Structure Plan

Mundijong-Whitby Sub-Precinct G1



Prepared for Peet Syndicate Ltd

Prepared by Taylor Burrell Barnett

23 April 2024

Taylor Burrell Barnett

Document Information

Structure Plan

Mundijong-Whitby Sub-Precinct G

06~066

Prepared by: Taylor Burrell Barnett

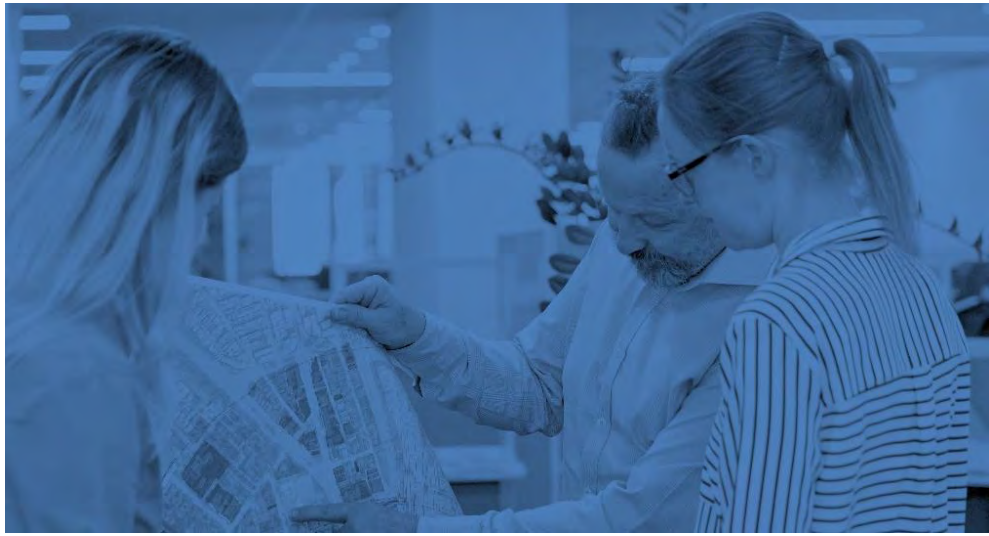
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Emerge Associates
RPS Group
Herring Storer
Riley Consulting
Ethnosciences
Wave International



Doc ID: 06~066 Mundijong-Whitby Sub-Precinct G1 Structure Plan 1.3 Rev 5 FINAL

Revision	Status	Author	Approved by	Date Issued
	Rev 1	KS	RC	Feb 2016
	Rev 2	KS	RC	23/06/2023
	Rev 3	RC	RC	28/03/2024
	Rev 4	KS	RC	11/04/2024
	Rev 5	KS	RC	23/04/2024

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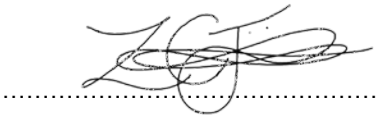
Endorsement

This Structure Plan is prepared under the provision of the Shire of Serpentine Jarrahdale Town Planning Scheme No. 3

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

01 May 2024

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



.....

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

Witness:  .....

Date: 02 May 2024

Date of Expiry: 02 May 2034

Table of Amendments

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

Table of Density Plan

Density Plan No.	Area of Density Plan Application	Date Endorsed by WAPC

Executive Summary

This Structure Plan applies to Lots 1 & 2 Bishop Road, Lots 3, 5, 10, 11 & 9000 Taylor Road, Lots 1, 2 & 4 (Service Corridor) and unnamed / unmade portions of road reserve, Mundijong (the subject land). The subject land is located in the Perth Metropolitan South East Corridor, within the municipality of the Shire of Serpentine Jarrahdale. The subject land is approximately 1 kilometre (km) north-west of the Mundijong town centre and 40km south-east of the Perth Central Area, and is accessible via South Western Highway, Mundijong Road, and the Kwinana Freeway.

The Structure Plan proposes residential development predominately at a R25 density and ranging up to R60, areas for conservation and public open space (POS), two primary schools, one community site and one neighbourhood centre. One existing private school (Court Grammar School, Pre-K to Year 12) is located in the north-eastern corner of the Structure Plan area.

The subject land forms part of Precinct G of the Mundijong-Whitby District Structure Plan (DSP). The proposed Structure Plan is consistent with the Mundijong-Whitby DSP which identifies the site for residential development and two primary schools. There has been no previous local structure planning over the subject land.

Item	Data		Structure Plan Ref. (Section No.)
Total area covered by the Structure Plan	206.4525 ha		1.2.2
Area of each land use proposed:	**Hectares (ha)**	**Lot Yield**	3.2
• Residential	103.4043 3079	2,897	
• Commercial	0.7149	1	
• Public Purposes (Primary School)	14.4962	1	
• Public Purposes (Utility Corridor)	7.1910	1	
Total Estimated Lot Yield	2,897		3.2.1
Estimated No. of Dwellings	2,897		3.2.1
Estimated Residential Site Density	14.53 dwellings per gross ha of urban zoned land 29.96 dwellings per site/ ha		3.2.1
Estimated Population	8,546 (based on 2.95 people per dwelling)		3.6
No. of High Schools	N/A		3.6
No. of Primary Schools (proposed)	2		3.7
No. of Primary Schools (existing)	1		3.7
Estimated Commercial Floor Space	2,500sqm		3.3
Estimated area and percentage of Public Open Space given over to:			3.3
• Neighbourhood Parks (>3,000sqm)	20.4704 ha	17 parks	
• Local Parks (<3,000sqm)	1.5323 ha	10 parks	
Estimated percentage of natural area			3.3
• Manjedal Brook (including 50m buffer)	15.0133 ha	7.27%	
• Conservation Category Wetland (including 50m buffer)	5.4194 ha	2.63%	

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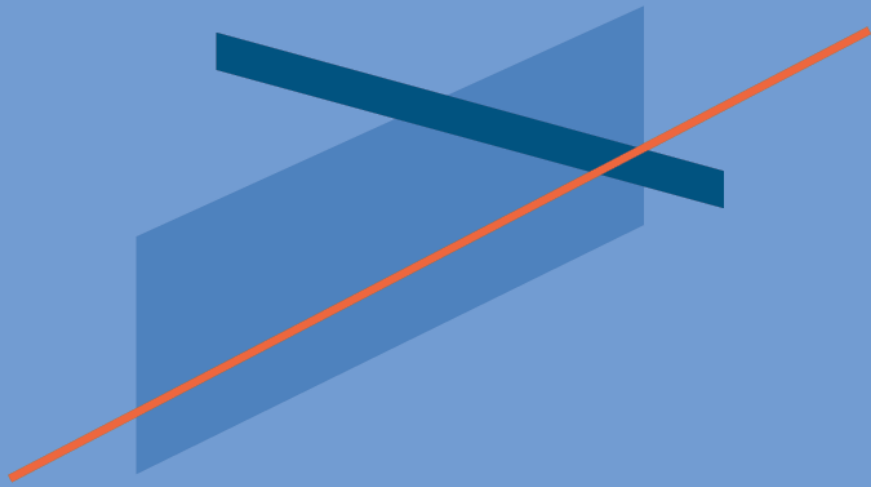
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Part 1.0

Implementation



1.0 Structure Plan Area

This Structure Plan (SP) shall apply to Lots 1 & 2 Bishop Road, Lots 3, 5, 10, 11 & 9000 Taylor Road, Lots 1, 2 & 4 (Service Corridor) and unnamed / unmade portions of road reserve, Mundijong, being the land contained within the inner edge of the line denoting the SP boundary on the SP Map (**Plan 1**).

2.0 Operation

This SP comes into operation when it is endorsed by the Western Australian Planning Commission (WAPC) pursuant to section 16 of the Planning and Development Act 2005.

3.0 Staging

The staging of subdivision and development will be heavily influenced by market forces, connection to infrastructure, demand for community facilities and changes to the district road and rail network.

Servicing infrastructure required to support future development of the subject land is either in place or can be provided to service the SP area and as such is not regarded as an impediment to staging.

Land outside of the area subject to future investigation of the potential freight rail realignment will be a driver in considering the initial stages of development. Development from the north and east of the SP area with access via existing Bishop and Soldiers Roads is heavily constrained, depending on the resolution of future traffic and rail matters.

.

There presents an opportunity to commence development where access is able to be obtained from the existing road network (i.e., Taylor Road). Staging within this area is also highly dependent on the demand for community facilities such as the proposed primary school and neighbourhood centre.

Consideration will also be given to the delivery of open space and other areas of high amenity in the early stages of development. Whilst it will not be possible to create all open space within the first stage of development due to the size and timeframe of the project, consideration will be given to delivery having regard for accessibility to residents, urban water management requirements and staged infrastructure provision.

The delivery timeframe of the neighbourhood centre will be largely determined by economic factors, the rate of population growth and future traffic volumes.

4.0 Subdivision and Development Requirements

4.1 Land Use

The SP map (**Plan 1**) outlines the following land use, zones and reserves applicable within the SP area:

4.1.1 Residential (R10-R60)

4.1.1.1 Dwelling Target

Objective: To provide for a minimum 15 dwellings per gross ha of urban zoned land within the SP area.

a) Subdivisions are generally to achieve the following:

   i) 15 dwellings per gross ha.

4.1.1.2 Density

a) **Plan 1** (Structure Plan) defines the broad residential density ranges that apply to different areas within the SP. Lot-specific residential densities, generally in accordance with the defined residential density ranges, are to be subsequently assigned in accordance with a Residential Density Code Plan approved by the WAPC.

b) A Residential Density Code Plan is to be submitted at the time of application for subdivision approval to the WAPC, and shall indicate the Residential Density Code applicable to each lot within the proposed subdivision and shall be generally consistent with the residential density ranges identified in the SP and locational criteria identified in Clause 4.1.1.3.

c) The Residential Density Code Plan is to include a summary of the proposed dwelling yield of the proposed subdivision.

d) Approval of the Residential Density Code Plan shall be undertaken at the time of determination of the subdivision application by the WAPC. The approved Residential Density Code Plan shall then form part of the SP and shall be used for the determination of future development applications.

e) Variations to the Residential Density Code Plan will require further approval of the WAPC, with a revised Residential Density Code Plan submitted generally consistent with the approved plan of subdivision issued by the WAPC. The revised Residential Density Code Plan shall be consistent with Residential Density ranges identified on **Plan 1** and the locational criteria contained in clause 4.1.1.3.

f) A revised Residential Density Code Plan, consistent with clause 4.1.1.2 (e) will replace, wholly or partially, the previously approved Residential Density Code Plan, and shall then form part of the SP as outlined in clause 4.1.1.2 (d).

g) Residential Density Code Plan are not required if the WAPC considers that the subdivision is for one or more of the following:

   i) the amalgamation of lots;

   ii) consolidation of land for ‘superlot’ purposes to facilitate land assembly for future development;

   iii) the purposes of facilitating the provision of access, services or infrastructure; or

   iv) land which by virtue of its zoning or reservation under the SP cannot be developed for residential purposes.

4.1.1.3 Locational Criteria

The allocation of residential densities on the Residential Density Code Plan shall be in accordance with the following criteria:

a) R10:
R10 density shall apply in areas abutting major road and rail corridors to help alleviate and/or manage noise, in addition to noise mitigation measures through quiet house requirements as identified in the Noise and Vibration Assessment prepared by Herring Storer (dated December 2015) and Addendum (dated April 2023), as amended.

b) R40/R60:
R40/R60 density shall apply in areas of high amenity, being lots located within 400m of public open space (POS) and conservation areas, schools or a neighbourhood centre and lots abutting higher order streets (i.e. neighbourhood connector roads) and public transport routes.

c) R25:
R25 density shall apply for the remainder of residential land in the SP area.

4.1.2 Public Open Space and Drainage

POS is intended to be public land vested with the local government, and is to function as open space for a wide variety of active and passive uses. POS is to be provided generally in accordance with **Plan 1** and achieve a minimum of 10% POS provision in accordance with the WAPC's Liveable Neighbourhoods.

4.1.3 Environmental Conservation

The SP provides for the retention of natural environmental features including the Conservation Category Wetland (CCW) and Manjedal Brook. The SP allows for the protection of these attributes through the provision of appropriate buffers.

A 50m wide buffer either side of the Manjedal Brook has been identified on the SP. A biophysical assessment will be required to support a reclassification of the Brook to a Resource Enhancement Wetland (REW) and subsequent modification to the SP to enable a reduced buffer, subject to consultation with the Department of Water and Environmental Regulation (DWER) and approval of a SP amendment by the WAPC.

