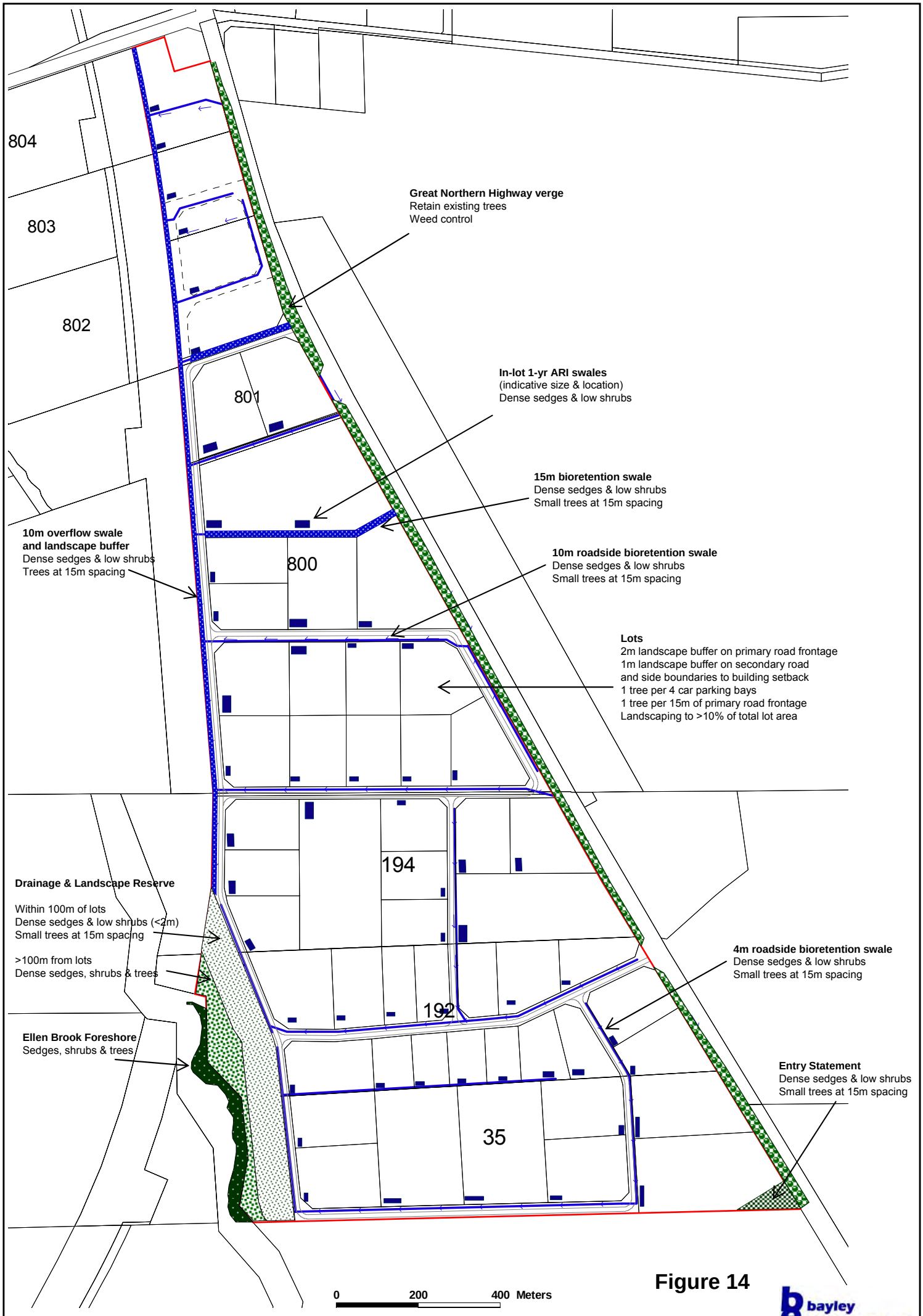


Figure 14

LANDSCAPE MASTER PLAN

bayley environmental services

Appendix A

DWER LWMS Checklist

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	☑	Page 8
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	☑ ☑	Figures 1-3 Section 2
Landscape – proposed public open space areas, public open space credits, water source, bore(s), lake details, irrigation areas (if applicable)	Landscape plan	☑	Sections 3, 7
Design criteria			
Agreed design objectives and source of objectives		☑	Section 1.5
Pre-development environment			
Existing information and more detailed assessments (monitoring). How do the site characteristics affect the design?		☑	Section 2
Site conditions – existing topography/contours, aerial photo underlay, major physical features	Site condition plan	☑	Section 2
Geotechnical – topography, soils including acid sulfate soils and infiltration capacity, test pit locations	Geotechnical plan	☑	Section 2
Environmental – areas of significant flora and fauna, wetlands and buffers, waterways and buffers, contaminated sites	Environmental plan plus supporting data where appropriate	☑	Section 2
Surface water – topography, 100-year floodways and flood fringe areas, water quality of flows entering and leaving (if applicable)	Surface-water plan	☑	Section 2
Groundwater – topography, pre-development groundwater levels and water quality, test bore locations	Groundwater plan plus site investigations	☑	Section 2

Local water management strategy item	Deliverable	☑	Notes
Water sustainability initiatives			
Water efficiency measures – private and public open spaces including method of enforcement		☑	Section 3
Water supply (fit-for-purpose) strategy, agreed actions and implementation		☑	Section 3
Wastewater management		☑	Section 4
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	☑ ☑	Section 5
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	☑	Section 5
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	☑ ☑	Section 5
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
Actions to address acid sulfate soils or contamination		☑	Sections 2.2.4 and 2.6
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 9
Monitoring			
Recommended future monitoring plan including timing, frequency, locations and parameters, together with arrangements for ongoing actions		☑	Section 8
Implementation			
Developer commitments		☑	Section 9
Roles, responsibilities, funding for		☑	Section 9

Local water management strategy item	Deliverable	☑	Notes
implementation			
Review		☑	Section 9

Appendix B

Soil Logs

SOIL PROFILE LOG

PROJECT NUMBER:	J18015
SITE ID:	MB1
EASTING:	
NORTHING:	
METHOD:	Auger Rig
TOTAL DEPTH (mbgl):	4.5
REFUSAL (Y/N):	N
DATE:	3/08/2018
DEPTH TO WATER (mbgl)	1.0

SOIL PROFILE		SAMPLE DATA	
DEPTH (m)	SOIL DESCRIPTION	SAMPLE ID	INTERVAL (m)
0 - 0.5	Grey-brown gravelly silty loam		
1 - 1.5	Yellow-brown clayey silt, wet		
2 - 3.5	Yellow clayey silt, wet		
4 - 4.5	Pink-grey silty clay, very wet		



SOIL PROFILE LOG

PROJECT NUMBER:	J18015
SITE ID:	MB2
EASTING:	
NORTHING:	
METHOD:	Auger Rig
TOTAL DEPTH (mbgl):	3.0
REFUSAL (Y/N):	N
DATE:	3/08/2018
DEPTH TO WATER (mbgl)	0.5

SOIL PROFILE		SAMPLE DATA	
DEPTH (m)	SOIL DESCRIPTION	SAMPLE ID	INTERVAL (m)
0	Dk grey sandy topsoil		
0.5 - 1	Grey silty sand, wet		
1.5 - 2	Grey brown sandy silt, very wet		
2.5	Yellow-brown clayey silt, very wet		
3	Green-brown clayey silt, very wet		



SOIL PROFILE LOG

PROJECT NUMBER:	J18015
SITE ID:	MB3
EASTING:	
NORTHING:	
METHOD:	Auger Rig
TOTAL DEPTH (mbgl):	4.0
REFUSAL (Y/N):	N
DATE:	3/08/2018
DEPTH TO WATER (mbgl)	3.0

SOIL PROFILE		SAMPLE DATA	
DEPTH (m)	SOIL DESCRIPTION	SAMPLE ID	INTERVAL (m)
0	Grey-brown gravelly loam		
0.5	Brown pebbly silt		
1 - 2.5	Orange-brown gravelly clayey silt		
3 - 3.5	Pink-brown clayey silt, very wet		
4	Pink-grey silty clay, very wet		



SOIL PROFILE LOG

PROJECT NUMBER:	J18015
SITE ID:	MB5
EASTING:	
NORTHING:	
METHOD:	Auger Rig
TOTAL DEPTH (mbgl):	4.0
REFUSAL (Y/N):	N
DATE:	3/08/2018
DEPTH TO WATER (mbgl)	1.0

SOIL PROFILE		SAMPLE DATA	
DEPTH (m)	SOIL DESCRIPTION	SAMPLE ID	INTERVAL (m)
0 - 0.5	Yellow-brown silty loam, moist		
1 - 1.5	Yellow-brown gravelly silt, very wet		
2	Yellow-brown silt, very wet		
2.5 - 4	Yellow-brown clayey silt, moist		



SOIL PROFILE LOG

PROJECT NUMBER:	J18015
SITE ID:	MB7
EASTING:	
NORTHING:	
METHOD:	Auger Rig
TOTAL DEPTH (mbgl):	6.0
REFUSAL (Y/N):	N
DATE:	3/08/2018
DEPTH TO WATER (mbgl)	0.0

SOIL PROFILE		SAMPLE DATA	
DEPTH (m)	SOIL DESCRIPTION	SAMPLE ID	INTERVAL (m)
0	Brown gravelly loam, wet		
0.5	Orange-brown pebbly silt, moist		
1	Red-brown pebbly clay, moist		
1.5 - 2	Orange-brown silty clay, wet grading to moist		
2.5 - 3	Orange-brown clay, moist		
3.5 - 6	Brown clay, wet		





SOIL PROFILE LOG

PROJECT NUMBER:	J18015
SITE ID:	MB8
EASTING:	
NORTHING:	
METHOD:	Auger Rig
TOTAL DEPTH (mbgl):	5.0
REFUSAL (Y/N):	N
DATE:	3/08/2018
DEPTH TO WATER (mbgl)	1.0

SOIL PROFILE		SAMPLE DATA	
DEPTH (m)	SOIL DESCRIPTION	SAMPLE ID	INTERVAL (m)
0 - 1.5	Brown silty clayey gravel, moist		
2 - 2.5	Pale yellow-brown silt, wet		
3 - 5	Grey silty clay, very wet		



Appendix C

BES Permeability Test Results

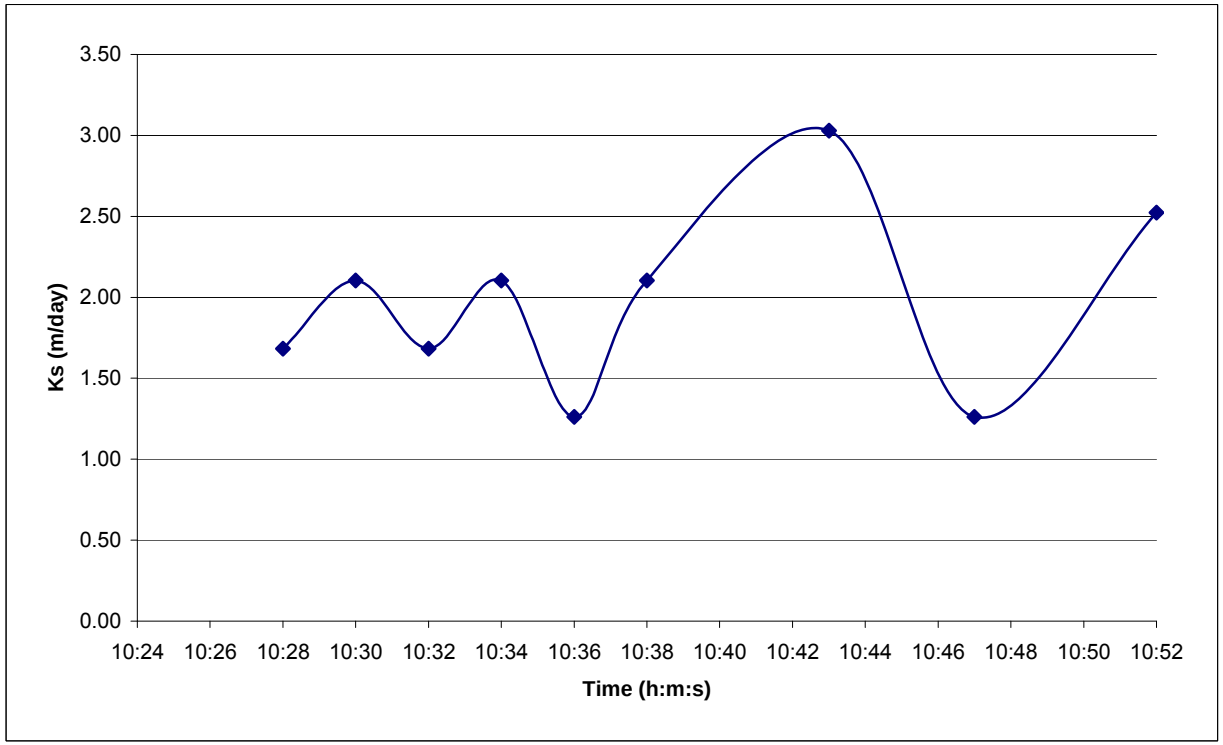
SOIL PERMEABILITY TEST

Site No.	MI1-S
Date	26/11/18
Easting	
Northing	
Depth	0.5m

Time (h:m:s)	Weight (kg)	Change in Weight (kg)	Ks (m/d)
10:26:00	39.8		
10:28:00	39.4	0.4	**1.68**
10:30:00	38.9	0.5	**2.10**
10:32:00	38.5	0.4	**1.68**
10:34:00	38	0.5	**2.10**
10:36:00	37.7	0.3	**1.26**
10:38:00	37.2	0.5	**2.10**
10:43:00	35.4	1.8	**3.03**
10:47:00	34.8	0.6	**1.26**
10:52:00	33.3	1.5	**2.52**
		33.3	

H =	25
r =	**4.5**

Ks = 1.9 m/d



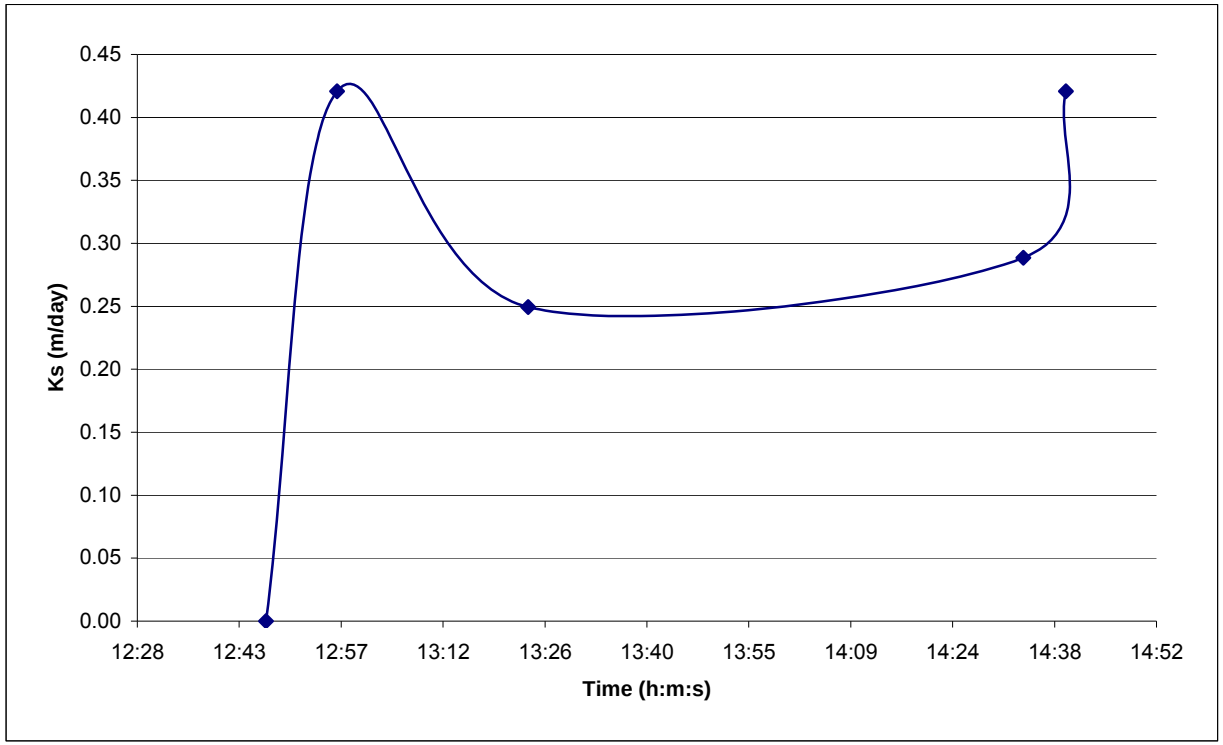
SOIL PERMEABILITY TEST

Site No.	MI1-D
Date	26/11/18
Easting	
Northing	
Depth	1m

Time (h:m:s)	Weight (kg)	Change in Weight (kg)	Ks (m/d)
12:42:00	40.4		
12:47:00	40.4		
12:57:00	39.9	0.5	**0.42**
13:24:00	39.1	0.8	**0.25**
14:34:00	36.7	2.4	**0.29**
14:40:00	36.4	0.3	**0.42**
		36.4	

H =	25
r =	**4.5**

Ks = 0.25 m/d



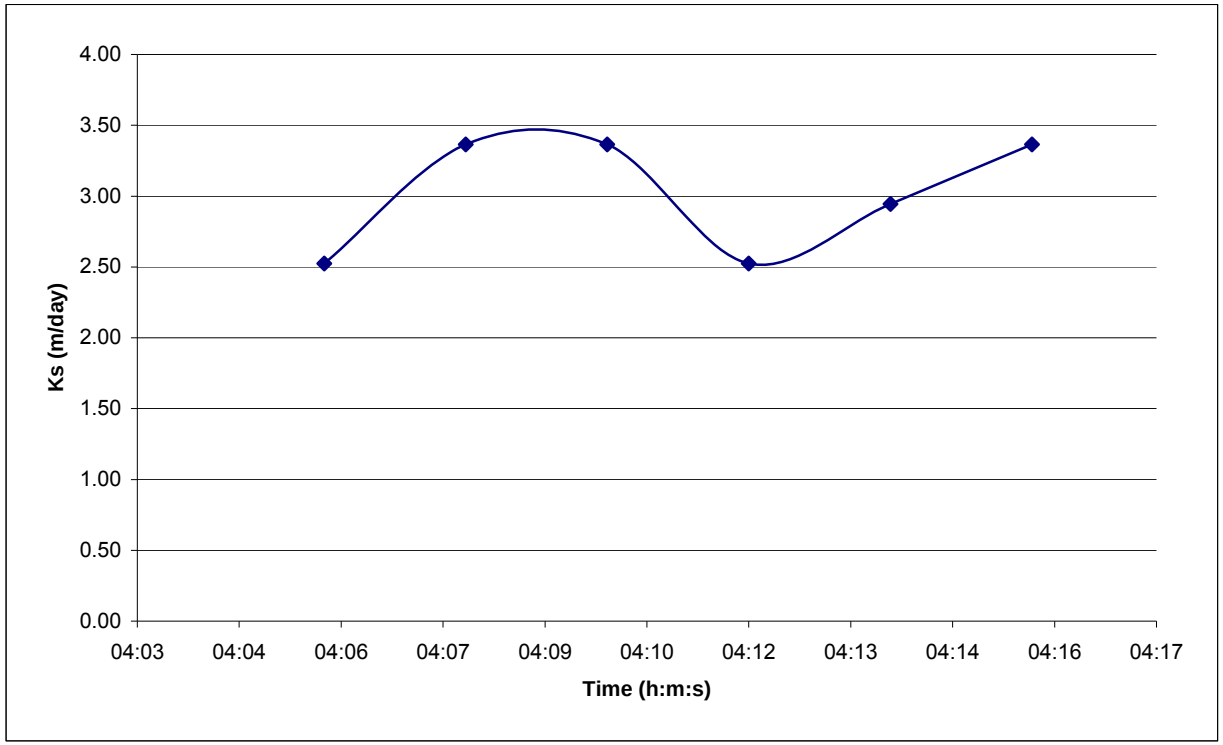
SOIL PERMEABILITY TEST

Site No.	MI2
Date	26/11/18
Easting	
Northing	
Depth	0.5m

Time (h:m:s)	Weight (kg)	Change in Weight (kg)	Ks (m/d)
04:05:00	36.3		
04:06:00	36	0.3	**2.52**
04:08:00	35.2	0.8	**3.37**
04:10:00	34.4	0.8	**3.37**
04:12:00	33.8	0.6	**2.52**
04:14:00	33.1	0.7	**2.94**
04:16:00	32.3	0.8	**3.37**
		32.3	

H =	25
r =	**4.5**

Ks = 3.0 m/d



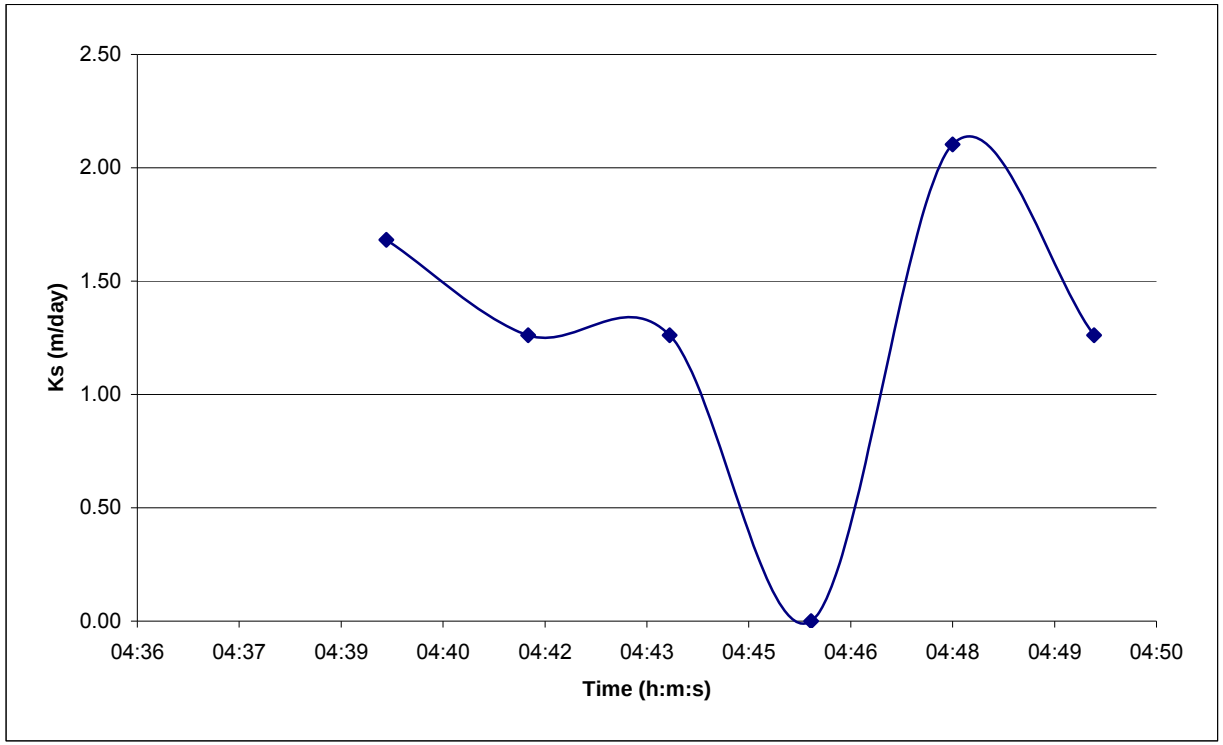
SOIL PERMEABILITY TEST

Site No.	MI3
Date	26/11/18
Easting	
Northing	
Depth	0.5m

Time (h:m:s)	Weight (kg)	Change in Weight (kg)	Ks (m/d)
04:38:00	27.1		
04:40:00	26.7	0.4	**1.68**
04:42:00	26.4	0.3	**1.26**
04:44:00	26.1	0.3	**1.26**
04:46:00	26.1		
04:48:00	25.6	0.5	**2.10**
04:50:00	25.3	0.3	**1.26**
		25.3	

H =	25
r =	**4.5**

Ks = 1.25 m/d



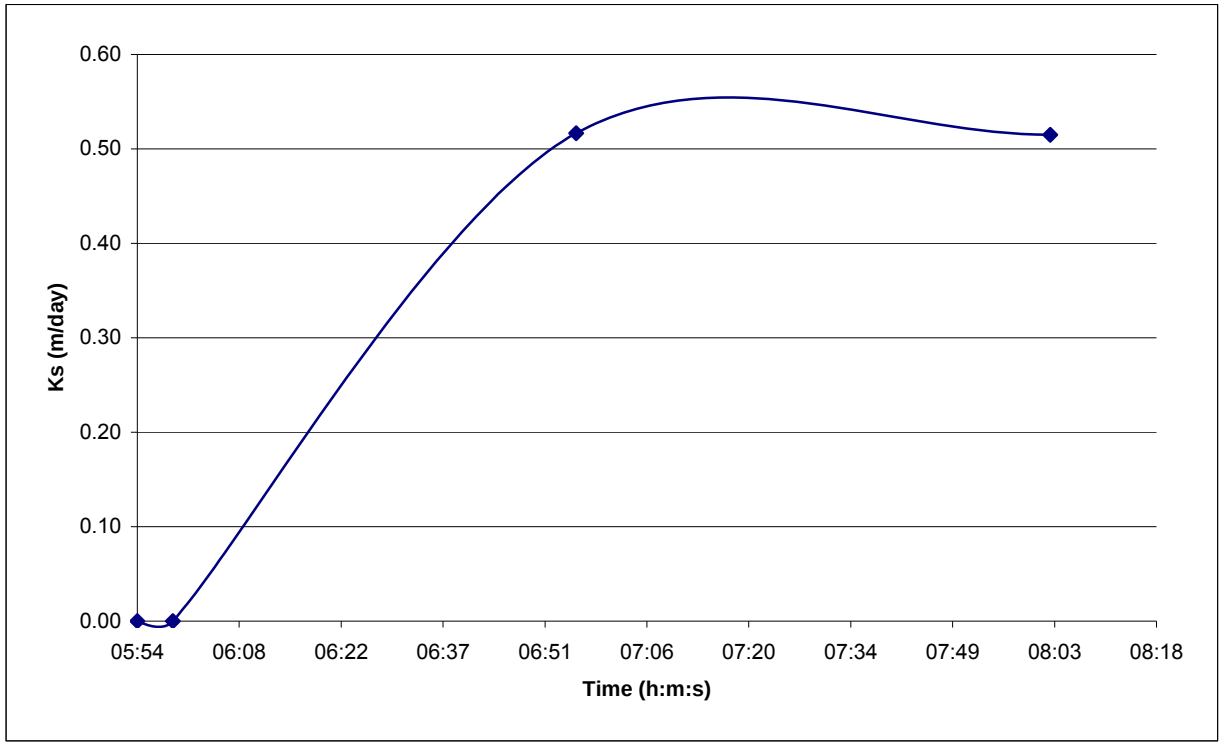
SOIL PERMEABILITY TEST

Site No.	MI4
Date	26/11/18
Easting	
Northing	
Depth	0.5m

Time (h:m:s)	Weight (kg)	Change in Weight (kg)	Ks (m/d)
05:49:00	34		
05:54:00	34		
05:59:00	34		
06:56:00	30.5	3.5	**0.52**
08:03:00	26.4	4.1	**0.51**
		26.4	

H =	25
r =	**4.5**

Ks = 0.5 m/d



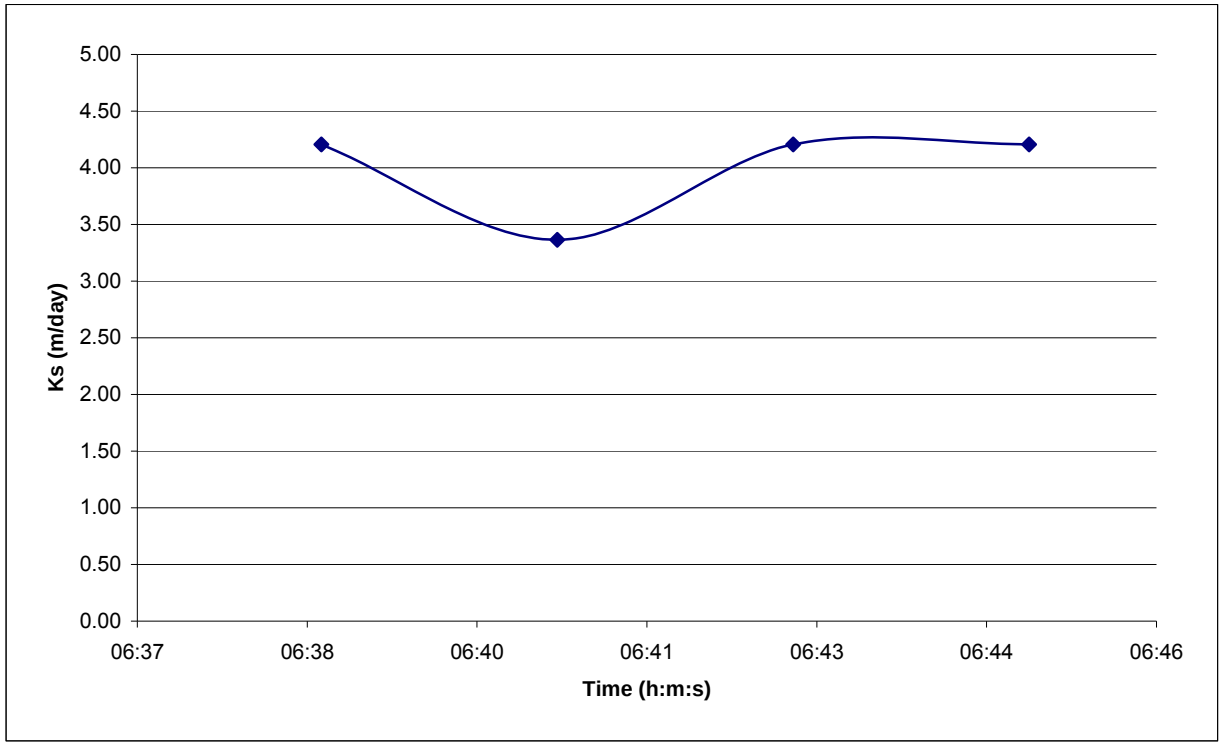
SOIL PERMEABILITY TEST

Site No.	MI5
Date	26/11/18
Easting	
Northing	
Depth	0.5

Time (h:m:s)	Weight (kg)	Change in Weight (kg)	Ks (m/d)
06:36:00	22.9		
06:39:00	21.4	1.5	**4.21**
06:41:00	20.6	0.8	**3.37**
06:43:00	19.6	1	**4.21**
06:45:00	18.6	1	**4.21**
		18.6	

H =	25
r =	**4.5**

Ks = 4.2 m/d



Appendix D

Geotechnical Report

Doc GE2.2.1

GEOTECHNICAL INVESTIGATION

For: Tomahawk Property on behalf of Muchea Employment Node Precinct 3 Land Owners

Project Address: Muchea Employment Node - Precinct 3 - Muchea

Project Number: D206263

Job Number: J315642

Revision Number: 1

Author: David Harding

Date: 20/12/2018

Structerre Consulting Engineers
(+618) 9205 4500
1 Erindale Road, Balcatta WA 6021
wageotecheng@structerre.com.au
www.structerre.com.au

TABLE OF CONTENTS

1. PROJECT DETAILS 1
1.1. Introduction 1
1.2. Site Description & Proposed Development 1
1.3. Field Investigation – Scope of Works 2
2. DESK STUDY 2
2.1. Geological Setting 2
2.2. Ground Surface and Groundwater Level 2
2.3. Acid Sulphate Soils 2
2.4. Site History 3
3. RESULTS OF THE INVESTIGATION 3
3.1. Subsurface Soil Profile 3
3.2. Groundwater 4
3.3. Percolation Testing 4
3.4. Laboratory Test Results 5
3.4.1. Atterberg Limits 5
3.4.1. Phosphorus Retention Index 6
3.4.2. California Bearing Ratio (CBR) 7
4. GEOTECHNICAL CONSTRUCTION CONSIDERATIONS 8
4.1. Site Classification 8
4.2. Drainage 8
4.3. Seismic Site Subsoil Class 8
4.4. Earthworks 9
4.5. Geotechnical Design Parameters 10
4.6. Shallow Footings – Allowable Soil Bearing Capacities 11
5. CONCLUSIONS 13
6. LIMITATION OF FIELD INVESTIGATIONS 14
7. REFERENCES 15

1 Erindale Road, Balcatta, Western Australia 6021 | PO Box 792, Balcatta, Western Australia 6914
Phone (+618) 9205 4500 | Fax (+618) 9205 4501 | Email wageotecheng@structerre.com.au | Web www.structerre.com.au
ABN 71 349 772 837 Zemla Pty Ltd ACN 008 966 283 as trustee for the Young Purich and Higham Unit Trust trading as Structerre Consulting Engineers

TABLE 1 – HISTORICAL SITE INFORMATION 3
TABLE 2 – SUBSURFACE SOIL PROFILE 3
TABLE 3 – IN SITU PERCOLATION TEST RESULTS 4
TABLE 4 – ATTERBERG LIMIT TEST RESULTS 5
TABLE 5 – PHOSPHORUS RETENTION INDEX RESULTS 6
TABLE 6 – CBR RESULTS 7
TABLE 7 – SUMMARY OF SEISMIC PARAMETERS 8
TABLE 8 – COMPACTION REQUIREMENTS 9
TABLE 9 – SOIL PARAMETERS 10
TABLE 10 – ALLOWABLE BEARING CAPACITIES FOR PAD FOOTINGS 11
TABLE 11 – ALLOWABLE BEARING CAPACITIES FOR STRIP FOOTINGS 12

APPENDIX 1 – SITE LOCATION MAP 1
APPENDIX 2 – SITE PHOTOS 2
APPENDIX 3 – BORELOGS 3
APPENDIX 4 – LABORATORY TEST RESULTS 4
APPENDIX 5 – PRI TEST RESULTS 5
APPENDIX 6 – CBR RESULTS 6
APPENDIX 7 – BORELOG TERMINOLOGY 7

1 Erindale Road, Balcatta, Western Australia 6021 | PO Box 792, Balcatta, Western Australia 6914
Phone (+618) 9205 4500 | Fax (+618) 9205 4501 | Email wageotecheng@structerre.com.au | Web www.structerre.com.au
ABN 71 349 772 837 Zemla Pty Ltd ACN 008 966 283 as trustee for the Young Purich and Higham Unit Trust trading as Structerre Consulting Engineers

1. PROJECT DETAILS

1.1. Introduction

At the request of Tom Carmody of Tomahawk Property on behalf of Muchea Employment Node Precinct 3 Land Owners, Structerre Consulting Engineers (Structerre) have conducted a Geotechnical Investigation at Muchea Employment Node Precinct 3, Muchea, WA. The purpose of the investigation was to provide the following for industrial purposes:

- Desk top study including a summary of geology, groundwater, site history (obtained from historical photographs) and potential presence of Acid Sulfate Soils (ASS)
- Summary of encountered ground and groundwater conditions
- Site Classification in accordance with AS2870
- Earthquake site factor in accordance with AS1170.4
- Recommendations for stormwater drainage design
- Site preparation requirements (earthworks), including site traffic, excavation, reuse of materials and batter slopes
- Ground bearing capacity and estimated settlements for pad and strip footings founded at 0.5m and 1.0m
- Geotechnical design parameters for retaining structures and or deep foundations
- Preliminary pavement design parameter, indicative California Bearing Ratio (CBR) values determined from penetrometer results and ground conditions encountered

This report details the scope of the geotechnical investigation, presents an interpretation of ground conditions and material properties across the site, provides geotechnical design parameters for the design of the proposed infrastructure, and evaluates the suitability of materials for use in earthworks. Interpretation of site conditions is based on the subsurface lithology revealed during the investigation programme, visual assessments of the in situ materials and the results of in situ field tests.

Terms of reference for this investigation were presented in a Structerre Consulting Engineers proposal reference Q78062 (dated 21 November 2018), which was submitted to and accepted by Muchea Employment Node Precinct 3 Land Owners.

1.2. Site Description & Proposed Development

The site is located at Muchea Employment Node Precinct 3, Muchea, Shire of Chittering. Great Northern Highway lies to the east of the site, Brand Highway to the north, Perth To Darwin Highway to the west and rural properties to the south.

The site gently sloping towards the western section. At the time of the field investigation existing industrial/farm buildings occupied the site. The land is largely cleared farmland with some vegetation and trees existing.

We understand that the site is to be used for an industrial development.

1.3. Field Investigation – Scope of Works

The field investigation was carried out on 26 and 27 November 2018 and comprised:

- 37 x Sample Retrieval Probe boreholes (BH) to a depth of 2.5m over the site for material assessment and soil profiling;
- 7 x In situ percolation tests to determine the permeability of the materials within the upper 1.0m; and
- 37 x Dynamic Cone Penetrometer (DCP) tests in accordance with AS 1289.6.3.2 (1997) to a depth of 1.0m for evaluation of relative densities of the upper layers.

The borehole, percolation and DCP test locations are shown on the attached site plan in Appendix 1.

A suitability qualified geotechnical personnel from Structerre supervised the fieldwork and all fieldwork, interpretation and terminology used in this report are in accordance with the guidelines presented in AS1726-2017 Geotechnical Site Investigations.

2. DESK STUDY

2.1. Geological Setting

The Muchea sheet 1: 50,000 Environmental Geology Series (Sheet 2034 I and Part of 2134 IV, 1986) prepared by the Geological Survey of Western Australia indicates that the following geological layer underlies the site:

- Pebbly SILT (Mgs1) – strong brown silt with common, fine to occasionally coarse-grained, sub-rounded laterite quartz, heavily weathered granite pebble, some fine to medium-grained quartz sand, of alluvial origin (Guildford Formation Qpa)

2.2. Ground Surface and Groundwater Level

The Perth Groundwater Atlas (Waters & Rivers Commission) indicates the ground surface level at this site was approximately 58.0m at southeast to 41.0m at southwest.

Department of Water and Environment Regulation has published minimum groundwater levels for this site.

2.3. Acid Sulphate Soils

Information from publicly available Landgate website indicates that the site lies within a zone of no known risk of ASS occurring within 3m of natural surface.

2.4. Site History

Historical aerial photographs dating back to 1965 are publicly available through Landgate Map Viewer were assessed and a summary is presented in Table 1.