4.1.4 Public Purposes – Education, Primary School, High School

Unless otherwise advised by the Department of Education and agreed by the WAPC, the two proposed primary school sites as depicted on **Plan 1** shall be ceded free of cost to the Crown as a reserve for 'Public Purposes – Primary School' at the appropriate subdivision stage. One existing private school (Court Grammar School) is located within the north-eastern corner of the SP area.

4.1.5 Public Purposes – Infrastructure Services

The land identified along the western boundary of the SP has already been transferred to the Water Corporation for a future Service Corridor. Accordingly, the land has been depicted on **Plan 1** as a future Public Purposes Reserve – Infrastructure Services.

5.0 Local Development Plans

Local Development Plans (LDP) shall be prepared and implemented by the Shire of Serpentine-Jarrahdale pursuant to Part 6, Clause 47 of the Planning and Development (Local Planning Schemes) Regulations 2015, prior to subdivision and/or development of:

- Lots smaller than 260m^2;
- Lots abutting POS areas;
- Lots abutting the Water Corporation Service Corridor, depicted as 'Public Purposes - Infrastructure Services' on **Plan 1**;
- Lots deemed to be bushfire prone as identified in an approved Bushfire Management Plan;
- Lots deemed to be impacted by noise and/or vibration as identified in the Noise and Vibration Assessment prepared by Herring Storer (dated December 2015) and Addendum (dated April 2023), as amended;
- Rear-loaded (laneway) lots; and
- The Neighbourhood Centre.

LDPs shall be prepared in a manner and form in accordance with Part 6, Clause 48(1) of the Planning and Development (Local Planning Schemes) Regulations 2015.

Matters to be addressed in the LDPs may include (but are not limited to) the following:

- In regard to the Neighbourhood Centre, distribution of residential and non-residential land uses;
- Access and parking arrangements;
- Dwelling orientation and passive surveillance of the adjoining public realm;
- Noise amelioration measures; and
- Higher building standards in accordance with AS3959.

6.0 Other Requirements

6.1 Local Planning Policies

6.1.1 Local Planning Policy 2.2 – Residential Development Standards (R25-R60)

Presently, the development standards outlined in Local Planning Policy 2.2 – Residential Development Standards (R25 – R60) (LPP 2.2) apply to all residential development with an R-Code between R25 and R60 as shown on an approved SP. The provisions of the R-Codes will apply in all other areas where not varied by LPP 2.2 or a LDP.

6.1.2 Built Form Design Guidelines

As outlined in Appendix 9 – Development Areas of the Shire of Serpentine-Jarrahdale Town Planning Scheme No. 2 (TPS 2), for land located within Development Area 1 (DA1), a LPP (Built Form Design Guidelines) may be adopted by the Shire of Serpentine-Jarrahdale prior to the development of the subject land.

6.1.3 Landscape Design Guidelines

As outlined in Appendix 9 – Development Areas of TPS 2, for land located within DA1, a LPP (Landscape Design Guidelines) may be prepared to establish measures to be adopted to implement public and private landscaping, prior to applications for development.

6.2 Water Corporation Service Corridor and Waste Water Pump Station

The Water Corporation Service Corridor (60m wide) is located along the western boundary of the subject land associated with the future construction of a permanent waste water pump station (WWPS). The Water Corporation has recently constructed an interim Type 90 WWPS to the south of Scott Road to service the subject land. The 30m buffer measured from the centre of the wet well will not extend into the subject land.

The ultimate Type 350 WWPS to service the Mundijong area is also proposed south of Scott Road. The 50m buffer associated with the WWPS is not likely to extend into the subject land. The exact location of the ultimate WWPS is subject to land acquisition by the Water Corporation.

6.3 Development Contributions

The Shire has prepared a Development Contribution Arrangement for the Mundijong-Whitby Development Contribution Area (DCA) for the provision of traditional and community infrastructure, inclusive of the LSP area.

Landowners will be required to make a contribution towards a shared funding arrangement for both traditional and community infrastructure at the time of subdivision/development.

6.4 Aboriginal Heritage

An application was made under Section 18 of the *Aboriginal Heritage Act 1972* (AHA) on 12 December 2019 and consent granted by the Minister for Aboriginal Affairs on 26 April 2020 (subject to conditions). Archaeological sites identified as meeting the requirements of section 5 of the in the AHA and proposed to be disturbed through development of the subject land are outlined in the Aboriginal Archaeological Assessment prepared by Thomson Cultural Heritage Management (April 2014).

Furthermore, an Aboriginal Heritage Management Plan shall be prepared and implemented prior to subdivision.

6.5 Bushfire Management

The SP is supported by a Bushfire Management Plan (BMP) prepared by Emerge Associates.

Where appropriate, development and subdivision will have regard to the Bushfire Attack Level (BAL) Assessment contained in this Report and be determined in accordance with State Planning Policy 3.7 Planning in Bushfire Prone Areas (SPP 3.7). Applications

for Subdivision Approval and Development Approval will be required to be accompanied by stage specific Bushfire Management Plans in accordance with the provisions of SPP 3.7. Future stage-specific BMPs will need to address the vegetation classification and associated BAL rating of the multiple use corridors (MUCs) for the post-development scenario.

Where a subdivision application includes land with a BAL of 12.5 or greater, the Local Government shall recommend to the WAPC that a condition be imposed on the grant of subdivision approval for a notification to be placed on the Certificate of Title.

6.6 Noise and Vibration

Noise attenuation treatments as per the recommendations outlined in the Noise and Vibration Assessment prepared by Herring Storer (dated December 2015) and Addendum (dated April 2023), or as amended, including but not limited to the construction of noise walls, notifications on title, and quiet house design, shall be implemented as conditions of subdivision approval for any lots affected by the presence of future Tonkin Highway and passing freight trains, unless an updated and more accurate Acoustic Assessment is provided with, and approved for, any future subdivision application for the lots within the trigger distance of major roads and rail.

Updated Noise Management Plans will also be required at the subdivision stage.

6.7 Area Subject to Future Planning Investigation

The LSP does not constitute a SP pursuant to the Planning and Development (Local Planning Scheme) Regulations 2015 Schedule 2 – Deemed provisions for the area identified on Plan 1 as 'Area Subject to Future Planning Investigation (Freight Rail Realignment)' until such time as a subsequent Structure Plan amendment has been lodged and assessed to the satisfaction of the WAPC.

6.8 Grade-separated Crossing

The SP accommodates an at-grade key road connection between the SP area and Whitby Town Centre. However, the Department of Planning, Lands & Heritage (DPLH) and the Shire have advised that the increase in traffic in the locality may require a grade separated crossing to be developed at this location.

In the absence of any State Government commitment to the grade-separated crossing and designs/land area requirements, the SP identifies the area subject to further investigation for a grade-separated railway crossing to provide an area to be set aside to accommodate the future grade-separated structure.

6.9 Gas Pipeline

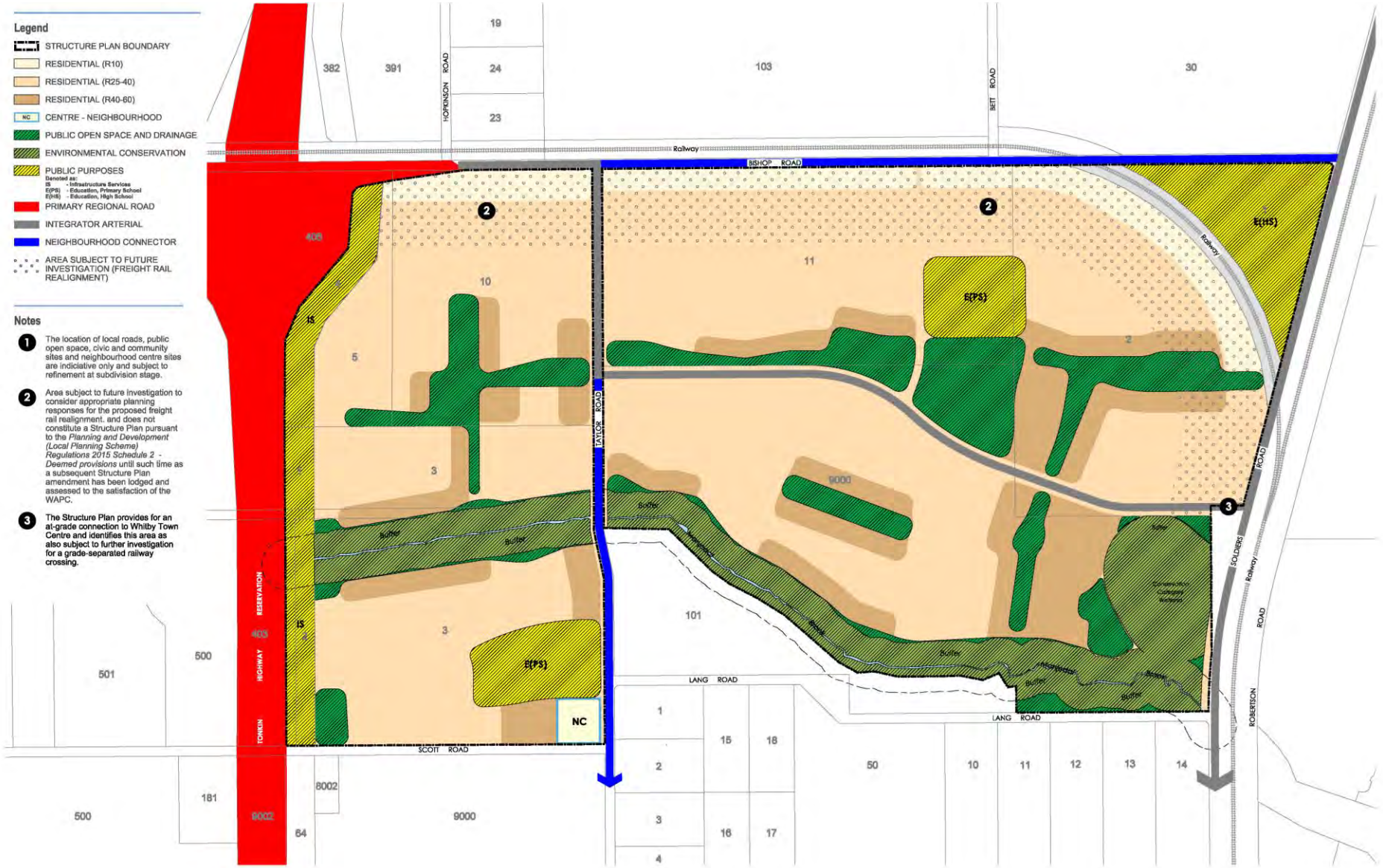
Evidence of pre-application consultation with the relevant pipeline owner/operator will be required for any subdivision within 300m of the MAOP 1900+ pipeline.

7.0 Additional Information

Table 1 outlines additional information that will be required at future approval stages. Additional information requirements may not be limited to those listed; the Shire or WAPC may require other information in relation to particular proposals.

Table 1 Management Plans, Report and Strategies

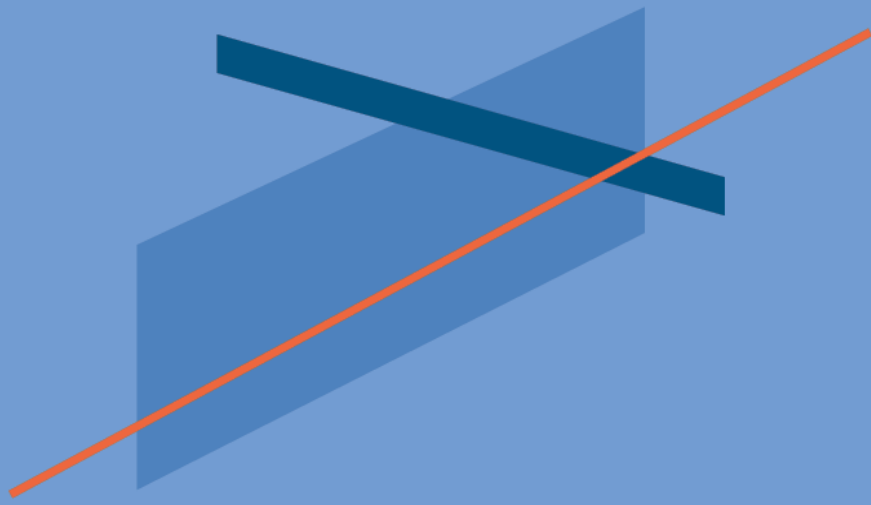
ADDITIONAL INFORMATION	APPROVAL STAGE	APPROVING AUTHORITY
Water Management		
Local Water Management Strategy (LWMS)	Documented in SP Implementation via UWMP	WAPC, Shire, DWER
Urban Water Management Plan (UWMP)	Condition of subdivision	WAPC, Shire, DWER
Environment		
Environmental Assessment Report	Documented in SP Implementation via Subdivision	WAPC, Shire, DWER
Site Contamination Assessment	Submitted in conjunction with any subdivision application over Lots 2 & 11 only.	WAPC, Shire and DWER
Wetland Management Plan	Condition of subdivision	WAPC, Shire, DBCA
Stage specific Bushfire Management Plan (BMP)	Documented in SP Implementation via staged Subdivision / Development approval	WAPC, Shire
Foreshore Management Plan	Condition of Subdivision	WAPC, Shire, DBCA
Landscape Management Plan	Condition of subdivision	Shire
Aboriginal Heritage Management Plan	Condition of subdivision	DPLH (Aboriginal Heritage)
Acoustic Report (Noise Management Plan)	Documented in SP.	WAPC, Shire
Updated Noise Management Plan/s	At subdivision stage once individual lot design has been finalised and recommendations implemented through conditions of subdivision / development approval, where required.	WAPC, Shire
Engineering		
Traffic Report	Documented in SP	WAPC
Traffic Impact Statement or Traffic Impact Assessment	In support of subdivision / planning application, where required	WAPC, Shire
Servicing Report	Documented in SP Servicing Conditions of Subdivision	Shire, Water Corp, Western Power, ATCO Gas
Acid Sulphate Soils	Condition of Subdivision, where required	Shire
Geotechnical	Condition of Subdivision	Shire
Pre-application Consultation with Pipeline Operator	Prior to subdivision application within 300m of the MAOP 1900+ pipeline	ATCO Gas
Other		
Local Development Plan(s)	Condition of subdivision	Shire



Plan 1 Local Structure Plan

Part 2.0

Explanatory Information



1.0 Planning Background

1.1 Introduction and Purpose

This Structure Plan (SP) has been prepared on behalf of Peet Mundijong Syndicate Limited and covers a portion of the land bounded to the north by Bishop Road, to the south by Scott Road, to the east by Soldiers Road and to the west by the Tonkin Highway reservation in Mundijong.

The SP will accommodate the future subdivision and development of the site for primarily residential purposes, providing an additional level of detail over the existing district structure planning framework of the Mundijong-Whitby District Structure Plan (DSP).

The SP has been prepared to address the requirements of the Shire of Serpentine-Jarrahdale Town Planning Scheme No. 2 (TPS 2) and the Planning and Development (Local Planning Schemes) Regulations 2015. The SP and report has been prepared in accordance with the Western Australian Planning Commission's (WAPC) Structure Plan Framework August 2015. The SP will guide future subdivision and development of the site with the determining authorities having due regard for it in the assessment of development and subdivision applications.

The following technical documentation has been prepared in support of this town planning report and Addendums to original reports prepared where necessary:

- Environmental Assessment and Management Strategy (refer **Appendix B**);
- Local Water Management Strategy (refer **Appendix C**);
- Bushfire Management Plan (refer **Appendix D**);
- Ethnographic and Aboriginal Heritage Report (refer **Appendix E**);
- Noise Assessment – Noise Management Plan (Herring Storer, December 2015) and Addendum (Herring Storer, April 2023) (refer **Appendix F**);
- Integrated Landscape and Management Strategy (refer **Appendix G**);
- Transport Report (Riley Consulting, 2016) and Addendum (Riley Consulting, 2022) (refer **Appendix H**); and
- Infrastructure Servicing Report (Wave International, 2015) and Addendum (TABEC Civil Engineering Consultants, 2023) (refer **Appendix I**).

The Project Team, responsible for preparing the information contained within this report, (in consultation with the Shire of Serpentine-Jarrahdale and relevant Service Authorities) include those detailed in **Table 2**.

Table 2 Project Team Responsibilities

PROJECT ROLE	CONSULTANT
Town Planning and Urban Design	Taylor Burrell Barnett
Civil Engineering and Hydrology	TABEC Civil Engineering (previously Wave International)
Hydrology	RPS Group (previously Wave International)
Environment Management	Emerge Associates
Road and Rail Noise	Herring Storer
Traffic and Transport	Riley Consulting
Landscape	Emerge Associates
Aboriginal Heritage	Ethnosciences
Bush Fire Management	Emerge Associates

1.2 Land Description

1.2.1 Location

The subject land is located within the suburb of Mundijong, situated within the Shire of Serpentine-Jarrahdale. Locally, the subject land is located:

- east of the future Tonkin Highway extension;
- north of the Manjedal Brook;
- west of Soldiers Road and the Passenger and Freight rail; and
- south of Bishop Road and Rural zoned land.

Taylor Road bisects the SP area in a north-south direction. Court Grammar School (Pre-K to Year 12) is located within the north-eastern corner of the SP area.

The surrounding area consists of predominately Rural zoned land to the north, Industrial zoned land to the west; and predominately Urban zoned land under development for residential purposes forming part of the wider Mundijong-Whitby DSP area to the south and east.

The land is situated approximately 1 kilometre (km) north-west of the Mundijong townsite and 40km south east of the Perth Central Area and is accessible via the South Western Highway, Mundijong Road, and the Kwinana Freeway (refer **Figure 1** Location Plan). The subject land is located approximately 2km from the future Mundijong Road and Tonkin Highway interchange.

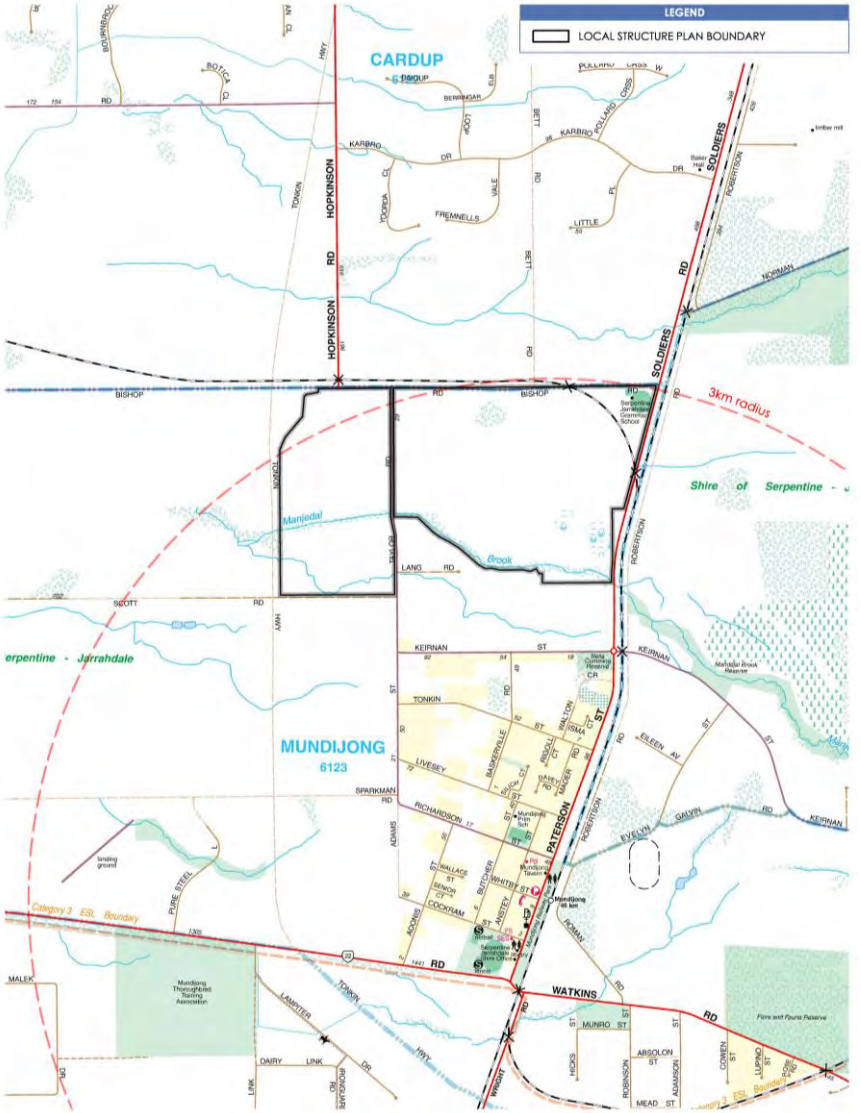


Figure 1 Location Plan

1.2.2 Area and Land Use

The subject land consists of 10 separate allotments with their areas and ownership detailed in **Table 3.**

The subject land consists of two definable areas, land under the ownership of Peet Mundijong Syndicate Ltd generally located to the west of Taylor Road and land under the ownership of Wellstrand Pty Ltd. The subject land comprises an area of approximately 206 hectares (ha). The land is currently used for grazing and similar agricultural activities (refer **Figure 2**).

Three unnamed and unmade portions of road reserve traverse the western portion of the subject land. These existing road reserves will be partially closed and realigned, as appropriate, as part of the detailed design and subdivision stage.

Table 3 Land Ownership

LOT	PLAN	OWNERSHIP	AREA (HA)
1 (Service Corridor)	P401590	Water Corporation	1.0155
2 (Service Corridor)	P401590	Water Corporation	1.8652
1 Bishop Road	D88303	Court Grammar School Inc	6.9600
2 Bishop Road	D88303	Wellstrand Pty Ltd	31.3673
3 (No. 35) Taylor Road	P401590	Peet Mundijong Syndicate Ltd	37.5393
4 (Service Corridor)	P401591	Water Corporation	3.2559
5 Taylor Road	P401591	Peet Mundijong Syndicate Ltd	4.9262
10 (No. 52) Taylor Road	D89282	Wellstrand Pty Ltd	21.8626
11 (No. 29) Taylor Road	D89282	Wellstrand Pty Ltd	34.6235
9000 Taylor Road	P44318	Peet Mundijong Syndicate Ltd	60.8138
Unnamed, unmade portion of road reserves			2.2232
TOTAL			**206.4525**

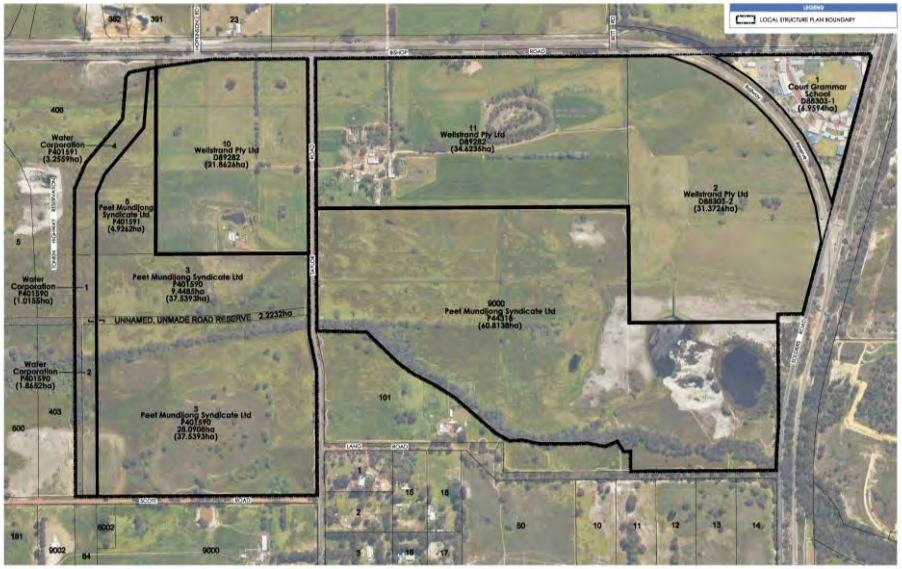


Figure 2 Aerial Photograph (August 2022)

1.3 Planning Framework

1.3.1 Zoning and Reservations

1.3.1.1 Metropolitan Region Scheme

The subject land is zoned 'Urban' under the Metropolitan Region Scheme (MRS). The land to the south, east and south-east of the subject land is also zoned 'Urban'. Abutting the site to the west is a 'Primary Regional Roads' reservation for the future Tonkin Highway extension. Land north of Bishop Road is zoned 'Rural'. Land west of the future Tonkin Highway extension is zoned 'Industrial' (refer **Figure 3**).