Table 1 – Historical Site Information

Date	Description
1965	The site is fully cleared
1977	Industrial/Farm buildings constructed
2012	A small portion of the site was cleared being Lot 802 & 803
2018	Construction started on the Perth To Darwin Highway to the west of the site
2018	Site remains relatively unchanged to the current day

3. RESULTS OF THE INVESTIGATION

3.1. Subsurface Soil Profile

The subsurface soil profile presented below was determined from the ground conditions encountered within the boreholes and through the interpretation of the DCP test results:

Table 2 – Subsurface Soil Profile

Depth to Base of Strata (m)	Material Description
0.1	TOPSOIL
0.2 – 1.0 (Ave. 0.5)	NATURAL: SAND/Gravelly SAND (fine to coarse grained), trace silt, loose to very dense
Not Penetrated (>2.5m)	NATURAL: Clayey SAND/Sandy CLAY/Clayey GRAVEL (medium to high plasticity), trace gravel, dense to very dense

The soils encountered are consistent with the expected site conditions as predicted from the Environmental Geology Map. It is important to note that there may be pockets of fill on site that are deeper than that encountered by the investigation boreholes. The subsurface soil conditions encountered are presented in the bore logs, within Appendix 3.

3.2. Groundwater

Groundwater was encountered in boreholes BH01, BH02, BH05 and BH12 at an approximate depth of 1.0m below the existing ground level. Groundwater is expected to perch above the impermeable materials.

3.3. Percolation Testing

Percolation testing of the in situ soils was undertaken in seven locations. Results of the testing are summarised below:

Table 3 – In Situ Percolation Test Results

Test Location	Testing Depth	Soil Type	Permeability
1	0 - 1.0m	SAND/Clayey SAND	0.6m/day
2	0 – 0.7m	SAND/Clayey SAND	0.5m/day
3	0 - 1.0m	SAND/Clayey SAND	0.3m/day
4	0 - 1.0m	SAND/Clayey SAND	0.7m/day
5	0 – 0.5m	SAND/Gravelly SAND	1.0m/day
6	0 - 1.0m	SAND/Clayey SAND	1.2m/day
7	0 – 0.6m	SAND/Clayey SAND	0.9m/day

3.4. Laboratory Test Results

Selected representative soil samples were tested by Structerre's in-house NATA accredited laboratory for Atterberg Limits, shrink-swell index, phosphate retention index and soil compaction. The results are attached in Appendix 4, 5 & 6.

3.4.1. Atterberg Limits

Atterberg Limits were tested by Structerre's in-house NATA accredited laboratory. Results of the testing are summarised below:

Table 4 – Atterberg Limit Test Results

Sample	Test Hole	Depth (m)	Soil Description	Liquid Limit % AS1289 3.1.2	Plastic Limit % AS1289 3.2.1	Plasticity Index % AS1289 3.3.1	Linear Shrinkage % AS1289 3.4.1
1	BH01	0.1-1.0	Sandy CLAY with gravel	52	20	32	9
2	BH07	0.7-1.0	Clayey GRAVEL with sand	36	17	19	6.5
3	BH12	0.7-1.3	Clayey GRAVEL with sand	34	14	20	7
4	BH20	0.4-0.9	Clayey SAND with gravel	37	15	22	9

Test results indicate that the natural clay has moderate shrink swell capacity or degree of expansion.

A copy of the results are presented in Appendix 4.

3.4.1. Phosphorus Retention Index

Six samples were submitted to CSBP Soil & Plant Analysis Laboratory for analysis of phosphate retention and calculation of Phosphorus Retention Index (PRI). The results are summarised below, with the certificate provided in Appendix 5.

Table 5 – Phosphorus Retention Index Results

Sample No.	Soil Type	PRI	Classification
BH02_ 0.1-0.4	SAND	4.5	Weakly
BH04_ 0.1-0.4	SAND	1.8	Very Weakly
BH05_ 0.1-0.4	Clayey SAND	185.8	Very Strongly
BH11_ 0.1-0.4	Sandy GRAVEL	6.4	Moderately
BH18_ 0.1-0.4	Sandy GRAVEL	445.7	Very Strongly
BH23_ 0.1-0.4	SAND	1.1	Very Weakly

The soil samples tested within the site areas indicate that the soil tested can be described as varying from very weakly to very strongly adsorbing (reference Method for Analysis of Phosphorus in Western Australia Soils, DG Allen & RC Jeffery, March 1990, Chemistry Centre, Agricultural Chemistry Laboratory).

3.4.2. California Bearing Ratio (CBR)

Representative samples were tested by Structerre's in-house NATA accredited laboratory in accordance with AS1289.5.2.1 (2003). The test certificates are presented in Appendix 6 and are summarised below.

Table 5 – CBR Results

Test Hole	Depth (m)	Soil Description	Optimum Moisture Content %	Maximum Dry Density t/m3	CBR @ 2.5mm Penetration (%)	CBR @ 5mm Penetration (%)
BH02	0.1 - 0.4	SAND	8.5	1.95	30	-
BH04	0.1 - 0.4	SAND	10.0	1.81	18	-
BH11	0.1 - 0.4	Sandy GRAVEL	7.0	2.20	-	50
BH05	0.2 - 0.6	SAND	12.0	1.73	30	-

Based on the above results a conservative soaked CBR of 18% would be recommended for design purposes.

4. GEOTECHNICAL CONSTRUCTION CONSIDERATIONS

4.1. Site Classification

AS 2870-2011 Residential Slabs and Footings provides guidance on site classification for residential slabs and footing design based on the expected ground surface movement and depth of expected moisture changes.

Although the proposed development falls outside the scope of AS 2870, site classification can be used to assist in the design of foundations. The foundation design should be undertaken by a Structural Engineer, taking into consideration ground bearing capacity and the acceptable total and differential settlements of the proposed foundation system.

Based on results of this investigation the building areas can be classified as an Class “S” provided that all unsuitable materials are removed and replaced with engineer-controlled sand fill materials in accordance with earthwork recommendations outlined in Section 4.3 in this report. The site in its current condition is classified as Class “P”.

4.2. Drainage

The existing ground conditions are not suitable for on-site disposal of stormwater runoff through the use of soakwells.

The design of the drainage system, is unknown at this time, but may include:

- Rainwater Tanks;
- Dams / Compensation basin;
- Overland flow paths; and
- Soakwells, if permeable cover and / or design are appropriate.

Sub soil drainage may be required to control groundwater perching in the upper soil layers within the building footprint.

4.3. Seismic Site Subsoil Class

The seismic subsoil site class has been assessed in accordance with AS 1170.4-2007, using the results of this investigation and published information.

Table 6 – Summary of Seismic Parameters

Hazard Factor	Site Sub-soil Class
0.1	Class Ce –shallow soil site

4.4. Earthworks

The building areas can be classified as Class "S", provided that the recommended earthworks are undertaken.

All earthworks shall be undertaken in accordance with AS 3798-2007 Guidelines on Earthworks For Commercial and Residential Developments and are to include the following:

- All unsuitable materials to be stripped and removed from the site. Unsuitable materials include topsoil, deleterious and organic materials.
- It is considered that the near surface loose sand materials require improvement. Therefore, it is proposed to excavate and stockpile the materials for reuse, provided it is dry, free from clay/silt (i.e. <5%), organic and deleterious materials. The depth of excavation may vary depending on conditions encountered (i.e. groundwater) and is subject to inspection.
- Excavations should not exceed 2.0m and / or undermine surrounding structures. A 1V:2H slope should be maintained for temporary excavations. If excavation is required closer than the 1V:2H slope would allow, it is recommended that this office be contacted for retaining design.
- Proof compact the exposed base. The compaction requirements are set out in the table below, as per AS 3798-2007:

Table 7 – Compaction Requirements

Item	Application	Minimum relative compaction, %	
		Minimum density ratio (Standard Compaction Effort) (Cohesive soils)	Minimum density index (Cohesionless soils)
1	Residential - lot, fill, house, sites	95	70
2	Commercial – fills to support minor loadings, including floor loading of up to 20kPa and isolated pad or strip footings to 100kPa	98	75
3	Fill to support pavements a) General fill b) Subgrade (to a depth of 0.3m)	 95 98	 70 75

- After excavation and proof compaction, the excavated base is to be inspected and approved by a representative from this office prior to backfilling. At this stage it can be

assessed whether any further materials need to be removed or whether further compaction of the base is required.

- The ground level should be built up to design levels with the stockpiled sand materials and imported fill. If required, the imported fill should consist of free draining sand with not more than 5% passing a 75µm sieve and be free of organic matter and other deleterious materials. The fill sand materials should be placed in layers not exceeding 300mm loose thickness and compacted to achieve the values stated in the table above. As a guide a minimum of 8 PSP blows over the interval 150 – 450mm, 9 PSP blows over the interval 450 – 750mm and 11 PSP blows over the interval 750 – 1050mm should be achieved, however its is recommended that this be verified with appropriate laboratory testing.
- A minimum of 0.6m of sand cover is required to be maintained above the reactive material in order to achieve a Class "S".
- After remedial earthworks have been completed, the earthworks should be inspected and approved by a representative from this office.

It is considered that standard small to medium sized earthmoving equipment would be appropriate for the proposed development. The near surface ground was generally competent and should not pose an issue to site traffic movements.

The material encountered on site can be deemed as 'easy' to excavate with medium sized earthwork equipment (i.e. a 20t excavator). Should excavations be required below groundwater level, dewatering will be necessary.

4.5. Geotechnical Design Parameters

Based on the on site observations and the DCP results, the interpreted geotechnical soil parameters of the encountered materials are presented in Table 9:

Table 8 – Soil Parameters

Soil Type	Depths (m)	Friction Angle Ø' (^{0})	Cohesion c' (kPa)	Density Y (t/m^3)	Elastic Modulus E (MPa)
FILL: SAND to silty SAND	0 – 0.6	32	0	1.85	15
Clayey SAND to Sandy CLAY	0.6 – 2.5	32	20	1.80	20

4.6. Shallow Footings – Allowable Soil Bearing Capacities

Based on the findings of the current preliminary geotechnical investigation, shallow pad and strip footings are considered appropriate for the proposed development. Allowable bearing capacities for shallow footings at the site have been calculated under the following assumptions:

- The site preparation procedures specified in Section 4.4 have been carried out;
- The specified level of compaction has been achieved below the base of each footing;
- Loads are vertical and not eccentric;
- Isolated footings (i.e. interaction of foundations has not been considered);
- The foundations are flexible;
- A factor of safety (FoS) of 3.0 against bearing capacity failure;
- Maximum allowable settlement of 20mm.

The tables below present the allowable bearing pressures for pad and strip footings of various dimensions, with embedment depths of 0.5m and 1.0m below finished surface levels.

Table 9 – Allowable Bearing Capacities for Pad Footings

Minimum Depth of Embedment (m)	Minimum Plan Dimension (m)	Allowable Bearing Capacities (kPa)	Settlement (mm)
0.5	0.5	140	< 20
	1.0	155	
	1.5	165	
	2.0	140	
1.0	0.5	245	< 20
	1.0	250	
	1.5	190	
	2.0	160	

* Note: it is recommended to limit these values to 250kPa.

Table 10 – Allowable Bearing Capacities for Strip Footings

Minimum Depth of Embedment (m)	Minimum Plan Dimension (m)	Allowable Bearing Capacities (kPa)	Settlement (mm)
0.5	0.5	115	< 20
	1.0	135	
	1.5	150	
1.0	0.5	160	< 20
	1.0	180	
	1.5	200	

The recommended allowable bearing capacities are dependent on the site being dry and well drained, so that the foundation material does not become saturated.

The actual allowable bearing capacity of a particular foundation will be dependent on its location, geometry and founding depth, as well as the founding horizon. Therefore, once specific foundation geometries have been determined and the earthworks completed, it is recommended that the allowable bearing capacity and associated settlements be verified.

Additionally, should undermining issue prevent the excavation of the near surface loose materials, it is recommended that the allowable bearing capacity be reviewed. However, this will likely result in lower allowable bearing capacities.

5. CONCLUSIONS

A site investigation was carried out at the proposed commercial development site to assess the geotechnical conditions. Parameter and design recommendations are incorporated in the body of the report. The following conclusions have been drawn from the site investigation:

- The subsurface soil profile encountered comprised of topsoil to 0.1m, loose to dense sand / gravelly sand / sandy gravel from the surface to 1.0m, underlain by clayey sand/sandy clay to the investigated depth of 2.5m.
- The water table was encountered at the approximately 1.0m below the existing surface in boreholes BH01, BH02, BH05 and BH12.
- The building areas can be classified as a Class “S” in accordance with AS 2870-2011 provided the recommended earthworks are undertaken.
- It is considered that the site is not suitable for on-site drainage.
- Recommended earthworks for the building areas, include stripping of fill sand and unsuitable materials, excavation of loose materials, proof compaction of the base, placement of engineered fill and compaction of final level.
- Allowable bearing capacity for pad footings range from 140kPa to 250kPa and from 115kPa to 200kPa for strip footings. The estimation of settlement of the footings is limited to 20mm.

6. LIMITATION OF FIELD INVESTIGATIONS

This report has been prepared in accordance with generally accepted consulting practice for Tomahawk Property on behalf of Muchea Employment Node Precinct 3 Land Owners using information supplied at the time and for the project specific requirements as understood by Structerre. To the best of our knowledge the information contained in this report is accurate at the date of issue, however it should be emphasised that any changes to ground conditions and/or the proposed structures may invalidate the recommendations given herein.

The conclusions and recommendations in this report are based on the site conditions revealed through selective point sampling, representing the conditions of the site in total, although the area investigated represents only a small portion of the site. The actual characteristics may vary significantly between successive test locations and sample intervals other than where observations, explorations and investigations have been made.

The materials and their geotechnical properties presented in this report may not represent the full range of materials and strengths that actually exist on site and the recommendations should be regarded as preliminary in nature. Allowances should be made for variability in ground conditions and any consequent impact on the development. Structerre accepts no responsibility and shall not be liable for any consequence of variations in ground conditions.

If ground conditions encountered during construction are different to that described in this report, this office should be notified immediately.

For and behalf of

STRUCTERRE CONSULTING ENGINEERS



Author: David Harding
Title: Geotechnical Supervisor



Checked By: Daniel Smith
Title: Geotechnical Engineer
Credentials: BEng Civil, MIEAust, AGS

Disclaimer
This report is at the request of the addressee and no liability is accepted by Structerre Consulting Engineers to any third person reading or relying upon the report, not withstanding any rule of law and/or equity to the contrary and that this report is strictly confidential and intended to be read and relied upon only be the addressee.

Job #	Revision	Authored	Checked	Authorised
J315642	0	DO	DAS	MEC
J315642	1	DO	DAS	MEC

7. REFERENCES

Department of Water – Perth Groundwater Atlas

Geological Survey of Western Australia 1:50,000 Environmental Geology Series

AS 1170.4-2007 Structural design actions – Earthquake actions in Australia

AS 1289.3.1.2-2009 Methods of testing soils for engineering purposes – Soil classification tests – Determination of the liquid limit of a soil

AS 1289.3.2.1-2009 Methods of testing soils for engineering purposes – Soil classification tests – Determination of the plastic limit of a soil

AS 1289.3.3.1-2009 Methods of testing soils for engineering purposes – Soil classification tests – Calculation of the plasticity index of a soil

AS 1289.3.4.1-2009 Methods of testing soils for engineering purposes – Soil classification tests – Determination of the linear shrinkage of a soil

AS 1289.5.2.1-2009 Soil compaction and density tests – Soil classification tests – Determination of the dry density/moisture content relation of a soil using modified compactive effort

AS 1289.6.1.1-2009 Soil strength and consolidation tests – Soil classification tests – Determination of the California Bearing Ratio of a soil

AS 1289.6.3.2-1997 Methods of testing soils for engineering purposes – Soil strength and consolidation tests – Determination of the penetration resistance of a soil – 9kg dynamic cone penetrometer test

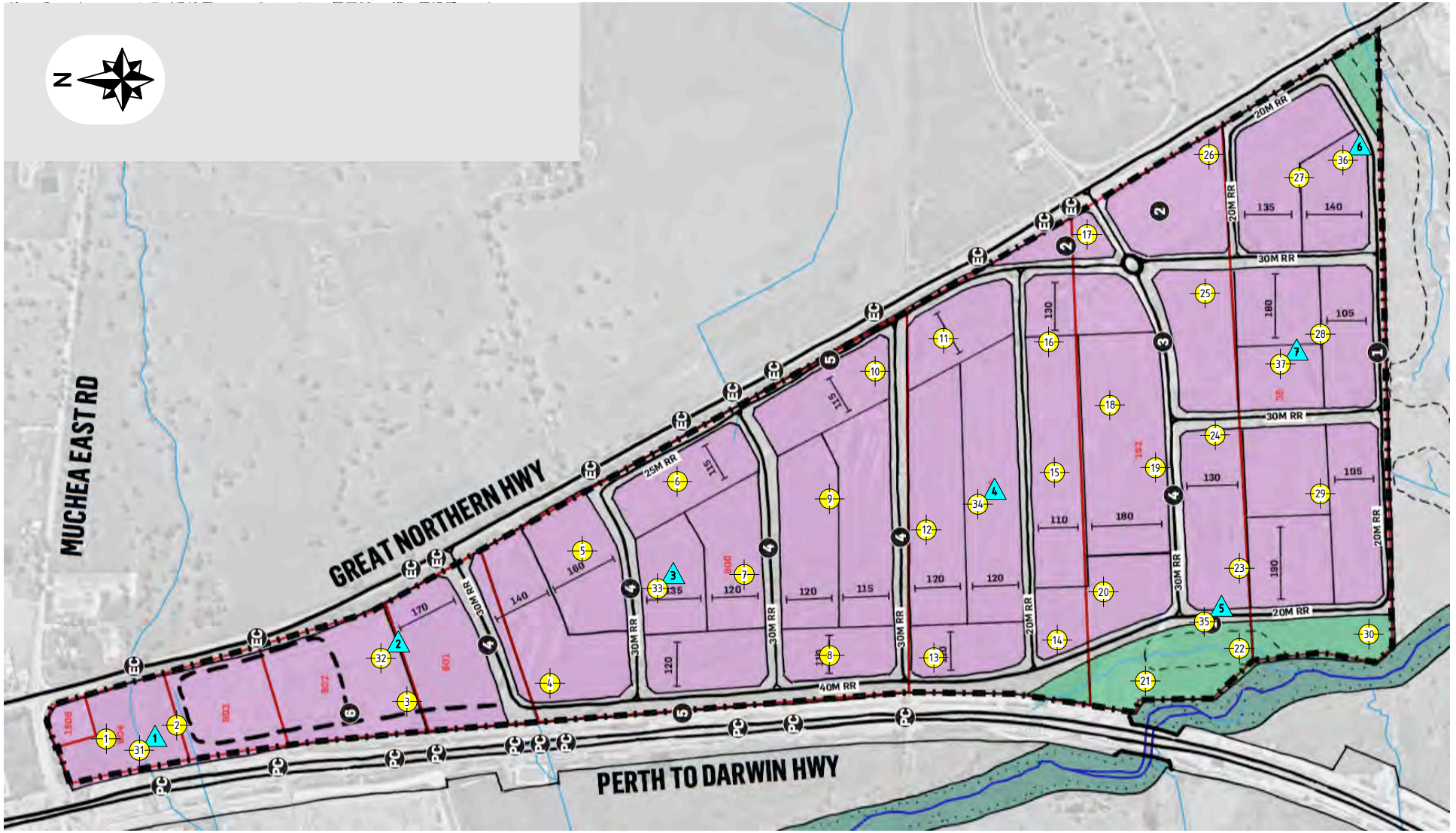
AS 1726-2017 Geotechnical site investigation

AS 2870-2011 Residential slabs and footings

AS 3798-2007 Guidelines on earthworks for commercial and residential developments

AS 4055-2012 Wind loads for housing

APPENDIX 1 – SITE LOCATION MAP



Note: Showing approximate test locations only

LEGEND

BH: Borehole

PERC: Percolation Test

STRUCterre consulting engineers

Zemla Pty Ltd (ABN 71 349 772 837) ATF the Young Purich and Higham Unit Trust trading as Structerre Consulting Engineers

1 ERINDALE ROAD, BALCATTA, WA 6021
TEL 9205 4500 FAX 9205 4501 EMAIL: wageotecheng@structerre.com.au

PROJECT:	Muchea Employment Node - Precinct 3 - Muchea
PROJECT #:	D206263
JOB #:	J315642
CLIENT:	**Muchea Employment Node Precinct 3 Land Owners**
SCALE:	NTS
TITLE:	Geotechnical Investigation Site Plan
DATE:	26 Nov '18
DRAWN BY:	MM
CHECKED BY:	DH

© COPYRIGHT STRUCTERRE CONSULTING GROUP - JUL'05

APPENDIX 2 – SITE PHOTOS



PHOTO 1



PHOTO 2

STRUCterre consulting engineers

Zemla Pty Ltd (ABN 71 349 772 837) ATF the Young Purich and Higham Unit Trust trading as Structerre Consulting Engineers

1 ERINDALE ROAD, BALCATTA, WA 6021
TEL 9205 4500 FAX 9205 4501 EMAIL: wageotecheng@structerre.com.au

PROJECT:	Muchea Employment Node - Precinct 3 - Muchea
PROJECT #:	D206263
JOB #:	J315642
CLIENT:	**Muchea Employment Node Precinct 3 Land Owners**
SCALE:	NTS
TITLE:	Site Photographs
DATE:	26 Nov '18
DRAWN BY:	MM
CHECKED BY:	DH

© COPYRIGHT STRUCTERRE CONSULTING GROUP - JUL'05



PHOTO 3 - Sample taken BH1



PHOTO 4 - Sample taken BH28

STRUCterre consulting engineers

Zemla Pty Ltd (ABN 71 349 772 837) ATF the Young Purich and Higham Unit Trust trading as Structerre Consulting Engineers

1 ERINDALE ROAD, BALCATTA, WA 6021
TEL 9205 4500 FAX 9205 4501 EMAIL: wageotecheng@structerre.com.au

PROJECT:	Muchea Employment Node - Precinct 3 - Muchea
PROJECT #:	D206263
JOB #:	J315642
CLIENT:	**Muchea Employment Node Precinct 3 Land Owners**
SCALE:	NTS
TITLE:	Site Photographs
DATE:	26 Nov '18
DRAWN BY:	MM
CHECKED BY:	DH

© COPYRIGHT STRUCTERRE CONSULTING GROUP - JUL'05

APPENDIX 3 – BORELOGS

STRUCterre consulting engineers

Project Muchea Employment Node - Precinct 3 - Muchea

Client Muchea Employment Node Precinct 3 Land Owners

Test No. **BH01**

Project No.	D206263	**Logged By**	Craig Pummell	**Machine**	Soil Retrieval Probe	**Easting**	404631
Job No.	J315642	**Date**	26/11/2018	**Hole Dia.**	65mm	**Northing**	6505901

Depth	Graphic	Stratum Description	Consistency	DCP Blows/150mm (5 10 15 20)	Samples Depth	Samples Type	Moisture	Water Level
		Topsoil:	MD		0.1 - 1.0	B	D to M	
		CH: Sandy CLAY: fine to medium grained, high plasticity, with gravel, grey (Guildford Formation)						
		mottled grey/brown	St-VSt				M	
1								
							S	
		trace gravel			1.8 - 2.3	B		
2								
		Terminated at 2.30 m						
3								

Remarks

1. Termination reason: Refusal - interpreted on stiff clay
2. Hole stability: Hole partially stable
3. Samples taken: As indicated
4. Co-ordinate system: WGS 84

1 Erindale Road, Balcatta, Western Australia 6021 | PO Box 792, Balcatta, Western Australia 6914
Phone (+618) 9205 4500 | Fax (+618) 9205 4501 | Email wageotecheng@structerre.com.au | Web www.structerre.com.au
ABN 71 349 772 837 Zemla Pty Ltd ACN 008 966 283 as trustee for the Young Purich and Higham Unit Trust trading as Structerre Consulting Engineers

STRUCterre consulting engineers

Project Muchea Employment Node - Precinct 3 - Muchea

Client Muchea Employment Node Precinct 3 Land Owners

Test No. **BH02**

Project No.	D206263	**Logged By**	Craig Pummell	**Machine**	Soil Retrieval Probe	**Easting**	404659
Job No.	J315642	**Date**	26/11/2018	**Hole Dia.**	65mm	**Northing**	6505814

Depth	Graphic	Stratum Description	Consistency	DCP Blows/150mm (5 10 15 20)	Samples Depth	Samples Type	Moisture	Water Level
		Topsoil:						
		SP: SAND: fine to medium grained, non-plastic, trace clay, grey/brown (Guildford Formation)	L				D to M	
			MD - D					
			L				M	▼
1		SC: Clayey SAND: fine to medium grained, low plasticity, with gravel, mottled grey/brown					S	
2		CH: Sandy CLAY: fine to medium grained, high plasticity, trace gravel, mottled grey/brown						
		Terminated at 2.50 m						
3								

Remarks

1. Termination reason: Target depth
2. Hole stability: Hole partially stable
3. Samples taken: None
4. Co-ordinate system: WGS 84

STRUCterre consulting engineers

Project Muchea Employment Node - Precinct 3 - Muchea

Client Muchea Employment Node Precinct 3 Land Owners

Test No. **BH03**

Project No.	D206263	**Logged By**	Craig Pummell	**Machine**	Soil Retrieval Probe	**Easting**	404781
Job No.	J315642	**Date**	26/11/2018	**Hole Dia.**	65mm	**Northing**	6505225

Depth	Graphic	Stratum Description	Consistency	DCP Blows/150mm (5 10 15 20)	Samples Depth	Samples Type	Moisture	Water Level
		Topsoil:					D to M	
		SP: SAND: fine to medium grained, non-plastic, grey (Guildford Formation)	L					
		SC: Clayey SAND: fine to medium grained, medium plasticity, with gravel, mottled grey/brown	MD					
			D - VD					
1							M	
		CH: Sandy CLAY: fine to medium grained, high plasticity, trace gravel, mottled grey/brown						
		Terminated at 1.90 m						
2								
3								

Remarks

1. Termination reason: Refusal - interpreted on stiff clay
2. Hole stability: Hole partially stable
3. Samples taken: None
4. Co-ordinate system: WGS 84

STRUCterre consulting engineers

Project Muchea Employment Node - Precinct 3 - Muchea

Client Muchea Employment Node Precinct 3 Land Owners

Test No. **BH04**

Project No.	D206263	**Logged By**	Craig Pummell	**Machine**	Soil Retrieval Probe	**Easting**	404762
Job No.	J315642	**Date**	26/11/2018	**Hole Dia.**	65mm	**Northing**	6504830

Depth	Graphic	Stratum Description	Consistency	DCP Blows/150mm (5 10 15 20)	Samples Depth	Samples Type	Moisture	Water Level
		Topsoil:	D				D to M	
		SP: SAND: fine to medium grained, non-plastic, grey (Guildford Formation)	L - MD					
		SP: Gravelly SAND: coarse grained, non-plastic, trace silt, mottled red/brown						
1		SC: Clayey SAND: fine to medium grained, medium plasticity, with gravel, mottled red/brown					M	
		CH: Sandy CLAY: fine to medium grained, high plasticity, trace gravel, mottled grey/brown						
		Terminated at 1.50 m						
2								
3								

Remarks

1. Termination reason: Refusal - interpreted on stiff clay
2. Hole stability: Hole partially stable
3. Samples taken: None
4. Co-ordinate system: WGS 84

WA | QLD | NSW | VIC

1 Erindale Road, Balcatta, Western Australia 6021 | PO Box 792, Balcatta, Western Australia 6914

Phone (+618) 9205 4500 | Fax (+618) 9205 4501 | Email wageotecheng@structerre.com.au | Web www.structerre.com.au

ABN 71 349 772 837 Zemla Pty Ltd ACN 008 966 283 as trustee for the Young Purich and Higham Unit Trust trading as Structerre Consulting Engineers

STRUCterre consulting engineers

Project Muchea Employment Node - Precinct 3 - Muchea

Client Muchea Employment Node Precinct 3 Land Owners

Test No. **BH05**

Project No.	D206263	**Logged By**	Craig Pummell	**Machine**	Soil Retrieval Probe	**Easting**	405086
Job No.	J315642	**Date**	26/11/2018	**Hole Dia.**	65mm	**Northing**	6504857

Depth	Graphic	Stratum Description	Consistency	DCP Blows/150mm (5 10 15 20)	Samples Depth	Samples Type	Moisture	Water Level
		Topsoil:			0.1 - 1.0	B	D to M	
		SC: Clayey SAND: fine to medium grained, medium plasticity, with gravel, grey (Guildford Formation)	L				M	
		brown						
1			D - VD				W	▼
		CH: Sandy CLAY: fine to medium grained, high plasticity, trace gravel, mottled grey/brown					S	
2								
		Terminated at 2.50 m						
3								

Remarks

1. Termination reason: Target depth
2. Hole stability: Hole partially stable
3. Samples taken: As indicated
4. Co-ordinate system: WGS 84

STRUCterre consulting engineers

Project Muchea Employment Node - Precinct 3 - Muchea

Client Muchea Employment Node Precinct 3 Land Owners

Test No. **BH06**

Project No.	D206263	**Logged By**	Craig Pummell	**Machine**	Soil Retrieval Probe	**Easting**	405259
Job No.	J315642	**Date**	26/11/2018	**Hole Dia.**	65mm	**Northing**	6504622

Depth	Graphic	Stratum Description	Consistency	DCP Blows/150mm (5 10 15 20)	Samples Depth	Samples Type	Moisture	Water Level
0		Topsoil:	D - VD				D to M	
		GP: Sandy GRAVEL: coarse grained, non-plastic, trace silt, grey/brown (Guildford Formation)						
		SC: Clayey SAND: fine to medium grained, medium plasticity, with gravel, brown						
1		Terminated at 1.30 m						
2								
3								

Remarks

1. Termination reason: Refusal - interpreted on stiff clay
2. Hole stability: Hole partially stable
3. Samples taken: None
4. Co-ordinate system: WGS 84

WA | QLD | NSW | VIC

1 Erindale Road, Balcatta, Western Australia 6021 | PO Box 792, Balcatta, Western Australia 6914

Phone (+618) 9205 4500 | Fax (+618) 9205 4501 | Email wageotecheng@structerre.com.au | Web www.structerre.com.au

ABN 71 349 772 837 Zemla Pty Ltd ACN 008 966 283 as trustee for the Young Purich and Higham Unit Trust trading as Structerre Consulting Engineers

STRUCterre consulting engineers

Project Muchea Employment Node - Precinct 3 - Muchea

Client Muchea Employment Node Precinct 3 Land Owners

Test No. **BH07**

Project No.	D206263	**Logged By**	Craig Pummell	**Machine**	Soil Retrieval Probe	**Easting**	404994
Job No.	J315642	**Date**	26/11/2018	**Hole Dia.**	65mm	**Northing**	6504472

Depth	Graphic	Stratum Description	Consistency	DCP Blows/150mm (5 10 15 20)	Samples Depth	Samples Type	Moisture	Water Level
		Topsoil:	D - VD		0.5 - 1.0	B	D to M	
		SP: Gravelly SAND: medium grained, non-plastic, trace silt, grey (Guildford Formation)						
		GP: Sandy GRAVEL: coarse grained, non-plastic, trace silt, grey/brown						
		GC: Clayey GRAVEL: medium to coarse grained, medium plasticity, with sand, mottled red/brown						
1		Terminated at 1.00 m						
2								
3								

Remarks

1. Termination reason: Refusal - interpreted on stiff clay
2. Hole stability: Hole partially stable
3. Samples taken: As indicated
4. Co-ordinate system: WGS 84

WA | QLD | NSW | VIC

1 Erindale Road, Balcatta, Western Australia 6021 | PO Box 792, Balcatta, Western Australia 6914

Phone (+618) 9205 4500 | Fax (+618) 9205 4501 | Email wageotecheng@structerre.com.au | Web www.structerre.com.au

ABN 71 349 772 837 Zemla Pty Ltd ACN 008 966 283 as trustee for the Young Purich and Higham Unit Trust trading as Structerre Consulting Engineers

STRUCterre consulting engineers

Project Muchea Employment Node - Precinct 3 - Muchea

Client Muchea Employment Node Precinct 3 Land Owners

Test No. **BH08**

Project No.	D206263	**Logged By**	Craig Pummell	**Machine**	Soil Retrieval Probe	**Easting**	404755
Job No.	J315642	**Date**	26/11/2018	**Hole Dia.**	65mm	**Northing**	6504337

Depth	Graphic	Stratum Description	Consistency	DCP Blows/150mm (5 10 15 20)	Samples Depth	Samples Type	Moisture	Water Level
		Topsoil:						
		SP: SAND: fine to medium grained, non-plastic, trace silt, pale grey (Guildford Formation)	L					
		GP: Sandy GRAVEL: coarse grained, low plasticity, with clay, red/brown	D - VD				D to M	
		SC: Clayey SAND: fine to medium grained, medium plasticity, with gravel, mottled grey/brown						
1		Terminated at 1.00 m						
2								
3								

Remarks

1. Termination reason: Refusal - interpreted on stiff clay
2. Hole stability: Hole partially stable
3. Samples taken: None
4. Co-ordinate system: WGS 84

WA | QLD | NSW | VIC

1 Erindale Road, Balcatta, Western Australia 6021 | PO Box 792, Balcatta, Western Australia 6914

Phone (+618) 9205 4500 | Fax (+618) 9205 4501 | Email wageotecheng@structerre.com.au | Web www.structerre.com.au

ABN 71 349 772 837 Zemla Pty Ltd ACN 008 966 283 as trustee for the Young Purich and Higham Unit Trust trading as Structerre Consulting Engineers

STRUCterre consulting engineers

Project Muchea Employment Node - Precinct 3 - Muchea

Client Muchea Employment Node Precinct 3 Land Owners

Test No. **BH09**

Project No.	D206263	**Logged By**	Craig Pummell	**Machine**	Soil Retrieval Probe	**Easting**	405126
Job No.	J315642	**Date**	26/11/2018	**Hole Dia.**	65mm	**Northing**	6504288

Depth	Graphic	Stratum Description	Consistency	DCP Blows/150mm (5 10 15 20)	Samples Depth	Samples Type	Moisture	Water Level
		Topsoil:	D - VD				D to M	
		SP: Gravelly SAND: medium grained, non-plastic, trace silt, grey (Guildford Formation)						
		GP: Sandy GRAVEL: coarse grained, medium plasticity, with clay, mottled grey/brown						
		SC: Clayey SAND: fine to medium grained, medium plasticity, with gravel, mottled grey/brown						
1		Terminated at 1.00 m						
2								
3								

Remarks

1. Termination reason: Refusal - interpreted on stiff clay
2. Hole stability: Hole partially stable
3. Samples taken: None
4. Co-ordinate system: WGS 84

WA | QLD | NSW | VIC

1 Erindale Road, Balcatta, Western Australia 6021 | PO Box 792, Balcatta, Western Australia 6914

Phone (+618) 9205 4500 | Fax (+618) 9205 4501 | Email wageotecheng@structerre.com.au | Web www.structerre.com.au

ABN 71 349 772 837 Zemla Pty Ltd ACN 008 966 283 as trustee for the Young Purich and Higham Unit Trust trading as Structerre Consulting Engineers

STRUCterre consulting engineers

Project Muchea Employment Node - Precinct 3 - Muchea

Client Muchea Employment Node Precinct 3 Land Owners

Test No. **BH10**

Project No.	D206263	**Logged By**	Craig Pummell	**Machine**	Soil Retrieval Probe	**Easting**	405415
Job No.	J315642	**Date**	26/11/2018	**Hole Dia.**	65mm	**Northing**	6504305

Depth	Graphic	Stratum Description	Consistency	DCP Blows/150mm (5 10 15 20)	Samples Depth	Samples Type	Moisture	Water Level
0		Topsoil:	L				D	
		SP: Gravelly SAND: medium grained, non-plastic, trace silt, grey (Guildford Formation)						
		GP: Sandy GRAVEL: coarse grained, non-plastic, trace silt, grey/brown	D - VD				D to M	
		SC: Clayey SAND: fine to medium grained, medium plasticity, with gravel, brown						
		Terminated at 0.70 m						
1								
2								
3								

Remarks

1. Termination reason: Refusal - interpreted on stiff clay
2. Hole stability: Hole partially stable
3. Samples taken: None
4. Co-ordinate system: WGS 84

WA | QLD | NSW | VIC

1 Erindale Road, Balcatta, Western Australia 6021 | PO Box 792, Balcatta, Western Australia 6914

Phone (+618) 9205 4500 | Fax (+618) 9205 4501 | Email wageotecheng@structerre.com.au | Web www.structerre.com.au

ABN 71 349 772 837 Zemla Pty Ltd ACN 008 966 283 as trustee for the Young Purich and Higham Unit Trust trading as Structerre Consulting Engineers

STRUCterre consulting engineers

Project Muchea Employment Node - Precinct 3 - Muchea

Client Muchea Employment Node Precinct 3 Land Owners

Test No. **BH11**

Project No.	D206263	**Logged By**	Craig Pummell	**Machine**	Soil Retrieval Probe	**Easting**	405519
Job No.	J315642	**Date**	26/11/2018	**Hole Dia.**	65mm	**Northing**	6504153

Depth	Graphic	Stratum Description	Consistency	DCP Blows/150mm (5 10 15 20)	Samples Depth	Samples Type	Moisture	Water Level
0		Topsoil:	L				D	
		GP: Sandy GRAVEL: medium to coarse grained, non-plastic, trace silt, grey (Guildford Formation)	D - VD					
		brown						
		Terminated at 0.60 m						
1								
2								
3								

Remarks

1. Termination reason: Refusal - interpreted on dense gravel
2. Hole stability: Hole partially stable
3. Samples taken: None
4. Co-ordinate system: WGS 84

STRUCterre consulting engineers

Project Muchea Employment Node - Precinct 3 - Muchea

Client Muchea Employment Node Precinct 3 Land Owners

Test No. **BH12**

Project No.	D206263	**Logged By**	Craig Pummell	**Machine**	Soil Retrieval Probe	**Easting**	405023
Job No.	J315642	**Date**	26/11/2018	**Hole Dia.**	65mm	**Northing**	6504163

Depth	Graphic	Stratum Description	Consistency	DCP Blows/150mm (5 10 15 20)	Samples Depth	Samples Type	Moisture	Water Level
		Topsoil:						
		GP: Sandy GRAVEL: medium to coarse grained, non-plastic, trace silt, grey (Guildford Formation)	L - MD				D	
		brown						
		GC: Clayey GRAVEL: medium to coarse grained, low plasticity, with sand, brown	MD - D		0.7 - 1.3	B	D to M	▼
1							S	
		Terminated at 1.50 m						
2								
3								

Remarks

1. Termination reason: Refusal - interpreted on stiff clay
2. Hole stability: Hole partially stable
3. Samples taken: As indicated
4. Co-ordinate system: WGS 84

STRUCterre consulting engineers

Project Muchea Employment Node - Precinct 3 - Muchea

Client Muchea Employment Node Precinct 3 Land Owners

Test No. **BH13**

Project No.	D206263	**Logged By**	Craig Pummell	**Machine**	Soil Retrieval Probe	**Easting**	404781
Job No.	J315642	**Date**	26/11/2018	**Hole Dia.**	65mm	**Northing**	6504129