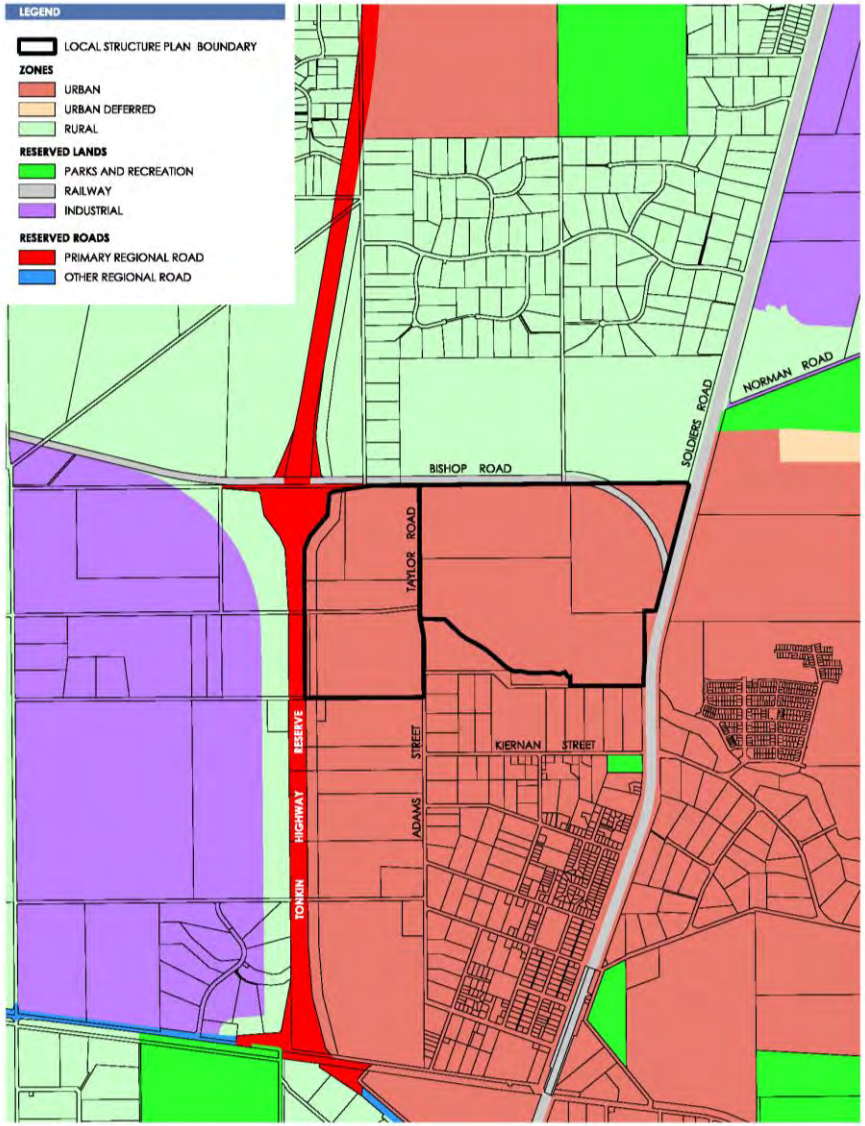


Figure 3 MRS Zoning

1.3.1.2 Shire of Serpentine-Jarrahdale Town Planning Scheme No. 2

The subject land is zoned 'Urban Development' under the Shire of Serpentine Jarrahdale TPS 2 (refer **Figure 4**). It is located within Development Area 1 – Mundijong (DA1), and development must adhere to the DA1 Provisions within the Scheme Text. As stated in the Scheme, the purpose of the Urban Development zone is:

> *"to provide for the orderly planning of large areas of land in a locally integrated manner and within a regional context, whilst retaining flexibility to review planning with changing circumstances."*

TPS 2 requires any SPs over DA1 to be consistent with the provisions of the DSP. This SP proposes to designate land for residential use with accompanying public open space (POS) and conservation, two primary schools, and roads consistent with the purpose and intent of the 'Development' zone, as well as the Mundijong-Whitby DSP.

The Shire of Serpentine-Jarrahdale has prepared a Draft Local Planning Scheme No. 3 (LPS 3), which was considered by the WAPC for Final Determination in March 2023. It is understood the Shire is in the process of making the required modifications prior to gazettal. The subject land is proposed to be retained within the 'Urban Development' zone under Draft LPS 3.

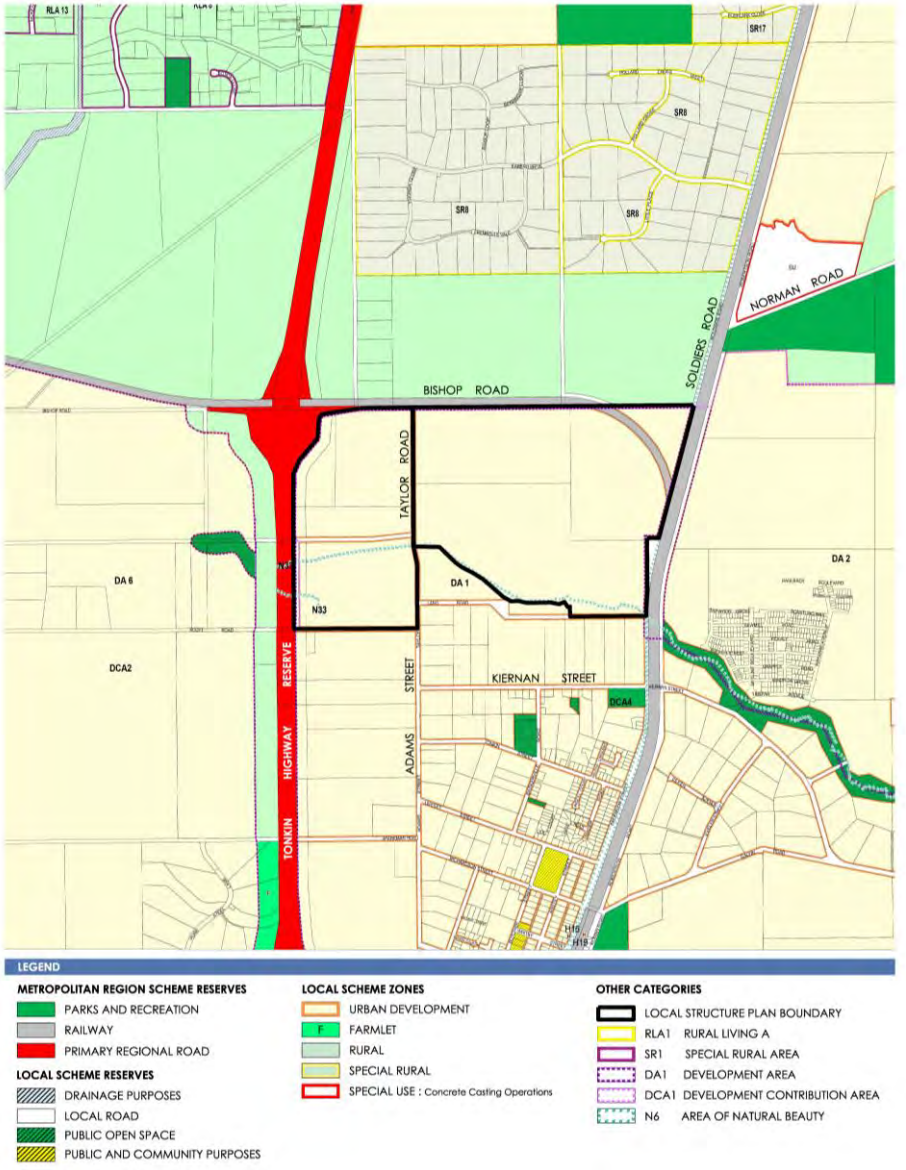


Figure 4 TPS 2 Zoning

1.3.2 Regional and Sub-regional Structure Plan

1.3.2.1 Mundijong-Whitby District Structure Plan (2011)

In August 2011 the Shire of Serpentine-Jarrahdale adopted the Mundijong-Whitby DSP (refer **Figure 5**). This document aims to provide guidance to the structure, vision and objectives identified for the planning and development of the Mundijong-Whitby area, as well as guiding the preparation of more detailed SPs.

SPs are to be prepared in accordance with the precincts defined in the DSP. As stated in the Shire's Local Planning Policy No 29 – Mundijong-Whitby Planning Framework (LPP 29), SPs prepared for any area geographically smaller than the sub-precincts defined in the DSP will not be supported by Council unless specifically resolved otherwise. The DSP originally comprised seven precincts selected based on various criteria intended to enable efficient and coordinated development to be progressed. Following the adoption of the Shire's LPP 29, a proposal was lodged with the Shire on 14 July 2015 to modify the DSP precinct boundaries to separate Precinct G (within which the subject land is located) into two sub-precincts based on land ownership, existing roads and land use for the purposes of SP preparation. The proposal is likely to be considered by the Shire as part of the assessment of this structure plan. Given the positive outcomes which have resulted from the boundary changes to Precinct E it is expected that there will be support to this structure plan over Precinct G1.

Clause 7.5 of the Mundijong-Whitby DSP considers 11 matters to be addressed within a SP for Precinct G. **Table 4** demonstrates how the SP addresses these statutory requirements.

1.3.2.2 Mundijong District Structure Plan (2021)

Since the preparation of the Mundijong-Whitby DSP in 2011, the Shire has undergone a significant amount of change due to population growth and therefore have been a number of significant planning initiatives and proposals in the region which have required consideration. Further, the Shire is projected to accommodate an additional 90,000 people by 2050. This has resulted in the need to revisit the 2011 DSP to provide clear direction for the future planning of Mundijong and surrounds. The DSP was approved by Council in 2021, however is yet to be endorsed by the WAPC (refer **Figure 6**).

The DSP (2021) identifies the SP area as predominately 'Low (Suburban): R20-35' residential with the eastern portion designated 'Medium-High: R40-100'. A neighbourhood centre, primary school and two areas of neighbourhood open space are also identified within the SP area. Three 'District Distributor' roads are identified within the SP area, being Taylor Road, the proposed east-west connector road to Whitby Town Centre and the proposed access street east of the primary school.

The Shire of Serpentine-Jarrahdale has also commenced pre-consultation in relation to proposed Amendment No. 2 to the Mundijong-Whitby DSP. The amendment essentially proposes modifications to the district movement network relating to connections to the Whitby Town Centre and issues associated with railway level crossings (refer **Figure 6**). Whilst the DSP has not been endorsed by the WAPC, consideration has been given to the 2021 DSP in the preparation of this SP.

SPs for adjoining land to the north, west and further to the east of the subject land within the DSP area have provided further context for the SP design (refer **Figure 7**).

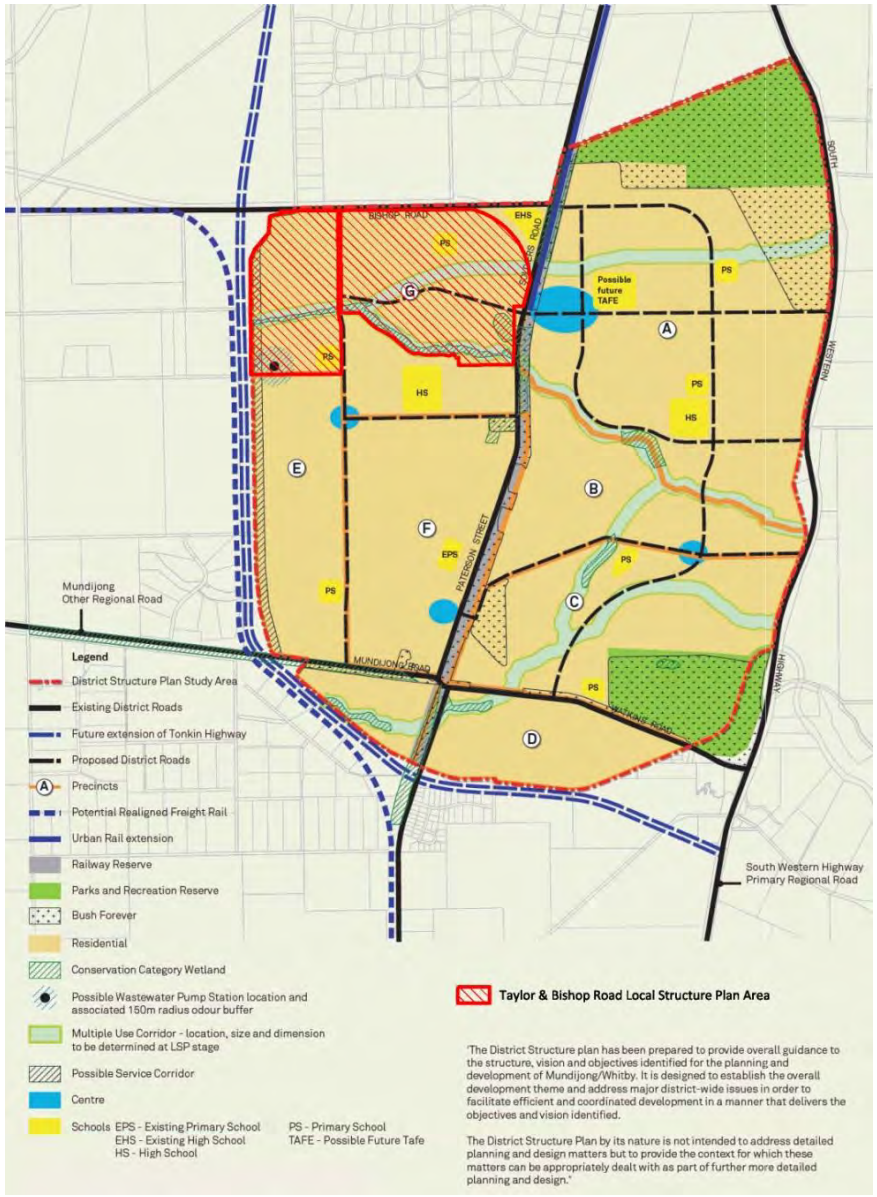


Figure 5 Mundijong-Whitby DSP

Table 4 LSP compliance with statutory requirements for Precinct G of the Mundijong-Whitby DSP