Depth	Graphic	Stratum Description	Consistency	DCP Blows/150mm (5 10 15 20)	Samples Depth	Samples Type	Moisture	Water Level
		Topsoil:	VL					
		SP: SAND: fine to medium grained, non-plastic, trace silt, pale grey (Guildford Formation)	MD				D to M	
			VD					
1		SC: Clayey SAND: fine to medium grained, medium plasticity, trace gravel, grey/brown					M	
		SM: Silty SAND: fine to medium grained, grey/brown						
		Terminated at 1.10 m						
2								
3								

Remarks

1. Termination reason: Refusal - interpreted on cemented ground
2. Hole stability: Hole partially stable
3. Samples taken: None
4. Co-ordinate system: WGS 84

STRUCterre consulting engineers

Project Muchea Employment Node - Precinct 3 - Muchea

Client Muchea Employment Node Precinct 3 Land Owners

Test No. **BH14**

Project No.	D206263	**Logged By**	Craig Pummell	**Machine**	Soil Retrieval Probe	**Easting**	404762
Job No.	J315642	**Date**	26/11/2018	**Hole Dia.**	65mm	**Northing**	6503876

Depth	Graphic	Stratum Description	Consistency	DCP Blows/150mm (5 10 15 20)	Samples Depth	Samples Type	Moisture	Water Level
		Topsoil:	L				D to M	
		SP: SAND: fine to medium grained, non-plastic, trace clay, grey (Guildford Formation)	D					
		SC: Clayey SAND: fine to medium grained, medium plasticity, grey/brown					M	
		SM: Silty SAND: fine to medium grained, grey/brown						
		Terminated at 0.60 m	VD					
1								
2								
3								

Remarks

1. Termination reason: Refusal - interpreted on cemented ground
2. Hole stability: Hole stable
3. Samples taken: None
4. Co-ordinate system: WGS 84

1 Erindale Road, Balcatta, Western Australia 6021 | PO Box 792, Balcatta, Western Australia 6914
Phone (+618) 9205 4500 | Fax (+618) 9205 4501 | Email wageotecheng@structerre.com.au | Web www.structerre.com.au
ABN 71 349 772 837 Zemla Pty Ltd ACN 008 966 283 as trustee for the Young Purich and Higham Unit Trust trading as Structerre Consulting Engineers

STRUCterre consulting engineers

Project Muchea Employment Node - Precinct 3 - Muchea

Client Muchea Employment Node Precinct 3 Land Owners

Test No. **BH15**

Project No.	D206263	**Logged By**	Craig Pummell	**Machine**	Soil Retrieval Probe	**Easting**	405114
Job No.	J315642	**Date**	26/11/2018	**Hole Dia.**	65mm	**Northing**	6503886

Depth	Graphic	Stratum Description	Consistency	DCP Blows/150mm (5 10 15 20)	Samples Depth	Samples Type	Moisture	Water Level
		Topsoil:	MD				D	
		GP: Sandy GRAVEL: coarse grained, non-plastic, trace silt, grey (Guildford Formation)	VD					
		brown						
		SC: Clayey SAND: fine to medium grained, medium plasticity, with gravel, brown					M	
1								
		Terminated at 1.50 m						
2								
3								

Remarks

1. Termination reason: Refusal - interpreted on stiff clay
2. Hole stability: Hole partially stable
3. Samples taken: None
4. Co-ordinate system: WGS 84

WA | QLD | NSW | VIC

1 Erindale Road, Balcatta, Western Australia 6021 | PO Box 792, Balcatta, Western Australia 6914

Phone (+618) 9205 4500 | Fax (+618) 9205 4501 | Email wageotecheng@structerre.com.au | Web www.structerre.com.au

ABN 71 349 772 837 Zemla Pty Ltd ACN 008 966 283 as trustee for the Young Purich and Higham Unit Trust trading as Structerre Consulting Engineers

STRUCterre consulting engineers

Project Muchea Employment Node - Precinct 3 - Muchea

Client Muchea Employment Node Precinct 3 Land Owners

Test No. **BH16**

Project No.	D206263	**Logged By**	Craig Pummell	**Machine**	Soil Retrieval Probe	**Easting**	405541
Job No.	J315642	**Date**	27/11/2018	**Hole Dia.**	65mm	**Northing**	6503958

Depth	Graphic	Stratum Description	Consistency	DCP Blows/150mm (5 10 15 20)	Samples Depth	Samples Type	Moisture	Water Level
		Topsoil:						
		GP: Sandy GRAVEL: coarse grained, non-plastic, trace silt, grey (Guildford Formation)	VD				D	
		SC: Clayey SAND: fine to medium grained, medium plasticity, with gravel, brown					M	
1		Terminated at 1.10 m						
2								
3								

Remarks

1. Termination reason: Refusal - interpreted on stiff clay
2. Hole stability: Hole partially stable
3. Samples taken: None
4. Co-ordinate system: WGS 84

1 Erindale Road, Balcatta, Western Australia 6021 | PO Box 792, Balcatta, Western Australia 6914
Phone (+618) 9205 4500 | Fax (+618) 9205 4501 | Email wageotecheng@structerre.com.au | Web www.structerre.com.au

ABN 71 349 772 837 Zemla Pty Ltd ACN 008 966 283 as trustee for the Young Purich and Higham Unit Trust trading as Structerre Consulting Engineers

STRUCterre consulting engineers

Project Muchea Employment Node - Precinct 3 - Muchea

Client Muchea Employment Node Precinct 3 Land Owners

Test No. **BH17**

Project No.	D206263	**Logged By**	Craig Pummell	**Machine**	Soil Retrieval Probe	**Easting**	405694
Job No.	J315642	**Date**	27/11/2018	**Hole Dia.**	65mm	**Northing**	6503838

Depth	Graphic	Stratum Description	Consistency	DCP Blows/150mm (5 10 15 20)	Samples Depth	Samples Type	Moisture	Water Level
		Topsoil:	MD					
		GP: Sandy GRAVEL: coarse grained, non-plastic, trace silt, grey (Guildford Formation)	VD				D	
		SC: Clayey SAND: fine to medium grained, medium plasticity, with gravel, brown					M	
1		Terminated at 1.00 m						
2								
3								

Remarks

1. Termination reason: Refusal - interpreted on stiff clay
2. Hole stability: Hole partially stable
3. Samples taken: None
4. Co-ordinate system: WGS 84

WA | QLD | NSW | VIC

1 Erindale Road, Balcatta, Western Australia 6021 | PO Box 792, Balcatta, Western Australia 6914

Phone (+618) 9205 4500 | Fax (+618) 9205 4501 | Email wageotecheng@structerre.com.au | Web www.structerre.com.au

ABN 71 349 772 837 Zemla Pty Ltd ACN 008 966 283 as trustee for the Young Purich and Higham Unit Trust trading as Structerre Consulting Engineers

STRUCterre consulting engineers

Project Muchea Employment Node - Precinct 3 - Muchea

Client Muchea Employment Node Precinct 3 Land Owners

Test No. **BH18**

Project No.	D206263	**Logged By**	Craig Pummell	**Machine**	Soil Retrieval Probe	**Easting**	405441
Job No.	J315642	**Date**	27/11/2018	**Hole Dia.**	65mm	**Northing**	6503828

Depth	Graphic	Stratum Description	Consistency	DCP Blows/150mm (5 10 15 20)	Samples Depth	Samples Type	Moisture	Water Level
		Topsoil:						
		GP: Sandy GRAVEL: coarse grained, non-plastic, trace silt, grey (Guildford Formation)	VD				D	
		SC: Clayey SAND: fine to medium grained, medium plasticity, with gravel, brown			0.5 - 1.0	B	M	
1		Terminated at 1.00 m						
2								
3								

Remarks

1. Termination reason: Refusal - interpreted on stiff clay
2. Hole stability: Hole partially stable
3. Samples taken: As indicated
4. Co-ordinate system: WGS 84

1 Erindale Road, Balcatta, Western Australia 6021 | PO Box 792, Balcatta, Western Australia 6914
Phone (+618) 9205 4500 | Fax (+618) 9205 4501 | Email wageotecheng@structerre.com.au | Web www.structerre.com.au

ABN 71 349 772 837 Zemla Pty Ltd ACN 008 966 283 as trustee for the Young Purich and Higham Unit Trust trading as Structerre Consulting Engineers

STRUCterre consulting engineers

Project Muchea Employment Node - Precinct 3 - Muchea

Client Muchea Employment Node Precinct 3 Land Owners

Test No. **BH19**

Project No.	D206263	**Logged By**	Craig Pummell	**Machine**	Soil Retrieval Probe	**Easting**	405139
Job No.	J315642	**Date**	27/11/2018	**Hole Dia.**	65mm	**Northing**	6503673

Depth	Graphic	Stratum Description	Consistency	DCP Blows/150mm (5 10 15 20)	Samples Depth	Samples Type	Moisture	Water Level
		Topsoil:	D - VD				D	
		GP: Sandy GRAVEL: coarse grained, non-plastic, trace silt, grey (Guildford Formation)						
		SC: Clayey SAND: fine to medium grained, medium plasticity, with gravel, brown					M	
1								
		Terminated at 1.20 m						
2								
3								

Remarks

1. Termination reason: Refusal - interpreted on stiff clay
2. Hole stability: Hole partially stable
3. Samples taken: None
4. Co-ordinate system: WGS 84

1 Erindale Road, Balcatta, Western Australia 6021 | PO Box 792, Balcatta, Western Australia 6914
Phone (+618) 9205 4500 | Fax (+618) 9205 4501 | Email wageotecheng@structerre.com.au | Web www.structerre.com.au
ABN 71 349 772 837 Zemla Pty Ltd ACN 008 966 283 as trustee for the Young Purich and Higham Unit Trust trading as Structerre Consulting Engineers

STRUCterre consulting engineers

Project Muchea Employment Node - Precinct 3 - Muchea

Client Muchea Employment Node Precinct 3 Land Owners

Test No. **BH20**

Project No.	D206263	**Logged By**	Craig Pummell	**Machine**	Soil Retrieval Probe	**Easting**	404895
Job No.	J315642	**Date**	27/11/2018	**Hole Dia.**	65mm	**Northing**	6503792

Depth	Graphic	Stratum Description	Consistency	DCP Blows/150mm (5 10 15 20)	Samples Depth	Samples Type	Moisture	Water Level
		Topsoil:						
		SP: SAND: fine to medium grained, non-plastic, trace silt, grey (Guildford Formation)					D to M	
		SC: Clayey SAND: fine to medium grained, medium plasticity, with gravel, grey	L - MD		0.4 - 0.9	B		
1		CH: Sandy CLAY: fine to medium grained, high plasticity, trace gravel, red/brown	St		0.9 - 1.4	B	M	
		Terminated at 1.40 m						
2								
3								

Remarks

1. Termination reason: Refusal - interpreted on stiff clay
2. Hole stability: Hole partially stable
3. Samples taken: As indicated
4. Co-ordinate system: WGS 84

1 Erindale Road, Balcatta, Western Australia 6021 | PO Box 792, Balcatta, Western Australia 6914
Phone (+618) 9205 4500 | Fax (+618) 9205 4501 | Email wageotecheng@structerre.com.au | Web www.structerre.com.au

ABN 71 349 772 837 Zemla Pty Ltd ACN 008 966 283 as trustee for the Young Purich and Higham Unit Trust trading as Structerre Consulting Engineers

STRUCterre consulting engineers

Project Muchea Employment Node - Precinct 3 - Muchea

Client Muchea Employment Node Precinct 3 Land Owners

Test No. **BH21**

Project No.	D206263	**Logged By**	Craig Pummell	**Machine**	Soil Retrieval Probe	**Easting**	404757
Job No.	J315642	**Date**	27/11/2018	**Hole Dia.**	65mm	**Northing**	6503652

Depth	Graphic	Stratum Description	Consistency	DCP Blows/150mm (5 10 15 20)	Samples Depth	Samples Type	Moisture	Water Level
		Topsoil:	VL				D to M	
		SP: SAND: fine to medium grained, non-plastic, trace silt, grey (Guildford Formation)	D					
		GP: Sandy GRAVEL: medium to coarse grained, non-plastic to low plasticity, with silt, trace clay, brown	VD				W	
		Terminated at 0.90 m						
1								
2								
3								

Remarks

1. Termination reason: Refusal - interpreted on dense gravel
2. Hole stability: Hole stable
3. Samples taken: None
4. Co-ordinate system: WGS 84

1 Erindale Road, Balcatta, Western Australia 6021 | PO Box 792, Balcatta, Western Australia 6914
Phone (+618) 9205 4500 | Fax (+618) 9205 4501 | Email wageotecheng@structerre.com.au | Web www.structerre.com.au
ABN 71 349 772 837 Zemla Pty Ltd ACN 008 966 283 as trustee for the Young Purich and Higham Unit Trust trading as Structerre Consulting Engineers

STRUCterre consulting engineers

Project Muchea Employment Node - Precinct 3 - Muchea

Client Muchea Employment Node Precinct 3 Land Owners

Test No. **BH22**

Project No.	D206263	**Logged By**	Craig Pummell	**Machine**	Soil Retrieval Probe	**Easting**	404782
Job No.	J315642	**Date**	27/11/2018	**Hole Dia.**	65mm	**Northing**	6503525

Depth	Graphic	Stratum Description	Consistency	DCP Blows/150mm (5 10 15 20)	Samples Depth	Samples Type	Moisture	Water Level
		Topsoil:	L				D to M	
		SP: SAND: fine to medium grained, non-plastic, trace silt, grey (Guildford Formation)	VD					
		GP: Sandy GRAVEL: medium to course grained, non-plastic, trace silt, dark brown						
		Terminated at 0.50 m						
1								
2								
3								

Remarks

1. Termination reason: Refusal - interpreted on dense gravel
2. Hole stability: Hole stable
3. Samples taken: None
4. Co-ordinate system: WGS 84

1 Erindale Road, Balcatta, Western Australia 6021 | PO Box 792, Balcatta, Western Australia 6914
Phone (+618) 9205 4500 | Fax (+618) 9205 4501 | Email wageotecheng@structerre.com.au | Web www.structerre.com.au

ABN 71 349 772 837 Zemla Pty Ltd ACN 008 966 283 as trustee for the Young Purich and Higham Unit Trust trading as Structerre Consulting Engineers

STRUCterre consulting engineers

Project Muchea Employment Node - Precinct 3 - Muchea

Client Muchea Employment Node Precinct 3 Land Owners

Test No. **BH23**

Project No.	D206263	**Logged By**	Craig Pummell	**Machine**	Soil Retrieval Probe	**Easting**	404883
Job No.	J315642	**Date**	27/11/2018	**Hole Dia.**	65mm	**Northing**	6503505

Depth	Graphic	Stratum Description	Consistency	DCP Blows/150mm (5 10 15 20)	Samples Depth	Samples Type	Moisture	Water Level
		Topsoil:						
		SP: SAND: fine to medium grained, non-plastic, trace silt, grey (Guildford Formation)	L - MD				D to M	
		pale brown						
		SC: Clayey SAND: fine to medium grained, medium plasticity, trace gravel, grey/brown	D - VD				M	
1		GP: Sandy GRAVEL: medium to course grained, low to medium plasticity, with clay, grey/brown						
		Terminated at 1.00 m						
2								
3								

Remarks

1. Termination reason: Refusal - interpreted on dense gravel
2. Hole stability: Hole stable
3. Samples taken: None
4. Co-ordinate system: WGS 84

1 Erindale Road, Balcatta, Western Australia 6021 | PO Box 792, Balcatta, Western Australia 6914
Phone (+618) 9205 4500 | Fax (+618) 9205 4501 | Email wageotecheng@structerre.com.au | Web www.structerre.com.au

ABN 71 349 772 837 Zemla Pty Ltd ACN 008 966 283 as trustee for the Young Purich and Higham Unit Trust trading as Structerre Consulting Engineers

STRUCterre consulting engineers

Project Muchea Employment Node - Precinct 3 - Muchea

Client Muchea Employment Node Precinct 3 Land Owners

Test No. **BH24**

Project No.	D206263	**Logged By**	Craig Pummell	**Machine**	Soil Retrieval Probe	**Easting**	405259
Job No.	J315642	**Date**	27/11/2018	**Hole Dia.**	65mm	**Northing**	6503609

Depth	Graphic	Stratum Description	Consistency	DCP Blows/150mm (5 10 15 20)	Samples Depth	Samples Type	Moisture	Water Level
		Topsoil:	D - VD				D	
		SP: Gravelly SAND: medium grained, non-plastic, trace silt, grey (Guildford Formation)						
		GP: Sandy GRAVEL: coarse grained, trace silt, pale brown						
		SC: Clayey SAND: fine to medium grained, medium plasticity, with gravel, mottled grey/brown					M	
1								
		Terminated at 1.50 m						
2								
3								

Remarks

1. Termination reason: Refusal - interpreted on stiff clay
2. Hole stability: Hole partially stable
3. Samples taken: None
4. Co-ordinate system: WGS 84

1 Erindale Road, Balcatta, Western Australia 6021 | PO Box 792, Balcatta, Western Australia 6914
Phone (+618) 9205 4500 | Fax (+618) 9205 4501 | Email wageotecheng@structerre.com.au | Web www.structerre.com.au
ABN 71 349 772 837 Zemla Pty Ltd ACN 008 966 283 as trustee for the Young Purich and Higham Unit Trust trading as Structerre Consulting Engineers

STRUCterre consulting engineers

Project Muchea Employment Node - Precinct 3 - Muchea

Client Muchea Employment Node Precinct 3 Land Owners

Test No. **BH25**

Project No.	D206263	**Logged By**	Craig Pummell	**Machine**	Soil Retrieval Probe	**Easting**	405659
Job No.	J315642	**Date**	27/11/2018	**Hole Dia.**	65mm	**Northing**	6503544

Depth	Graphic	Stratum Description	Consistency	DCP Blows/150mm (5 10 15 20)	Samples Depth	Samples Type	Moisture	Water Level
		Topsoil:						
		GP: Sandy GRAVEL: coarse grained, non-plastic, trace silt, grey (Guildford Formation)					D	
		mottled red/brown	VD					
		SC: Clayey SAND: fine to medium grained, medium plasticity, with gravel, brown					M	
1								
		Terminated at 1.20 m						
2								
3								

Remarks

1. Termination reason: Refusal - interpreted on stiff clay
2. Hole stability: Hole partially stable
3. Samples taken: None
4. Co-ordinate system: WGS 84

1 Erindale Road, Balcatta, Western Australia 6021 | PO Box 792, Balcatta, Western Australia 6914
Phone (+618) 9205 4500 | Fax (+618) 9205 4501 | Email wageotecheng@structerre.com.au | Web www.structerre.com.au
ABN 71 349 772 837 Zemla Pty Ltd ACN 008 966 283 as trustee for the Young Purich and Higham Unit Trust trading as Structerre Consulting Engineers

STRUCterre consulting engineers

Project Muchea Employment Node - Precinct 3 - Muchea

Client Muchea Employment Node Precinct 3 Land Owners

Test No. **BH26**

Project No.	D206263	**Logged By**	Craig Pummell	**Machine**	Soil Retrieval Probe	**Easting**	405858
Job No.	J315642	**Date**	27/11/2018	**Hole Dia.**	65mm	**Northing**	6503568

Depth	Graphic	Stratum Description	Consistency	DCP Blows/150mm (5 10 15 20)	Samples Depth	Samples Type	Moisture	Water Level
		Topsoil:					D	
		GP: Sandy GRAVEL: coarse grained, non-plastic, trace silt, mottled red/brown (Guildford Formation)	VD					
		trace clay,					D to M	
		Terminated at 0.70 m						
1								
2								
3								

Remarks

1. Termination reason: Refusal - interpreted on dense gravel
2. Hole stability: Hole partially stable
3. Samples taken: None
4. Co-ordinate system: WGS 84

1 Erindale Road, Balcatta, Western Australia 6021 | PO Box 792, Balcatta, Western Australia 6914
Phone (+618) 9205 4500 | Fax (+618) 9205 4501 | Email wageotecheng@structerre.com.au | Web www.structerre.com.au
ABN 71 349 772 837 Zemla Pty Ltd ACN 008 966 283 as trustee for the Young Purich and Higham Unit Trust trading as Structerre Consulting Engineers

STRUCterre consulting engineers

Project Muchea Employment Node - Precinct 3 - Muchea

Client Muchea Employment Node Precinct 3 Land Owners

Test No. **BH27**

Project No.	D206263	**Logged By**	Craig Pummell	**Machine**	Soil Retrieval Probe	**Easting**	405874
Job No.	J315642	**Date**	27/11/2018	**Hole Dia.**	65mm	**Northing**	6503343

Depth	Graphic	Stratum Description	Consistency	DCP Blows/150mm (5 10 15 20)	Samples Depth	Samples Type	Moisture	Water Level
		Topsoil:	MD				D	
		GP: Sandy GRAVEL: coarse grained, non-plastic, trace silt, grey (Guildford Formation)						
		trace clay, mottled grey/brown	VD					
		SC: Clayey SAND: fine to medium grained, medium plasticity, with gravel, brown					D to M	
1		CH: Sandy CLAY: fine to medium grained, high plasticity, with gravel, brown					M	
		Terminated at 1.50 m						
2								
3								

Remarks

1. Termination reason: Refusal - interpreted on stiff clay
2. Hole stability: Hole partially stable
3. Samples taken: None
4. Co-ordinate system: WGS 84

1 Erindale Road, Balcatta, Western Australia 6021 | PO Box 792, Balcatta, Western Australia 6914
Phone (+618) 9205 4500 | Fax (+618) 9205 4501 | Email wageotecheng@structerre.com.au | Web www.structerre.com.au

ABN 71 349 772 837 Zemla Pty Ltd ACN 008 966 283 as trustee for the Young Purich and Higham Unit Trust trading as Structerre Consulting Engineers

STRUCterre consulting engineers

Project Muchea Employment Node - Precinct 3 - Muchea

Client Muchea Employment Node Precinct 3 Land Owners

Test No. **BH28**

Project No.	D206263	**Logged By**	Craig Pummell	**Machine**	Soil Retrieval Probe	**Easting**	405419
Job No.	J315642	**Date**	27/11/2018	**Hole Dia.**	65mm	**Northing**	6503299

Depth	Graphic	Stratum Description	Consistency	DCP Blows/150mm (5 10 15 20)	Samples Depth	Samples Type	Moisture	Water Level
		Topsoil:	L				D	
		GP: Sandy GRAVEL: coarse grained, non-plastic, trace silt, grey (Guildford Formation)	VD					
		SC: Clayey SAND: fine to medium grained, medium plasticity, with gravel, pale brown						
		Terminated at 0.60 m						
1								
2								
3								

Remarks

1. Termination reason: Refusal - interpreted on dense gravel
2. Hole stability: Hole partially stable
3. Samples taken: None
4. Co-ordinate system: WGS 84

1 Erindale Road, Balcatta, Western Australia 6021 | PO Box 792, Balcatta, Western Australia 6914
Phone (+618) 9205 4500 | Fax (+618) 9205 4501 | Email wageotecheng@structerre.com.au | Web www.structerre.com.au

ABN 71 349 772 837 Zemla Pty Ltd ACN 008 966 283 as trustee for the Young Purich and Higham Unit Trust trading as Structerre Consulting Engineers

STRUCterre consulting engineers

Project Muchea Employment Node - Precinct 3 - Muchea

Client Muchea Employment Node Precinct 3 Land Owners

Test No. **BH29**

Project No.	D206263	**Logged By**	Craig Pummell	**Machine**	Soil Retrieval Probe	**Easting**	405018
Job No.	J315642	**Date**	27/11/2018	**Hole Dia.**	65mm	**Northing**	6503272

Depth	Graphic	Stratum Description	Consistency	DCP Blows/150mm (5 10 15 20)	Samples Depth	Samples Type	Moisture	Water Level
		Topsoil:						
		SP: SAND: fine to medium grained, non-plastic, trace silt, pale grey (Guildford Formation)	L - MD				D to M	
		SC: Clayey SAND: fine to medium grained, medium plasticity, grey	D - VD				M	
		SP: Silty SAND: fine to medium grained, grey/brown					D	
		Terminated at 0.80 m						
1								
2								
3								

Remarks

1. Termination reason: Refusal - interpreted on cemented ground
2. Hole stability: Hole partially stable
3. Samples taken: None
4. Co-ordinate system: WGS 84

1 Erindale Road, Balcatta, Western Australia 6021 | PO Box 792, Balcatta, Western Australia 6914
Phone (+618) 9205 4500 | Fax (+618) 9205 4501 | Email wageotecheng@structerre.com.au | Web www.structerre.com.au
ABN 71 349 772 837 Zemla Pty Ltd ACN 008 966 283 as trustee for the Young Purich and Higham Unit Trust trading as Structerre Consulting Engineers

STRUCterre consulting engineers

Project Muchea Employment Node - Precinct 3 - Muchea

Client Muchea Employment Node Precinct 3 Land Owners

Test No. **BH30**

Project No.	D206263	**Logged By**	Craig Pummell	**Machine**	Soil Retrieval Probe	**Easting**	404849
Job No.	J315642	**Date**	27/11/2018	**Hole Dia.**	65mm	**Northing**	6503206

Depth	Graphic	Stratum Description	Consistency	DCP Blows/150mm (5 10 15 20)	Samples Depth	Samples Type	Moisture	Water Level
		Topsoil:	L					
		SP: SAND: fine to medium grained, non-plastic, trace silt, pale grey (Guildford Formation)	D		0.6 - 1.0	B	D to M	
		SC: Clayey SAND: fine to medium grained, medium plasticity, grey	MD					
			VD				M	
1		Terminated at 1.00 m						
2								
3								

Remarks

1. Termination reason: Refusal - interpreted on dense gravel
2. Hole stability: Hole partially stable
3. Samples taken: As indicated
4. Co-ordinate system: WGS 84

WA | QLD | NSW | VIC

1 Erindale Road, Balcatta, Western Australia 6021 | PO Box 792, Balcatta, Western Australia 6914

Phone (+618) 9205 4500 | Fax (+618) 9205 4501 | Email wageotecheng@structerre.com.au | Web www.structerre.com.au

ABN 71 349 772 837 Zemla Pty Ltd ACN 008 966 283 as trustee for the Young Purich and Higham Unit Trust trading as Structerre Consulting Engineers

STRUCterre consulting engineers

Project Muchea Employment Node - Precinct 3 - Muchea

Client Muchea Employment Node Precinct 3 Land Owners

Test No. **BH31**

Project No.	D206263	**Logged By**	Craig Pummell	**Machine**	Hand Auger	**Easting**	
Job No.	J315642	**Date**	27/11/2018	**Hole Dia.**	65mm	**Northing**	

Depth	Graphic	Stratum Description	Consistency	DCP Blows/150mm (5 10 15 20)	Samples Depth	Samples Type	Moisture	Water Level
		Topsoil:						
		SP: SAND: fine to medium grained, non-plastic, with silt, trace gravel, brown (Guildford Formation)	MD - D				D to M	
		SC: Clayey SAND: fine to medium grained, low plasticity, trace gravel, yellow/brown	L - MD				D to M	
1		Terminated at 1.00 m	D					
2								
3								

Remarks

1. Termination reason: Target depth - permeability test
2. Hole stability: Hole stable
3. Samples taken: None
4. Co-ordinate system: WGS 84

STRUCterre consulting engineers

Project Muchea Employment Node - Precinct 3 - Muchea

Client Muchea Employment Node Precinct 3 Land Owners

Test No. **BH32**

Project No.	D206263	**Logged By**	Craig Pummell	**Machine**	Hand Auger	**Easting**	
Job No.	J315642	**Date**	27/11/2018	**Hole Dia.**	65mm	**Northing**	

Depth	Graphic	Stratum Description	Consistency	DCP Blows/150mm (5 10 15 20)	Samples Depth	Samples Type	Moisture	Water Level
		Topsoil:	MD - D				D to M	
		SP: SAND: fine to medium grained, non-plastic, trace gravel, trace organic material (fine roots), grey/brown (Guildford Formation)						
		SC: Clayey SAND: fine to medium grained, low plasticity, trace gravel, yellow/brown						
		Terminated at 0.70 m	VD					
1								
2								
3								

Remarks

1. Termination reason: Refusal - interpreted on dense gravel
2. Hole stability: Hole stable
3. Samples taken: None
4. Co-ordinate system: WGS 84

1 Erindale Road, Balcatta, Western Australia 6021 | PO Box 792, Balcatta, Western Australia 6914
Phone (+618) 9205 4500 | Fax (+618) 9205 4501 | Email wageotecheng@structerre.com.au | Web www.structerre.com.au
ABN 71 349 772 837 Zemla Pty Ltd ACN 008 966 283 as trustee for the Young Purich and Higham Unit Trust trading as Structerre Consulting Engineers

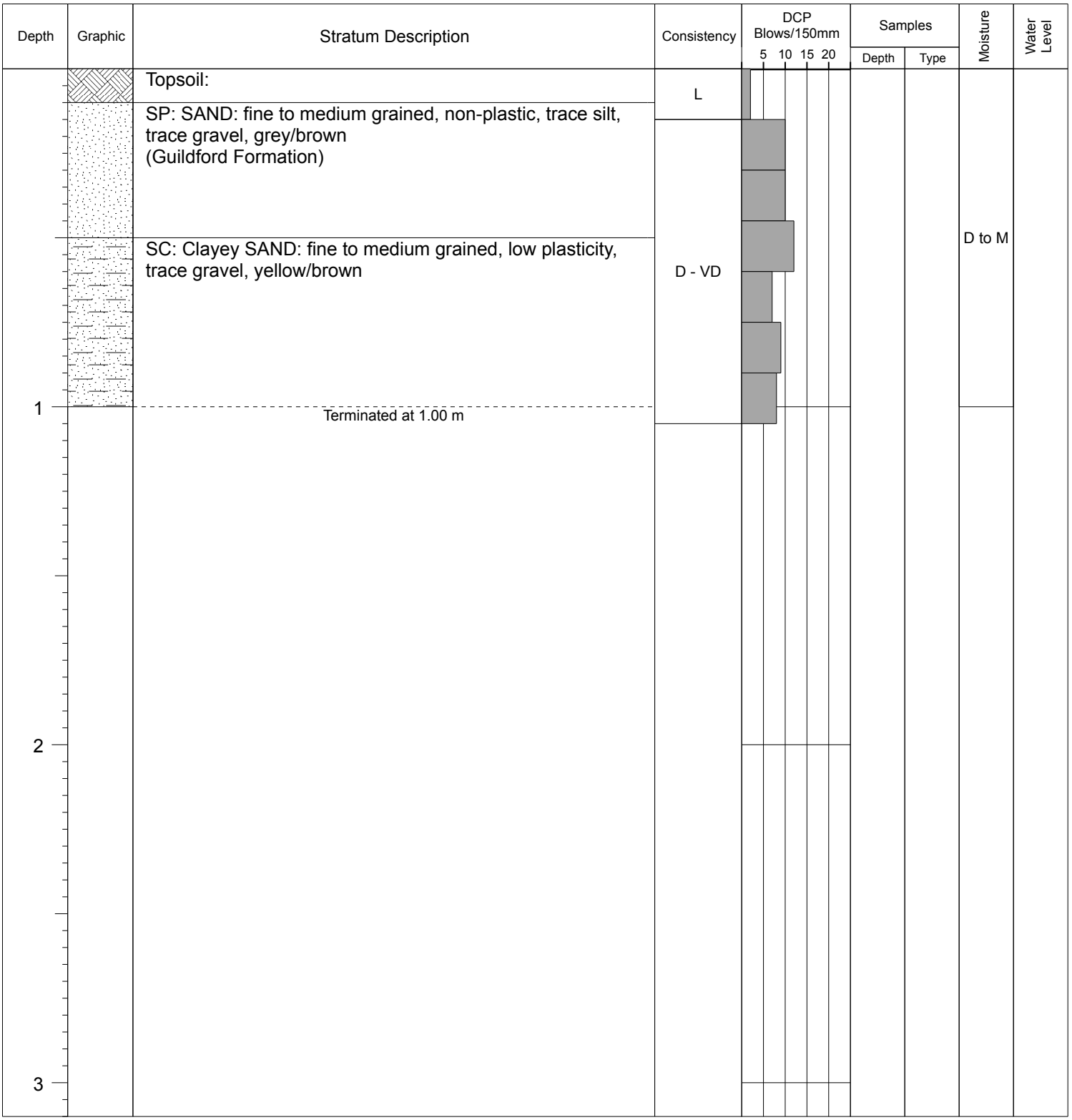
STRUCterre consulting engineers

Project Muchea Employment Node - Precinct 3 - Muchea

Client Muchea Employment Node Precinct 3 Land Owners

Test No. **BH33**

Project No.	D206263	**Logged By**	Craig Pummell	**Machine**	Hand Auger	**Easting**	
Job No.	J315642	**Date**	27/11/2018	**Hole Dia.**	65mm	**Northing**	



Remarks

1. Termination reason: Target depth - permeability test
2. Hole stability: Hole stable
3. Samples taken: None
4. Co-ordinate system: WGS 84

WA | QLD | NSW | VIC

1 Erindale Road, Balcatta, Western Australia 6021 | PO Box 792, Balcatta, Western Australia 6914

Phone (+618) 9205 4500 | Fax (+618) 9205 4501 | Email wageotecheng@structerre.com.au | Web www.structerre.com.au

ABN 71 349 772 837 Zemla Pty Ltd ACN 008 966 283 as trustee for the Young Purich and Higham Unit Trust trading as Structerre Consulting Engineers

STRUCterre consulting engineers

Project Muchea Employment Node - Precinct 3 - Muchea

Client Muchea Employment Node Precinct 3 Land Owners

Test No. **BH34**

Project No.	D206263	**Logged By**	Craig Pummell	**Machine**	Soil Retrieval Probe	**Easting**	
Job No.	J315642	**Date**	27/11/2018	**Hole Dia.**	65mm	**Northing**	

Depth	Graphic	Stratum Description	Consistency	DCP Blows/150mm (5 10 15 20)	Samples Depth	Samples Type	Moisture	Water Level
		Topsoil:						
		SP: Gravelly SAND: fine to medium grained, non-plastic, with silt, grey/brown (Guildford Formation)	VD				D	
		SC: Clayey SAND: fine to medium grained, low plasticity, with gravel, mottled grey/brown					D to M	
1		Terminated at 1.00 m						
2								
3								

Remarks

1. Termination reason: Target depth - permeability test
2. Hole stability: Hole partially stable
3. Samples taken: None
4. Co-ordinate system: WGS 84

1 Erindale Road, Balcatta, Western Australia 6021 | PO Box 792, Balcatta, Western Australia 6914
Phone (+618) 9205 4500 | Fax (+618) 9205 4501 | Email wageotecheng@structerre.com.au | Web www.structerre.com.au
ABN 71 349 772 837 Zemla Pty Ltd ACN 008 966 283 as trustee for the Young Purich and Higham Unit Trust trading as Structerre Consulting Engineers

STRUCterre consulting engineers

Project Muchea Employment Node - Precinct 3 - Muchea

Client Muchea Employment Node Precinct 3 Land Owners

Test No. **BH35**

Project No.	D206263	**Logged By**	Craig Pummell	**Machine**	Soil Retrieval Probe	**Easting**	
Job No.	J315642	**Date**	27/11/2018	**Hole Dia.**	65mm	**Northing**	

Depth	Graphic	Stratum Description	Consistency	DCP Blows/150mm (5 10 15 20)	Samples Depth	Samples Type	Moisture	Water Level
		Topsoil:	L				D to M	
		SP: SAND: fine to medium grained, non-plastic, trace silt, grey (Guildford Formation)	VD					
		GP: Sandy GRAVEL: medium to course grained, non-plastic, trace silt, dark brown						
		Terminated at 0.50 m						
1								
2								
3								

Remarks

1. Termination reason: Refusal - interpreted on stiff clay
2. Hole stability: Hole partially stable
3. Samples taken: None
4. Co-ordinate system: WGS 84

1 Erindale Road, Balcatta, Western Australia 6021 | PO Box 792, Balcatta, Western Australia 6914
Phone (+618) 9205 4500 | Fax (+618) 9205 4501 | Email wageotecheng@structerre.com.au | Web www.structerre.com.au

ABN 71 349 772 837 Zemla Pty Ltd ACN 008 966 283 as trustee for the Young Purich and Higham Unit Trust trading as Structerre Consulting Engineers

STRUCterre consulting engineers

Project Muchea Employment Node - Precinct 3 - Muchea

Client Muchea Employment Node Precinct 3 Land Owners

Test No. **BH36**

Project No.	D206263	**Logged By**	Craig Pummell	**Machine**	Soil Retrieval Probe	**Easting**	
Job No.	J315642	**Date**	27/11/2018	**Hole Dia.**	65mm	**Northing**	

Depth	Graphic	Stratum Description	Consistency	DCP Blows/150mm (5 10 15 20)	Samples Depth	Samples Type	Moisture	Water Level
		Topsoil:	MD					
		SP: Gravelly SAND: fine to medium grained, non-plastic, with silt, pale grey/brown (Guildford Formation)	VD				D	
		SC: Clayey SAND: fine to medium grained, low plasticity, trace gravel, brown					D to M	
1		Terminated at 1.00 m						
2								
3								

Remarks

1. Termination reason: Target depth - permeability test
2. Hole stability: Hole partially stable
3. Samples taken: None
4. Co-ordinate system: WGS 84

1 Erindale Road, Balcatta, Western Australia 6021 | PO Box 792, Balcatta, Western Australia 6914
Phone (+618) 9205 4500 | Fax (+618) 9205 4501 | Email wageotecheng@structerre.com.au | Web www.structerre.com.au
ABN 71 349 772 837 Zemla Pty Ltd ACN 008 966 283 as trustee for the Young Purich and Higham Unit Trust trading as Structerre Consulting Engineers

STRUCterre consulting engineers

Project Muchea Employment Node - Precinct 3 - Muchea

Client Muchea Employment Node Precinct 3 Land Owners

Test No. **BH37**

Project No.	D206263	**Logged By**	Craig Pummell	**Machine**	Soil Retrieval Probe	**Easting**	
Job No.	J315642	**Date**	27/11/2018	**Hole Dia.**	65mm	**Northing**	

Depth	Graphic	Stratum Description	Consistency	DCP Blows/150mm (5 10 15 20)	Samples Depth	Samples Type	Moisture	Water Level
		Topsoil:	L				D	
		GP: Sandy GRAVEL: coarse grained, non-plastic, trace silt, grey (Guildford Formation)	VD					
		SC: Clayey SAND: fine to medium grained, medium plasticity, with gravel, pale brown						
		Terminated at 0.60 m						
1								
2								
3								

Remarks

1. Termination reason: Refusal - interpreted on stiff clay
2. Hole stability: Hole partially stable
3. Samples taken: None
4. Co-ordinate system: WGS 84

1 Erindale Road, Balcatta, Western Australia 6021 | PO Box 792, Balcatta, Western Australia 6914
Phone (+618) 9205 4500 | Fax (+618) 9205 4501 | Email wageotecheng@structerre.com.au | Web www.structerre.com.au
ABN 71 349 772 837 Zemla Pty Ltd ACN 008 966 283 as trustee for the Young Purich and Higham Unit Trust trading as Structerre Consulting Engineers

APPENDIX 4 – LABORATORY TEST RESULTS

Sample No.	**32126**	**Client**	Geotechnical
Job No.	J315642	**Project**	Muchea Employment Node - Precinct 3, Muchea

Laboratory testing carried out at Balcatta Laboratory 1 Erindale Rd, Balcatta WA 6021

SAMPLE DETAILS

BH No. / Depth : 1 0.1-1m
Sample History : 50°C Oven Dried

Sampling Method Client
Sample Preparation AS 1289 1.1

ATTERBERG LIMITS

Description	Method	Result (%)
Liquid Limit	AS 1289.3.1.2	52
Plastic Limit	AS 1289.3.2.1	20
Plasticity Index	AS 1289.3.3.1	32
Linear Shrinkage	AS 1289.3.4.1	9
Nature of Shrinkage		Flat

PARTICLE SIZE DISTRIBUTION

Method: AS 1289.3.6.1
Description: Particle size distribution by sieve analysis

Sieve Size (mm)	% Passing
19.0	98
2.36	73
0.425	59
0.075	42

AS 1726:2017 Clause 6.1
Material Description: Sandy CLAY with gravel
AS Group Symbol: CH or OH

Accredited for compliance with ISO/IEC 17025
NATA
WORLD RECOGNISED ACCREDITATION
STRUCTERRE CONSULTING ENGINEERS BALCATTA LABORATORY ACCREDITATION NUMBER 18742

Wayne Rozmianiec
Laboratory Manager

Date: 07-Dec-18

WA | QLD | NSW | VIC
1 Erindale Road, Balcatta, Western Australia 6021 | PO Box 792, Balcatta, Western Australia 6914
Phone (+618) 9205 4500 | Fax (+618) 9205 4501 | Email wageotechlab@structerre.com.au | Web www.structerre.com.au
ABN 71 349 772 837 Zemla Pty Ltd ACN 008 966 283 as trustee for the Young Purich and Higham Unit Trust trading as Structerre Consulting Engineers

Sample No.	**32127**	**Client**	Geotechnical
Job No.	J315642	**Project**	Muchea Employment Node - Precinct 3

Laboratory testing carried out at Balcatta Laboratory 1 Erindale Rd, Balcatta WA 6021

SAMPLE DETAILS

BH No. / Depth : 7 0.7-1m
Sample History : 50°C Oven Dried

Sampling Method Client
Sample Preparation AS 1289 1.1

ATTERBERG LIMITS

Description	Method	Result (%)
Liquid Limit	AS 1289.3.1.2	36
Plastic Limit	AS 1289.3.2.1	17
Plasticity Index	AS 1289.3.3.1	19
Linear Shrinkage	AS 1289.3.4.1	6.5
Nature of Shrinkage		Flat

PARTICLE SIZE DISTRIBUTION

Method: AS 1289.3.6.1
Description: Particle size distribution by sieve analysis

Sieve Size (mm)	% Passing
19.0	88
2.36	59
0.425	52
0.075	33

AS 1726:2017 Clause 6.1
Material Description: Clayey GRAVEL with sand
AS Group Symbol: GC

Accredited for compliance with ISO/IEC 17025
NATA
WORLD RECOGNISED ACCREDITATION
STRUCTERRE CONSULTING ENGINEERS BALCATTA LABORATORY ACCREDITATION NUMBER 18742

Wayne Rozmianiec
Laboratory Manager

Date: 07-Dec-18

WA | QLD | NSW | VIC
1 Erindale Road, Balcatta, Western Australia 6021 | PO Box 792, Balcatta, Western Australia 6914
Phone (+618) 9205 4500 | Fax (+618) 9205 4501 | Email wageotechlab@structerre.com.au | Web www.structerre.com.au
ABN 71 349 772 837 Zemla Pty Ltd ACN 008 966 283 as trustee for the Young Purich and Higham Unit Trust trading as Structerre Consulting Engineers

Sample No.	**32128**	**Client**	Geotechnical
Job No.	J315642	**Project**	Muchea Employment Node - Precinct 3

Laboratory testing carried out at Balcatta Laboratory 1 Erindale Rd, Balcatta WA 6021

SAMPLE DETAILS

BH No. / Depth : 12 0.7-1.3m
Sample History : 50°C Oven Dried

Sampling Method Client
Sample Preparation AS 1289 1.1

ATTERBERG LIMITS

Description	Method	Result (%)
Liquid Limit	AS 1289.3.1.2	34
Plastic Limit	AS 1289.3.2.1	14
Plasticity Index	AS 1289.3.3.1	20
Linear Shrinkage	AS 1289.3.4.1	7
Nature of Shrinkage		Flat

PARTICLE SIZE DISTRIBUTION

Method: AS 1289.3.6.1
Description: Particle size distribution by sieve analysis

Sieve Size (mm)	% Passing
19.0	100
2.36	56
0.425	50
0.075	33

AS 1726:2017 Clause 6.1
Material Description: Clayey GRAVEL with sand
AS Group Symbol: GC

Accredited for compliance with ISO/IEC 17025
NATA
WORLD RECOGNISED ACCREDITATION
STRUCTERRE CONSULTING ENGINEERS BALCATTA LABORATORY ACCREDITATION NUMBER 18742

Wayne Rozmianiec
Laboratory Manager

Date: 10-Dec-18

WA | QLD | NSW | VIC
1 Erindale Road, Balcatta, Western Australia 6021 | PO Box 792, Balcatta, Western Australia 6914
Phone (+618) 9205 4500 | Fax (+618) 9205 4501 | Email wageotechlab@structerre.com.au | Web www.structerre.com.au
ABN 71 349 772 837 Zemla Pty Ltd ACN 008 966 283 as trustee for the Young Purich and Higham Unit Trust trading as Structerre Consulting Engineers

Sample No.	**32129**	**Client**	Geotechnical
Job No.	J315642	**Project**	Muchea Employment Node - Precinct 3

Laboratory testing carried out at Balcatta Laboratory 1 Erindale Rd, Balcatta WA 6021

SAMPLE DETAILS

BH No. / Depth : 20 0.4-0.9m
Sample History : 50°C Oven Dried

Sampling Method Client
Sample Preparation AS 1289 1.1

ATTERBERG LIMITS

Description	Method	Result (%)
Liquid Limit	AS 1289.3.1.2	37
Plastic Limit	AS 1289.3.2.1	15
Plasticity Index	AS 1289.3.3.1	22
Linear Shrinkage	AS 1289.3.4.1	9
Nature of Shrinkage		Cracked

PARTICLE SIZE DISTRIBUTION

Method: AS 1289.3.6.1
Description: Particle size distribution by sieve analysis

Sieve Size (mm)	% Passing
19.0	100
2.36	71
0.425	62
0.075	33

AS 1726:2017 Clause 6.1
Material Description: Clayey SAND with gravel
AS Group Symbol: SC

Accredited for compliance with ISO/IEC 17025
NATA
WORLD RECOGNISED ACCREDITATION
STRUCTERRE CONSULTING ENGINEERS BALCATTA LABORATORY ACCREDITATION NUMBER 18742

Wayne Rozmianiec
Laboratory Manager

Date: 10-Dec-18

WA | QLD | NSW | VIC
1 Erindale Road, Balcatta, Western Australia 6021 | PO Box 792, Balcatta, Western Australia 6914
Phone (+618) 9205 4500 | Fax (+618) 9205 4501 | Email wageotechlab@structerre.com.au | Web www.structerre.com.au
ABN 71 349 772 837 Zemla Pty Ltd ACN 008 966 283 as trustee for the Young Purich and Higham Unit Trust trading as Structerre Consulting Engineers

APPENDIX 5 – PRI TEST RESULTS

Analysis Results

CSBP Soil and Plant Laboratory

88282
Structerre Consulting Engineers

Lab No	5IS18042	5IS18043	5IS18044	5IS18045	5IS18046	5IS18047
Name	BH2_0.1-0.4M	BH4_0.1-0.4M	BH5_0.1-0.4M	BH11_0.1-0.4M	BH18_0.1-0.4M	BH23_0.1-0.4M
Code	J315642	J315642	J315642	J315642	J315642	J315642
Customer	Structerre	Structerre	Structerre	Structerre	Structerre	Structerre
Depth	0-10	0-10	0-10	0-10	0-10	0-10
Phosphorus Retention Index	4.5	1.8	185.8	6.4	445.7	1.1

CSBP Lab. Extract Value.

APPENDIX 6 – CBR RESULTS

Material Test Certificate

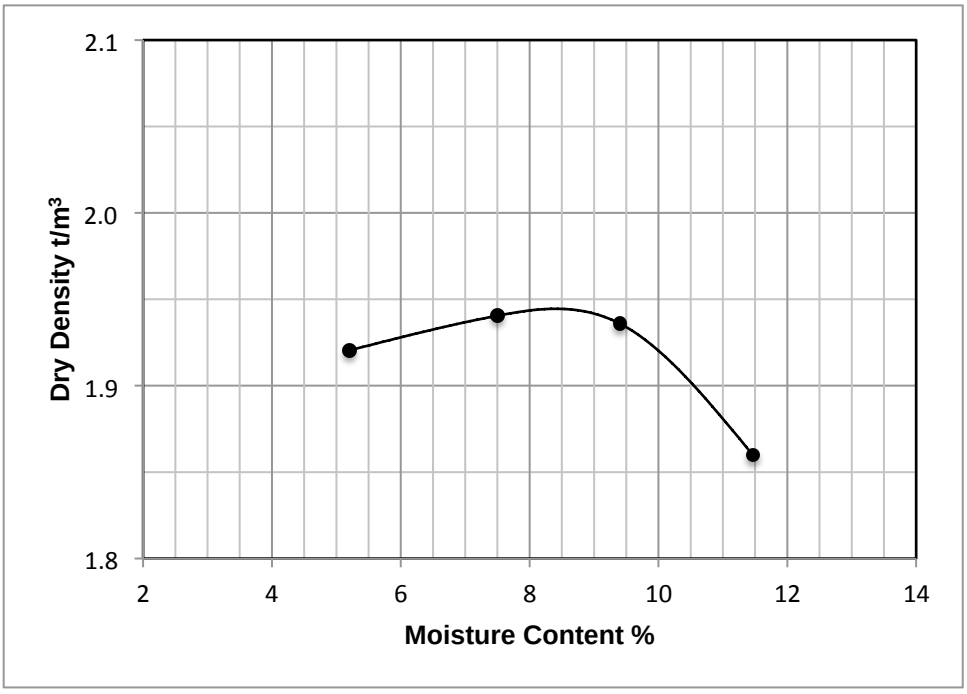
AS 1289.5.2.1 Determination of the dry density/moisture content relation of a soil using modified compactive effort

Client:	INHAM RURAL PROPERTY GROUP PTY LTD	**Job Number:**	S905648
Project:	Muchea Employment Node Precinct 3 - GREAT NORTHERN HWY MUCHEA	**Issue Number:**	1
Report Number:	S905648-A	**Page:**	1 of 1

Laboratory testing carried out at Balcatta Laboratory 1 Erindale Rd Balcatta WA 6021

Sample ID:	BH2_0.1-0.4m	**Date Tested:**	29 Nov 2018
Proposed Use:	-	**Laboratory Number:**	S905648-A-1
Material Type:	Sand	**Depth of Test:**	- mm
		Layer Thickness:	- mm
Sampling Method :	Client	**Site Selection Method:**	Client

Maximum Dry Density t/m³	1.94	**Optimum Moisture Content %**	8.5
% Retained 19mm Sieve	0	**% Retained 37.5mm Sieve**	0
Curing Time hrs	24	**Method used to determine LL**	Visual/Tactile



Notes:

Accredited for compliance with ISO/IEC 17025 – Testing
WORLD RECOGNISED ACCREDITATION
STRUCTERRE CONSULTING ENGINEERS BALCATTA LABORATORY ACCREDITATION NUMBER 18742

Approved Signatory: Laboratory Manager Wayne Rozmianiec Date: 5 Dec 2018

WA | QLD | NSW | VIC
1 Erindale Road, Balcatta, Western Australia 6021 | PO Box 792, Balcatta, Western Australia 6914
Phone (+618) 9205 4500 | Fax (+618) 9205 4501 | Email wageotechlab@structerre.com.au | Web www.structerre.com.au
ABN 71 349 772 837 Zemla Pty Ltd ACN 008 966 283 as trustee for the Young Purich and Higham Unit Trust trading as Structerre Consulting Engineers

Material Test Certificate

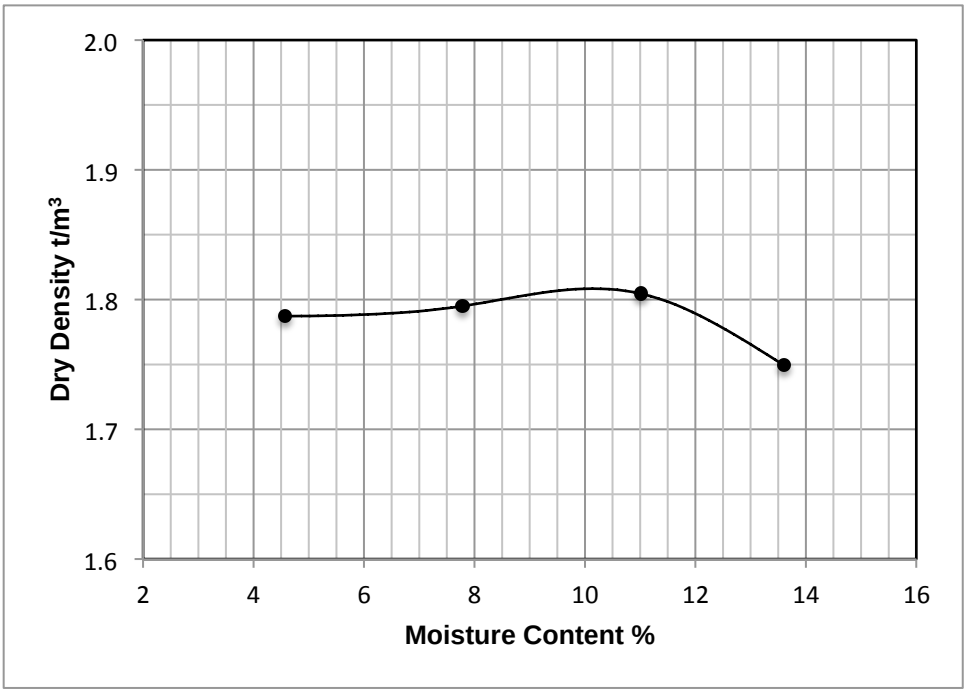
AS 1289.5.2.1 Determination of the dry density/moisture content relation of a soil using modified compactive effort

Client:	INHAM RURAL PROPERTY GROUP PTY LTD	**Job Number:**	S905648
Project:	Muchea Employment Node Precinct 3 - GREAT NORTHERN HWY MUCHEA	**Issue Number:**	1
Report Number:	S905648-A	**Page:**	1 of 1

Laboratory testing carried out at Balcatta Laboratory 1 Erindale Rd Balcatta WA 6021

Sample ID:	BH4_0.1-0.4m	**Date Tested:**	29 Nov 2018
Proposed Use:	-	**Laboratory Number:**	S905648-A-2
Material Type:	Sand	**Depth of Test:**	- mm
		Layer Thickness:	- mm
Sampling Method :	Client	**Site Selection Method:**	Client

Maximum Dry Density t/m³	1.81	**Optimum Moisture Content %**	10.0
% Retained 19mm Sieve	0	**% Retained 37.5mm Sieve**	0
Curing Time hrs	24	**Method used to determine LL**	Visual/Tactile



Notes:

NATA Accredited for compliance with ISO/IEC 17025 – Testing
WORLD RECOGNISED ACCREDITATION
STRUCTERRE CONSULTING ENGINEERS BALCATTA LABORATORY ACCREDITATION NUMBER 18742

Approved Signatory:
Laboratory Manager

Wayne Rozmianiec

Date: 5 Dec 2018

WA | QLD | NSW | VIC

1 Erindale Road, Balcatta, Western Australia 6021 | PO Box 792, Balcatta, Western Australia 6914

Phone (+618) 9205 4500 | Fax (+618) 9205 4501 | Email wageotechlab@structerre.com.au | Web www.structerre.com.au

ABN 71 349 772 837 Zemla Pty Ltd ACN 008 966 283 as trustee for the Young Purich and Higham Unit Trust trading as Structerre Consulting Engineers

Material Test Certificate

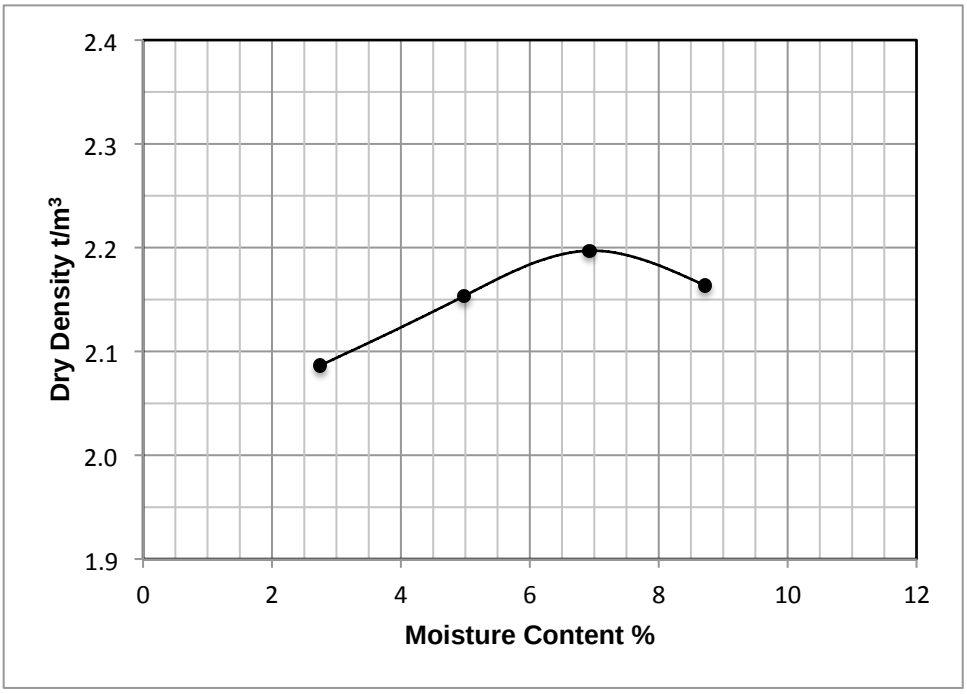
AS 1289.5.2.1 Determination of the dry density/moisture content relation of a soil using modified compactive effort

Client:	INHAM RURAL PROPERTY GROUP PTY LTD	**Job Number:**	S905648
Project:	Muchea Employment Node Precinct 3 - GREAT NORTHERN HWY MUCHEA	**Issue Number:**	1
Report Number:	S905648-A	**Page:**	1 of 1

Laboratory testing carried out at Balcatta Laboratory 1 Erindale Rd Balcatta WA 6021

Sample ID:	BH11_0.1-0.4	**Date Tested:**	29 Nov 2018
Proposed Use:	-	**Laboratory Number:**	S905648-A-3
Material Type:	Sand	**Depth of Test:**	- mm
		Layer Thickness:	- mm
Sampling Method :	Client	**Site Selection Method:**	Client

Maximum Dry Density t/m³	2.20	**Optimum Moisture Content %**	7.0
% Retained 19mm Sieve	1	**% Retained 37.5mm Sieve**	0
Curing Time hrs	24	**Method used to determine LL**	Visual/Tactile



Notes:

NATA Accredited for compliance with ISO/IEC 17025 – Testing
WORLD RECOGNISED ACCREDITATION
STRUCTERRE CONSULTING ENGINEERS BALCATTA LABORATORY ACCREDITATION NUMBER 18742

Approved Signatory:
Laboratory Manager Wayne Rozmianiec Date: 5 Dec 2018

WA | QLD | NSW | VIC
1 Erindale Road, Balcatta, Western Australia 6021 | PO Box 792, Balcatta, Western Australia 6914
Phone (+618) 9205 4500 | Fax (+618) 9205 4501 | Email wageotechlab@structerre.com.au | Web www.structerre.com.au
ABN 71 349 772 837 Zemla Pty Ltd ACN 008 966 283 as trustee for the Young Purich and Higham Unit Trust trading as Structerre Consulting Engineers

Material Test Certificate

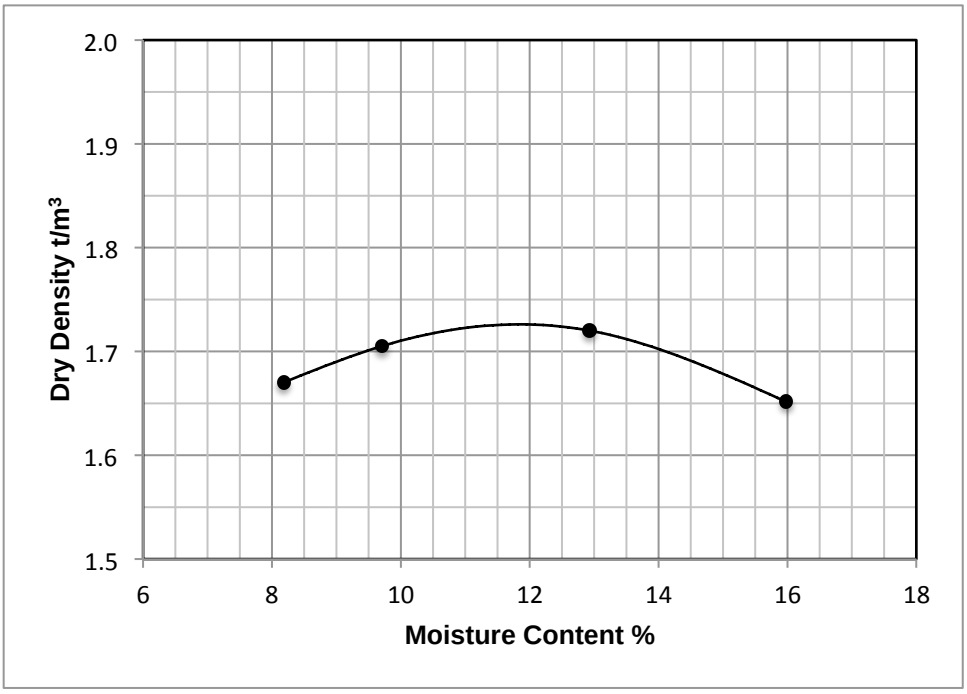
AS 1289.5.2.1 Determination of the dry density/moisture content relation of a soil using modified compactive effort

Client:	INHAM RURAL PROPERTY GROUP PTY LTD	**Job Number:**	S905648
Project:	Muchea Employment Node Precinct 3 - GREAT NORTHERN HWY MUCHEA	**Issue Number:**	1
Report Number:	S905648-A	**Page:**	1 of 1

Laboratory testing carried out at Balcatta Laboratory 1 Erindale Rd Balcatta WA 6021

Sample ID:	BH23_0.1-0.4m	**Date Tested:**	29 Nov 2018
Proposed Use:	-	**Laboratory Number:**	S905648-A-4
Material Type:	Sand	**Depth of Test:**	- mm
		Layer Thickness:	- mm
Sampling Method :	Client	**Site Selection Method:**	Client

Maximum Dry Density t/m³	1.73	**Optimum Moisture Content %**	12.0
% Retained 19mm Sieve	0	**% Retained 37.5mm Sieve**	0
Curing Time hrs	24	**Method used to determine LL**	Visual/Tactile



Notes:

Accredited for compliance with ISO/IEC 17025 – Testing
NATA
WORLD RECOGNISED ACCREDITATION
STRUCTERRE CONSULTING ENGINEERS BALCATTA LABORATORY ACCREDITATION NUMBER 18742

Approved Signatory:
Laboratory Manager

Wayne Rozmianiec

Date: 5 Dec 2018

WA | QLD | NSW | VIC

1 Erindale Road, Balcatta, Western Australia 6021 | PO Box 792, Balcatta, Western Australia 6914

Phone (+618) 9205 4500 | Fax (+618) 9205 4501 | Email wageotechlab@structerre.com.au | Web www.structerre.com.au

ABN 71 349 772 837 Zemla Pty Ltd ACN 008 966 283 as trustee for the Young Purich and Higham Unit Trust trading as Structerre Consulting Engineers

Material Test Certificate

AS 1289.6.1.1 Determination of the California Bearing Ratio of a soil - Standard laboratory method for a remoulded specimen

Client:	INHAM RURAL PROPERTY GROUP PTY LTD	**Job Number:**	S905648
Project:	Muchea Employment Node Precinct 3 - GREAT NORTHERN HWY MUCHEA	**Issue Number:**	1
Report Number:	S905648-A	**Page:**	1 of 1

Laboratory testing carried out at Balcatta Laboratory 1 Erindale Rd Balcatta WA 6021

Sample ID:	BH2_0.1-0.4m	**Date Tested:**	30 Nov 2018
Proposed Use:	Subgrade	**Laboratory Number**	S905648-A-1
Material Type:	Sand	**Depth of Test:**	- mm
Moisture content method	AS 1289.2.1.1	**Layer Thickness:**	- mm
Sampling Method :	Client	**Site Selection Method:**	Client

Compaction

Maximum dry density	t/m^3	1.95
Optimum moisture content	%	8.5
Moisture content at compaction	%	8.0
Laboratory density ratio	%	95.0
Laboratory moisture ratio	%	95.0
Curing time	hrs	2
Method used to determine LL:		Visual/Tactile
Percent retained on 19 mm	%	0
Excluded from compaction or retained		Excluded
Hammer		AS 1289.5.2.1

Soaking

Moisture condition		Soaked
Period of soaking	days	4
Surcharge	kg	4.50
Swell	%	0.0
Dry density after soaking	t/m^3	1.85

Penetration

Moisture content top 30 mm	%	12.1
Moisture content of remainder	%	11.7
California Bearing Ratio	%	30
Penetration	mm	2.5

Notes:

Approved Signatory:
Laboratory Manager Wayne Rozmianiec Date: 19-Jan-18

WA | QLD | NSW | VIC

1 Erindale Road, Balcatta, Western Australia 6021 | PO Box 792, Balcatta, Western Australia 6914

Phone (+618) 9205 4500 | Fax (+618) 9205 4501 | Email wageotechlab@structerre.com.au | Web www.structerre.com.au

ABN 71 349 772 837 Zemla Pty Ltd ACN 008 966 283 as trustee for the Young Purich and Higham Unit Trust trading as Structerre Consulting Engineers

Material Test Certificate

AS 1289.6.1.1 Determination of the California Bearing Ratio of a soil - Standard laboratory method for a remoulded specimen

Client:	INHAM RURAL PROPERTY GROUP PTY LTD	**Job Number:**	S905648
Project:	Muchea Employment Node Precinct 3 - GREAT NORTHERN HWY MUCHEA	**Issue Number:**	1
Report Number:	S905648-A	**Page:**	1 of 1

Laboratory testing carried out at Balcatta Lab 1 Erindale Rd Balcatta WA 6021

Sample ID:	BH4_0.1-0.4m	**Date Tested:**	30 Nov 2018
Proposed Use:	Subgrade	**Laboratory Number**	S905648-A-2
Material Type:	Sand	**Depth of Test:**	- mm
Moisture content method	AS 1289.2.1.1	**Layer Thickness:**	- mm
Sampling Method :	Client	**Site Selection Method:**	Client

Compaction

Maximum dry density	t/m^3	1.81
Optimum moisture content	%	10.0
Moisture content at compaction	%	9.7
Laboratory density ratio	%	95.5
Laboratory moisture ratio	%	96.0
Curing time	hrs	2
Method used to determine LL:		Visual/Tactile
Percent retained on 19 mm	%	0
Excluded from compaction or retained		Excluded
Hammer		AS 1289.5.2.1

Soaking

Moisture condition		Soaked
Period of soaking	days	4
Surcharge	kg	4.50
Swell	%	0.0
Dry density after soaking	t/m^3	1.73

Moisture content top 30 mm	%	15.3
Moisture content of remainder	%	34.0
California Bearing Ratio	%	18
Penetration	mm	2.5

Notes:

Approved Signatory:
Laboratory Manager Wayne Rozmianiec Date: 19-Jan-18

WA | QLD | NSW | VIC

1 Erindale Road, Balcatta, Western Australia 6021 | PO Box 792, Balcatta, Western Australia 6914
Phone (+618) 9205 4500 | Fax (+618) 9205 4501 | Email wageotechlab@structerre.com.au | Web www.structerre.com.au
ABN 71 349 772 837 Zemla Pty Ltd ACN 008 966 283 as trustee for the Young Purich and Higham Unit Trust trading as Structerre Consulting Engineers

Material Test Certificate

AS 1289.6.1.1 Determination of the California Bearing Ratio of a soil - Standard laboratory method for a remoulded specimen

Client:	INHAM RURAL PROPERTY GROUP PTY LTD	**Job Number:**	S905648
Project:	Muchea Employment Node Precinct 3 - GREAT NORTHERN HWY MUCHEA	**Issue Number:**	1
Report Number:	S905648-A	**Page:**	1 of 1

Laboratory testing carried out at Balcatta Lab 1 Erindale Rd Balcatta WA 6021

Sample ID:	BH11_0.1-0.4m	**Date Tested:**	30-Nov-18
Proposed Use:	Subgrade	**Laboratory Number**	S905648-A-3
Material Type:	Sandy Gravel	**Depth of Test:**	- mm
Moisture content method	AS 1289.2.1.1	**Layer Thickness:**	- mm
Sampling Method :	Client	**Site Selection Method:**	Client

Compaction

Maximum dry density	t/m^3	2.20
Optimum moisture content	%	7.0
Moisture content at compaction	%	6.8
Laboratory density ratio	%	94.5
Laboratory moisture ratio	%	97.5
Curing time	hrs	2
Method used to determine LL:		Visual/Tactile
Percent retained on 19 mm	%	1
Excluded from compaction or retained		Excluded
Hammer		AS 1289.5.2.1

Soaking

Moisture condition		Soaked
Period of soaking	days	4
Surcharge	kg	4.50
Swell	%	0.0
Dry density after soaking	t/m^3	2.08

Moisture content top 30 mm	%	10.3
Moisture content of remainder	%	9.8
California Bearing Ratio	%	50
Penetration	mm	5.0

Notes:

Approved Signatory:
Laboratory Manager — Wayne Rozmianiec — Date: 19-Jan-18

WA | QLD | NSW | VIC

1 Erindale Road, Balcatta, Western Australia 6021 | PO Box 792, Balcatta, Western Australia 6914
Phone (+618) 9205 4500 | Fax (+618) 9205 4501 | Email wageotechlab@structerre.com.au | Web www.structerre.com.au
ABN 71 349 772 837 Zemla Pty Ltd ACN 008 966 283 as trustee for the Young Purich and Higham Unit Trust trading as Structerre Consulting Engineers

Material Test Certificate

AS 1289.6.1.1 Determination of the California Bearing Ratio of a soil - Standard laboratory method for a remoulded specimen

Client:	INHAM RURAL PROPERTY GROUP PTY LTD	**Job Number:**	S905648
Project:	Muchea Employment Node Precinct 3 - GREAT NORTHERN HWY MUCHEA	**Issue Number:**	1
Report Number:	S905648-A	**Page:**	1 of 1

Laboratory testing carried out at Balcatta Lab 1 Erindale Rd Balcatta WA 6021

Sample ID:	BH23_0.1-0.4m	**Date Tested:**	30 Nov 2018
Proposed Use:	Subgrade	**Laboratory Number**	S905648-A-4
Material Type:	Sandy Gravel	**Depth of Test:**	- mm
Moisture content method	AS 1289.2.1.1	**Layer Thickness:**	- mm
Sampling Method :	Client	**Site Selection Method:**	Client

Compaction

Maximum dry density	t/m^3	1.73
Optimum moisture content	%	12.0
Moisture content at compaction	%	11.7
Laboratory density ratio	%	95.0
Laboratory moisture ratio	%	98.5
Curing time	hrs	2
Method used to determine LL:		Visual/Tactile
Percent retained on 19 mm	%	0
Excluded from compaction or retained		Excluded
Hammer		AS 1289.5.2.1

Soaking

Moisture condition		Soaked
Period of soaking	days	4
Surcharge	kg	4.50
Swell	%	0.0
Dry density after soaking	t/m^3	1.64

Moisture content top 30 mm	%	18.7
Moisture content of remainder	%	18.0
California Bearing Ratio	%	30
Penetration	mm	2.5

Notes:

Approved Signatory:
Laboratory Manager — Wayne Rozmianiec — Date: 19-Jan-18

WA | QLD | NSW | VIC

1 Erindale Road, Balcatta, Western Australia 6021 | PO Box 792, Balcatta, Western Australia 6914
Phone (+618) 9205 4500 | Fax (+618) 9205 4501 | Email wageotechlab@structerre.com.au | Web www.structerre.com.au
ABN 71 349 772 837 Zemla Pty Ltd ACN 008 966 283 as trustee for the Young Purich and Higham Unit Trust trading as Structerre Consulting Engineers

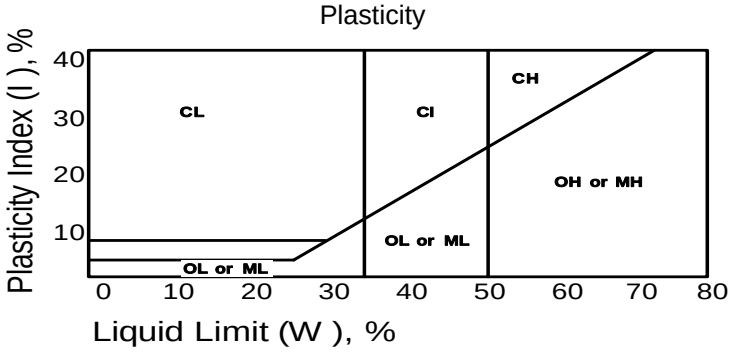
APPENDIX 7 – BORELOG TERMINOLOGY

BORELOG TERMINOLOGY

Particle Size Distribution

Major Division	Subdivision	Size
Boulders		>200mm
Cobbles		200 - 63mm
Gravel	Coarse	63 - 20mm
	Medium	20- 6mm
	Fine	6 - 2.36mm
Sand	Coarse	2.36 - 0.6mm
	Medium	0.6 - 0.2mm
	Fine	0.2 - 0.075mm

Plasticity



Consistency of Cohesive Soils

Term	Undrained Strength Su (kPa)	Field Guide
Very Soft	< 12	Exudes between the fingers when squeezed in hand
Soft	12 - 25	Can be moulded by light finger pressure
Firm	25 - 50	Can be moulded by strong finger pressure
Stiff	50 - 100	Cannot be moulded by Fingers. Can be indented by thumb.
Very Stiff	100 - 200	Can be indented by thumb nail
Hard	> 200	Can be indented with difficulty by thumb nail.
Friable	-	Crumbles or powders when scraped by thumbnail

Consistency/Density of Non-Cohesive Soils

Term	Density Index (%)	SPT "N" Value Comparison
Very Loose	< 15	0 - 4
Loose	15 - 35	4 - 10
Medium Dense	35 - 65	10 - 30
Dense	65 - 85	30 - 50
Very Dense	> 85	> 50

Moisture Content

D	Dry
M	Moist
W	Wet
S	Saturated

Minor Components

Term	Assessment Guide	Proportion of Minor Component In:
Trace	Presence just detectable by feel or eye, but soil properties little or no different to general properties of primary component	Coarse grained soils: < 5 % Fine grained soils: <15%
With	Presence easily detected by feel or eye, soil properties little different to general properties of primary component	Coarse grained soils: 5 - 12 % Fine grained soils: 15 - 30%

Soil Legend

FILL	CLAY	GRAVEL	CONCRETE
TOPSOIL	SILT	LIMESTONE	COMBINATIONS
PEAT	SAND	BEDROCK	eg: Clay, Silty, Sandy

USCS

GW	Well graded gravel	SC	Clayey sand	OL	Organic low plasticity silt	CL	Low plasticity clay
GP	Poorly graded gravel	SM	Silty sand	ML	Low plasticity silt	CI	Intermediate plasticity clay
SW	Well graded sand			MH	High plasticity silt	CH	High plasticity clay
SP	Poorly graded sand			OH	Organic high plasticity silt	PT	Peat

DOC:GE:3.003

WA | QLD | NSW | VIC

1 Erindale Road, Balcatta, Western Australia 6021 | PO Box 792, Balcatta, Western Australia 6914

Phone (+618) 9205 4500 | Fax (+618) 9205 4501 | Email wageotecheng@structerre.com.au | Web www.structerre.com.au

ABN 71 349 772 837 Zemla Pty Ltd ACN 008 966 283 as trustee for the Young Purich and Higham Unit Trust trading as Structerre Consulting Engineers

Appendix E

Floodway Modelling Report

MEMORANDUM

Project:	Muchea Employment Node P3 Waterways		Project No:	P18311
To:	Copy:	Name:	Organisation:	Facsimile:
☒	☐	Phil Bayley	Bayley Environmental Services	
☒	☐	Tom Carmody	Tomahawk Property	
☐	☐			
From:	Brett Stinton		Date: 25 January 2019	Total Pages: 9

Subject:	Muchea Employment Node P3 – Floodway Definition

If you do not receive all pages, or some are unclear, please advise immediately

BG&E Pty Limited (BG&E) has been engaged by the Muchea Employment Node Precinct 3 Landowners Group to carry out a waterways assessment for Ellen Brook to inform the development of the Muchea Employment Node Precinct 3.

As part of the Northlink Stage 3 project, BG&E prepared a TUFLOW hydraulic model for the new Perth to Darwin National Highway (PDNH) bridge which crosses Ellen Brook. This model has been utilised and updated to incorporate the boundary of the concept plan for the Muchea Employment Node Precinct prepared by Urbis. The southern section of the development layout is directly adjacent to the Ellen Brook floodplain where public open space and drainage reserve areas are proposed.

SCOPE

The following scope of works was carried out:

1. Review modelling assumptions in accordance with 2016 edition of Australian Rainfall and Runoff
2. Simulate 1 in 100 annual exceedance probability (AEP) event under current day scenario (including new PDNH)
3. Preliminary definition of floodway based on review of hydraulic model results (depths, velocities etc)
4. Meet with representatives from DWER and Main Roads WA to discuss the project and agree on allowable backwater criteria
5. Update hydraulic model to include earthworks up to the preliminary floodway and review 1 in 100 AEP backwater
6. Refine the floodway and update the hydraulic model with revised earthworks extents to achieve suitable backwater (up to 5 post-development iterations have been assumed)
7. Prepare a memo report summarising the methodology and findings of the project, including polygons for floodway and flood fringe areas similar to those provided by DWER for other areas within Ellen Brook.