MATTERS TO BE ADDRESSED IN SP	SP SECTION/COMMENT
Matters outlined in the Shire of Serpentine-Jarrahdale TPS 2, Clause 5.18.2.4.	The SP has been prepared in accordance with Clause 5.18.2.4 of the Scheme (Details to be included in a Structure Plan).
Matters outlined in the Shire of Serpentine-Jarrahdale TPS 2, Schedule 15.	The SP area is contained with DA1 and is prepared in accordance with the relevant provisions listed in Schedule 15 of the Scheme.
Matters outlined in the Shire of Serpentine-Jarrahdale LPP 29.	As outlined in the following sections of this report.
The identification of one site for the purpose of public primary schools generally in the location indicated in the DSP. The final location of the primary school sites within a LSP shall be determined in accordance with Liveable Neighbourhoods Element 8 and in liaison with the Shire and Department of Education.	Precinct G1 of the DSP contains two of the public primary schools required for the entire Precinct G. The location of both primary schools is depicted on Plan 1 within the northern and western portion of the SP area in accordance with the locations identified in the DSP.
Public Open Space (POS) shall be provided in accordance with clause 6.3 of the DSP and relevant policy.	POS is provided in accordance with clause 6.3 of the DSP and relevant policy including Element 4 of Liveable Neighbourhoods.
SPs should establish objectives for built form and any design guidelines that are required to be established, typically as Local Planning Policies (LPP) or Centre Plans that are required prior to applications for subdivision and/or subdivision. These should be cognisant of sections 8.8 and 8.9 of the Enquire by Design Report and should reflect the structure described in Explanatory Part 2, chapter 6, clause 6.2.2 (5) of the Mundijong-Whitby DSP.	Part 1 – Implementation outlines the requirement for the preparation of Built Form Design Guidelines to guide the acceptable built form outcome.
Landscape design guidelines shall be provided as part of any SP. These shall address matters to be adopted to implement both public and private landscaping that reflects the historic landscape character of Mundijong/Whitby and should reflect the structure described in Explanatory Part 2, chapter 6, clause 6.2.2 (5) of the Mundijong-Whitby DSP.	Part 1 – Implementation outlines the requirement for the preparation of Landscape Design Guidelines.

The SPs are to acknowledge and allow for appropriate interface to Bush Forever sites.	There are no Bush Forever sites located within the subject land, however Bush Forever Site 350 “Byford to Serpentine Rail/Road Reserves and Adjacent Bushland” (Bush Forever Site 350) is located immediately east. The connectivity of this linkage will be maintained through the long term retention of vegetation within the Bush Forever area, and is not dependent on the retention of vegetation within the subject land, nor will it be impacted by the proposed development.
Such other information as may reasonably be required by the Council or the WAPC.	The SP has been prepared and information has been provided in accordance with the WAPC’s Planning and Development (Local Planning Schemes) Regulations 2015 Structure Plan Framework. Any additional information as may reasonably be required by the Council or WAPC may be provided at request.

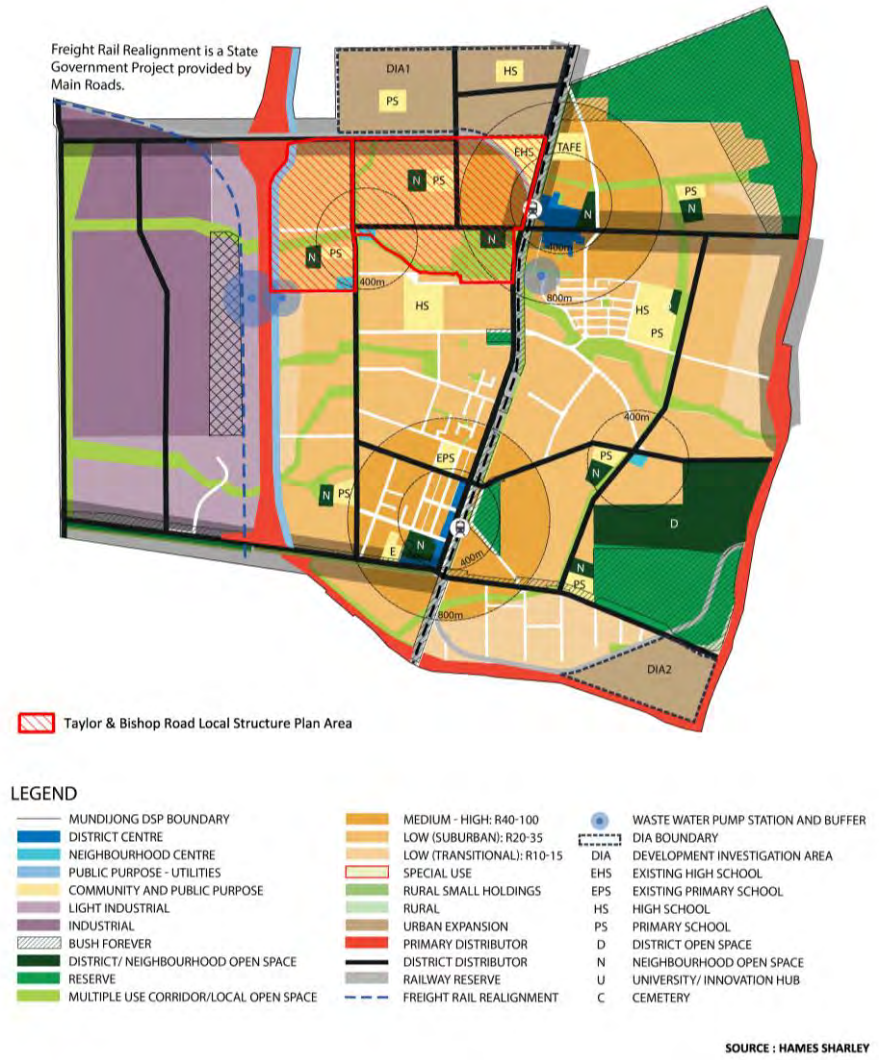


Figure 6 Mundijong DSP (2021)

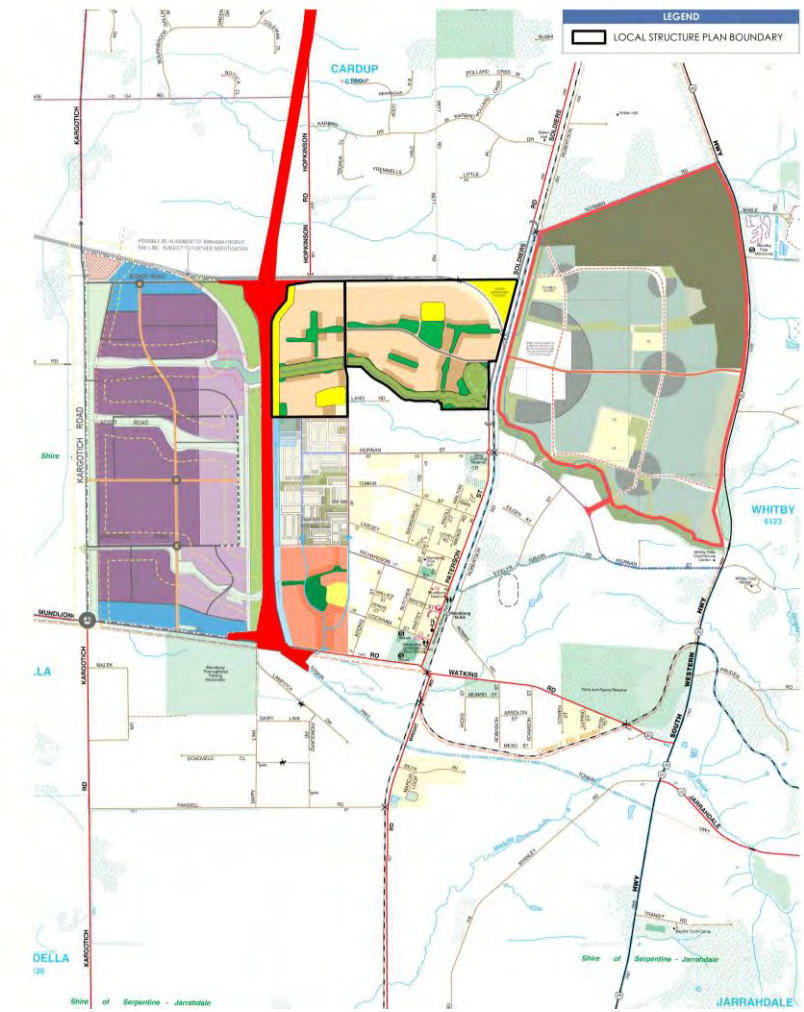


Figure 7 LSP Context Plan

1.3.3 Planning strategies

1.3.3.1 Perth and Peel@3.5million and South Metropolitan Peel Sub-Regional Planning Framework

Perth and Peel@3.5Million is a suite of documents released by the WAPC in 2018 for the Perth and Peel Metropolitan Regions to identify:

- where future homes and jobs should be located;
- how to protect important environmental assets;
- how to best utilise existing and proposed infrastructure; and
- appropriate areas for greater infill development and residential density.

As part of this documentation, sub-regional planning frameworks have been developed to guide future development. The subject land is included within the study boundary of the South Metropolitan Peel Sub-regional Planning Framework. Consistent with the MRS, the subject land is identified as 'Urban' under the Sub-regional Planning Framework (refer **Figure 8**). The Rural zoned land to the north and west is identified as 'Urban Expansion' and 'Industrial Expansion' respectively.

The Framework identifies investigation into the realignment of the Mundijong Freight Rail post-2031. The investigation will consider the realignment of the freight railway that currently passes through the Mundijong-Whitby DSP area, to the western side of the subject land along the future Tonkin Highway extension. It is understood the purpose of the realignment is to improve the amenity of Mundijong and ameliorate severance effects.