The scope of works is limited to the Ellen Brook waterway and does not consider local catchment flows which occur throughout the site from the east via existing culverts beneath Great Eastern Highway. It is expected suitable drainage reserves and infrastructure would be required to manage local catchment flows which would need to be identified as part of a separate study.

TUFLOW MODEL

The TUFLOW 2D hydraulic has been updated to include the outline of the proposed development that lies within the flood extents of the Ellen Brook flood plain and other scenarios where the boundary encroaches further toward the main Ellen Brook channel.

MEETING WITH MAIN ROADS AND DWER

A meeting was held on 15th January 2019 with Simon Rodgers (Supervising Engineer - Floodplain Management) from the Department of Water and Environmental Regulation (DWER) and Eric Cheung (Senior Waterways Engineer) from Main Roads WA, to discuss any potential impacts the development may have. Preliminary results showing the impact on flood levels were tabled. The DWER representative indicated that the impacts were not of concern from a DWER perspective. The Main Roads WA representative was concerned of any potential impacts to the recently constructed PDNH alignment that passes adjacent to the proposed development.

FLOODWAY DEFINITION

The Department of Water and Environmental Regulation (DWER) define the Floodway as *"the river channel and a portion of the floodplain where a significant flow or storage of water occurs during floods. If the floodway is even partially blocked then the natural flooding regime of the area may be detrimentally impacted with flood levels being raised and affecting areas which may not have been previously affected"*.

The following items were considered when defining the floodway:

- 1% AEP pre-development velocity and depth mapping (attached) used to identify areas where higher depths and velocities occur which provide an indication of flood conveyance
- The presence of existing flowpaths within the floodplain which includes the main channel and breakout channel downstream of the PDNH culvert crossing to the north of the bridge. These flowpaths should be maintained to avoid redistribution of flow
- Potential impacts to flood levels as a result of partially blocking the floodplain, based on the hydraulic model results
- The floodway extent adopted by DWER for Ellen Brook to the south of the site. Shapefiles were provided by DWER which show the floodway extending to the edge of the floodplain in some areas. Flood behaviour in the northern section of the dataset is expected to be similar to that within the project site (Figure 1).

Refer to attached plots for 1% AEP pre-development and post-development flood extents. These include the proposed floodway and flood fringe extents. The proposed development footprint is close to but does not encroach into the floodway. The results indicate a maximum increase in flood level of approximately 30 mm near the proposed road, reducing to approximately 10mm at the PDNH PSP.

Scenarios where the earthworks footprint encroaches further into the floodway with offsets ranging from 20m to 80m were also simulated in the hydraulic model to assess potential impacts on the adjacent PDNH. The results indicate an increase in flood levels along the PDNH alignment varying between 40mm for a 40m offset to 90mm for an 80m offset.



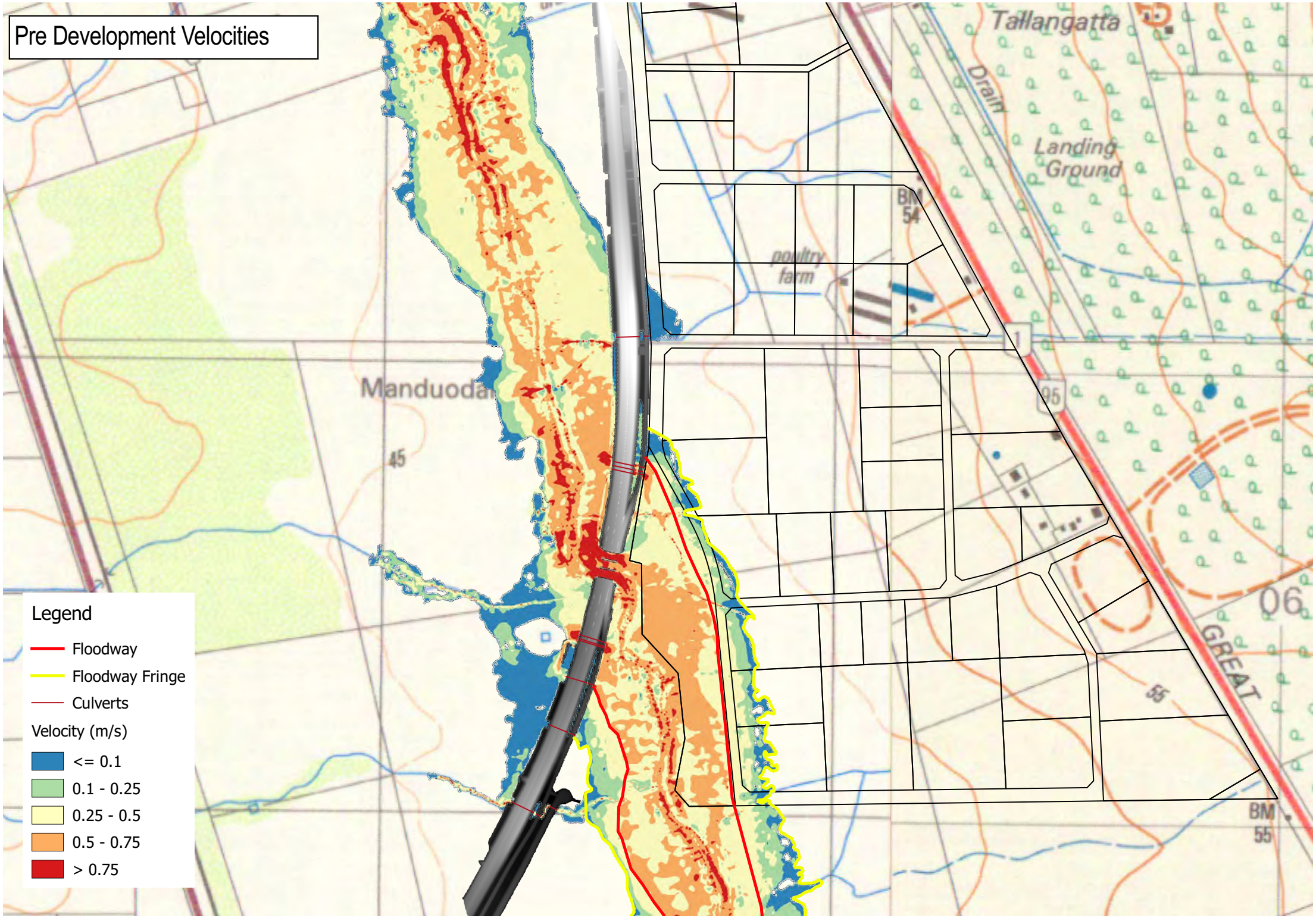
Figure 1 – Downstream floodway definition by DWER

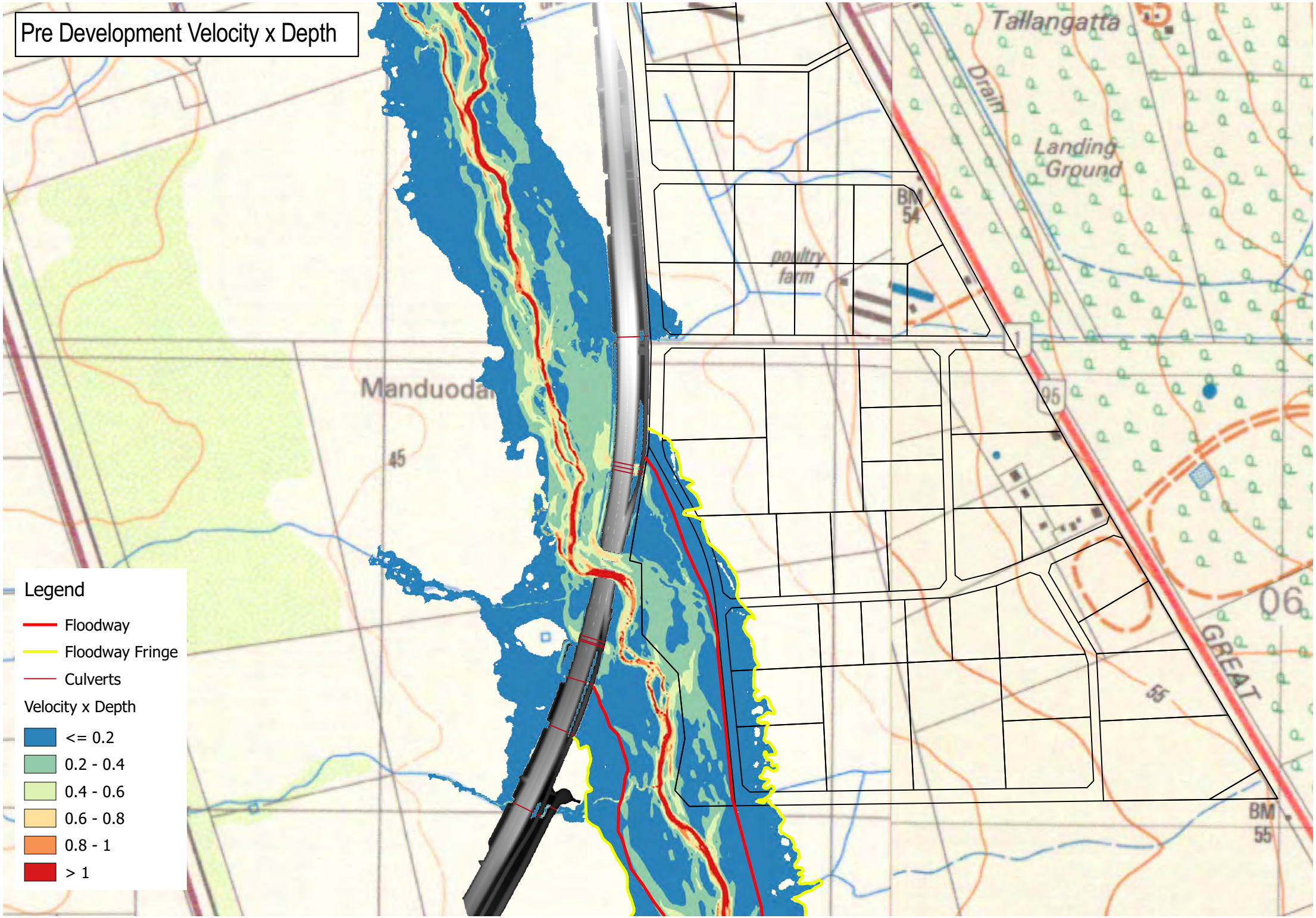
LIMITATIONS

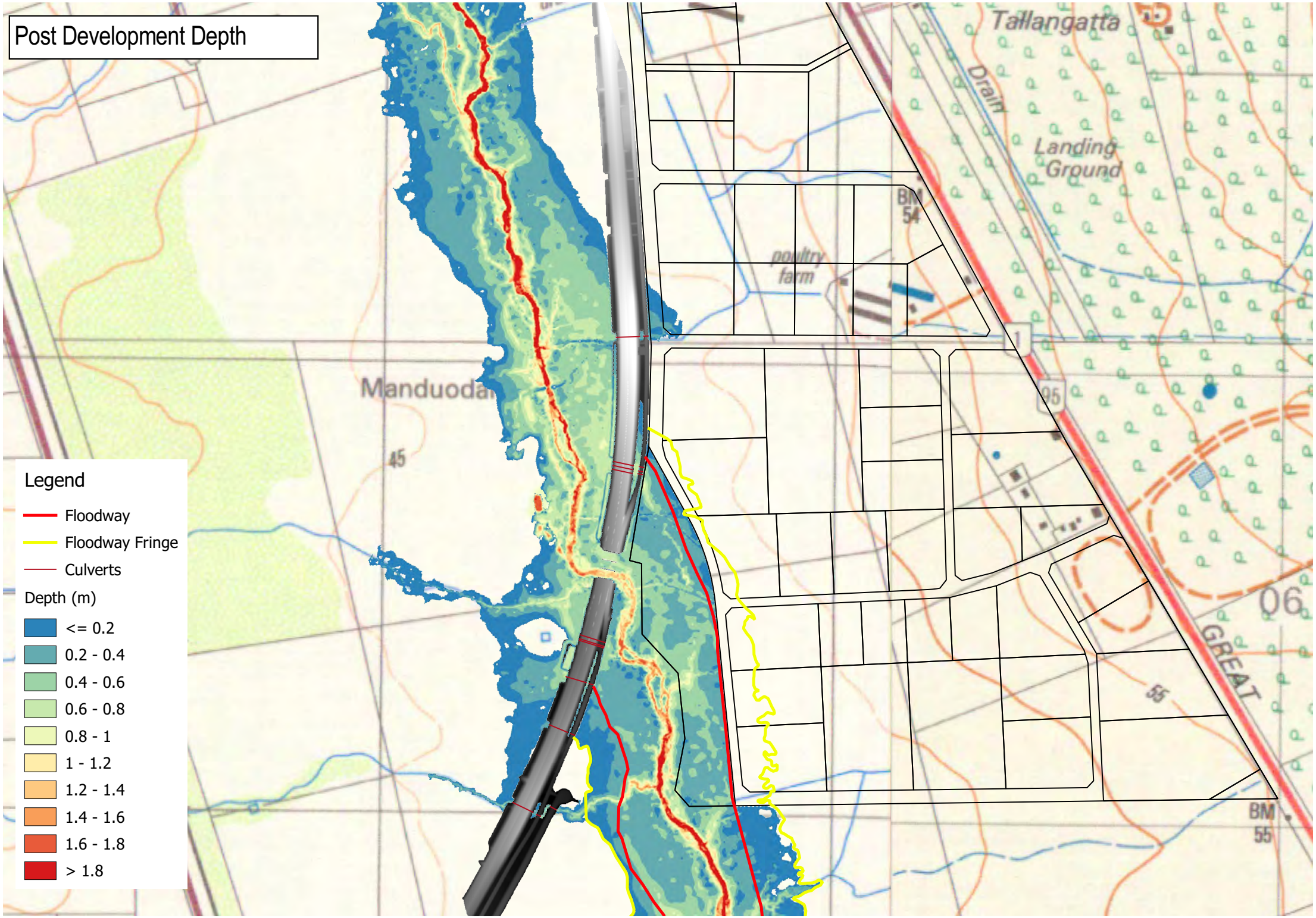
The findings of this study are subject to the following limitations:

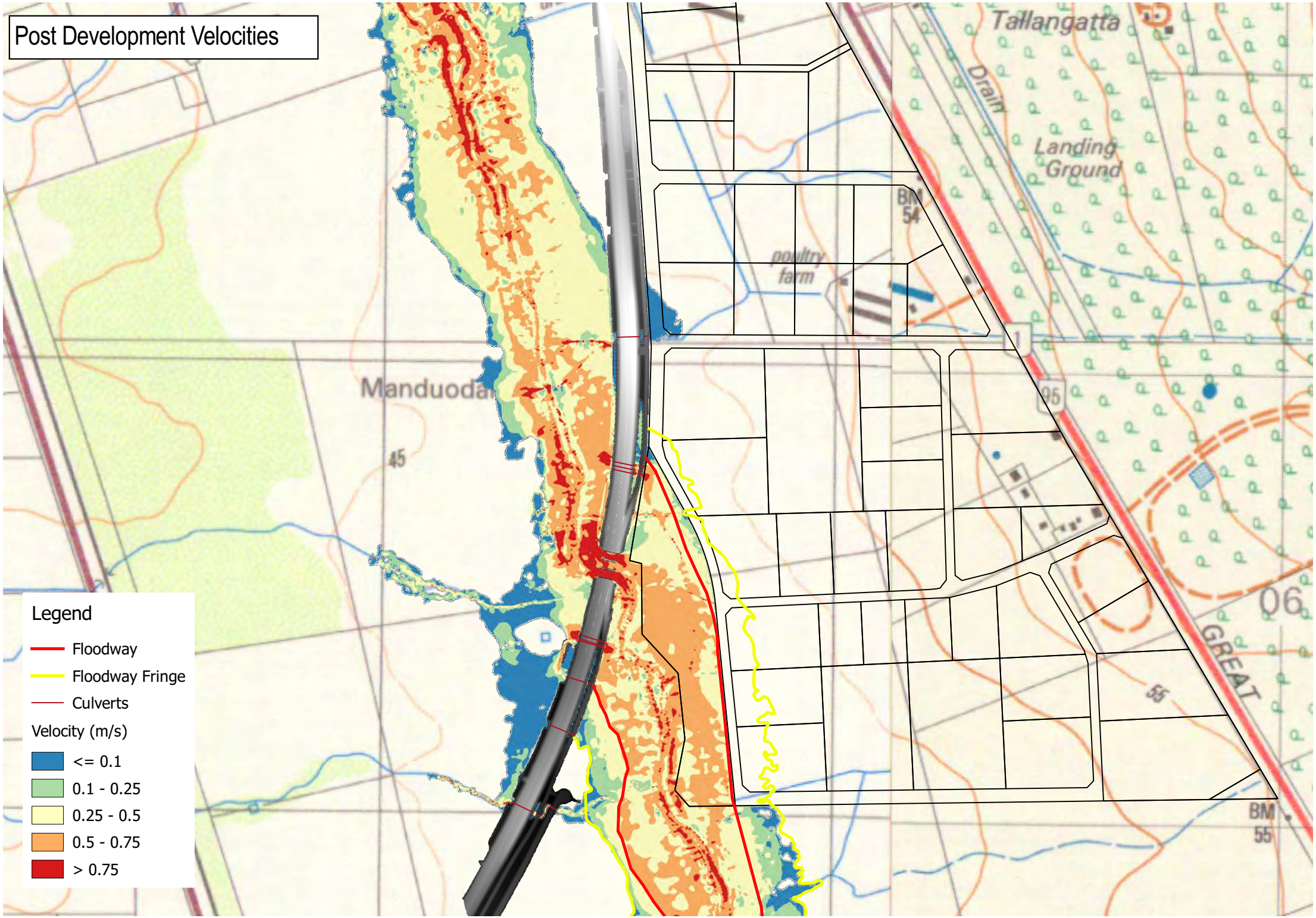
- The scope of works is limited to the Ellen Brook waterway and does not consider local catchment flows which occur throughout the site from the east via existing culverts beneath Great Eastern Highway. It is expected suitable drainage reserves and infrastructure would be required to manage local catchment flows which would need to be identified as part of a separate study.
- No allowance has been made for blockage of drainage infrastructure or increasing flows due to climate change.

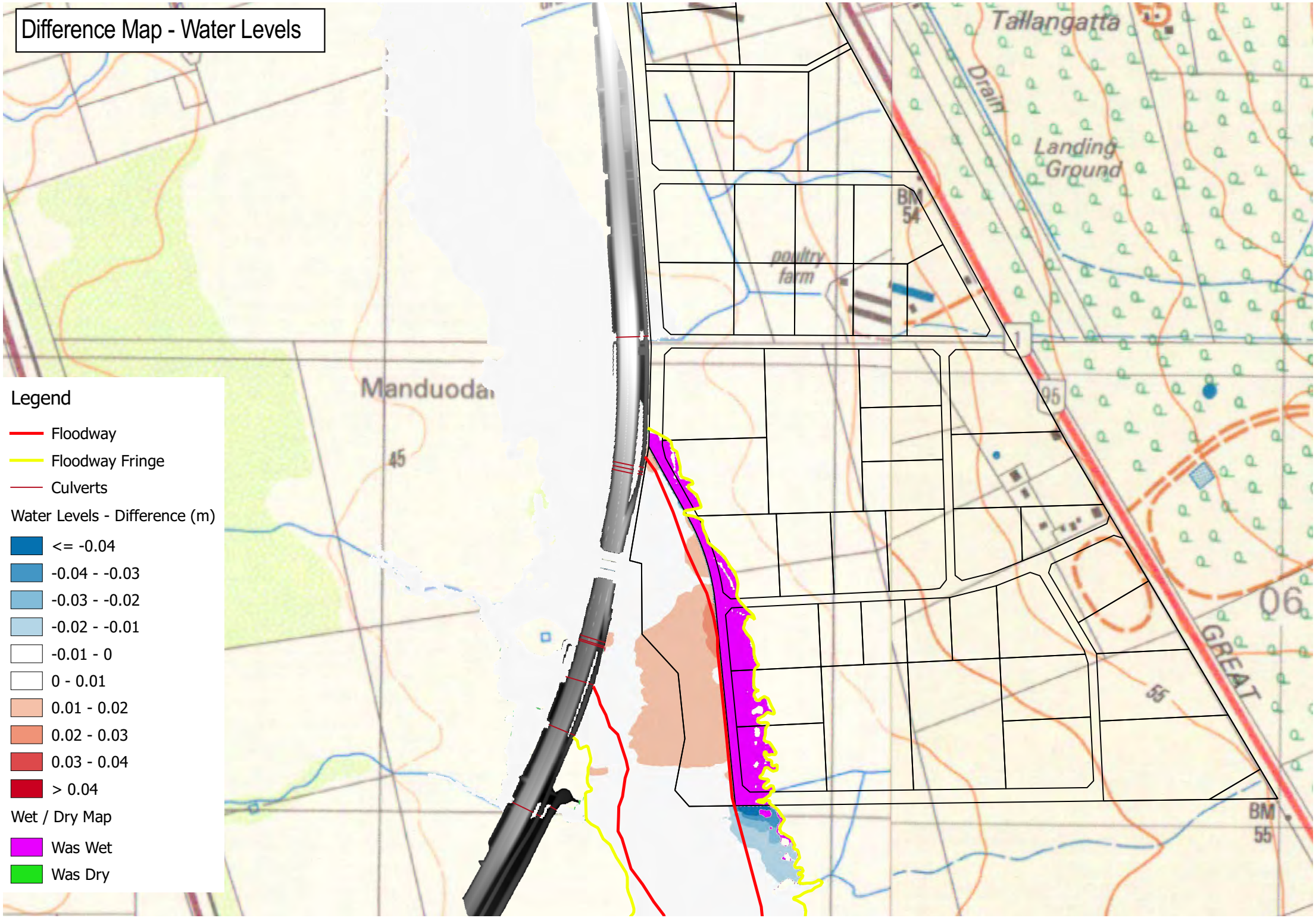

Pre Development Depth
Tallangatta
Drain
Landing Ground
poultry farm
BM 54
Manduoda
45
95
06
GREAT
55
BM 55
Legend
Floodway
Floodway Fringe
Culverts
Depth (m)
<= 0.2
0.2 - 0.4
0.4 - 0.6
0.6 - 0.8
0.8 - 1
1 - 1.2
1.2 - 1.4
1.4 - 1.6
1.6 - 1.8
> 1.8


Pre Development Velocities
Tallangatta
Drain
Landing Ground
poultry farm
BM 54
Manduoda
45
95
06
GREAT
55
BM 55
Legend
Floodway
Floodway Fringe
Culverts
Velocity (m/s)
<= 0.1
0.1 - 0.25
0.25 - 0.5
0.5 - 0.75
> 0.75


Pre Development Velocity x Depth
Tallangatta
Drain
Landing Ground
poultry farm
BM 54
Manduoda
45
95
06
GREAT
55
BM 55
Legend
Floodway
Floodway Fringe
Culverts
Velocity x Depth
<= 0.2
0.2 - 0.4
0.4 - 0.6
0.6 - 0.8
0.8 - 1
> 1


Post Development Depth
Tallangatta
Drain
Landing Ground
poultry farm
BM 54
Manduoda
45
95
06
55
GREAT
BM 55
Legend
Floodway
Floodway Fringe
Culverts
Depth (m)
<= 0.2
0.2 - 0.4
0.4 - 0.6
0.6 - 0.8
0.8 - 1
1 - 1.2
1.2 - 1.4
1.4 - 1.6
1.6 - 1.8
> 1.8


Post Development Velocities
Tallangatta
Drain
Landing Ground
poultry farm
BM 54
Manduoda
45
95
06
GREAT
55
BM 55
Legend
Floodway
Floodway Fringe
Culverts
Velocity (m/s)
<= 0.1
0.1 - 0.25
0.25 - 0.5
0.5 - 0.75
> 0.75


Difference Map - Water Levels
Tallangatta
Drain
Landing Ground
poultry farm
BM 54
Manduoda
45
95
06
55
GREAT
BM 55
Legend
Floodway
Floodway Fringe
Culverts
Water Levels - Difference (m)
<= -0.04
-0.04 - -0.03
-0.03 - -0.02
-0.02 - -0.01
-0.01 - 0
0 - 0.01
0.01 - 0.02
0.02 - 0.03
0.03 - 0.04
> 0.04
Wet / Dry Map
Was Wet
Was Dry

Appendix F

Foreshore Definition Report

MUCHEA EMPLOYMENT NODE
PRECINCT 3

ELLEN BROOK FORESHORE RESERVE DEFINITION

Prepared for

Muchea Employment Node
Precinct 3 Landowner Group
c/- Tomahawk Property
8/355 Stirling Hwy
CLAREMONT WA 6010

Draft Report No. J18015d
22 January 2020

BAYLEY ENVIRONMENTAL SERVICES
30 Thomas Street
SOUTH FREMANTLE WA 6162

Sundowner Nominees Pty Ltd as trustee for the Bayley Cook Family Trust ABN 20 822 598 897
trading as Bayley Environmental Services

INTRODUCTION

The owners of Lots 35, 192, 194 and 800-804 Great Northern Highway, Muchea (the subject site) have applied to the WAPC for the lots to be rezoned from Agricultural Resource to Light Industrial. The subject site is bordered on the east by Great Northern Highway and on the west by the new Perth-Darwin National Highway (PDNH) and Ellen Brook. Figure 1 shows the location of the site.

Foreshore reserve requirements for waterways are governed by WAPC Development Control Policy No. DC2.3: *Public Open Space in Residential Areas.* DC2.3 specifies a default foreshore reserve width of 30 metres for waterways but includes provision to vary the default setback for reasons of topography, condition of banks or floodway protection. DWER policy on foreshore setbacks is set out in Operational Policy River Restoration Series No. RR16 – *Determining Foreshore Reserves* (WRC, 2001) and Foreshore Policy 1 - *Identifying the Foreshore Area* (WRC, 2002a). These documents also set out a methodology for determining the foreshore setback in each case.

The Muchea Employment Node Structure Plan (WA Govt, 2011) designated a nominal 15-40m foreshore reserve in the subject site east of Ellen Brook. The Structure Plan noted that the reserve could be modified at the Urban Water Management Plan stage in accordance with DWER *Operational Policy 4.3: Determining foreshore reserves* (DoW, 2012), *Water Note 23 – Determining Foreshore Reserves* (DoW, 2001) and *River Restoration Manual Chapter 16 – Determining foreshore reserves* (DoW, 2001).

This Foreshore Definition Study was undertaken in accordance with the above DoW policies to better define the foreshore reserve of Ellen Brook in the light of detailed flood modelling in 2018.

DETERMINATION OF FORESHORE SETBACK USING THE METHODOLOGY SET OUT IN RIVER RESTORATION SERIES 16

Step 1: Background information and preliminary investigations

Waterway significance and management issues

Ellen Brook is a major tributary of the Swan-Canning River system, which is the major river of the Perth Region. The Ellen Brook catchment is the largest sub-catchment of the Swan-Canning River system, contributing 6% of the total annual flow in the system, and is the largest single contributor of nutrients to the system (WA Govt, 2011).

Ellen Brook has a surface catchment of 715 km^2 (WRC, 2012). The Brook rises as Chandala Brook about 20km north-northwest of the subject site. The Brook is seasonal, flowing generally between May and November with an annual flow ranging from 2.1 to 48.6 GL (SRT, 2009).

Flows in Ellen Brook are normally confined to the defined channel of the Brook, although high flows can cause inundation of adjacent land. BG&E Pty Ltd modelled the 100-year ARI floodplain of Ellen Brook for the Perth-Darwin National Highway (PDNH) project on behalf of Main Roads Western Australia (MRWA) in 2018. Figure 2 shows the 100-year ARI floodplain as modelled by BG&E.

Further flood modelling was carried out by BG&E for this project, in order to map the 100-year floodway of the Brook for the purposes of defining the foreshore reserve. The floodway modelling was confined to the part of Ellen Brook south of the PDNH crossing, where the Structure Plan area adjoins the Brook. Figure 2 shows the floodway as mapped by BG&E.

Ellen Brook is significant in ecological, hydrological and amenity terms. The principal management issues facing the river are water quality, which has suffered as a result of nutrient inputs from development in its catchment, and the loss of riparian vegetation due to agricultural clearing in the lower reaches of the river.

Aerial photography

Figure 1 shows an aerial photograph of Ellen Brook where it adjoins the subject land.

Maps of extent of floodway and floodplains, topographical features, cadastral boundaries, soils, underlying geology and vegetation complexes.

These features are shown on Figure 2.

Relevant reports on the river and region

In 1999 the Water & Rivers Commission commissioned a foreshore condition assessment of a 2.8km section of Ellen Brook in Upper Swan, about 17km downstream of the subject site. The assessment focussed on bank stability, vegetation cover, habitat diversity and surrounding land uses. The report included recommendations on

weed control, native vegetation protection, sediment management and fencing of the foreshore reserve.

In 2002 the WRC produced *Hydrogeological Information for Management Planning in the Ellen Brook Catchment* (WRC, 2002b). This report identified nutrient loads (particularly very high levels of phosphorus), inundation, salinisation and erosion as key issues for the Ellen Brook catchment. The report made management recommendations including:

- reduction of groundwater recharge through increased tree cover (tree crops and native vegetation);
- reduction of nutrient loads through improved fertiliser and irrigation management and soil amendment;
- runoff reduction through streamlining and vegetation planting;
- sediment controls through planting, fencing and other stock controls; and
- salinity controls through increased tree cover and drainage works to lower groundwater levels.

The *Swan Canning Water Quality Improvement Program* (Swan River Trust, 2009) identified Ellen Brook as a major contributor of phosphorus and nitrogen contamination to the Swan-Canning River system, mostly originating from grazing on sandy soils in its catchment. The WQIP recommended management strategies including land use changes, increased native vegetation planting, fencing of foreshore reserves and soil modification to reduce nutrient loads, but recognised that any nutrient reductions achieved in the foreseeable future were likely to be modest.

Site Visit
A detailed inspection of Ellen Brook adjacent to the project site was carried out in July 2018. Figure 3 shows photographs of the river and its fringing vegetation.

Relevant stakeholders
The owners of the lots fronting the river, David and Barton Jones (Lot 192) and Neil Bovenizer (Lot 35), are proponents of the structure plan and are involved in the planning of the site.

Step 2: Biophysical criteria of the waterway

Riparian vegetation
The riparian vegetation of Ellen Brook is mostly restricted to the immediate banks and flats of the Brook, with the remainder of the subject land being mostly cleared. The native fringing vegetation is mostly confined to within 10-15m of the main channel.

The fringing vegetation consists of a sparse to dense woodland of *Eucalyptus rudis, Melaleuca preissiana, Jacksonia furcellata and Acacia saligna.* This woodland thins rapidly with distance from the Brook. The ground cover over most of this area consists

of a heavy growth of pasture grasses and weeds, which extends into the waterway itself. In places there are dense patches of *Watsonia maireana bulbillifera* and bulrush, either the native *Typha domingensis* or the introduced *T. orientalis*. The Typha has not colonised the watercourse itself, possibly because wet conditions coincide with fast-flowing water that prevents establishment. There are also occasional native sedges (*Juncus* or *Baumea*) and a heavy infestation of one-leaf cape tulip (*Morea flaccida*), a declared pest species in Western Australia.

The condition of the Brook vegetation is mostly Degraded to Completely Degraded, with a few areas of Good condition. The *Jacksonia furcellata* and smaller Acacias are heavily browsed by cattle.

The riparian vegetation of the subject land, including Ellen Brook and its foreshore, is mapped by Heddle *et al.* (1980) as "Yanga Complex: low open-forest of *Casuarina obesa*, *Actinostrobus* (now *Callitris*) *pyramidalis, Melaleuca* spp. (including *M. lateritia, M. hamulosa*, *M. preissiana and M. rhaphiophylla*) and *Eucalyptus rudis* in the lower-lying areas, with *Banksia* spp., *Eucalyptus todtiana* and *Corymbia calophylla* open-woodland in the higher areas. The Yanga Complex has been moderately heavily cleared since European settlement, with 17.75% of its original extent remaining and less than 1% formally protected.

Soils that support riparian vegetation
The Geological Survey of Western Australia (GSWA, 1978) maps the Ellen Brook bed and surrounds as Qpa: Guildford Formation, with sandy soils (S11) in the immediate vicinity of the Brook and pebbly silt (Mgs_1) further away from the Brook.

Floodway and floodplain – 1 in 100 yr flood levels, peak flow and river hydrology
Flows in Ellen Brook are normally confined to the defined channel of the Brook, although high flows can cause inundation of adjacent land. BG&E Pty Ltd modelled the 100-year ARI floodplain of Ellen Brook for the Perth-Darwin National Highway (PDNH) project on behalf of Main Roads Western Australia (MRWA) in 2018. Figure 2 shows the 100-year ARI floodplain as modelled by BG&E.

Emerge (2019) modelled combined flows in Ellen Brook and the minor drainages across the site for the Muchea Regional Water Management Strategy. The boundary of the floodplain modelled by Emerge (2019) agrees closely with the floodplain boundary modelled by BG&E for MRWA.

Further flood modelling was carried out by BG&E in 2018 in order to map the 100-year floodway of the Brook for the purposes of defining the foreshore reserve. The floodway modelling was confined to the part of Ellen Brook south of the PDNH crossing, where the Structure Plan area adjoins the Brook. The BG&E floodway modelling report is attached in Appendix D of the LWMS. Figure 2 shows the floodway as mapped by BG&E.

Soil types prone to erosion

Ellen Brook follows a slightly meandering course adjacent to the subject land for a distance of about 600 metres. The channel appears stable, with little evidence of undercutting or erosion on bends. The channel splits in some places, with sand banks in the middle isolated by high flows.

The soils surrounding the river channel are predominantly sands transported by past flood flows overlain on Guildford Formation pebbly silts. This profile suggests that deposition, rather than erosion, is the dominant soil process occurring in this part of the watercourse.

Landgate aerial photography since 1965 shows that the alignment of the watercourse has shifted a few metres to the east or west with changes in water levels and sand banks, but there has been no significant or long-term change in the alignment.

Landforms and drainage lines important to watercourse function

The bed of the Brook falls from an elevation of about 41m AHD at the PDNH crossing to 40m AHD at the southern boundary of the project area, at a gradient of about 1 in 600 (0.16%). The top of the bank is generally less than 1m above the level of the bed. Away from the Brook, the land rises very slowly to the east, reaching 42m AHD between 170m and 33m from the Brook at a gradient of about 0.6%.

Two small drains enter the Brook from the subject land, draining runoff from low-lying paddocks. One of these also carries runoff from the access road constructed to service the PDNH roadworks and laydown areas east of the PDNH. In July 2018 this was observed to be carrying heavy sediment loads into the Brook. A silt curtain had been installed in the Brook downstream of the drain inflow but was being overtopped by the high flow in the Brook. The sediment inflow was not reflected in water samples collected downstream in the Brook.

Habitat areas

The vegetation in and immediately adjacent to the main channel of Ellen Brook provides habitat for waterbirds including ducks as well as dryland birds including (observed) twenty eight parrots, rosellas, willie wagtails and grey fantails. In the paddock near the Brook are a few isolated large flooded gums containing small hollows that might provide nesting sites for small birds. Signs of kangaroos were observed near the Brook. There is probably not enough dense ground cover to provide habitat for quenda, and no evidence of quenda was observed.

Adjacent land use with potential to affect the foreshore

The current grazing land use on the subject land has had significant impacts on Ellen Brook, including clearing of fringing vegetation, trampling and bank erosion. Cattle have historically had access to the Brook, which has resulted in bank erosion, grazing of native vegetation and trampling and spread of weeds.

Development of the subject land as planned will benefit the Brook by removing the impact of cattle and allowing native vegetation to regenerate, thereby helping to stabilise the river banks. Development will also provide opportunities for rehabilitation of degraded parts of the foreshore.

Aboriginal Heritage Sites
The Department of Aboriginal Affairs' online database shows the whole of Ellen Brook and its surrounds up to 5.6km east as part of a registered Aboriginal Heritage Site, ID 3525 (Ellen Brook: Upper Swan). Site 3525 is a mythological site associated with the Waugal mythology, and is understood to relate to the watercourse of Ellen Brook. In other similar cases, a reserve of 50m either side of the watercourse has been considered sufficient protection for the mythological site.

Step 3: Other factors

Fire Management
The vegetation in the foreshore zone presents a low to moderate fire hazard due to the absence of heavy understorey or middle storey vegetation. With the removal of cattle grazing there could be heavy growth of grasses and weeds, which could pose a high fire risk unless it were managed. Therefore, weed control, mowing of grasses and/or replacement with native low understorey species will be required to manage the fire hazard.

Risks and consequences resulting from the proposed foreshore alignment
The principal consequence of establishing a foreshore setback in this location will be the opportunity to undertake rehabilitation of the foreshore. This will improve the ecological value of the foreshore as well as providing increased social amenity.

The main risk in the proposed alignment is the possibility of flooding above the modelled 100 year flood level, which could affect development outside the foreshore setback. However, any buildings within the flood fringe will have a floor level at least 0.5m above the modelled 100-year flood level so the risk of property damage is low.

Step 4: Finalisation of the alignment

Rationale for the alignment
The key factors in the delineation of the foreshore setback are:

- Compliance with policy - The WAPC's Development Control Policy 2.3 specifies a default minimum setback of 30m from waterways. The proposed foreshore reserve extends a minimum of 125m from the edge of the main channel.

- 100 year floodway - The proposed foreshore reserve coincides with the outside edge of the modelled 100-year ARI floodway.

- Vegetation - The proposed foreshore reserve includes all remaining riparian vegetation.

- Shoreline processes - The proposed foreshore reserve is more than sufficiently wide to accommodate any foreseeable variations in the alignment of the watercourse.

- Fire protection - Fire protection will be achieved by a combination of separation from the edge the foreshore reserve and control of revegetation height and density in the part of the foreshore reserve closest to development areas. The zoning of vegetation plantings within the foreshore reserve is shown on Figure 4. A detailed treatment of fire hazard and fire protection measures is presented in the Bushfire Management Plan (Appendix G to the Structure Plan report).

- Aboriginal heritage - The registered Aboriginal mythological site no. 3525 extends up to 5.6km east of the Brook. Previous experience suggests that the site can be protected by a foreshore reserve at least 50m wide. This is easily accommodated within the proposed minimum 125m foreshore reserve. Approval under Section 18 of the *Aboriginal Heritage Act 1945* will be required for any earthworks within the registered Aboriginal heritage site, which extends beyond the boundaries of the project area.

Map of Foreshore Setback
Figure 4 shows the proposed boundary of the foreshore reserve.

FORESHORE TENURE AND MANAGEMENT

The river and foreshore within the subject land are currently privately owned and zoned Agricultural Resource under the Shire of Chittering Town Planning Scheme (TPS). With the subdivision of the subject land, the river and foreshore reserve are expected to be ceded as Public Open Space to the Shire and rezoned accordingly.

The owners of the foreshore at the time of subdivision will manage the foreshore reserve for at least two years after the completion subdivision adjacent to the reserve and revegetation works in the reserve. After two years the foreshore reserve will be handed over to the Shire of Chittering to be managed primarily for conservation.

REFERENCES

Swan River Trust (2009). *Swan Canning Water Quality Improvement Plan.* Swan River Trust, Perth.

WA Govt (2011). *Muchea Employment Node Structure Plan.* WAPC, Perth.

Water & Rivers Commission (1999). *Foreshore Assessment in the Ellen Brook Catchment.* Water Resource Management Series No. 16. Water & Rivers Commission, Perth.

WRC (2001). *Water Note 23: Determining Foreshore Reserves*. Water & Rivers Commission, Perth.

WRC (2002a). *Foreshore Policy 1: "Identifying the Foreshore Area".* Water & Rivers Commission, Perth.

WRC (2002b). *Hydrogeological Information for Management Planning in the Ellen Brook Catchment*. Salinity and Land Use Impacts Series No. SLUI 11. Water & Rivers Commission, Perth.

Figures



Figure 1

LOCATION AND LAYOUT

bayley environmental services

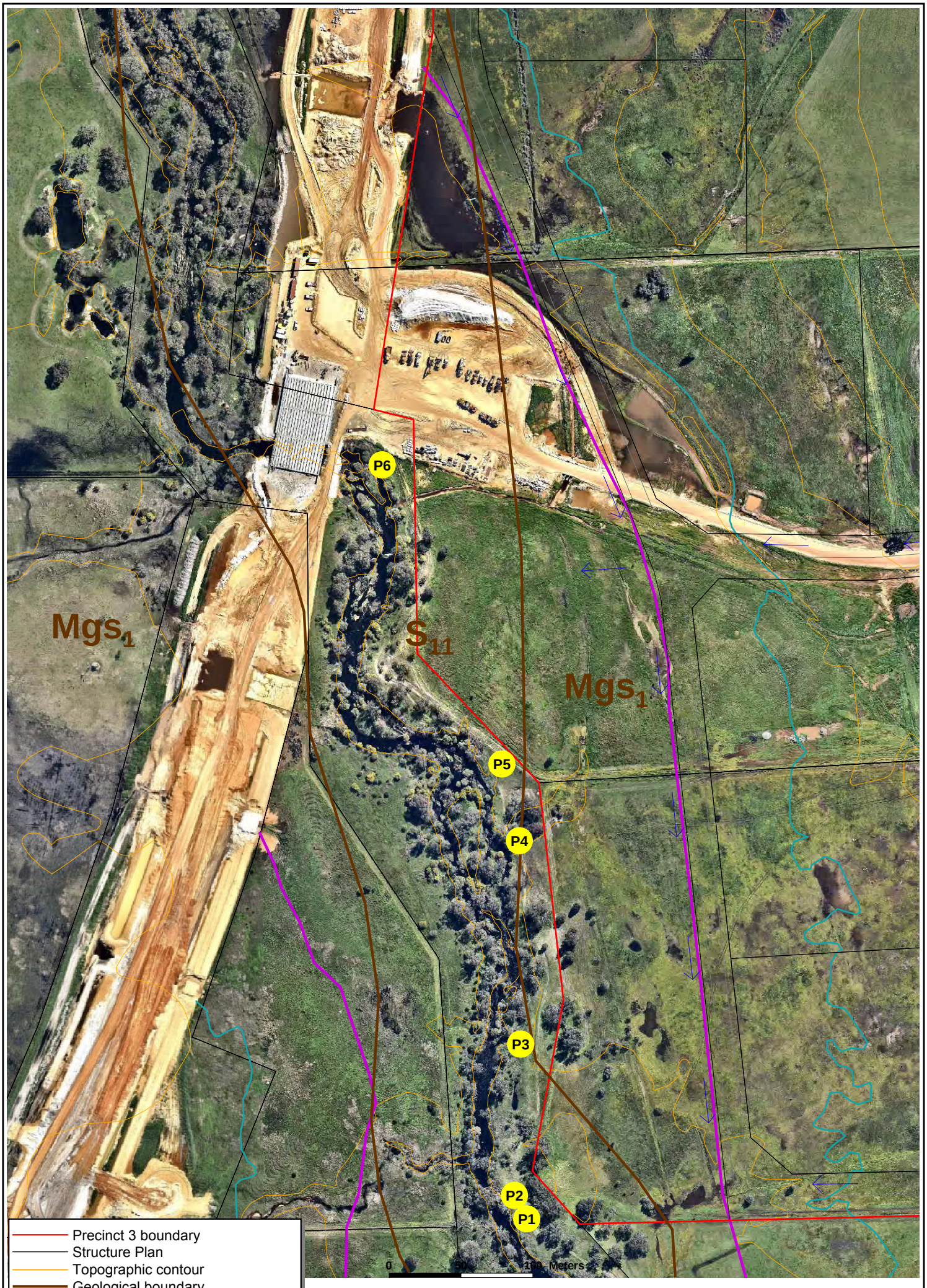


Figure 2

ENVIRONMENTAL FEATURES

bayley environmental services



P1



P2



P3



P4



P5



P6

Figure 3

GROUND LEVEL PHOTOGRAPHS

See Figure 2 for photo locations

bayley environmental services

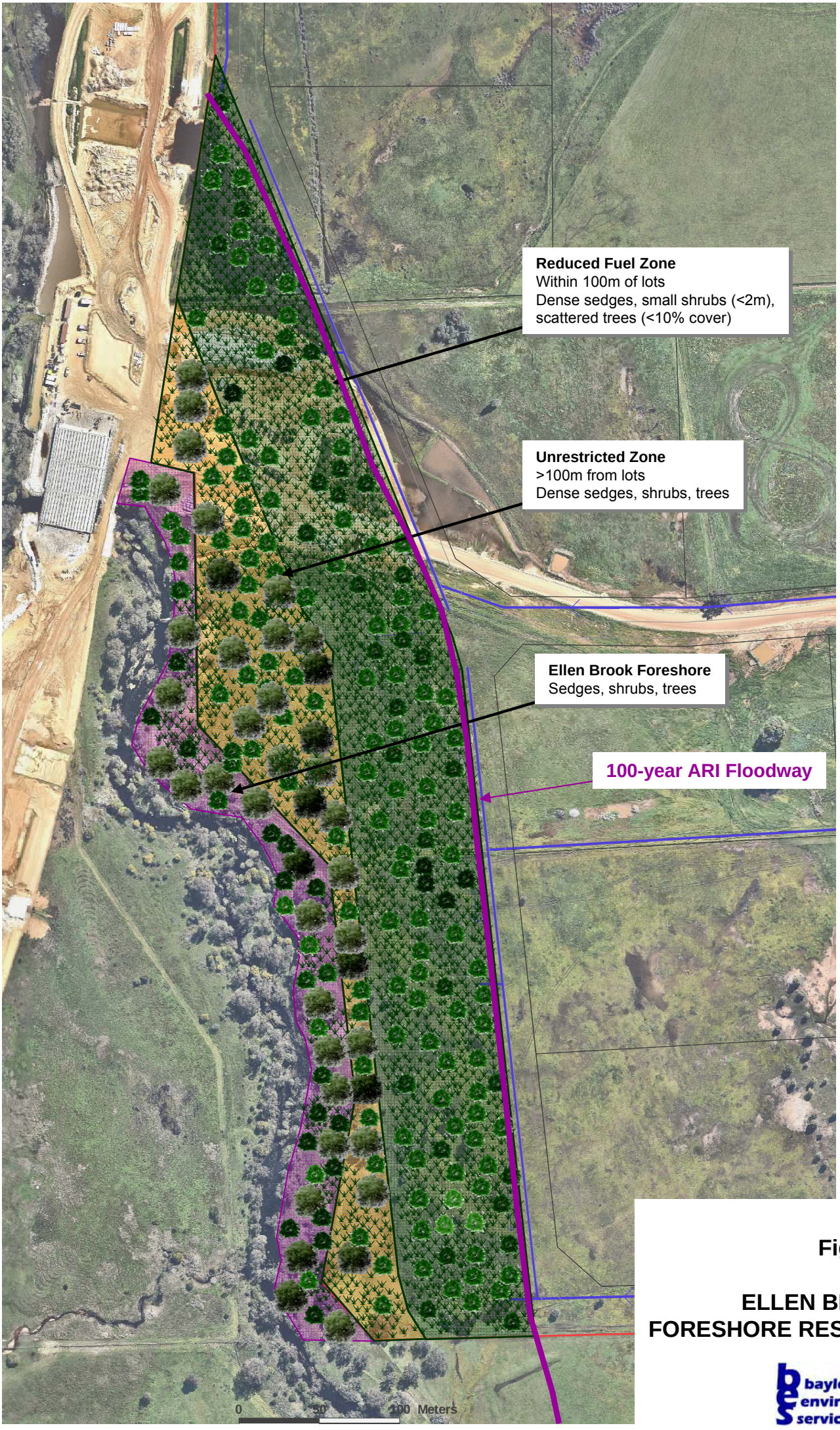


Figure 4

ELLEN BROOK FORESHORE RESERVE

bayley environmental services

Appendix G

Letter from Aqua Ferre Pty Ltd

AQUA FERRE PTY LTD
ACN 121 146 772
PO Box 1982 West Perth WA 6872
Level 1, 5 Ord Street West Perth WA 6005
Tel: 08 9282 5400
Fax: 08 9282 5484

29 January 2018

Tom Carmody
Director and Licensee
Tomahawk Property on behalf of the Muchea Employment Node Precinct 3 Landowner Group
8/355 Stirling Highway
Claremont WA 6010

Dear Mr Carmody

Muchea Employment Node Precinct 3 Landowner Group

I refer to your enquiries to Aqua Ferre Pty Ltd (Aqua Ferre) regarding the availability of water and the potential future supply of water, within the Muchea region.

You have advised that you represent a number of landowners with properties on Great Northern Highway and Brand Highway in Muchea (collectively described as the Muchea Employment Node Precinct 3 Landowner Group or more generally the landowner group).

On behalf of the landowner group you have requested information from Aqua Ferre in support of two planning documents:

- Shire of Chittering Town Planning Scheme No 6 Amendment No.67 - Rezoning Lots M1601, 800-804, 192, 194 and 35 Great Northern Highway, Muchea from 'Agricultural Resource' zone to 'Industrial Development' zone, and amending the Scheme Maps accordingly; and
- Precinct 3 Muchea Industrial Park Structure Plan.

In particular you have sought information regarding Aqua Ferre's water entitlements, the prospect that some of Aqua Ferre's water entitlement may be allocated to the landowner group properties, and whether the water can be practically supplied from Aqua Ferre's operations to the landowner group properties.

1 MEN & Precinct 3

The Muchea Employment Node Structure Plan (MENSP) was adopted by the WAPC in August 2011, and provides a 20-year planning framework for industrial development within the Shire of Chittering. We understand that the MENSP is currently under review and a revised document is expected to be released during 2019.

You have advised that the subject land is located within Precinct 3, which forms the eastern portion of the MENSP, to the west of Great Northern Highway (GNH).

Precinct 3 of the Muchea Employment Node (more recently referred to as the Muchea Industrial Park (MIP)) ('the Structure Plan area') is approximately 185ha in area and located to the south east of the

DRAFT

townsite of Muchea. Precinct 3 is triangular in shape and extends in a lineal pattern from Brand Highway in the north, along Great Northern Highway (GNH) in the east, to the southern boundary of the Shire of Chittering, and along the Perth-Darwin Highway (PDNH) to the west, which is currently under construction.

Figure 1 below shows the proposed Precinct 3 development boundaries (Urbis 2019, LPS Amendment, Muchea Employment Node, DWG-11).

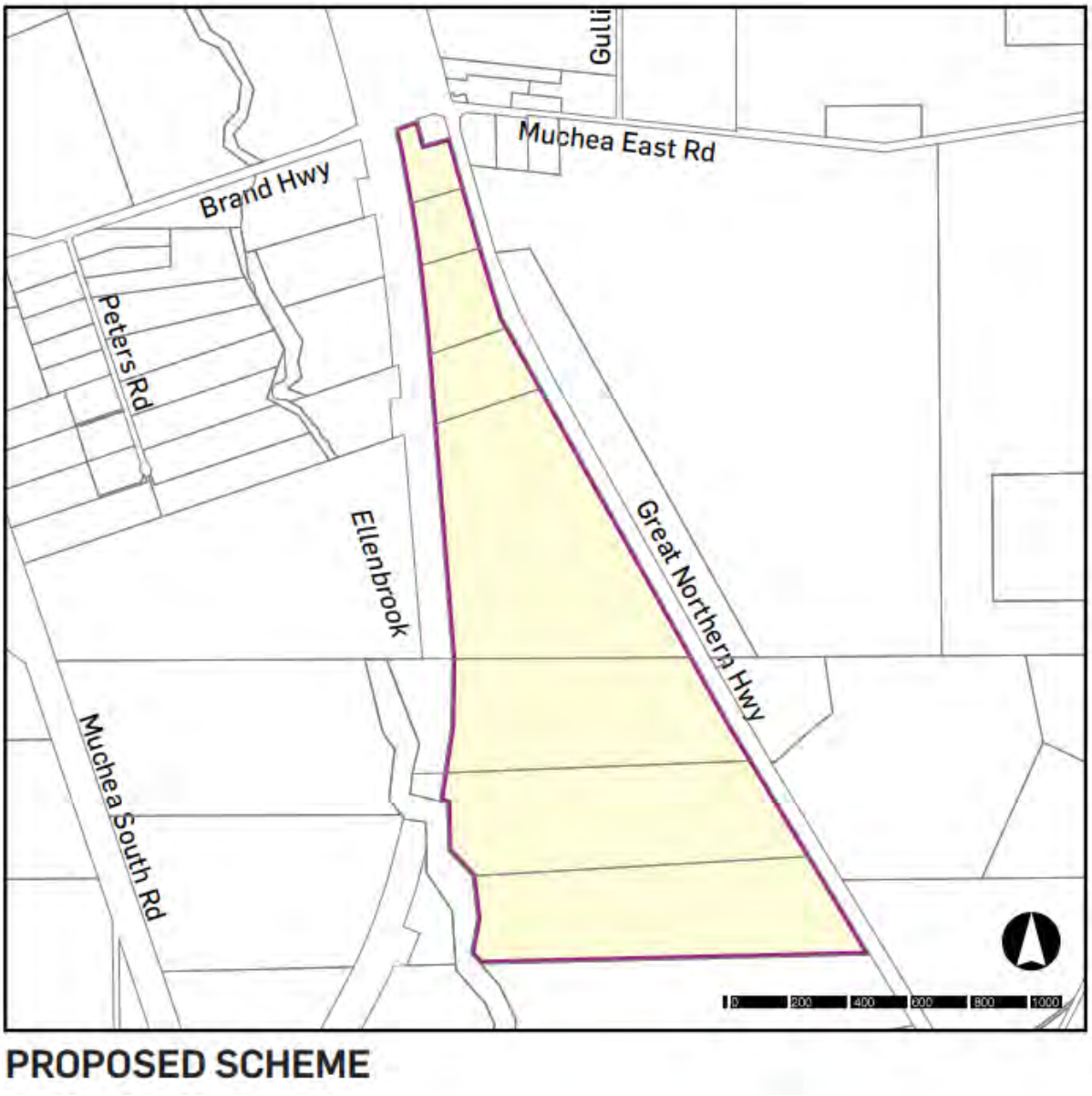


Figure 1 Proposed Precinct 3 development

Urbis[1] have indicated that the land has largely been historically cleared for agricultural purposes and contains stands of large, mature trees with degraded understorey, and a number of rural drainage lines.

[1] Urbis Pty Ltd 2019, Precinct 3, Muchea Industrial Park, Structure Plan, Draft January 2019

You have advised that the Structure Plan[2] will provide approximately 51 lots of approximately 1.3ha to 7.6ha providing flexibility for a range of industrial uses, expected to be primarily transport logistics related.

We understand that the Structure Plan is being progressed concurrently with Amendment No.67 to LPS6 which proposes to rezone the land from 'Agricultural Resource Zone' to the 'Industrial Development' zone, to introduce land use permissibility for Precinct 3; clarify requirements for the preparation of Management Plans, and introduce provisions relating to provision of reticulated water and construction of the loop road.

2 Aqua Ferre

Aqua Ferre was established to be an independent water service provider following approaches by property development groups seeking water services in the Chittering/Muchea region. Aqua Ferre is proposing to build and operate a potable water supply system at Reserve Road, Chittering (as shown in Figure 2).

The proposed water treatment plant (WTP) would be operated as a constant flow rate to promote a stable process with the intention of producing reliable potable water that meets the Australian Drinking Water Guidelines.

Figure 2 below broadly shows the Precinct 3 development (outlined in red) to the south of Harvis' proposed MEN (Phase 1) development (outlined in yellow) and Aqua Ferre's proposed water facility to the north.

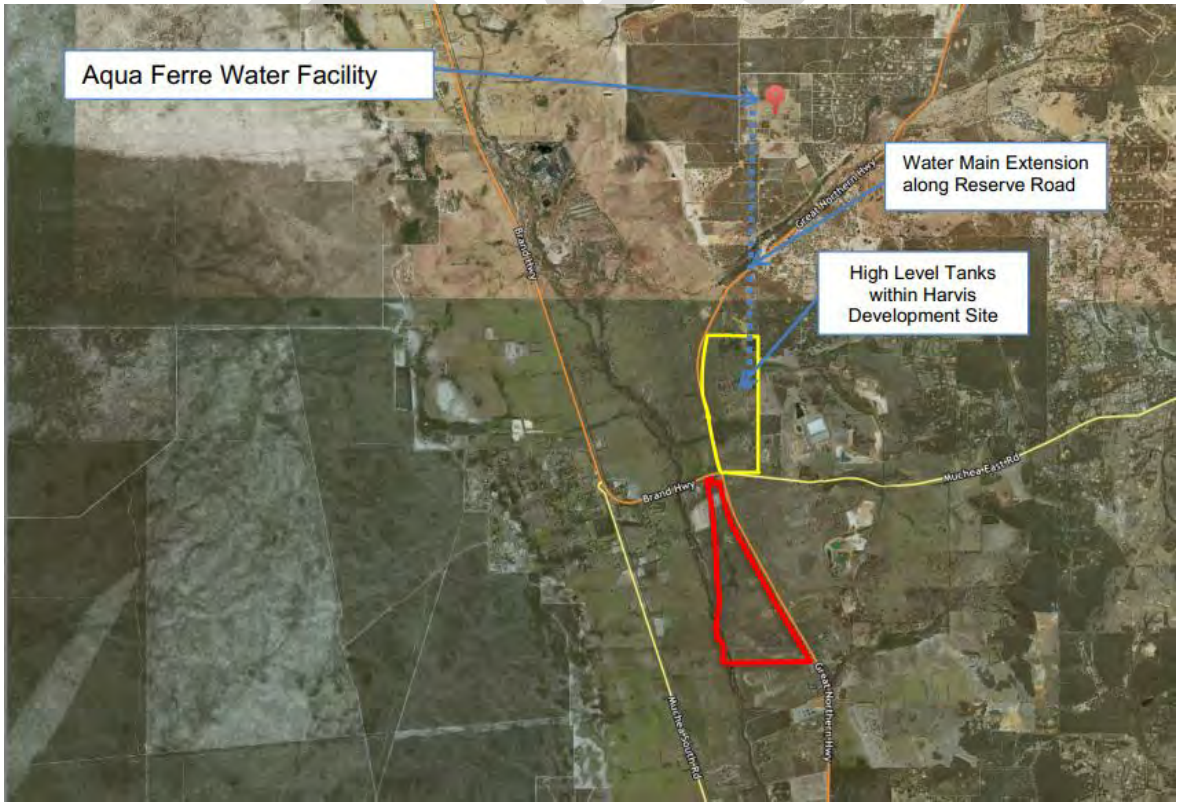


Figure 2 Development boundaries

[2] Urbis Pty Ltd 2019, Precinct 3, Muchea Industrial Park, Structure Plan, Draft January 2019

2.1 Water Entitlement

The Reserve Road (Chittering) property currently has a total water entitlement or allocation (licence to abstract water from an artesian aquifer) of 288,800 kL per annum. The developer of the Reserve Road residential development, Riverside, has transferred the Water Licence GWL 59907(3) to the Water Corporation to enable the licence to be changed from an agricultural extraction to public water supply. It is intended that this water entitlement will be transferred to Aqua Ferre when a water service licence has been granted.

Aqua Ferre has similar entitlement rights to a further 362,900 kL per annum licence, originally GWL 102502(4) which is now part of GWL 65011.

In total, it is intended that Aqua Ferre will have access to 651,700 kL of water per annum.

There is an existing production bore located within the proposed Reserve Road development that was previously used for wildflower irrigation, where the proposed potable WTP would be located.

2.2 Existing water supply commitments

Aqua Ferre intends supplying approximately 153 ML of treated potable water to the residential development at Reserve Road, Chittering, and to a commercial/industrial development at the adjacent MEN (northern Precinct 1 only). It is intended that a further 75 ML will be set aside for future demand across these two developments.

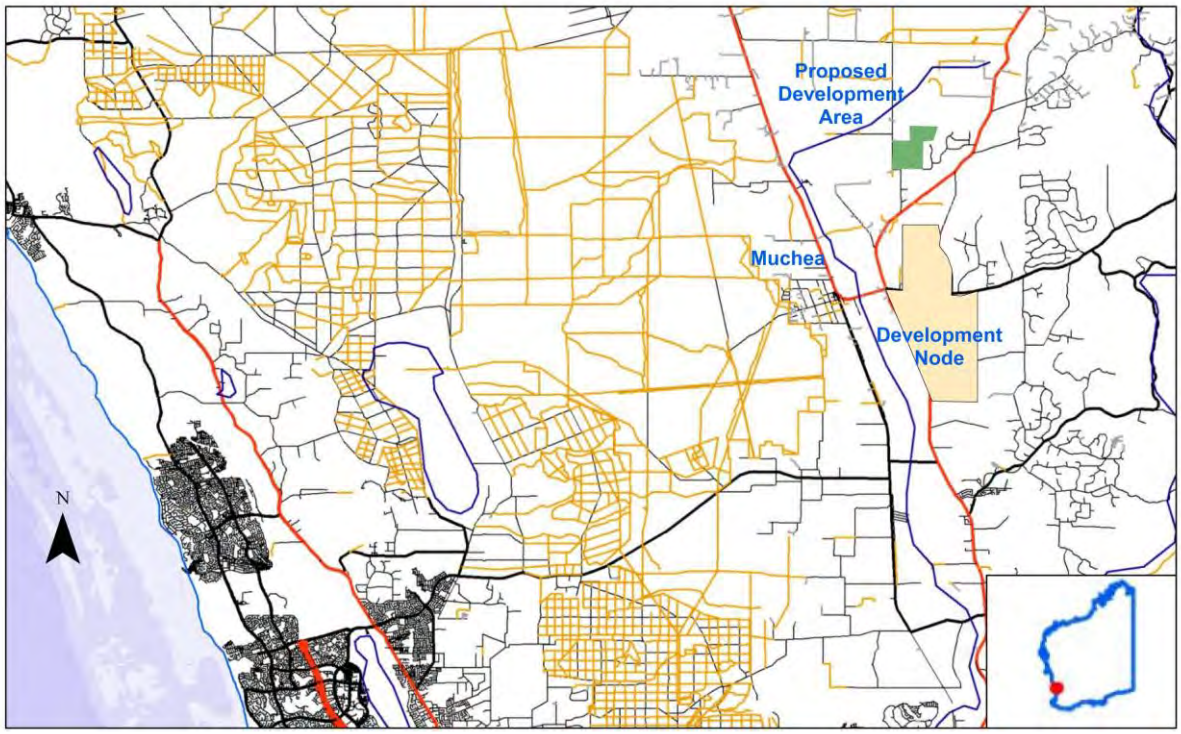


Figure 3 Location of Reserve Road residential development and MEN

The new Reserve Road rural living allotment development is located 8km north east of the Muchea town site and 80km north of the Perth central business district. It is also in close proximity (4km) to the

proposed MEN on the eastern side of Great Northern Highway. The development is in accordance with the Shire of Chittering's planning scheme (2004). The Reserve Road development covers an area of approximately 160 hectares and involves the creation of approximately 245 rural residential allotments in progressive stages. It is a requirement of the development approval that potable reticulated water is available.



Figure 4 Contour map (5m contour lines) of the Harvis MEN development showing ephemeral swale

Phase 1 of the MEN development is being undertaken by development group Harvis Capital Pty Ltd (Harvis). The Harvis development is located on the northern end of the proposed MEN. The site is slightly undulating with an ephemeral swale running through the development (Figure 4). The development is well placed and has been planned around the proposed Perth Darwin Highway.

It is the intention of the MEN development that these lots also have a reticulated water resource. Currently, the area does not have a public water supply scheme. Aqua Ferre is finalising documentation to allow the Economic Regulation Authority Western Australia to consider an application for a water services licence.

It is proposed that the water supply for the Harvis MEN development will have a standalone delivery and network system, to ensure that the demand of both systems can meet peak demand and firefighting requirements.

After treatment, it is intended that the water required for the Harvis MEN site will be delivered to a 500kL holding tank with aeration. Water would be reticulated to customers using a standard, continually pressurised water reticulation network. The piping would follow the general topography and alignment of the development streets and will have 600mm coverage.

3 Precinct 3 water requirement

You have advised that the intention is that the land the subject of the Structure Plan would be serviced with reticulated water provided by a licensed water provider.

The total area of supply is for an industrial development totalling approximately 185 hectares. No indication of staging of development has been provided at this point.

Estimated annual water usage has been provided (based on preliminary modelling by Cossill & Webley) as 203ML per annum on a net area of 139 hectares (after allowing for a 25% reduction in land area calculation to accommodate roads/drainage). The proposed system has been modelled at 4kL/day per hectare based on advice from Cossill & Webley of studies of similar industry types and uses. It is noted that this compares to the Water Corporation design standard for industrial land of approximately 17 kL/ha/day.

Based on your advice of estimated water usage, Aqua Ferre would have capacity under its entitlements to meet the demand of the subject land. This is not an undertaking to commit an allocation of water, or to supply water, to the Muchea Employment Node Precinct 3 Landowner Group. Any such arrangements would be the subject to future commercial negotiation, agreement on terms including pricing and remaining water availability under Aqua Ferre's entitlements.

4 Supply assessment

Aqua Ferre has conducted a preliminary desktop assessment of the potential supply route from its planned water treatment plant at Reserve Road to the proposed Precinct 3 development via Harvis' phase 1 MEN development. This represents a distance of approximately 3.5 kilometres.

The assessment did not highlight any major engineering impediments to the provision of water to the proposed development. (This is not to say, however, that any impediments would not become apparent on more detailed analysis.)

DRAFT

Any proposal for supply would be inclusive of the requirements of:

- Water Corporation Design Standard DS 63 – Water Reticulation Standard Design and Construction Requirements for Water Reticulation Systems or Water Reticulation Systems up to DN250
- DFES requirements for firefighting services
- Hydraulic modelling using EPANET 2 for system hydraulics.

Hydraulic modelling would require topographical mapping at 0.5m.

Additionally, there would be a requirement for a water reserve for tanks, pumps, sumps, generator and chlorination which would need to be met by the subject landowners' group.

5 Disclaimer

This report is dated 29 January 2019 and incorporates information available to Aqua Ferre up to that date only. It excludes consideration of any information arising, or event occurring, after that date which may impact opinions expressed or statements made by Aqua Ferre in this report.

Aqua Ferre has prepared this report on the instructions, and for the sole benefit, of Tomahawk Property (Instructing Party), for inclusion within a rezoning application and Structure Plan as described in paragraph 3 of this letter (Purpose) and not for any other purpose or use. To the extent permitted by applicable law, Aqua Ferre expressly disclaims all liability, whether direct or indirect:

- to the Instructing Party, which may arise in connection with any reliance or purported reliance on this report for any purpose other than the Purpose, and
- to any other person, which may arise in connection with any reliance or purported reliance on this report for any purpose whatsoever (including the Purpose).

All statements and opinions contained in or associated with this report are made on the basis of information supplied to Aqua Ferre as at the date of this report, and upon which Aqua Ferre has relied. To the extent permitted by applicable law, Aqua Ferre expressly disclaims any liability, whether direct or indirect, which may arise in connection with any errors or omissions in this report arising from information provided to Aqua Ferre by the Instructing Party or by any other person.

Achievement of any proposed or intended events or circumstances described in this report will depend, among other things, on the actions of others, over which Aqua Ferre has no control. To the extent permitted by applicable law, Aqua Ferre expressly disclaims any liability, whether direct or indirect, which may arise in connection with the delay in, or failure to occur of, any proposed or intended events or circumstances described in this report.

Yours sincerely

Peter Fogarty
Director

DRAFT

Appendix H

Runoff Calculations

1 YEAR ARI 1 HOUR FLOWS

Rainfall Intensity i (mm/h)	15.1	(1 Yr, 1 Hr Storm)
Runoff Coefficients		
Buildings	0	
Lowlands	0	
Hardstand	0	
Cleared Palusplain	0	
Vegetated Palusplain	0	
Cleared Uplands	0	
Forested Uplands	0	
Road Reserve	0.8	

Permeability k (m/hr) 0.0417

Catchment	Buildings	Lowlands	Hardstand	Cleared Palusplain	Vegetated Palusplain	Cleared Uplands	Forested Uplands	Road Reserve	Ai	Q (L/s)	Vinflow (m3)
North Pl 1	2926	0	23406	0	2926	0	0	0	0	0.00	0
North Pl 2	968	0	7741	0	968	0	0	0	0	0.00	0
AMS Pl 1	3014	0	24110	0	3014	0	0	0	0	0.00	0
AMS Pl 2	4530	757	35228	0	4502	0	0	11531	9225	38.72	139
AMS Pl 3	380	0	31914	0	2240	0	0	14270	11416	47.92	173
Ingham Pl 1	5810	0	46477	0	5810	0	0	16003	12802	53.74	193
Ingham Pl 2	1243	0	9943	0	1243	0	0	1177	942	3.95	14
Ingham Pl 3	2143	0	17146	0	2143	0	0	2240	1792	7.52	27
Ingham Pl 4	12461	0	99687	0	12461	0	0	10215	8172	34.30	123
Ingham Pl 5	9381	0	75044	0	9381	0	0	23070	18456	77.47	279
Ingham Pl 6	22286	0	178285	0	22286	0	0	42438	33950	142.52	513
Amuse	19440	0	155522	0	19440	0	0	10962	8770	36.81	133
RTA	65731	0	525851	0	65731	0	0	61273	49018	205.77	741
South	12769	0	102149	0	12769	0	0	17793	14234	59.75	215

Swale Sizing

	Storm Event	Depth	Slope 1:x	Base Width	Base Length	Top Width (m)	Top Length (m)	Volume	Effective Volume	Surface Area (m2)	Volume check	2% Area	Base Length Available
North Pl 1	1	0.3	4	**0**	**0**	2	2	1	1	6	ok	0	0
North Pl 2	1	0.3	4	**0**	**0**	2	2	1	1	6	ok	0	0
AMS Pl 1	1	0.3	4	**0**	**0**	2	2	1	1	6	ok	0	0
AMS Pl 2	1	0.3	4	**1**	**196**	3	198	123	141	675	ok	184	330
AMS Pl 3	1	0.3	4	**1**	**242**	3	244	152	173	830	ok	228	308
Ingham Pl 1	1	0.3	4	**1**	**271**	3	273	170	194	930	ok	256	288
Ingham Pl 2	1	0.3	4	**1**	**19**	3	21	13	15	73	ok	19	43
Ingham Pl 3	1	0.3	4	**1**	**37**	3	39	24	27	134	ok	36	71
Ingham Pl 4	1	0.3	4	**1**	**172**	3	174	108	124	593	ok	163	325
Ingham Pl 5	1	0.3	4	**1**	**391**	3	393	245	279	1338	ok	369	640
Ingham Pl 6	1	0.3	4	**1**	**720**	3	722	451	513	2456	ok	679	1314
Amuse	1	0.3	4	**1**	**185**	3	187	117	133	637	ok	175	390
RTA	1	0.3	4	**1**	**1040**	3	1042	650	741	3544	ok	980	2054
South	1	0.3	4	**1**	**301**	3	303	189	215	1032	ok	285	550

100 YEAR ARI DRAINAGE PROPERTIES - UPSTREAM

CATCHMENT	AREAS (m2)																		EFFECTIVE AREA (m2)		TIME OF CONCENTRATION PRE-DEVELOPMENT					TIME OF CONCENTRATION POST-DEVELOPMENT					CRITICAL STORM INTENSITY (mm/h)	
	Buildings		Lowlands		Hardstand, unsealed roads		Cleared Palusplain		Vegetated Palusplain		Cleared Uplands		Forested Uplands		Road Reserve		Total		Pre Dev	Post Dev	Longest Path (m)	RL Top (mAHD)	RL Bottom (mAHD)	Slope (m/km)	TC (min)	Longest Path (m)	RL Top (mAHD)	RL Bottom (mAHD)	Slope	TC (min)	Pre-Dev	Post-Dev
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post													
North 1	8542	8542	67975	67975	16885	16885	53602	53602	0	0	0	0	0	0	73179	73179	220183	220183	163406	163406	1500	85	53	21.00	56.7	1500	85	53	21.00	56.7	43.96	43.96
North 2	0	0	142617	142617	5392	5392	64500	64500	70603	70603	2879828	2879828	634745	634745	995	995	3798680	3798680	1175539	1175539	6316	235	52	28.97	183.8	6316	235	52	28.97	183.8	21.25	21.25
AMS	0	0	167304	167304	0	0	0	0	0	0	0	0	0	0	6056	6056	173360	173360	105227	105227	1448	70	52	12.43	63.5	1448	70	52	12.43	63.5	40.55	40.55
Inghams 1	0	0	302181	302181	0	0	0	0	0	0	75326	75326	0	0	4410	4410	381917	381917	207434	207434	2351	128	53	31.90	79.8	2351	128	53	31.90	79.8	36.64	36.64
Inghams 2	1371	1371	460463	460463	0	0	0	0	0	0	469488	469488	0	0	4800	4800	936122	936122	422198	422198	2216	129	53	34.30	69.1	2216	129	53	34.30	69.1	39.22	39.22
Inghams 3 a	540	540	522370	522370	0	0	0	0	0	0	422640	422640	0	0	7111	7111	952661	952661	446389	446389	3157	125	53	22.81	106.2	3157	125	53	22.81	106.2	30.31	30.31
Inghams 3 b	0	0	80404	80404	0	0	0	0	0	0	0	0	0	0	3554	3554	83958	83958	51086	51086	923	74	57	18.96	40.0	923	74	57	18.96	40.0	56.99	56.99
Inghams 4	0	0	150325	150325	0	0	56142	56142	0	0	1161350	1161350	13741	13741	4350	4350	1385908	1385908	489742	489742	2911	145	58	30.06	91.8	2911	145	58	30.06	91.8	33.77	33.77
Amuse	600	600	54719	54719	2525	2525	0	0	0	0	0	0	0	0	3465	3465	61309	61309	38163	38163	835	74	59	17.96	37.7	835	74	59	17.96	37.7	58.81	58.81
RTA	460	460	28914	28914	1294	1294	0	0	0	0	5150	5150	0	0	805	805	36623	36623	20987	20987	1024	87	60	26.86	45.3	1024	87	60	26.86	45.3	52.90	52.90
South	2432	2432	565560	565560	8045	8045	46611	46611	0	0	114641	114641	23577	23577	44784	44784	805650	805650	460185	460185	1528	111	55	36.65	46.6	1528	111	55	36.65	46.6	51.85	51.85

Runoff Coefficients	**Pre-Dev**	**Post-Dev**
Buildings	0.9	0.9
Lowlands	0.6	0.6
Hardstand, unsealed roads	0.8	0.8
Cleared Palusplain	0.8	0.8
Vegetated Palusplain	0.6	0.6
Cleared Uplands	0.3	0.3
Forested Uplands	0.2	0.2
Road Reserve	0.8	0.8

Rainfall IFD

Event	**Duration (mins)**	**Intensity (mm/hr)**
5 min	5	164.4
6 min	6	154
10 min	10	123.6
20 min	20	83.7
30 min	30	64.8
1 hr	60	41.4
2 hr	120	27
3 hr	180	21.4
6 hr	360	14.4
12 hr	720	9.5
24 hr	1440	5.75
48 hr	2880	3.2
72 hr	4320	2.2