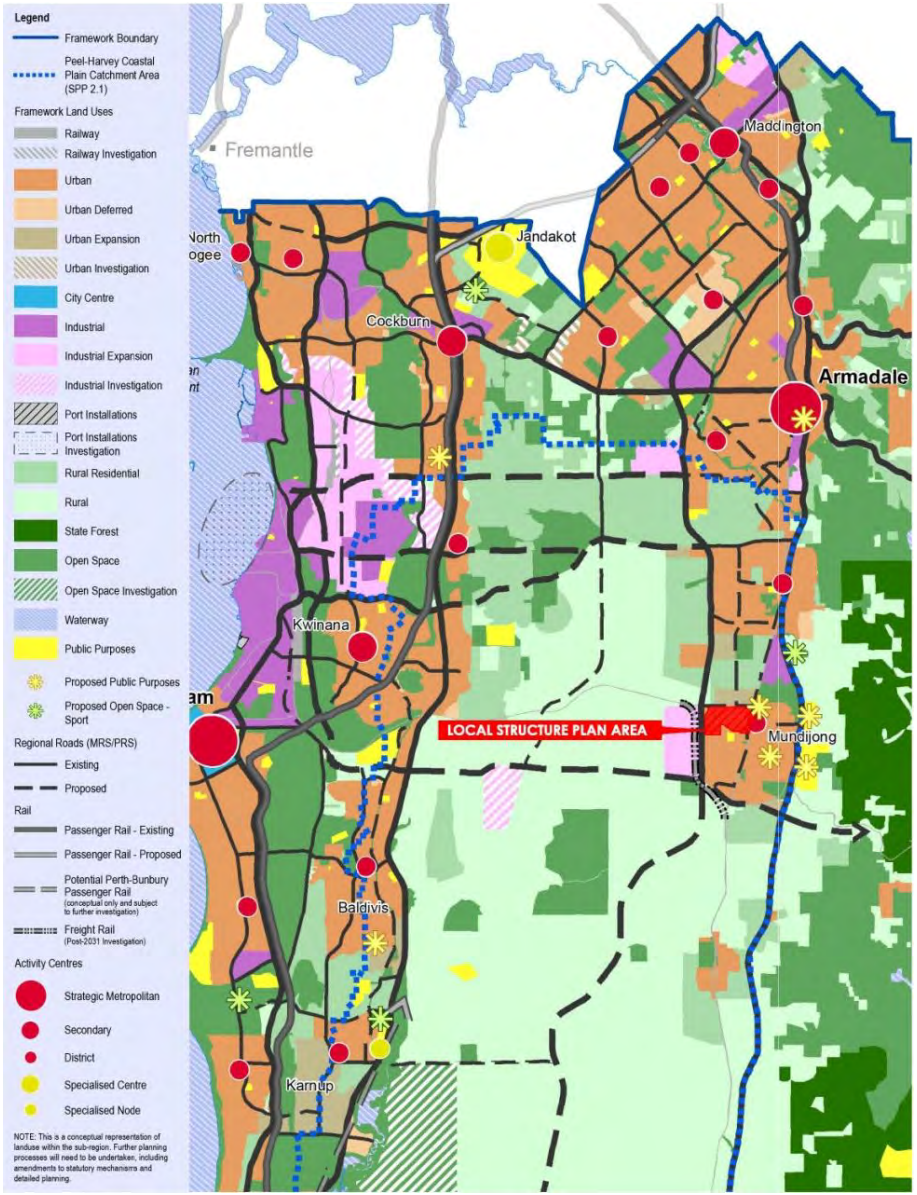


Figure 8 Sub-regional Planning Framework

1.3.4 Planning policies

1.3.4.1 SPP 3.6 – Development Contributions for Infrastructure

Development contributions for the provision of public infrastructure and facilities within the subject land will be as per State Planning Policy 3.6 – Development Contributions for Infrastructure (SPP 3.6), which sets out the principles and considerations that apply to development contributions for the provision of infrastructure in new and established urban areas.

Development Contribution Plans (DCP) are to be prepared in accordance with the provisions of SPP 3.6 and the provisions of clause 9 of the Scheme, and are to be prepared for each development contribution area (DCA).

The Shire has prepared a Development Contribution Arrangement for the Mundijong-Whitby DCA for the provision of traditional and community infrastructure, inclusive of the LSP area. Landowners will be required to make a contribution towards a shared funding arrangement for community infrastructure at the time of subdivision/development.

The following infrastructure items of relevance to the SP are included in the Mundijong Urban DCP:

- Bishop Road and Taylor Road upgrades
- Town Centre Distributor Road (Whitby New Road) construction, including at-grade rail crossing
- Taylor Road/Scott Road Primary School Neighbourhood Open Space improvements
- Land required for open space and/or drainage purposes
- District-scale post-development water quality monitoring
- Administrative costs that are identified in accordance with SPP 3.6

1.3.4.2 SPP 3.7 - Planning in Bushfire Prone Areas

SPP 3.7 Planning in Bushfire Prone Areas (SPP 3.7) forms the foundation for land use planning to address bushfire risk management in Western Australia. Gazetted on 7 December 2015, SPP 3.7 is used to inform and guide decision makers, referral authorities and proponents on achieving acceptable fire protection outcomes on planning proposals in bushfire prone areas.

In support of SPP 3.7, the Guidelines for Planning in Bushfire Prone Areas Version 1.4 (the Guidelines) set out a range of matters that need to be addressed at various stages of the planning process. SPP 3.7 does not require that there be no increase at all in the threat of bushfire to people property or infrastructure. Rather, as is seen in clause 2 of SPP 3.7, the intention of the policy is to implement effective, risk based land use planning and development to preserve life and reduce the impact of bushfire on property and infrastructure.

The SP area is located within a 'bushfire prone area' under the state-wide Map of Bush Fire Prone Areas prepared by the Office of Bushfire Risk Management (OBRM) (2021) and as such, bushfire considerations form an integral part of the LSP design, as outlined in Section 2.4 of this report and the Bushfire Management Plan (BMP).

1.3.4.3 SPP 5.4 - Road and Rail Transport Noise and Freight Considerations in Land Use Planning

The land to the west of the subject land is reserved under the MRS for the future extension of Tonkin Highway. SPP 5.4 – Road and Rail Transport Noise and Freight Considerations in Land Use Planning (SPP 5.4) will require consideration in context with the proposed development abutting the reserve. SPP 5.4 addresses transport noise from major transport corridors, including primary freight routes, and impact on nearby noise-sensitive land uses, such as residential.

SPP 5.4 identifies Mundijong Road as a Primary Freight route, however it is anticipated that the future Tonkin Highway connection to South West Highway will carry the majority of freight traffic, thus lessening the noise impact resultant from traffic travelling along Mundijong Road. Currently, Tonkin Highway only extends as far south as Thomas Road in Byford.

It is also expected that noise will be somewhat mitigated by the proposed 60 metre (m) wide service corridor (Water Corporation) on the western boundary of the subject land which will provide a buffer for noise and vibrations occurring from the traffic expected on Tonkin Highway.

In addition to road noise, the south-west rail line currently abuts the northern and eastern boundaries of the subject land. Noise emissions from the rail line are likely to have impacts on those lots adjacent the rail line and will require consideration in response to the requirements of SPP 5.4.

A preliminary noise and vibration assessment, including Addendum report in response to the current SPP 5.4 (2019) has been undertaken by Herring Storer to assess the implications of SPP 5.4 and inform the SP design.

1.3.5 Pre- lodgement Consultation

A considerable amount of pre- and post-lodgement consultation occurred between the Project Team, DPLH, the Shire of Serpentine-Jarrahdale and key service and referral authorities during the preparation of this SP.

A summary of the key pre-lodgement consultation undertaken during the preparation of the SP is included at **Appendix A**.

2.0 Site Conditions and Constraints

2.1 Environmental Assets and Constraints

An Environmental Assessment and Management Strategy (EAMS) has been prepared by Emerge Associates in support of the SP (refer **Appendix B**). The objective of the EAMS is to describe the relevant environmental characteristics of the subject land and present management and mitigation strategies in response to potential environmental impacts. The key environmental influences relating to the subdivision and development of the subject land include:

- Manjedal Brook;
- Conservation Category Wetland (CCW);
- Water quality and drainage; and
- Aboriginal heritage.

2.1.1 Vegetation and Flora

A spring flora and vegetation surveys (Emerge Associates 2017) was undertaken in order to understand the extent of remnant vegetation values within the subject land and is in addition to early surveys including Mundijong North- Spring Flora and Vegetation Survey (PGV 2012). Based on these detailed surveys, the majority of remnant vegetation across that site was found to be in “Completely Degraded” condition. Remnant vegetation associated with Manjedal Brook in the south of the subject land is in “Degraded” condition due to the high degree of disturbance of the understorey through historic clearing and cattle grazing.

The subject land is devoid of large areas of intact remnant vegetation due to the long history of cropping and stock grazing. Non-native pasture species are dominant across the site with scattered native trees such as Marri (*Corymbia calophylla*), Flooded Gum (*Eucalyptus rudis*) and Paperbark (*Melaleuca preissiana*). The vegetation interpreted from aerial imagery was confirmed during the field survey. A small rise in the south-western corner of the subject land (within Lot 3 Taylor Road) contains a variety of different scattered native trees such *as Banksia ilicifolia, Eucalyptus marginata* and *Xylomelum occidentale* over similar non-native pasture grasses. Stands of non-native planted trees also occur across the subject land, particularly in the north and surrounding the dairy located in Lot 11 Taylor Road.

A CCW (UFI 7835) occurs in the south-east of the subject land, and supports a large area of remnant vegetation consisting mainly of *Melaleuca preissiana*, *Melaleuca rhaphiophylla* and planted Eucalypt species over *Baumea articulata*, *Lepidosperma longitudinale* and *Juncus pallidus*. The majority of remnant wetland vegetation in this area was found to range from “Good – degraded” to “Excellent – very good” condition, with areas of “Degraded” vegetation at the perimeter of the wetland due to the extensive clearing of overstorey and understorey species (Emerge Associates 2017).

Based on a spring (Level 2) flora and vegetation survey undertaken by Emerge Associates (2017), there are no Threatened Flora (TF) or Priority Flora (PF) species, Threatened Ecological Communities (TECs) or Priority Ecological Communities (PECs) present within the subject land. One regionally significant flora species (but is not identified as threatened or priority flora), *Dielsia stenostachya*, was recorded in vegetation between the easternmost wetland feature and the LSP boundary.

Vegetation within the CCW and Manjedal Brook are considered to have once represented Floristic Community Type (FCT) 13 and FCT 11 respectively, neither of which are listed as TECs or PECs at a state or federal level.

Bush Forever Site 350 located to the east of the subject land is known to support several TECs, however this does not extend within the subject land. Environmentally Sensitive Areas (ESAs) and associated ecological linkages extend into the east of the subject land, associated with the flora and vegetation values known to occur within Bush Forever Site 350 and south associated with Manjedal Brook. Exemptions relating to clearing under Schedule 6 of the Environmental Protection Act 1986 apply.

2.1.2 Fauna

Based on the flora and vegetation survey (Emerge Associates 2017), the subject land potentially has value as habitat for threatened or priority fauna species, specifically suitable foraging and potential breeding habitat for black cockatoo species, however due to the completely degraded nature of vegetation within the site, and the large area of intact habitat vegetation reserved in Bush Forever Sites 354 and 361 approximately

650 m northeast of the subject land, it is unlikely that the site supports any significant foraging and/or breeding activities.

2.1.3 Wetlands

Based on the Department of Biodiversity, Conservation and Attractions (DBCA Geomorphic Wetland series mapping (2022), the majority of the subject land is mapped as Multiple Use Wetlands (MUW), with CCW located within the south-east and south of the subject land. CCW (UFI 14945 and UFI 15446) associated with Manjedal Brook are no longer representative of the current conservation status and support very limited remaining riparian vegetation, however the CCW (UFI 7835) and proposed 50m buffer located in the south-eastern corner of the subject land are recommended for retention.

The CCW will be managed and protected in line with the implementation of a Wetland Management Plan to be prepared at the subdivision stage.

2.1.4 Manjedal Brook

Manjedal Brook traverses the south of the subject land and flows in an east- west direction. A number of agricultural drains disect the subject land, associated with the historic rural land uses, which convey flows in a southerly direction to the Manjedal Brook. The creekline also conveys surface flows through the subject land to the west, and joins with Cardup Brook and eventually the Serpentine River.

A 50m wide buffer either side of the Manjedal Brook has been identified on the SP. A biophysical assessment will be required to support a reclassification of the Brook to a Resource Enhancement Wetland (REW) and subsequent modification to the LSP to enable a reduced buffer, subject to consultation with the Department of Water and Environmental Regulation (DWER) and approval of a SP amendment by the WAPC.

2.2 Landform and Soils

2.2.1 Landscape and Topography

The topography of the subject land is generally flat with a gradual decline from approximately 40m Australian Height Datum (AHD) in the east to approximately 25m AHD in the west, representing an average grade of approximately 0.8%. The western half of the subject land has a gentler slope of 0.5%, which increases to a grade of 1% towards the eastern end. The eastern boundary of the subject land is and declines to at the western boundary.

A geotechnical site investigation was undertaken by Galt Geotechnics in 2011 (refer to LWMS contained within **Appendix C**). The geology of the subject land is broadly described as consisting of sand of varying depth overlying clayey sands and/or ferricrete gravels.

2.2.2 Acid Sulfate Soils

The Acid Sulfate Soils (ASS) risk mapping indicates that the subject land is mapped almost entirely as *"moderate to low risk of acid sulphate soils occurring within 3m of natural surface".* There are two small areas of the subject land that are at 'high to moderate' risk. A site investigation was undertaken by Galt Geosciences to determine the likelihood of actual ASS or potential ASS occurring within the subject land. Based on 53 samples collected across the subject land (at varying depths) it was found that there is a low likelihood of actual or potential ASS occurring. As such, it is considered no further ASS investigation is warranted (refer to LWMS contained within **Appendix C**).

2.3 Groundwater and surface water

2.3.1 Groundwater

2.3.1.1 Flows and Levels

Groundwater generally flows from east to west across the subject land, generally following the topography of the land. Groundwater data from the DWER Perth Groundwater Map (DWER 2023b) shows minimum groundwater levels across the site occur approximately 1 to 2m below ground level (BGL).