100 YEAR ARI FLOWS - UPSTREAM

Storm Duration (mins)	North 1 Upstream			North 2 Upstream			AMS Upstream			Inghams 1 Upstream			Inghams 2 Upstream			Inghams 3a Upstream			Inghams 3b Upstream			Inghams 4 Upstream			Amuse Upstream			RTA Upstream			South Upstream		
	Pre-Dev Flow (l/s)	Post-Dev Flow (l/s)	Excess Flow (l/s)	Pre-Dev Flow (l/s)	Post-Dev Flow (l/s)	Excess Flow (l/s)	Pre-Dev Flow (l/s)	Post-Dev Flow (l/s)	Excess Flow (l/s)	Pre-Dev Flow (l/s)	Post-Dev Flow (l/s)	Excess Flow (l/s)	Pre-Dev Flow (l/s)	Post-Dev Flow (l/s)	Excess Flow (l/s)	Pre-Dev Flow (l/s)	Post-Dev Flow (l/s)	Excess Flow (l/s)	Pre-Dev Flow (l/s)	Post-Dev Flow (l/s)	Excess Flow (l/s)	Pre-Dev Flow (l/s)	Post-Dev Flow (l/s)	Excess Flow (l/s)	Pre-Dev Flow (l/s)	Post-Dev Flow (l/s)	Excess Flow (l/s)	Pre-Dev Flow (l/s)	Post-Dev Flow (l/s)	Excess Flow (l/s)	Pre-Dev Flow (l/s)	Post-Dev Flow (l/s)	Excess Flow (l/s)
5	1995.23	7462.19	5466.96	6939.14	7462.19	523.05	1185.24	4805.38	3620.13	2111.10	9472.84	7361.73	4599.51	19280.38	14680.87	3758.63	20385.09	16626.46	808.68	20385.09	19576.41	4593.52	22364.88	17771.36	623.47	1742.80	1119.33	308.36	958.39	650.02	6627.56	21015.09	14387.54
6	1995.23	6990.13	4994.89	6939.14	6990.13	50.99	1185.24	4501.39	3316.14	2111.10	8873.58	6762.48	4599.51	18060.70	13461.19	3758.63	19095.52	15336.89	808.68	19095.52	18286.84	4593.52	20950.07	16356.55	623.47	1632.55	1009.08	308.36	897.76	589.40	6627.56	19685.67	13058.11
10	1995.23	5610.26	3615.03	6939.14	5610.26	-1328.88	1185.24	3612.80	2427.56	2111.10	7121.91	5010.81	4599.51	14495.47	9895.96	3758.63	15326.02	11567.39	808.68	15326.02	14517.34	4593.52	16814.47	12220.95	623.47	1310.28	686.81	308.36	720.54	412.18	6627.56	15799.67	9172.11
20	1995.23	3799.18	1803.95	6939.14	3799.18	-3139.96	1185.24	2446.53	1261.29	2111.10	4822.85	2711.75	4599.51	9816.11	5216.60	3758.63	10378.54	6619.91	808.68	10378.54	9569.86	4593.52	11386.50	6792.98	623.47	887.30	263.83	308.36	487.94	179.57	6627.56	10699.29	4071.73
30	1995.23	2941.30	946.07	6939.14	2941.30	-3997.84	1185.24	1894.09	708.85	2111.10	3733.82	1622.72	4599.51	7599.57	3000.06	3758.63	8035.00	4276.37	808.68	8035.00	7226.32	4593.52	8815.35	4221.83	623.47	686.94	63.47	308.36	377.76	69.39	6627.56	8283.32	1655.76
60	1995.23	1879.16	-116.07	6939.14	1879.16	-5059.97	1185.24	1210.11	24.87	2111.10	2385.50	274.39	4599.51	4855.28	255.77	3758.63	5133.47	1374.84	808.68	5133.47	4324.79	4593.52	5632.03	1038.51	623.47	438.88	-184.59	308.36	241.35	-67.02	6627.56	5292.12	-1335.43
120	1995.23	1225.54	-769.69	6939.14	1225.54	-5713.60	1185.24	789.20	-396.04	2111.10	1555.76	-555.34	4599.51	3166.49	-1433.02	3758.63	3347.92	-410.71	808.68	3347.92	2539.24	4593.52	3673.06	-920.45	623.47	286.23	-337.24	308.36	157.40	-150.96	6627.56	3451.38	-3176.17
180	1995.23	971.36	-1023.88	6939.14	971.36	-5967.78	1185.24	625.52	-559.73	2111.10	1233.08	-878.02	4599.51	2509.73	-2089.77	3758.63	2653.53	-1105.10	808.68	2653.53	1844.85	4593.52	2911.24	-1682.28	623.47	226.86	-396.61	308.36	124.75	-183.61	6627.56	2735.54	-3892.02
360	1995.23	653.62	-1341.61	6939.14	653.62	-6285.52	1185.24	420.91	-764.33	2111.10	829.74	-1281.37	4599.51	1688.79	-2910.71	3758.63	1785.56	-1973.07	808.68	1785.56	976.88	4593.52	1958.97	-2634.55	623.47	152.65	-470.81	308.36	83.95	-224.42	6627.56	1840.74	-4786.82
720	1995.23	431.21	-1564.02	6939.14	431.21	-6507.93	1185.24	277.68	-907.56	2111.10	547.40	-1563.71	4599.51	1114.13	-3485.37	3758.63	1177.97	-2580.66	808.68	1177.97	369.29	4593.52	1292.37	-3301.14	623.47	100.71	-522.76	308.36	55.38	-252.98	6627.56	1214.38	-5413.18
1440	1995.23	261.00	-1734.24	6939.14	261.00	-6678.14	1185.24	168.07	-1017.17	2111.10	331.32	-1779.78	4599.51	674.34	-3925.16	3758.63	712.98	-3045.65	808.68	712.98	-95.70	4593.52	782.23	-3811.29	623.47	60.96	-562.51	308.36	33.52	-274.84	6627.56	735.02	-5892.54
2880	1995.23	145.25	-1849.98	6939.14	145.25	-6793.89	1185.24	93.54	-1091.71	2111.10	184.39	-1926.72	4599.51	375.29	-4224.22	3758.63	396.79	-3361.84	808.68	396.79	-411.89	4593.52	435.33	-4158.19	623.47	33.92	-589.54	308.36	18.65	-289.71	6627.56	409.05	-6218.50
4320	1995.23	99.86	-1895.37	6939.14	99.86	-6839.28	1185.24	64.31	-1120.94	2111.10	126.77	-1984.34	4599.51	258.01	-4341.50	3758.63	272.79	-3485.84	808.68	272.79	-535.89	4593.52	299.29	-4294.23	623.47	23.32	-600.15	308.36	12.83	-295.54	6627.56	281.22	-6346.33
Critical Storm	**1995.23**	**1995.23**	**0.00**	**6939.14**	**1995.23**	**-4943.90**	**1185.24**	**1185.24**	**0.00**	**2111.10**	**2111.10**	**0.00**	4599.51	**4599.51**	**0.00**	3758.63	**3758.63**	**0.00**	**808.68**	**3758.63**	**2949.95**	4593.52	**4593.52**	**0.00**	623.47	**623.47**	**0.00**	**308.36**	**308.36**	**0.00**	6627.56	**6627.56**	**0.00**
Duration (min)	56.72	56.72		183.84	0.00		63.55	63.55		79.84	79.84		69.09	69.09		106.20	106.20		40.02	106.20		91.81	91.81		37.68	37.68		45.26	45.26		46.61	46.61	
Intensity (mm/h)	43.96	43.96		21.25	0.00		40.55	40.55		36.64	36.64		39.22	39.22		30.31	30.31		56.99	30.31		33.77	33.77		58.81	58.81		52.90	52.90		51.85	51.85	

100 YEAR ARI DRAINAGE PROPERTIES - INTERNAL

CATCHMENT	AREAS (m2)																		EFFECTIVE AREA (m2)		TIME OF CONCENTRATION PRE-DEVELOPMENT					TIME OF CONCENTRATION POST-DEVELOPMENT					CRITICAL STORM INTENSITY (mm/h)	
	Buildings		Lowlands		Hardstand, unsealed roads		Cleared Palusplain		Vegetated Palusplain		Cleared Uplands		Forested Uplands		Road Reserve		Total		Pre Dev	Post Dev	Longest Path (m)	RL Top (mAHD)	RL Bottom (mAHD)	Slope (m/km)	TC (min)	Longest Path (m)	RL Top (mAHD)	RL Bottom (mAHD)	Slope	TC (min)	Pre-Dev	Post-Dev
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post													
North PI 1	493	2926	0	0	5774	23406	22991	0	0	2926	0	0	0	0	11113	11113	40371	40371	32346	32004	246	53	49	16.26	11.5	246	53	49	16.26	11.5	117.57	117.52
North PI 2	0	968	0	0	0	7741	9676	0	0	968	0	0	0	0	1880	1880	11556	11556	9245	9148	225	53	49	17.78	11.7	225	53	49	17.78	11.7	116.72	116.68
AMS PI 1	2776	3014	576	0	17122	24110	9663	0	0	3014	0	0	0	0	3556	3556	33693	33693	27117	26653	247	53	49	16.19	11.8	247	53	49	16.19	11.8	116.52	116.44
AMS PI 2	4530	4530	3052	1668	35228	23939	2207	0	0	3349	0	0	0	0	0	11531	45017	45017	35856	35463	263	53	49	13.31	12.7	550	53	49	6.36	30.8	112.91	64.20
AMS PI 3	380	380	16336	0	31914	31914	0	0	0	2240	0	0	0	0	12294	26390	60924	60924	45510	48329	630	53	48	7.62	33.2	630	53	48	7.62	33.0	62.34	62.49
Ingham PI 1	479	5810	65979	0	0	46477	4396	0	3641	5810	0	0	0	0	7970	24369	82465	82465	52096	65391	471	54	46	16.35	21.0	428	53	46	14.49	19.1	81.82	87.27
Ingham PI 2	1691	1243	8974	0	0	9943	834	0	2083	1243	0	0	0	0	0	1153	13582	13582	8823	10741	370	53	46	18.92	19.1	370	53	46	18.92	18.8	87.18	88.66
Ingham PI 3	1942	2143	13029	0	0	17146	3037	0	5597	2143	0	0	0	0	1467	3640	25072	25072	16527	19843	480	54	46	16.67	23.9	480	54	46	16.67	23.5	76.32	77.14
Ingham PI 4	1592	12461	80327	0	0	99687	42086	0	10294	12461	0	0	0	0	9243	18933	143542	143542	96869	113588	745	54	44	12.89	32.7	794	54	44	12.09	34.8	59.64	61.08
Ingham PI 5	0	9381	79851	0	0	75044	29773	0	7720	9381	0	0	0	0	11868	35407	129212	129212	85855	102432	738	55	45	13.96	32.3	834	54	45	11.15	37.5	63.01	58.95
Ingham PI 6	5735	22286	167415	0	0	178285	54819	0	37893	22286	0	0	0	0	12863	55869	278725	278725	182492	220751	876	55	43	13.70	35.7	876	58	43	16.55	33.7	60.37	61.91
Amuse	294	19440	151680	0	0	155522	49073	0	0	19440	0	0	0	0	11151	17795	212198	212198	139452	167814	1118	60	42	16.10	45.3	725	54	42	15.86	28.9	52.87	66.84
RTA	3334	65731	319119	0	121156	525851	275010	0	0	65731	0	0	0	0	11922	73227	730541	730541	520942	577860	1228	59	41	14.66	44.4	1212	60	41	15.68	42.8	53.54	54.80
South	0	12769	73662	0	0	102149	71196	0	0	12769	0	0	0	0	13085	30257	157943	157943	111622	125078	812	59	43	19.70	32.3	1362	59	41	13.22	58.0	63.00	42.93

Runoff Coefficients	**Pre-Dev**	**Post-Dev**
Buildings	0.9	0.9
Lowlands	0.6	0.6
Hardstand, unsealed roads	0.8	0.8
Cleared Palusplain	0.8	0.8
Vegetated Palusplain	0.6	0.6
Cleared Uplands	0.3	0.3
Forested Uplands	0.2	0.2
Road Reserve	0.8	0.8

Rainfall IFD

Event	**Duration (mins)**	**Intensity (mm/hr)**
5 min	5	164.4
6 min	6	154
10 min	10	123.6
20 min	20	83.7
30 min	30	64.8
1 hr	60	41.4
2 hr	120	27
3 hr	180	21.4
6 hr	360	14.4
12 hr	720	9.5
24 hr	1440	5.75
48 hr	2880	3.2
72 hr	4320	2.2

100 YEAR ARI FLOWS - INTERNAL

Storm Duration (mins)	North A			North B			AMS A			AMS B			AMS C			Ingham PI 1			Ingham PI 2			Ingham PI 3			Ingham PI 4			Ingham PI 5			Ingham PI 6			Amuse			RTA			South		
	Pre-Dev Flow (l/s)	Post-Dev Flow (l/s)	Excess Flow (l/s)	Pre-Dev Flow (l/s)	Post-Dev Flow (l/s)	Excess Flow (l/s)	Pre-Dev Flow (l/s)	Post-Dev Flow (l/s)	Excess Flow (l/s)	Pre-Dev Flow (l/s)	Post-Dev Flow (l/s)	Excess Flow (l/s)	Pre-Dev Flow (l/s)	Post-Dev Flow (l/s)	Excess Flow (l/s)	Pre-Dev Flow (l/s)	Post-Dev Flow (l/s)	Excess Flow (l/s)	Pre-Dev Flow (l/s)	Post-Dev Flow (l/s)	Excess Flow (l/s)	Pre-Dev Flow (l/s)	Post-Dev Flow (l/s)	Excess Flow (l/s)	Pre-Dev Flow (l/s)	Post-Dev Flow (l/s)	Excess Flow (l/s)	Pre-Dev Flow (l/s)	Post-Dev Flow (l/s)	Excess Flow (l/s)	Pre-Dev Flow (l/s)	Post-Dev Flow (l/s)	Excess Flow (l/s)	Pre-Dev Flow (l/s)	Post-Dev Flow (l/s)	Excess Flow (l/s)	Pre-Dev Flow (l/s)	Post-Dev Flow (l/s)	Excess Flow (l/s)	Pre-Dev Flow (l/s)	Post-Dev Flow (l/s)	Excess Flow (l/s)
5	1056.34	1461.53	405.19	299.75	1461.53	1161.78	877.69	1217.16	339.47	1124.57	1217.16	92.58	788.05	1217.16	429.11	1184.07	2986.19	1802.12	213.66	490.52	276.86	350.37	906.18	555.81	1604.81	5187.16	3582.35	1502.68	4677.71	3175.02	3060.11	10080.98	7020.87	2047.97	7983.52	5811.56	7747.59	26388.92	18641.34	1953.40	5711.87	3758.47
6	1056.34	1369.07	312.73	299.75	1369.07	1069.32	877.69	1140.16	262.47	1124.57	1140.16	15.58	788.05	1140.16	352.11	1184.07	2797.28	1613.21	213.66	459.49	245.83	350.37	848.85	498.49	1604.81	4859.02	3254.21	1502.68	4381.79	2879.11	3060.11	9443.26	6383.14	2047.97	7178.73	5130.76	7747.59	24719.55	16971.96	1953.40	5350.54	3397.14
10	1056.34	1098.81	42.47	299.75	1098.81	799.06	877.69	915.09	37.40	1124.57	915.09	-209.49	788.05	915.09	127.04	1184.07	2245.09	1061.02	213.66	368.78	155.12	350.37	681.29	330.92	1604.81	3899.84	2295.03	1502.68	3516.82	2014.13	3060.11	7579.13	4519.02	2047.97	5761.63	3713.66	7747.59	19839.85	12092.26	1953.40	4294.33	2340.93
20	1056.34	744.10	-312.24	299.75	744.10	444.35	877.69	619.68	-258.01	1124.57	619.68	-504.89	788.05	619.68	-168.37	1184.07	1520.34	336.27	213.66	249.74	36.07	350.37	461.36	110.99	1604.81	2640.91	1036.10	1502.68	2381.53	878.85	3060.11	5132.47	2072.36	2047.97	3901.68	1853.72	7747.59	13439.24	5687.65	1953.40	2908.05	954.65
30	1056.34	576.08	-480.26	299.75	576.08	276.33	877.69	479.75	-397.94	1124.57	479.75	-644.82	788.05	479.75	-308.29	1184.07	1177.04	-7.03	213.66	193.34	-20.32	350.37	357.18	6.81	1604.81	2044.58	439.77	1502.68	1843.77	341.08	3060.11	3973.53	913.41	2047.97	3020.66	972.69	7747.59	10401.47	2653.89	1953.40	2251.40	297.99
60	1056.34	368.05	-688.29	299.75	368.05	68.30	877.69	306.51	-571.18	1124.57	306.51	-818.06	788.05	306.51	-481.54	1184.07	752.00	-432.07	213.66	123.53	-90.14	350.37	228.20	-122.17	1604.81	1306.26	-298.55	1502.68	1177.96	-324.72	3060.11	2538.64	-521.47	2047.97	1929.87	-118.10	7747.59	6845.39	-1102.20	1953.40	1438.39	-515.01
120	1056.34	240.03	-816.31	299.75	240.03	-59.72	877.69	199.90	-677.79	1124.57	199.90	-924.68	788.05	199.90	-588.15	1184.07	490.43	-693.64	213.66	80.56	-133.10	350.37	148.82	-201.54	1604.81	851.91	-752.90	1502.68	768.24	-734.45	3060.11	1655.64	-1404.48	2047.97	1258.61	-789.36	7747.59	4333.95	-3413.64	1953.40	938.08	-1015.32
180	1056.34	160.25	-896.09	299.75	160.25	-139.50	877.69	158.44	-719.25	1124.57	158.44	-966.14	788.05	158.44	-629.61	1184.07	388.71	-795.36	213.66	63.85	-149.81	350.37	117.96	-232.41	1604.81	675.21	-929.59	1502.68	608.90	-893.78	3060.11	1312.24	-1747.87	2047.97	997.56	-1050.40	7747.59	3435.05	-4312.53	1953.40	743.52	-1209.89
360	1056.34	128.02	-928.32	299.75	128.02	-171.73	877.69	106.61	-771.08	1124.57	106.61	-1017.96	788.05	106.61	-681.44	1184.07	261.56	-922.51	213.66	42.97	-170.70	350.37	79.37	-270.99	1604.81	454.35	-1150.46	1502.68	409.73	-1092.96	3060.11	883.01	-2177.11	2047.97	671.26	-1376.71	7747.59	2311.44	-5436.15	1953.40	500.31	-1453.09
720	1056.34	84.46	-971.88	299.75	84.46	-215.29	877.69	70.33	-807.36	1124.57	70.33	-1054.24	788.05	70.33	-717.71	1184.07	172.56	-1011.51	213.66	28.35	-185.32	350.37	52.36	-298.00	1604.81	299.74	-1305.06	1502.68	270.31	-1232.38	3060.11	582.54	-2477.57	2047.97	442.84	-1605.12	7747.59	1524.91	-6222.68	1953.40	330.07	-1623.34
1440	1056.34	51.12	-1005.22	299.75	51.12	-248.63	877.69	42.57	-835.12	1124.57	42.57	-1082.00	788.05	42.57	-745.48	1184.07	104.44	-1079.63	213.66	17.16	-196.51	350.37	31.69	-318.67	1604.81	181.42	-1423.39	1502.68	163.61	-1339.08	3060.11	352.59	-2707.52	2047.97	268.04	-1779.93	7747.59	922.97	-6824.62	1953.40	199.78	-1753.63
2880	1056.34	28.46	-1027.89	299.75	28.46	-271.30	877.69	23.69	-854.00	1124.57	23.69	-1100.88	788.05	23.69	-764.36	1184.07	58.13	-1125.95	213.66	9.55	-204.11	350.37	17.64	-332.73	1604.81	100.97	-1503.84	1502.68	91.08	-1411.63	3060.11	196.22	-2863.89	2047.97	149.17	-1898.80	7747.59	513.65	-7233.93	1953.40	111.18	-1842.22
4320	1056.34	19.56	-1036.78	299.75	19.56	-280.19	877.69	16.29	-861.40	1124.57	16.29	-1108.29	788.05	16.29	-771.76	1184.07	39.96	-1144.11	213.66	6.56	-207.10	350.37	12.13	-338.24	1604.81	69.41	-1535.39	1502.68	62.60	-1440.09	3060.11	134.90	-2925.21	2047.97	102.55	-1945.41	7747.59	353.14	-7394.45	1953.40	76.44	-1876.97
Critical Storm	**1056.34**	**1044.74**	**-11.60**	299.75	**1044.74**	**744.99**	877.69	**862.08**	**-15.61**	1124.57	**862.08**	**-262.50**	788.05	**862.08**	**74.03**	**1184.07**	**1585.26**	**401.19**	213.66	**264.54**	**50.88**	350.37	**425.19**	**74.83**	1604.81	**1927.14**	**322.33**	1502.68	**1677.21**	**174.53**	3060.11	**3796.04**	**735.93**	2047.97	**3115.73**	**1067.77**	**7747.59**	**8795.74**	**1048.15**	**1953.40**	**1491.72**	**-461.68**
Duration (min)	11.51	11.52		11.72	11.74		11.77	11.79		12.68	30.77		33.16	32.96		20.99	19.10		19.13	18.76		23.90	23.47		32.73	34.77		32.30	37.50		35.68	33.71		45.30	28.92		44.44	42.83		32.31	58.03	
Intensity (mm/h)	117.57	117.52		116.72	116.68		116.52	116.44		112.91	64.20		62.34	62.49		81.82	87.27		87.18	88.66		76.32	77.14		59.64	61.08		63.01	58.95		60.37	61.91		52.87	66.94		53.54	54.80		63.00	42.93	

Total Peak Flows Pre Development 23811.06 m3/s
Post Development 27754.30 m3/s

100 YEAR ARI DRAINAGE PROPERTIES - COMBINED

Culvert	AREAS (m2)																		EFFECTIVE AREA (m2)		TIME OF CONCENTRATION PRE-DEVELOPMENT					TIME OF CONCENTRATION POST-DEVELOPMENT					CRITICAL STORM INTENSITY (mm/h)	
	Buildings		Lowlands		Hardstand, unsealed roads		Cleared Palusplain		Vegetated Palusplain		Cleared Uplands		Forested Uplands		Road Reserve		Total		Pre Dev	Post Dev	Longest Path (m)	RL Top (mAHD)	RL Bottom (mAHD)	Slope (m/km)	TC (min)	Longest Path (m)	RL Top (mAHD)	RL Bottom (mAHD)	Slope	TC (min)	Pre-Dev	Post-Dev
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post													
2.20	9035	11468	67975	67975	22659	40291	76593	53602	0	2926	0	0	0	0	84292	84292	260554	260554	195752	195410	1660	85	49	21.39	61.4	1660	85	49	21.39	61.4	41.06	41.06
2.28	0	968	142617	142617	5392	13133	74176	64500	70603	71571	2879828	2879828	634745	634745	2875	2875	3810236	3810236	1184784	1184687	6542	235	49	28.43	191.0	6542	235	49	28.43	191.0	20.97	20.97
2.39	2776	3014	576	0	17122	24110	9663	0	0	3014	0	0	0	0	3556	3556	33693	33693	27117	26653	218	53	49	16.06	10.4	218	53	49	16.06	10.4	121.97	121.89
2.60	4530	4530	3052	1668	35228	23939	2207	0	0	3349	0	0	0	0	0	13385	45017	46871	35856	36946	263	53	49	13.31	12.7	263	53	49	13.31	12.6	112.91	113.06
2.89	380	380	183640	167304	31914	31914	0	0	0	2240	0	0	0	0	18350	32446	234284	234284	150737	153556	1355	70	48	16.24	54.4	1355	70	48	16.24	54.3	45.78	45.86
3.11	479	5810	368160	302181	0	46477	4396	0	3641	5810	75326	75326	0	0	12380	28779	464382	464382	259530	272825	2822	128	47	28.88	95.6	2575	128	47	31.65	85.2	32.86	35.35
3.14	1691	1243	8974	0	0	9943	834	0	2083	1243	0	0	0	0	0	1153	13582	13582	8823	10741	378	53	46	18.52	19.6	378	53	46	18.52	19.2	85.19	86.72
3.20	0	2143	0	0	0	17146	0	0	0	2143	0	0	0	0	0	3640	0	25072	1	19843	20	46	46	0.50	5.3	456	54	46	17.54	22.1	161.23	79.79
3.52	0	13832	0	460463	0	99687	15914	0	7190	12461	0	469488	0	0	0	23733	23104	1079664	17045	535786	340	46	44	5.59	21.0	3116	129	44	27.28	99.3	81.80	31.97
3.64	0	9921	0	522370	0	75044	15208	0	2532	9381	0	422640	0	0	0	42518	17740	1081873	13686	548820	200	46	44	9.50	11.4	3715	125	44	21.86	123.5	118.18	26.68
3.89	11180	22286	1554184	244371	4605	178285	145713	56142	59586	22286	2053478	1161350	13741	13741	62387	63773	3904874	1762233	1767280	769764	3756	141	43	26.09	107.2	3725	141	43	26.31	115.3	30.08	28.12
Ebrook	4688	86232	554432	83633	124975	685193	324083	0	0	85172	5150	5150	0	0	27343	95292	1040671	1040671	719544	804824	2280	87	41	20.18	74.9	2280	87	41	20.18	74.1	37.82	38.02
South	2432	15201	639222	565560	8045	110194	117807	46611	0	12769	114641	114641	23577	23577	57869	75041	963593	963593	571807	585262	1528	111	54	37.30	45.4	1528	111	54	37.30	45.3	52.75	52.84

Runoff Coefficients	**Pre-Dev**	**Post-Dev**
Buildings	0.9	0.9
Lowlands	0.6	0.6
Hardstand, unsealed roads	0.8	0.8
Cleared Palusplain	0.8	0.8
Vegetated Palusplain	0.6	0.6
Cleared Uplands	0.3	0.3
Forested Uplands	0.2	0.2
Road Reserve	0.8	0.8

Rainfall IFD

Event	**Duration (mins)**	**Intensity (mm/hr)**
5 min	5	164.4
6 min	6	154
10 min	10	123.6
20 min	20	83.7
30 min	30	64.8
1 hr	60	41.4
2 hr	120	27
3 hr	180	21.4
6 hr	360	14.4
12 hr	720	9.5
24 hr	1440	5.75
48 hr	2880	3.2
72 hr	4320	2.2

100 YEAR ARI FLOWS - COMBINED

Storm Duration (mins)	2.20			2.28			2.39			2.60			2.89			3.11			3.14			3.20			3.52			3.64			3.89			Ebrook			South		
	Pre-Dev Flow (l/s)	Post-Dev Flow (l/s)	Excess Flow (l/s)	Pre-Dev Flow (l/s)	Post-Dev Flow (l/s)	Excess Flow (l/s)	Pre-Dev Flow (l/s)	Post-Dev Flow (l/s)	Excess Flow (l/s)	Pre-Dev Flow (l/s)	Post-Dev Flow (l/s)	Excess Flow (l/s)	Pre-Dev Flow (l/s)	Post-Dev Flow (l/s)	Excess Flow (l/s)	Pre-Dev Flow (l/s)	Post-Dev Flow (l/s)	Excess Flow (l/s)	Pre-Dev Flow (l/s)	Post-Dev Flow (l/s)	Excess Flow (l/s)	Pre-Dev Flow (l/s)	Post-Dev Flow (l/s)	Excess Flow (l/s)	Pre-Dev Flow (l/s)	Post-Dev Flow (l/s)	Excess Flow (l/s)	Pre-Dev Flow (l/s)	Post-Dev Flow (l/s)	Excess Flow (l/s)	Pre-Dev Flow (l/s)	Post-Dev Flow (l/s)	Excess Flow (l/s)	Pre-Dev Flow (l/s)	Post-Dev Flow (l/s)	Excess Flow (l/s)	Pre-Dev Flow (l/s)	Post-Dev Flow (l/s)	Excess Flow (l/s)
5	2232.55	8923.72	6691.16	6902.21	54100.71	47198.50	918.70	1217.16	298.46	1124.57	1687.22	562.64	1916.99	7012.41	5095.42	2368.69	12450.03	10080.34	208.80	490.52	281.72	0.04	906.18	906.13	387.32	24467.54	24080.22	449.28	25060.80	24613.52	14764.76	35152.56	20387.79	7558.27	36753.63	29195.36	8379.14	26726.97	18347.82
6	2232.55	8359.20	6126.64	6902.21	50678.28	43776.07	918.70	1140.16	221.46	1124.57	1580.48	455.91	1916.99	6568.80	4651.81	2368.69	11670.87	9302.17	208.80	459.49	250.69	0.04	848.85	848.81	387.32	22919.72	22532.40	449.28	23477.31	23028.04	14764.76	32928.80	18164.03	7558.27	34428.58	26870.32	8379.14	25036.21	16657.07
10	2232.55	6709.07	4476.52	6902.21	40674.26	33772.05	918.70	915.09	-3.61	1124.57	1268.49	143.92	1916.99	5272.10	3355.12	2368.69	9367.01	6998.32	208.80	368.78	159.99	0.04	681.29	681.24	387.32	18395.31	18007.99	449.28	18842.83	18393.55	14764.76	26428.57	11663.80	7558.27	27632.29	20074.02	8379.14	20094.00	11714.85
20	2232.55	4543.28	2310.72	6902.21	27543.97	20641.77	918.70	619.68	-299.01	1124.57	859.00	-265.57	1916.99	3570.19	1653.20	2368.69	6343.19	3974.50	208.80	249.74	40.94	0.04	461.36	461.31	387.32	12457.02	12069.69	449.28	12760.07	12310.79	14764.76	17897.01	3132.25	7558.27	18712.16	11153.89	8379.14	13607.34	5228.20
30	2232.55	3517.38	1284.82	6902.21	21324.37	14422.16	918.70	479.75	-438.94	1124.57	665.04	-459.54	1916.99	2764.02	847.03	2368.69	4910.86	2542.17	208.80	193.34	-15.45	0.04	357.18	357.13	387.32	9644.14	9256.82	449.28	9878.77	9429.49	14764.76	13855.75	-909.01	7558.27	14486.83	6928.56	8379.14	10534.72	2155.57
60	2232.55	2247.21	14.66	6902.21	13623.90	6721.70	918.70	306.51	-612.19	1124.57	424.88	-699.69	1916.99	1765.90	-151.09	2368.69	3137.49	768.80	208.80	123.53	-85.27	0.04	228.20	228.15	387.32	6161.53	5774.21	449.28	6311.43	5862.15	14764.76	8852.29	-5912.48	7558.27	9255.48	1697.21	8379.14	6730.51	-1648.63
120	2232.55	1465.57	-766.98	6902.21	8885.15	1982.95	918.70	199.90	-718.80	1124.57	277.10	-847.48	1916.99	1151.67	-765.31	2368.69	2046.19	-322.50	208.80	80.56	-128.24	0.04	148.82	148.78	387.32	4018.39	3631.07	449.28	4116.15	3666.87	14764.76	5773.23	-8991.53	7558.27	6036.18	-1522.09	8379.14	4389.47	-3989.68
180	2232.55	1161.60	-1070.95	6902.21	7042.31	140.10	918.70	158.44	-760.26	1124.57	219.63	-904.95	1916.99	912.81	-1004.18	2368.69	1621.80	-746.90	208.80	63.85	-144.95	0.04	117.96	117.91	387.32	3184.95	2797.63	449.28	3262.43	2813.15	14764.76	4575.82	-10188.94	7558.27	4784.23	-2774.04	8379.14	3479.06	-4900.09
360	2232.55	781.64	-1450.92	6902.21	4738.75	-2163.46	918.70	106.61	-812.08	1124.57	147.79	-976.79	1916.99	614.23	-1302.76	2368.69	1091.30	-1277.39	208.80	42.97	-165.83	0.04	79.37	79.33	387.32	2143.14	1755.82	449.28	2195.28	1746.00	14764.76	3079.06	-11685.71	7558.27	3219.30	-4338.97	8379.14	2341.05	-6038.10
720	2232.55	515.66	-1716.89	6902.21	3126.26	-3775.95	918.70	70.33	-848.36	1124.57	97.50	-1027.08	1916.99	405.22	-1511.77	2368.69	719.96	-1648.74	208.80	28.35	-180.45	0.04	52.36	52.32	387.32	1413.88	1026.56	449.28	1448.28	999.00	14764.76	2031.32	-12733.44	7558.27	2123.94	-5434.43	8379.14	1544.44	-6834.70
1440	2232.55	312.11	-1920.44	6902.21	1892.21	-5010.00	918.70	42.57	-876.13	1124.57	59.01	-1065.56	1916.99	245.26	-1671.72	2368.69	435.76	-1932.93	208.80	17.16	-191.64	0.04	31.69	31.65	387.32	855.77	468.45	449.28	876.59	427.31	14764.76	1229.48	-13535.28	7558.27	1285.48	-6272.78	8379.14	934.79	-7444.35
2880	2232.55	171.70	-2058.86	6902.21	1053.06	-5849.15	918.70	23.69	-895.01	1124.57	32.84	-1091.73	1916.99	136.49	-1780.49	2368.69	242.51	-2126.18	208.80	9.55	-199.26	0.04	17.64	17.59	387.32	476.26	88.93	449.28	487.84	38.56	14764.76	684.23	-14080.53	7558.27	715.40	-6842.87	8379.14	520.23	-7858.91
4320	2232.55	119.42	-2113.14	6902.21	723.98	-6178.23	918.70	16.29	-902.41	1124.57	22.58	-1102.00	1916.99	93.84	-1823.15	2368.69	166.73	-2201.96	208.80	6.56	-202.23	0.04	12.13	12.08	387.32	327.42	-59.90	449.28	335.39	-113.89	14764.76	470.41	-14294.35	7558.27	491.84	-7066.43	8379.14	357.66	-8021.48
Critical Storm	**2232.55**	**2228.52**	**-4.04**	**6902.21**	**13510.55**	**6608.34**	**918.70**	**902.45**	**-16.24**	**1124.57**	**1160.32**	**35.75**	1916.99	**1956.19**	**39.20**	2368.69	**2678.79**	**310.09**	**208.80**	**105.47**	**-103.33**	0.04	**439.79**	**439.74**	387.32	**4757.67**	**4370.35**	**449.28**	**4066.93**	**3617.65**	14764.76	**6013.48**	**-8751.28**	7558.27	**8498.85**	**940.58**	8379.14	**8589.71**	**210.56**
Duration (min)	61.42	61.44		190.99	0.00		10.41	10.43		12.68	12.64		54.38	54.28		95.60	85.22		19.63	85.22		5.30	22.07		21.00	99.30		11.36	123.46		107.18	115.32		43.00	74.10		30.08	45.34	
Intensity (mm/h)	41.06	41.06		20.97	0.00		121.97	121.89		112.91	113.06		45.78	45.86		32.86	35.35		85.19	35.35		161.23	79.79		81.80	31.97		118.18	26.68		30.08	28.12		0.00	38.02		0.00	52.84	

Total Peak Flows
Pre Development 47211.33 m3/s
Post Development 54908.71 m3/s

Culvert Flows	*Max Flow*	*Pre Development*			*Post Development*		
		Inflow(1)	*Flow Through*	*Bypass*	*Inflow(1)*	*Flow Through*	*Bypass*
2.20	0.26	2.23	0.26	1.97	2.23	0.26	1.97
2.28	14.57	8.87	8.87	0.00	15.48	14.57	0.91
2.39	1.45	0.92	0.92	0.00	1.82	1.45	0.36
2.60	8.06	1.12	1.12	0.00	1.52	1.52	0.00
2.89	1.68	1.92	1.68	0.24	1.96	1.68	0.28
3.11	1.04	2.61	1.04	1.57	2.96	1.04	1.92
3.14	1.40	1.78	1.40	0.38	2.02	1.40	0.62
3.20	0.94	0.00	0.00	0.00	1.06	0.94	0.12
3.52	0.73	0.39	0.39	0.00	4.88	0.73	4.15
3.64	1.73	0.45	0.45	0.00	8.21	1.73	6.49
3.89	3.46	14.76	3.46	11.30	12.50	3.46	9.04
Ebrook	0.00	18.86	18.86	0.00	17.54	17.54	0.00
South	0.00	8.38	8.38	0.00	8.59	8.59	0.00

(1) Inflow includes bypass from previous culvert

APPENDIX I LANDSCAPE MASTERPLAN

MUCHEA EMPLOYMENT NODE
PRECINCT 3

LANDSCAPE MASTER PLAN

Prepared for

Muchea Employment Node
Precinct 3 Landowner Group
c/- Tomahawk Property
8/355 Stirling Hwy
CLAREMONT WA 6010

Report No. J18015c
26 September 2019

BAYLEY ENVIRONMENTAL SERVICES
30 Thomas Street
SOUTH FREMANTLE WA 6162

Sundowner Nominees Pty Ltd as trustee for the Bayley Cook Family Trust ABN 20 822 598 897
trading as Bayley Environmental Services

TABLE OF CONTENTS

Page

1.0 INTRODUCTION 1

2.0 EXISTING LANDSCAPE 2

3.0 LANDSCAPING STRATEGY 3

4.0 LANDSCAPING ZONES 4
4.1 Great Northern Highway 4
4.2 Perth-Darwin National Highway 4
4.3 Entry Statement 5
4.4 Bioretention Swales 5
4.5 Lots 5
4.6 Drainage/Landscape Reserve 6
4.7 Ellen Brook Foreshore Reserve 6

5.0 SPECIES SELECTION AND PLANTING DENSITY 7
5.1 Entry Statement 7
5.2 Swales and Basins 7
5.3 Effluent Irrigation Areas 8
5.4 Lot Landscaping 9
5.5 Drainage/Landscape Reserve 10
5.5.1 Reduced Fuel Zone 10
5.5.2 Unrestricted Zone 10
5.6 Ellen Brook Foreshore 11

LIST OF FIGURES

Figure	Title
1	Muchea Employment Node Structure Plan
2	The Project Area and Surroundings
3	Subdivision Concept
4	Views of the Project Area
5	Landscape Master Plan
6	Bioretention Swales
7	Lot Example
8	Ellenbrook Foreshore and Drainage Reserve

1.0 INTRODUCTION

The owners of Lots 35, 192, 194 and 800-804 Great Northern Highway, Muchea (the Project Area) have applied to the WAPC for the lots to be rezoned from Rural to Light Industrial. The Muchea Employment Node Structure Plan 2011 (MENSP) showed the eastern parts of the subject lots as future industrial Precinct 3, bordered on the east by Great Northern Highway and on the west by the new Perth-Darwin National Highway (PDNH). Figure 1 shows the location of the Project Area within the Muchea Employment Node Structure Plan.

The owners have submitted a Local Structure Plan (LSP) for Precinct 3. The total area of the rezoning and LSP is approximately 185 hectares. Figure 2 shows an aerial view of the Project Area and surroundings.

The MENSP concept for Precinct 3 is for low water-use industries with a minimum lot size of one hectare. Figure 3 shows a preliminary conceptual plan of subdivision for the Project Area.

Precinct 3 will constitute the southern gateway to the Shire of Chittering. A priority of the Shire Council is that the precinct should present an attractive visual landscape for observers travelling on the main approaches into Chittering. This includes preserving native vegetation where it occurs (mostly roadside trees), landscape plantings within the precinct, building design and layout of development within lots.

The Shire of Chittering has set out its priorities in its *Muchea Industrial Park Design Guidelines* (2018). The Guidelines deal with development layout within lots, streetscaping, landscaping, bushfire management, fencing, signage and building design. The Shire of Chittering Town Planning Scheme No. 6 also contains provisions relating to landscape within industrial zones. This Landscape Master Plan recognises and reflects the recommendations of the Design Guidelines and the Scheme provisions.

2.0 EXISTING LANDSCAPE

The project area is visible from Great Northern Highway and Brand Highway. The view is screened in part by roadside trees and vegetation within the Project Area. Figure 4 shows views from Great Northern Highway and Brand Highway.

The landscape consists mostly of a mix of cleared paddocks with scattered trees and existing intensive commercial operations including Road Trains of Australia (RTA), Aussie Modular Solutions (AMS) and Inghams' poultry farms. The Perth-Darwin National Highway (PDNH) works have caused a major change to the landscape, particularly near the northern end of the project area.

3.0 LANDSCAPING STRATEGY

Landscaping of the Project Area will focus on the use of species with low water demand. Plantings will include bioretention swales and basins, landscape buffers (to a minimum of 10% of the area of each lot) and street trees. The plantings will not be irrigated after the establishment phase. No turf grass will be planted in public areas, although individual lot owners may choose to plant grass. Lawn areas will not count towards the landscaping requirement on each lot.