Further to the groundwater modelling undertaken as part of the District Water Management Strategy (DWMS) in support of the DSP (GHD, 2010), a total of six years of groundwater monitoring has been completed for the SP area and surrounds by BGE (2008–2011) and Aurora Environmental (2012–2013) and has been used to inform the LWMS and associated earthworks and drainage design. Site-specific pre-development groundwater monitoring recorded from 13 monitoring bores between 2008 and 2019 has determined the Maximum Groundwater Level (MGL) recorded across the subject land ranged between 25.6m AHD and 39.5m AHD.

2.3.1.2 Quality

Groundwater quality within the subject land was monitored as slightly acidic and ranges from pH 4.65 to 6.90, with the median value pH 5.9. The concentration of nutrients across the subject land is generally consistent with the current agricultural land use with elevated Nitrogen and Phosphorus levels. The development of the site provides the opportunity to remove nutrients by the implementation of surface and groundwater management in the form of stormwater to be infiltrated on site, as far as practicable with the subsoil condition, thus improving the quality of the groundwater. Post development groundwater monitoring will ensure that there is no deterioration in the quality of the groundwater.

2.3.2 Surface Water

Four external catchments discharge through the subject site, with the Manjedal Brook being the primary watercourse. Runoff from these catchments within the subject land merges into the Manjedal Brook discharging along the western boundary. Low lying areas and low permeability of underlying soils leads to portions of the subject land being water logged.

2.3.2.1 Flood Levels

The Mundijong-Whitby DWMS (GHD, 2010) determined indicative subcatchment scale peak flows and levels at critical locations both pre- and post-development. Furthermore, the Whitby LWMS (Cardno, 2011) and Whitby Estate Precinct 2 - Urban Water Management Plan (UWMP) (Emerge, 2015) have been taken into consideration, particularly with regards to increased flows identified for the modelling of the Manjedal Brook, to verify the pre-development flow rates and post-development runoff. Pre-development surface water flow paths and figures are outlined in the LWMS.

To mitigate the impact from flooding, the finished floor level is required to achieve a minimum of 0.3m above the 100 year (YR) flood level in all parts of the development, except 0.5m above the 100YR flood level in basins and open drains. The finished lot levels of lots adjacent the Manjedal Brook are dictated by sub-soil drainage and are likely to be marginally higher than the required 0.5m for the 100YR ARI flood level.

2.4 Bushfire Hazard

A BMP has been prepared by Emerge Associates in support of the SP (refer **Appendix D**). The BMP is a strategic level plan which identifies the bushfire protection measures to be applied to development on the subject site to accommodate compliance with:

- SPP 3.7 Planning in Bushfire Prone Areas;
- Guidelines for Planning in Bushfire Prone Areas; and
- Australian Standard for the construction of buildings in bushfire-prone areas (AS3959).

This BMP provides:

- Identification of those portions of the subject land designated as Bushfire Prone Areas under the Map of Bushfire Prone Areas (OBRM 2021).
- Overview of the proposed development.
- An assessment of the existing classified vegetation in the vicinity of the subject land (within 150m) and consideration of bushfire hazards that will exist in the post-development scenario.
- Commentary on how future development can achieve the bushfire protection criteria outlined within the Guidelines.
- An outline of the roles and responsibilities associated with implementing the BMP.

The bushfire hazard will be further refined as part of future subdivision or development stages in order to accurately assess the bushfire risk posed by surrounding classified vegetation and revegetation required to support environmental values and drainage functions to determine specific radiant heat exposure levels (and associated Bushfire Attack Levels (BAL)) for future lots created within the LSP area, including assessment of vegetation within 150m of the subject land. Temporary bushfire hazard within the site can be managed as part of development through either the clearing or management of vegetation to a low threat standard within a 50m to 100m wide area around each development stage. Vegetation will need to be managed by the proponent until the long-term development progresses.

2.4.1 Bushfire Attack Level Assessment

The indicative BHL assessment undertaken as part of this BMP has been undertaken in accordance with Method 1 of AS3959. Overall, the BHL assessment is based on the following assumptions:

- Vegetation associated with Manjedal Brook and the CCW (in the southeast) is expected to be retained, and where appropriate revegetated and is assumed to achieve a forest (Class A) classification. The 50m buffers associated with each are assumed to be revegetated to achieve a scrub (Class D) classification.

As depicted on the BHL map contained within the BMP, post-development, residential development (and therefore future habitable buildings) can achieve BAL-29 or below with majority of the subject land mapped as a "Low" bushfire hazard (BAL-12.5) and will consequently be subject to AS3959. Provision of appropriate separation distances from permanent bushfire hazards to ensure a BAL rating of BAL-29 or less can be achieved at future habitable buildings.

This BMP has assumed post-development vegetation classifications for the multiple use corridors (MUC), however stage-specific BMPs will be required at the subdivision stage to address any changes and confirm the post-development classification and associated BAL ratings once further detailed design of these areas has been undertaken.

This assessment does not take into account any future noise barrier that may be constructed along the eastern and northern boundaries, between the subject land and the freight railway line and Tonkin Highway, and assumes full fire conditions, which is unlikely to occur within this area. Any future noise barrier will form a non-combustible barrier between the subject land and the adjacent hazard, and will provide a shielding effect from the radiant heat flux of a fire, reducing radiant heat flux from classified vegetation east of the subject land. The actual BHL impacts will be significantly less than that predicted using a Method 1 assessment, when assessed using Method 2 of AS3959. The BAL ratings applicable to future habitable buildings in the western and north-eastern portions of the subject land will be further considered as part of future subdivision.

2.4.2 Heritage

2.4.2.1 Aboriginal

Thomson Cultural Heritage Management was commissioned by Ethnosciences to undertake an archaeological assessment of the landholdings for the subject land and surrounding area. The archaeological assessment has involved archaeological survey, detailed site recording and test excavations and consultation with representatives of the relevant traditional owners and Aboriginal elders. A copy of the Aboriginal Archaeological Assessment is contained within **Appendix E**.

Based on a review of the Department of Aboriginal Affairs (DAA) 'Aboriginal Heritage Inquiry System' (AHIS) online database (DAA 2016) there is one registered Indigenous heritage site mapped within the site in the south-east, and several 'Other Heritage Places' mapped throughout the subject land. The details for the registered heritage sites and other heritage places are as follows:

Table 5 Aboriginal and Other Heritage Places

SITE ID	DESCRIPTION
DESCRIPTION	
3648	Soldiers Road, Mundijong – Artefacts/Scatter
OTHER HERITAGE PLACES	
32591	MJ-01 – Artefacts/Scatter, Arch Deposit
32614	MJ-02 – Artefacts/Scatter, Arch Deposit
32615	MJ-03 – Artefacts/Scatter, Arch Deposit
32616	MJ-04 – Artefacts/Scatter, Arch Deposit
32619	MJ-05 – Artefacts/Scatter, Arch Deposit (within DAA Id 3648)

Note: Consultation with the representatives identified that the registered site (ID No. 3648) was incorrectly mapped, concluding that the values actually occurred north of this location, directly adjacent to the western boundary of the CCW.

Based on the results of the archaeological assessment and test excavations it was recommended that:

- MJ-01, MJ-02, MJ-03, MJ-04, DAA Id 3648 (including the MJ-05 extension) meet the requirements of section 5 of the Aboriginal Heritage Act 1972 (AHA) and

therefore should not be impacted upon in any way without Ministerial consent under section 18 of the AHA.

- Preparation and implementation of an Aboriginal Heritage Management Plan; and
- Implement suitable controls to prevent any impacts on archaeological sites during earthworks, including adequate physical demarcation of site boundaries and effective management processes such as ground disturbance permits and operator inductions.

An application was made under Section 18 of the AHA on 12 December 2019 and consent granted by the Minister for Aboriginal Affairs on 26 April 2020 (subject to conditions). In lodging this application, considerable consultation with the appropriate Nyungar Elders and Aboriginal Consultants was undertaken.

Furthermore, an Aboriginal Heritage Management Plan shall be prepared and implemented prior to subdivision.

2.4.2.2 European

A desktop search of the Australian Heritage Database (Department of Environment 2013), the State Heritage Office database (Heritage Council 2012) and the Shire of Serpentine Jarrahdale's local municipal heritage list indicated there are no registered heritage sites within or in close proximity to the subject land.

2.5 Existing Movement Network

2.5.1 Regional Roads

The subject land is connected to the regional road network (South Western Highway) via Soldiers Road / Paterson Street which connects into Mundijong Road / Watkins Road. South Western Highway provides a major connection between Perth and Pinjarra and other regional roads such as Tonkin Highway and Albany Highway.

An existing road reservation is located directly to the west of the subject land for the future Tonkin Highway extension. A construction procurement strategy and timings are currently being developed by Main Roads WA (MRWA) in partnership with industry. Construction is expected to commence in 2025 with target completion in late 2027, subject to regulatory approvals.

2.5.2 District and Local Roads

2.5.2.1 Watkins Road – Mundijong Road

Watkins Road – Mundijong Road is classified as a District Distributor Road B under MRWA's Functional Road Hierarchy. Watkins Road – Mundijong Road is constructed with a single 7.2m carriageway in both directions. A controlled level crossing is provided at the railway line.

MRWA traffic data sourced for Watkins Road indicates:

- 2,400 vpd west of South Western Highway (2008/09)

MRWA traffic data sourced for Mundijong Road indicates:

- 3,280 vpd west of Paterson Street (2013)
- 4,592 vpd east of King Road (2015)
- 3,946 vpd east of Kwinana Freeway (2013)

Watkins Road – Mundijong Road are operating well within their derived operational capacity and no upgrading will be required.

2.5.2.2 Paterson Street – Soldiers Road

Paterson Street – Soldiers Road is classified as a District Distributor Road A under MRWA's Functional Road Hierarchy and abuts the subject land to the east. Paterson Street – Soldiers Road is a 20m wide road reserve constructed with a single 9.0m carriageway in both directions. The widening of Paterson Street – Soldiers Road on the western edge to 30m where it abuts the SP area may be required in the future.

MRWA traffic data sourced for Paterson Street indicates:

- 2,200 vpd (2004/05)

2.5.2.3 Bishop Road

Bishop Road is classified as a Local Distributor Road under MRWA's Functional Road Hierarchy (and District Distributor under the Mundijong DSP) and abuts the subject land to the north. Bishop Road is a 20m wide road reserve constructed with a single 9.0m carriageway in both directions.

No traffic data is available, however it is expected that current volumes are well below 500 vpd. The forecast traffic demands indicate that an Integrator Type B is an

appropriate classification for Bishop Road. The widening of Bishop Road to 35.6m will occur based on an Integrator Type A classification with the eastern portion of Bishop Road identified as a 'neighbourhood connector' to feature a 30m road reserve.

2.5.2.4 Taylor Road – Adams Street

Taylor Road – Adams Street is classified as a Local Distributor Road under MRWA's Functional Road Hierarchy (and District Distributor under the Mundijong DSP) and provides a north-south link between Richardson Street and Bishop Road. Taylor Road – Adams Street is a 20m wide road reserve constructed with a single 6.0m carriageway in both directions, which will be widened to 35.6m between Bishop Road and the E-W connector and 30m for the southern portion where identified as a 'neighbourhood connector' to cater for significant increases in traffic demand. There is an existing bridge which crosses over Manjedal Brook approximately 400m south of Bishop Road.

2.5.3 Pedestrian Network and Cycling

Existing pedestrian and cyclist networks within the immediate vicinity of the subject land are limited. Development of the subject land and surrounding areas will result in improvements to the pedestrian and cyclist network. Footpaths and dual use paths will be provided on internal roads in accordance with Liveable Neighbourhoods objectives.

2.5.4 Public Transport

The subject land is located approximately 3.5km of the Mundijong Train Station. The station is located on the Perth to Bunbury line, utilised by the Australind service, which runs a service twice a day.

Two bus services (Routes 252 & 253) operate along Soldiers Road / Paterson Street and provide services to Armadale Train Station.

2.6 Road and Rail Transport Noise

As discussed, a preliminary noise and vibration assessment has been undertaken and Noise Management Plan prepared by Herring Storer for the subject land to determine the extent of potential impacts from vehicles on the future Tonkin Highway and passing freight trains. It is acknowledged that there are future proposals for possible realignment of the rail line. To allow for a conservative assessment, the rail line has been assessed at its current location and therefore provide for a worst-case scenario.