Fertiliser use will be minimal. New tube stock plantings will be fertilised with slow-release nitrogen and phosphorus tablets on establishment and thereafter will be unfertilised.

The bioretention basins and swales will be densely planted with inundation and drought tolerant native species including sedges and low shrubs in order to stabilise the swales and maximise their ability to immobilise nutrients and sediments from the water.

The immediate surrounds of Ellen Brook (extending up to 30m from the watercourse) and the drainage/landscape reserve will be densely planted with native trees, sedges, shrubs and other understorey species in order to slow and filter runoff that is not captured by the road drainage system.

The total area to be planted is approximately 32 hectares. If all of this area were planted simultaneously during the establishment phase, approximately 144 ML of water would be required to irrigate the new plantings in the first year. As the project area is likely to be developed in a number of stages, the requirement for irrigation water is likely to be spread out over a number of years, with only a small part of the total demand being required in any one year.

The density of planting within 100m of lots will be controlled to keep flammable ground fuel loads below 8 tonnes/ha, in accordance with the Bushfire Management Plan (Eco Logical Australia, 2018).

Figure 5 shows an overview of the Landscape Master Plan.

4.0 LANDSCAPING ZONES

4.1 Great Northern Highway

The Great Northern Highway road reserve includes a partly-vegetated verge 15m to 30m wide adjacent to Precinct 3. The verge supports remnant native trees including mature Wandoo, Marri and Flooded Gum. The understorey is degraded and consists mostly of weeds including Veldt Grass, Watsonia and pasture grasses.

With the completion of the PDNH, Great Northern Highway is likely to experience a substantial reduction in traffic, although it will still be used for oversize vehicles and will retain its Main Roads status.

The road verge trees play an important role in breaking up and softening the view of the industrial area from the Highway. There are, however, a number of gaps ranging from a few tens of metres up to 100m where no trees remain. The priority for landscaping in the road reserve is to protect and retain the existing trees and to control weeds in the understorey.

The road reserve is currently classed as “Grassland” under the Bushfire Management Plan, with a moderate fire hazard rating. This classification is due to the spacing of the existing trees, the separation of canopies and the absence of a mid-storey. The fire hazard would be increased by any substantial increase in the overstorey canopy density or by an increased understorey. The hazard could be reduced if the road reserve were managed to reduce the height of the grass ground cover.

4.2 Perth-Darwin National Highway

The PDNH, to be opened in 2019, will be the new major arterial route from Perth to the north and is expected to carry the majority of both heavy and light vehicle traffic (except oversize vehicles). Lots within Precinct 3 will not have frontage or direct access to the PDNH; all access will be via the interchange located about 1km north of the Precinct.

The PDNH is being constructed on a substantial embankment and as a result will offer views over much of Precinct 3.

The landscape objective for the PDNH is to create partial screening to break up and soften the views into the Precinct, without blocking the views altogether. This will be achieved by planting shrubs and widely-spaced trees in the overflow drainage swale within the subdivisional road adjacent to the PDNH and, in the north, at the rear of lots adjacent to the PDNH.

The density of planting in the PDNH buffer will be constrained by the need to limit flammable fuel loads as set out in the Bushfire Management Plan (Eco Logical Australia, 2018).

4.3 Entry Statement

A small (0.5ha) triangular reserve in the south-east corner of the precinct will act as the entry statement to the Precinct from the south, as well as protecting a small creek line crossing the corner of the Project Area. This reserve will be planted with sedges, small shrubs and scattered trees.

4.4 Bioretention Swales

Bioretention swales varying in width from 4m to 10m will be located on one side of all roads within the Precinct, as well as two dedicated 15m wide drainage corridors. The swales will carry runoff from the roads, excess lot runoff and, in some cases, flows from catchments to the east.

The swales will be densely planted with native sedges, small (<2m) shrubs and widely-spaced small trees to stabilise the swales, slow the water flows and maximise the uptake of sediments and nutrients from the water. Figure 6 shows conceptual profiles of the roadside swales.

4.5 Lots

The Shire of Chittering's Design Guidelines set out the Shire's requirements and recommendations for landscaping within lots. Other requirements arise from provisions for drainage and effluent disposal within the lots.

The general landscaping within lots will include:

- a minimum 2m wide landscape buffer on the primary road frontage;
- a minimum 1m wide landscape buffer on secondary road interface and side boundaries extending to the building setback line;
- one shade tree per four car parking bays;
- one tree per 10m of road frontage;
- a bioretention swale to hold the 1-year ARI 1-year storm, typically measuring about 3% of the total area of the lot;
- an effluent disposal area (probably ATU irrigation area) planted with low shrubs, with size depending on the lot workforce (about 23m^2 per full-time employee); and
- other landscape plantings to a total of 10% of the area of the lot.

Plantings within lots will generally feature sedges and other ground covers, low shrubs (<2m) and widely spaced trees in order to comply with the requirements of the Bushfire Management Plan. It is noted that the Design Guidelines requirement for one tree every 10m of road frontage may, depending on the size of the trees, exceed the permissible canopy density for "Shrubland" under the Bushfire Management Plan. It is proposed instead to space trees 15m apart in all areas within 100m of lots.

Figure 7 shows an indicative layout of landscape plantings for a typical lot.

4.6 Drainage/Landscape Reserve

The drainage/landscape reserve in the south-west of the Project Area, measuring 8.4ha, will accommodate the 100-year floodway of Ellen Brook as well as excess runoff from the industrial area during a 100-year storm. The reserve will be planted in a similar way to the swales, with dense sedges, shrubs and trees.

In the eastern part of the reserve within 100m of lots, shrub plantings will be limited to species less than 2m in height and trees will be spaced at least 15m apart to create less than 10% canopy cover, in line with the recommendations of the Bushfire Management Plan. In areas more than 100m from lots, the planting will be unrestricted and will include larger shrubs and a greater density of trees. Figure 8 shows the planting zones within the reserve.

4.7 Ellen Brook Foreshore Reserve

The Project Area abuts Ellen Brook for a length of about 600m south and east of the PDNH crossing. The foreshore supports remnant native vegetation but is degraded due to past clearing and cattle grazing, with high levels of weed invasion and loss of most native understorey species.

The priorities for landscaping in the foreshore reserve will be to maintain and improve the stability of the watercourse, control invasive weeds and re-establish native riparian species. Figure 8 shows the foreshore area to be rehabilitated.

5.0 SPECIES SELECTION AND PLANTING DENSITY

Species to be planted in the Project Area will be local native species, with species for specific areas selected for their height and inundation and/or drought tolerance. Recommended species for each situation are listed below:

5.1 Entry Statement

- Planting area approx. 0.5ha.
- Planted with sedges & herbs, small shrubs and scattered trees.

Sedges & Herbs

- Planting density 2,500/ha (2m spacing).
- Recommended species:

Hypolaena exsulca	*Lyginia imberbis*
Juncus kraussii	*Patersonia occidentalis*
Lepidosperma longitudinale	*Phlebocarya ciliata*

Low Shrubs (<2m)

- Planting density 2,500/ha (2m spacing).
- Recommended species:

Acacia lasiocarpa	*Phyllanthus calycinus*
Hibbertia hypericoides	*Xanthorrhoea preissii*
Hypocalymma angustifolium	

Tall Shrubs (>2m) and Trees

- Planting density <50/ha (15m spacing).
- Recommended species:

Allocasuarina fraseriana	*M. teretifolia*
Corymbia calophylla	*M. preissiana*
Eucalyptus wandoo	*M. rhaphiophylla*
Gastrolobium ebracteolatum	*Viminaria juncea*
Melaleuca incana	

5.2 Swales and Basins

- Includes in-lot 1-yr ARI basins, roadside swales and through-flow swales.
- Planting area approx. 10.1ha.
- Densely planted with sedges, herbs, low shrubs and scattered small trees.
- “Shrubland” classification.

Sedges & Herbs

- Planting density 10,000/ha (1m spacing)

- Recommended species:

Baumea articulata	*Juncus kraussii*
Baumea juncea	*Juncus pallidus*
Conostylis aculeata	*Lepidosperma longitudinale*
Dasypogon bromeliifolius	*Lyginia imberbis*
Gahnia trifida	*Patersonia occidentalis*
Hypolaena exsulca	*Phlebocarya ciliata*

Shrubs (<2m)

- Planting density 2,500/ha (2m spacing)
- Recommended species:

Acacia lasiocarpa	*Phyllanthus calycinus*
Hibbertia hypericoides	*Regelia ciliata*
Hypocalymma angustifolium	*Xanthorrhoea preissii*

Tall Shrubs (>2m) and Trees

- Planting density <50/ha (15m spacing).
- Recommended species:

Acacia saligna	*Melaleuca rhaphiophylla*
Casuarina obesa	*Viminaria juncea*
Melaleuca preissiana	

5.3 Effluent Irrigation Areas

- Planting area approx. 2.5ha (depending on workforce on individual lots).
- Planted with dense low shrubs, sedges &herbs.
- “Shrubland” classification.

Sedges & Herbs

- Planting density 10,000/ha (1m spacing).
- Recommended species:

Hypolaena exsulca	*Lyginia imberbis*
Juncus kraussii	*Patersonia occidentalis*
Lepidosperma longitudinale	*Phlebocarya ciliata*

Low Shrubs (<2m)

- Planting density 2,500/ha (2m spacing).
- Recommended species:

Acacia lasiocarpa	*Phyllanthus calycinus*
Hibbertia hypericoides	*Regelia ciliata*
Hypocalymma angustifolium	*Xanthorrhoea preissii*

5.4 Lot Landscaping

- Planting area approx. 8.4ha.
- Includes front & side boundary landscape buffers and other plantings to total 10% of lot area.
- Planted with sedges & herbs, low shrubs and scattered trees.
- "Shrubland" classification.

Sedges & Herbs

- Planting density 2,500/ha (2m spacing).
- Recommended species:

Hypolaena exsulca	*Lyginia imberbis*
Juncus kraussii	*Patersonia occidentalis*
Lepidosperma longitudinale	*Phlebocarya ciliata*

Low Shrubs (<2m)

- Planting density 2,500/ha (2m spacing).
- Recommended species:

Acacia lasiocarpa	*Phyllanthus calycinus*
Hibbertia hypericoides	*Xanthorrhoea preissii*
Hypocalymma angustifolium	

Tall Shrubs (>2m) and Trees

- Planting density <50/ha (15m spacing).
- Recommended species:

Allocasuarina fraseriana	*M. teretifolia*
Casuarina obesa	*M. preissiana*
Corymbia calophylla	*M. rhaphiophylla*
Eucalyptus rudis	*Gastrolobium ebracteolatum*
E. wandoo	*Viminaria juncea*
Melaleuca incana	

5.5 Drainage/Landscape Reserve

5.5.1 Reduced Fuel Zone

- Planting area approx. 5.9ha.
- Within 100m of lots.
- Planted with sedges, herbs, low shrubs (<2m) and scattered trees (<10% cover).
- "Shrubland" classification.

Sedges & Herbs
- Planting density 10,000/ha (1m spacing).
- Recommended species as for swales.

Low Shrubs (<2m)
- Planting density 2,500/ha (2m spacing).
- Recommended species as for swales.

Tall Shrubs (>2m) and Trees
- Planting density <50/ha (15m spacing).
- Recommended species as for swales.

5.5.2 Unrestricted Zone

- Planting area approx. 2.5ha.
- More than 100m from lots.
- Planted with sedges & herbs, shrubs and trees.
- "Woodland" classification.

Sedges & Herbs
- Planting density 10,000/ha (1m spacing).
- Recommended species as for swales.

Shrubs
- Planting density 400/ha (5m spacing).
- Recommended species:

Acacia lasiocarpa	*Melaleuca incana*
Acacia saligna	*Melaleuca teretifolia*
Hakea prostrata	*Gastrolobium ebracteolatum*
Hibbertia hypericoides	*Pericalymma ellipticum*
Hypocalymma angustifolium	*Phyllanthus calycinus*
Jacksonia furcellata	*Regelia ciliata*
J. sternbergiana	*Viminaria juncea*
Kunzea glabrescens	*Xanthorrhoea preissii*

Trees
- Planting density 50/ha (50m spacing).

- Recommended species:

Allocasuarina fraseriana	*Eucalyptus rudis*
Casuarina obesa	*Melaleuca. preissiana*
Corymbia calophylla	*M. rhaphiophylla*

5.6 Ellen Brook Foreshore

- Planting area approx. 1.6ha.
- Planted with sedges & herbs, shrubs and trees.
- Infill planting between existing native species.
- Weed control prior to planting.
- “Woodland” classification.

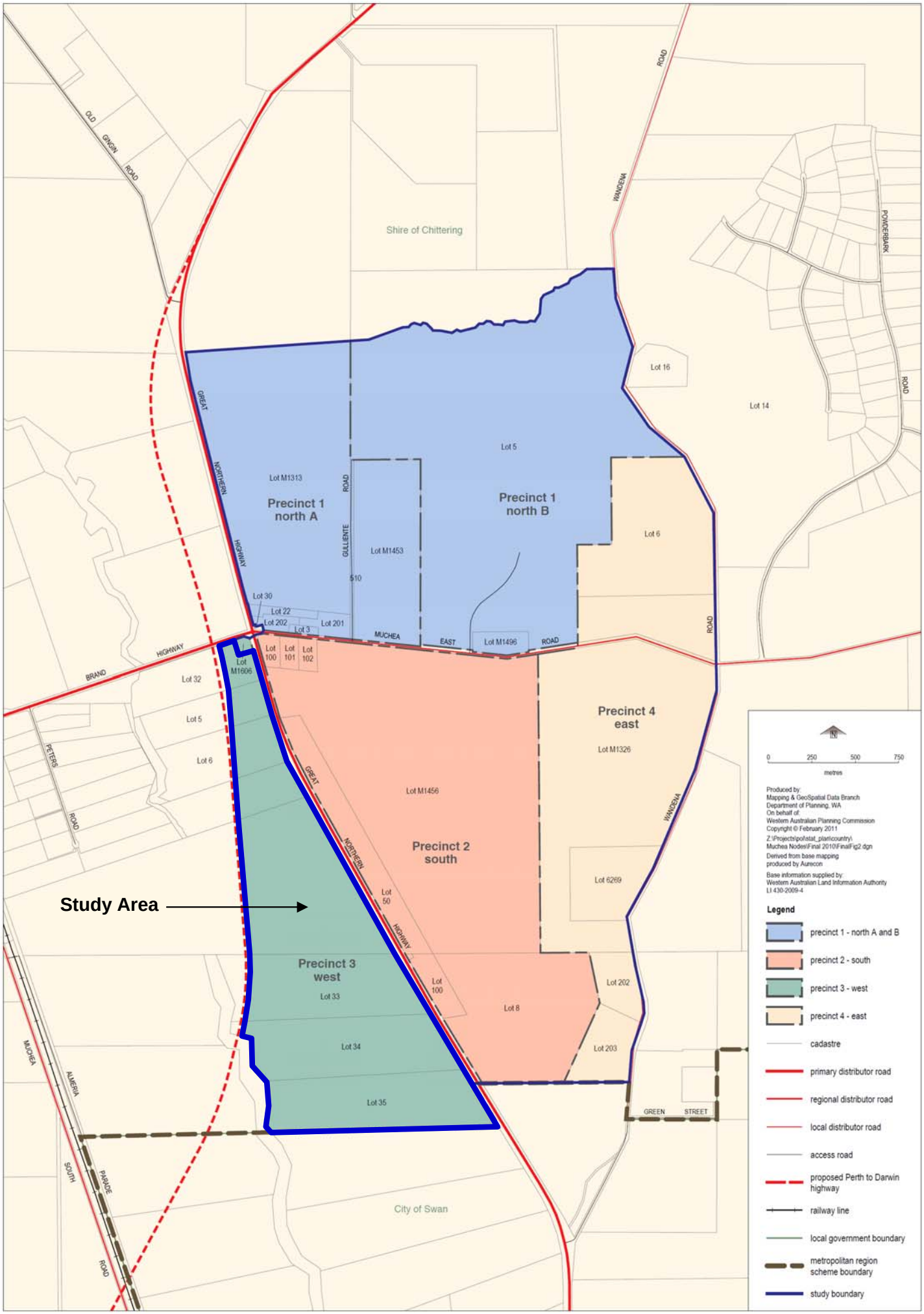
Sedges & Herbs

- Planting density up to 10,000/ha (1m spacing), in clumps.
- Recommended species:

Baumea articulata	*Lepidosperma longitudinale*
Baumea juncea	*Lyginia imberbis*
Hypolaena exsulca	*Patersonia occidentalis*
Juncus kraussii	*Phlebocarya ciliata*
Juncus pallidus	

–

Figures



Source: WAPC, 2011

Figure 1

MUCHEA EMPLOYMENT NODE STRUCTURE PLAN

bayley environmental services



Figure 2

THE PROJECT AREA AND SURROUNDINGS

Image: Google Earth

bayley environmental services

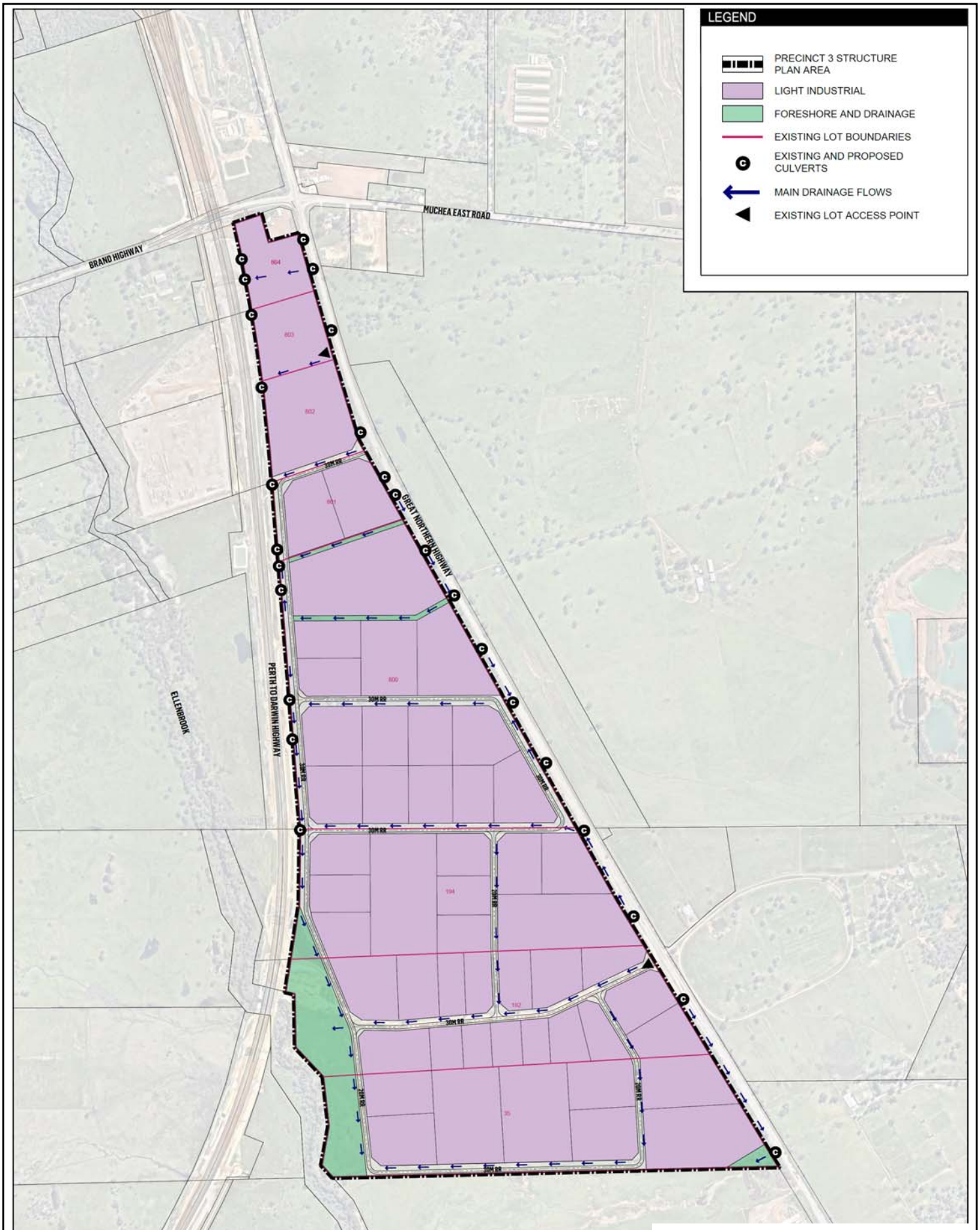


Figure 3

SUBDIVISION CONCEPT

URBIS

bayley environmental services



Lot 35 from Great Northern Highway



Lot 192 (RTA) from Great Northern Highway



Lot 800 (Inghams) from Great Northern Highway



Lot 803 (AMS) from Great Northern Highway



Lot 804 from Great Northern Highway

Figure 4

VIEWS OF THE PROJECT AREA

All images: Google

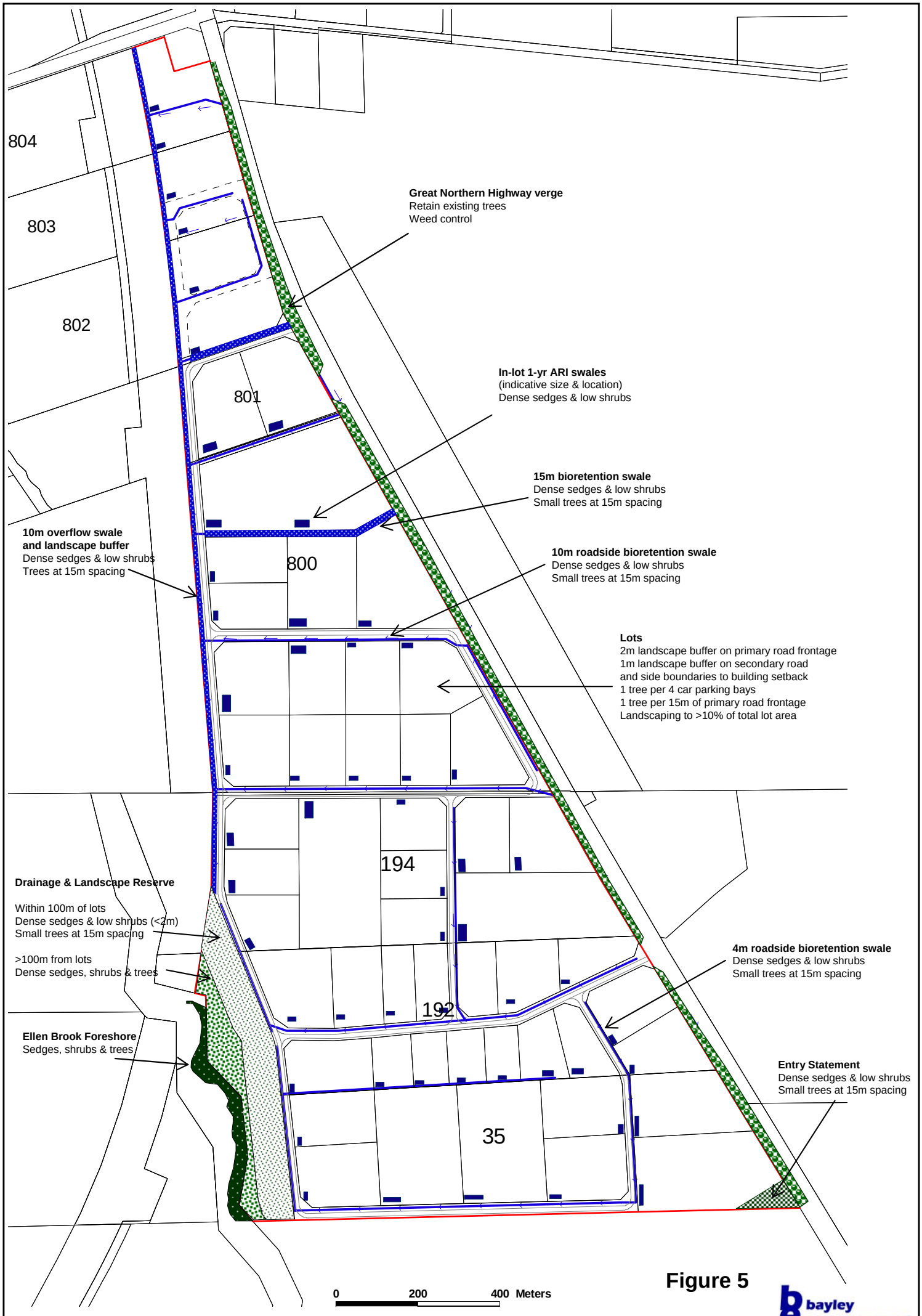


Figure 5

LANDSCAPE MASTER PLAN

bayley environmental services

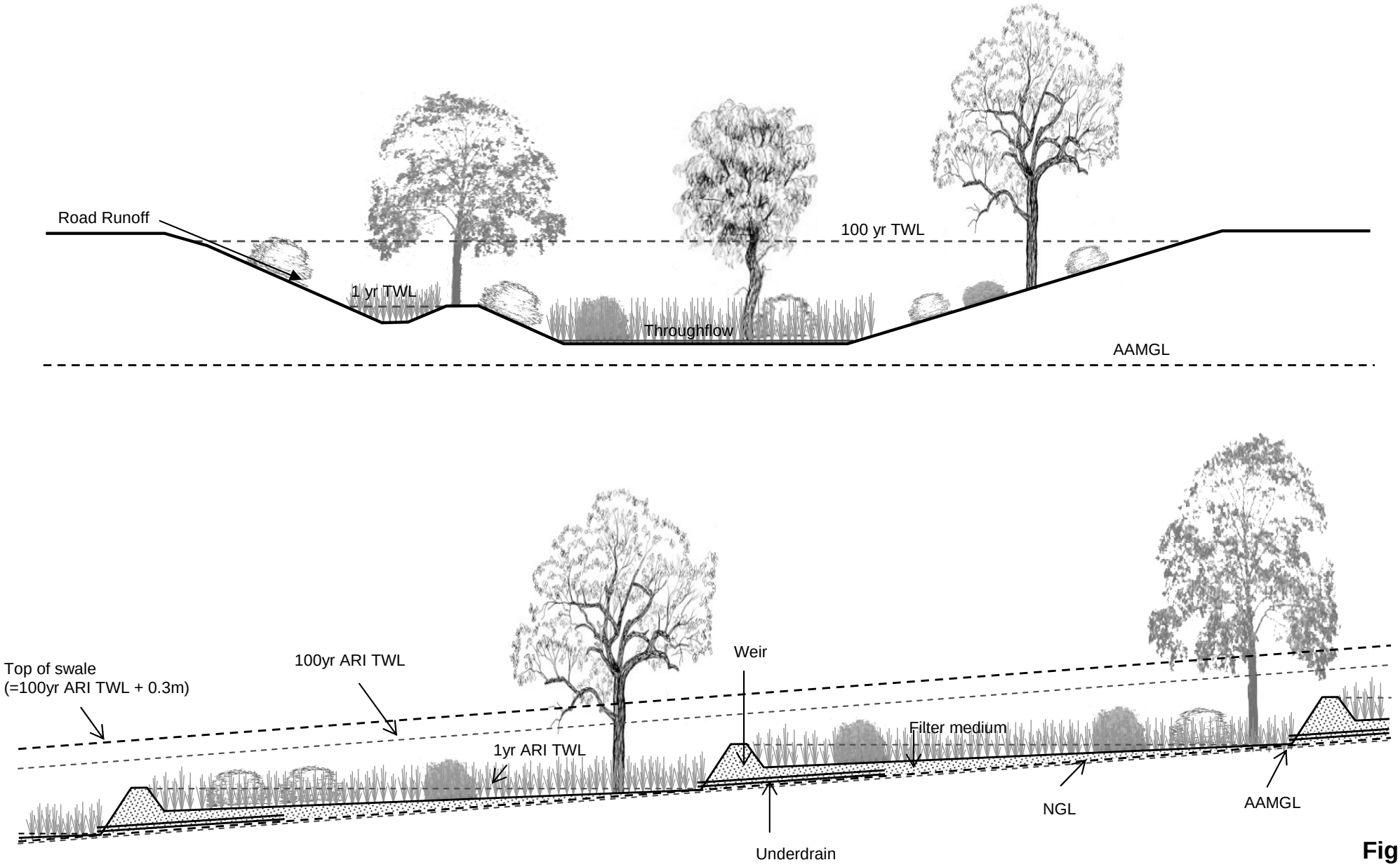


Figure 6

BIORETENTION SWALES

bayley environmental services

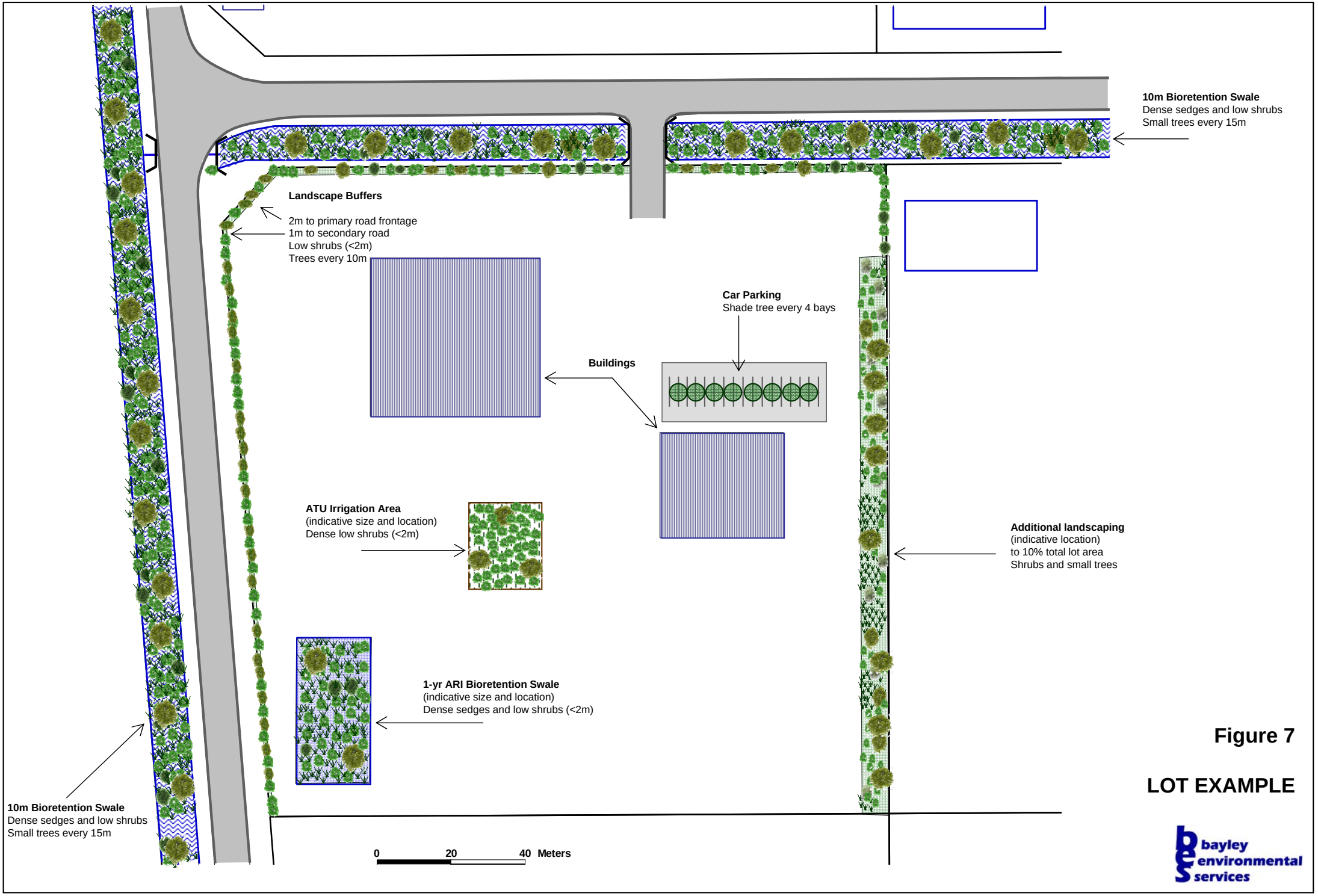


Figure 7

LOT EXAMPLE

bayley environmental services

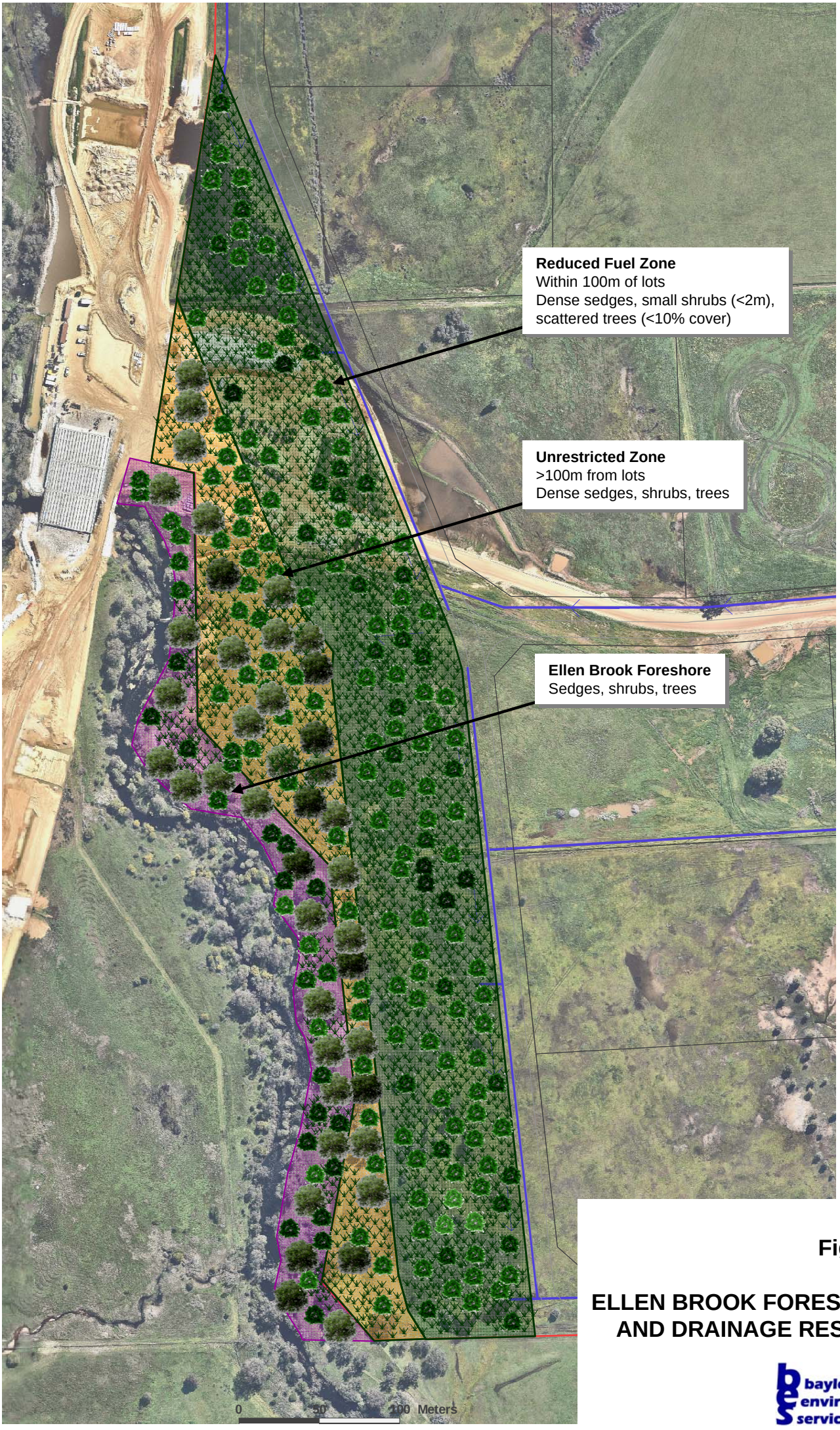


Figure 8

ELLEN BROOK FORESHORE AND DRAINAGE RESERVE

bayley environmental services

DISCLAIMER

This report is dated 3 October 20189 and incorporates information and events up to that date only and excludes any information arising, or event occurring, after that date which may affect the validity of Urbis Pty Ltd's (**Urbis**) opinion in this report. Urbis prepared this report on the instructions, and for the benefit only, of Tomahawk Property on behalf of the Muchea Employment Node Precinct 3 Landowners Group (**Instructing Party**) for the purpose of Structure Plan (**Purpose**) and not for any other purpose or use. To the extent permitted by applicable law, Urbis expressly disclaims all liability, whether direct or indirect, to the Instructing Party which relies or purports to rely on this report for any purpose other than the Purpose, and to any other person which relies or purports to rely on this report for any purpose whatsoever (including the Purpose).

In preparing this report, Urbis was required to make judgements which may be affected by unforeseen future events, the likelihood and effects of which are not capable of precise assessment.

All surveys, forecasts, projections and recommendations contained in or associated with this report are made in good faith and on the basis of information supplied to Urbis at the date of this report, and upon which Urbis relied. Achievement of the projections and budgets set out in this report will depend, among other things, on the actions of others over which Urbis has no control.

In preparing this report, Urbis may rely on or refer to documents in a language other than English, which Urbis may arrange to be translated. Urbis is not responsible for the accuracy or completeness of such translations and disclaims any liability for any statement or opinion made in this report being inaccurate or incomplete arising from such translations.

Whilst Urbis has made all reasonable inquiries it believes necessary in preparing this report, it is not responsible for determining the completeness or accuracy of information provided to it. Urbis (including its officers and personnel) is not liable for any errors or omissions, including in information provided by the Instructing Party or another person or upon which Urbis relies, provided that such errors or omissions are not made by Urbis recklessly or in bad faith.

This report has been prepared with due care and diligence by Urbis and the statements and opinions given by Urbis in this report are given in good faith and in the reasonable belief that they are correct and not misleading, subject to the limitations above.



BRISBANE
Level 7, 123 Albert Street
Brisbane QLD 4000
Australia
T +61 7 3007 3800

GOLD COAST
45 Nerang Street,
Southport QLD 4215
Australia
T +61 7 5600 4900

MELBOURNE
Level 12, 120 Collins Street
Melbourne VIC 3000
Australia
T +61 3 8663 4888

PERTH
Level 14, The Quadrant
1 William Street
Perth WA 6000
Australia
T +61 8 9346 0500

SYDNEY
Tower 2, Level 23, Darling Park
201 Sussex Street
Sydney NSW 2000
Australia
T +61 2 8233 9900

CISTRI – SINGAPORE
An Urbis Australia company
#12 Marina View
21 Asia Square, Tower 2
Singapore 018961
T +65 6653 3424
W cistri.com

URBIS.COM.AU