The study identified noise received from passing trains during the night as being the critical noise source and period for compliance with SPP 5.4, however for road traffic, compliance with the day period was required, as this would also achieve compliance with the night period. The assessment confirmed that without any noise amelioration, road and rail noise would exceed the 'noise targets'. As such, the assessment recommends the following amelioration measures are implemented for affected lots:

2.6.1 Road Noise

Option 1: no noise barrier

- Setbacks & quiet house design (Package A & Package B)
- Notifications on Title

Option 2: 1.8m noise barrier

- Quiet house design (Package A)
- Notifications on Title

2.6.2 Rail Noise

Option 1: no noise barrier

- Setbacks & quiet house design (Packages A & B)
- Notifications on Title

Option 2: 2.2m to 3.0m noise barrier

- Quiet house design (Packages A & B)
- Notifications on Title

Further information regarding the modelling undertaken and the necessary mitigation measures is provided in **Appendix F**

3.0 Concept Plan

3.1 Design Principles

There are a number of fundamental design principles that underpin the proposed SP, as summarised below:

- Respect for the inherent features/attributes of the land and its location, more specifically the Manjedal Brook and important identified Aboriginal Heritage sites to be retained within open space areas, where possible, and/or integrated with the wider public realm.
- Protection of the CCW and its associated buffer located in the south-eastern corner of the SP area, near Soldiers Road.
- A sound rationale for the development, including its context within the wider Mundijong locality, to ensure that future development is fully integrated with the existing and proposed surrounding development. Particular consideration has been given to; the existing residential area and Town Centre east of Taylor Road, Manjedal Brook, significant Aboriginal Heritage sites, integration with surrounding LSP areas, the future Tonkin Highway to the west, the abutting freight railway line to the east and north and the existing and proposed district movement network.
- A sensitive and innovative stormwater management approach to conveyance, treatment and storage in an urban context with careful consideration to the Manjedal Brook.
- Creation of a distinct identity and sense of place for future residents of the area taking advantage of unique site attributes such as the Manjedal Brook and other environmental features.
- Facilitate a diversity of built form in terms of housing typologies, affordability and sustainability.
- Optimise passive solar orientation of lots as far as practicable, taking into account constraints such as existing and future road alignments, drainage patterns, Manjedal Brook topography and mature trees.
- Configuration of street blocks to develop an efficient and legible layout that promotes walkability and reduces private motor vehicle journeys.
- Ensure that the development completes and builds upon the arterial road network identified in the Mundijong Whitby DSP, with consideration given to the proposed changes in the district movement network, namely the down-grading of Soldiers Road as an important north-south connector with a greater emphasis placed on Kiernan Street and Bishop Road as key east-west connectors.
- Creation of a network of attractive and well-utilised POS areas with prominent east-west and north-south ‘green links’ culminating at the Manjedal Brook.
- Establish an environment that provides a variety of active and passive recreational facilities that specifically seek to promote the mental and physical health and well-being of future residents with key connections promoted throughout the site and especially to the Manjedal Brook.
- Creation of a dynamic co-located Primary School and POS at the heart of the estate, incorporating a viable combination of recreation and education uses.

3.1.1 Opportunities and Constraints

An analysis of the existing site conditions and the potential opportunities and constraints that require consideration in the planning and development of the subject land has been undertaken. The key elements of this analysis are discussed below and depicted diagrammatically on **Figure 9, Figure 10** and **Figure 11** .

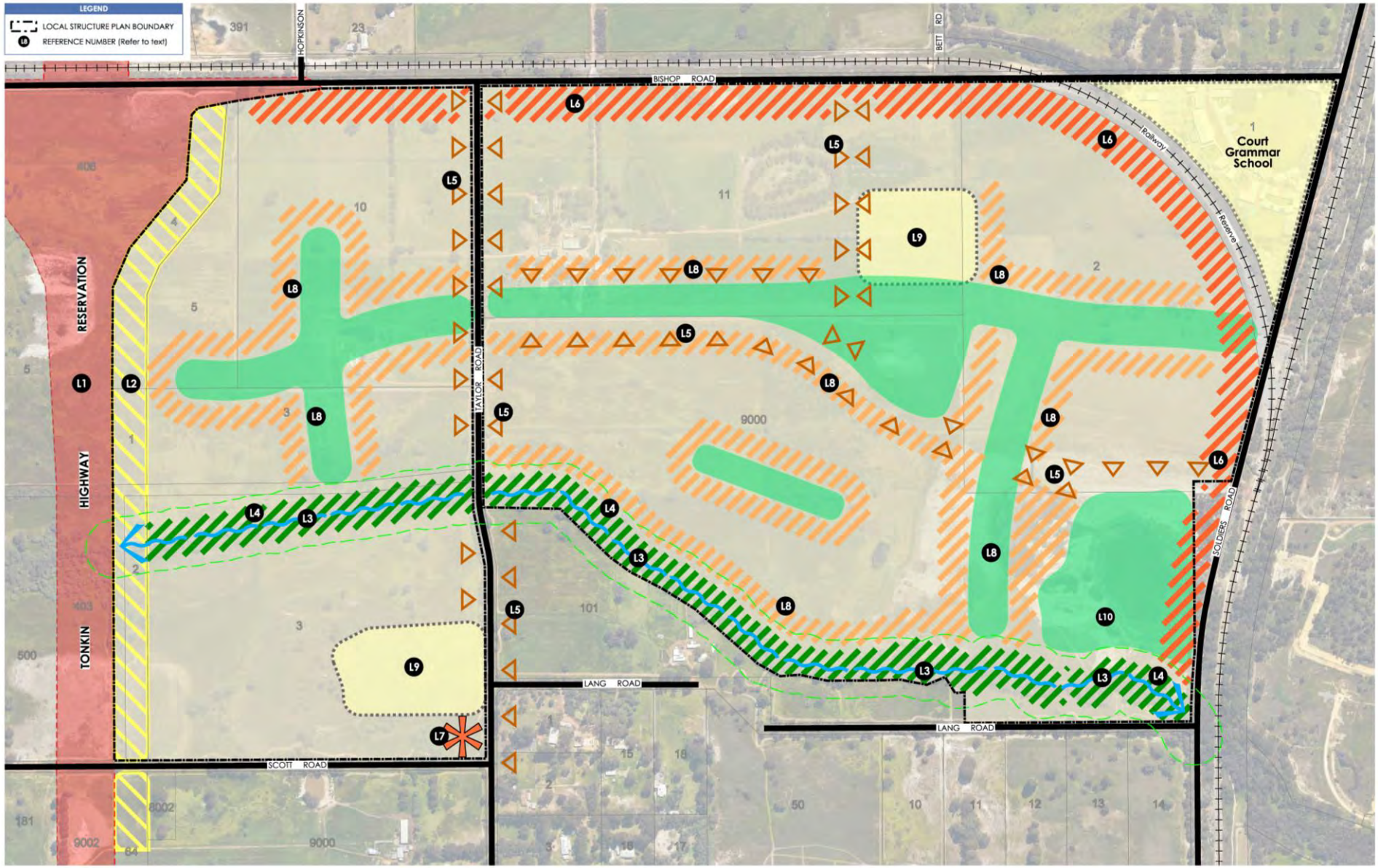


Figure 9 Land Use Opportunities and Constraints

3.1.1.1 Land Use

1. Future Tonkin Highway restricts access to the west and has the potential for noise attenuation requirements to be associated with new development.
2. Service corridor restricts access and development in this location.
3. Manjedal Brook dissects development specifically to west dissecting the development into north and south parcels in this area.
4. Extent of Manjedal Brook buffer constrains residential development away from the water's edge.
5. Careful consideration of abutting development required adjacent Taylor Road and east-west proposed roads.
6. Development abutting existing railway line to ensure it meets sound and vibration attenuation requirements.
7. Opportunity for neighbourhood centre located adjacent the proposed primary school.
8. Opportunity to promote higher density adjacent to POS areas, Manjedal Brook and CCW capitalising on the amenity and natural beauty.
9. Proposed primary schools located in specific areas to maximise catchment area as well as adjacent key movement connectors to promote passive surveillance.

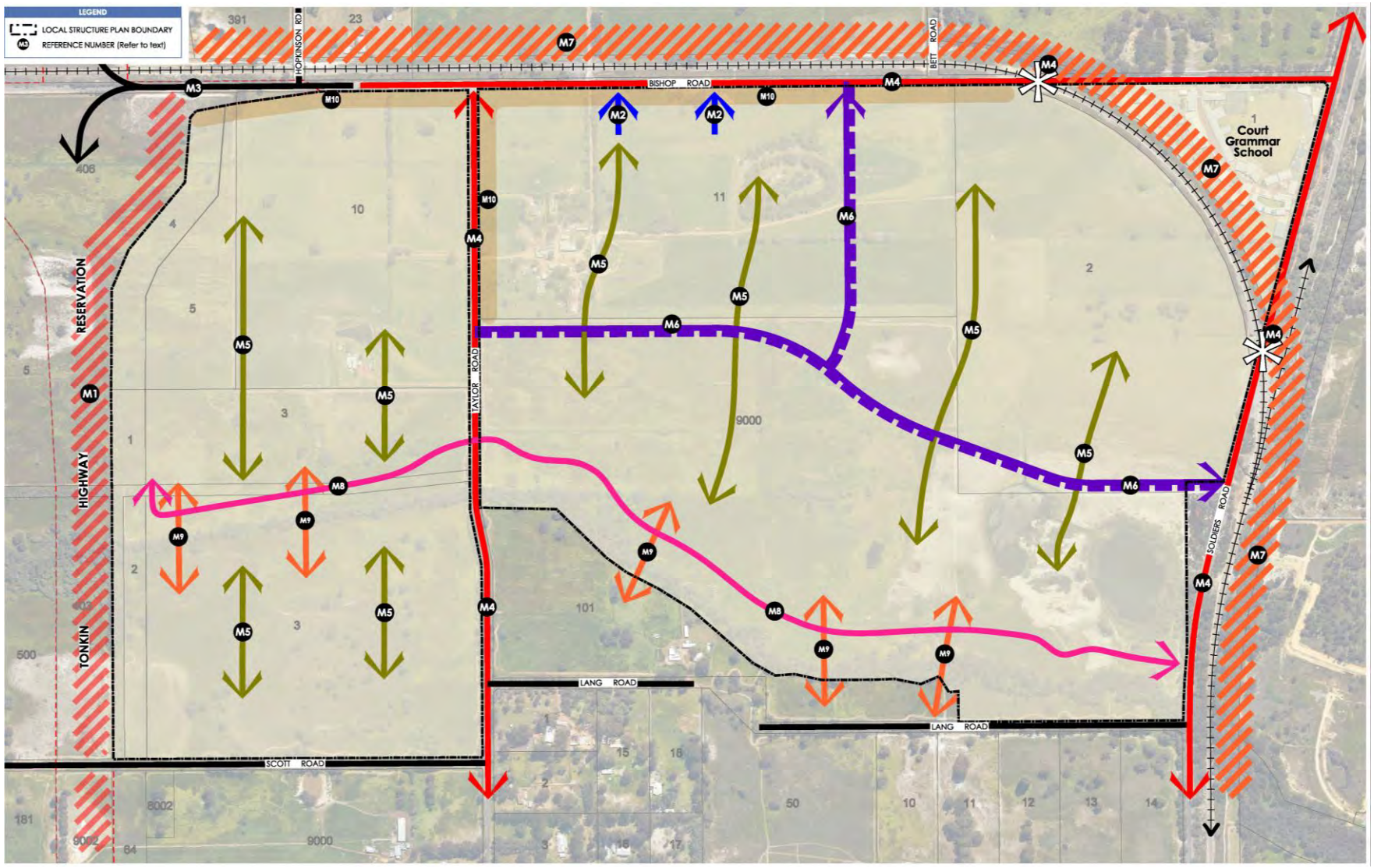


Figure 10 Movement Opportunities and Constraints

3.1.1.2 Movement

1. Potential noise attenuation requirements associated with future Tonkin Highway. Opportunity to utilise existing service corridor abutting proposed Tonkin Highway if required.
2. Proposed road connections to existing Bishop Road require careful consideration to ensure appropriate integration and intersection spacing, based on future traffic volumes and functional road classification.
3. Bishop Road (in the future) proposed to interchange with future Tonkin Highway providing direct and easy access to the wider surrounding areas.
4. Proposed road hierarchies developed in response to the broader district movement planning for Mundijong and surrounding areas. Potential for changes to freight rail alignment and existing at grade crossings to change (subject to investigation by the relevant agencies).
5. Opportunity to provide north-south access streets providing excellent solar orientation benefits to development and providing for direct vehicular, pedestrian and view connections to linear open space and Manjedal Brook.
6. Proposed central east-west road providing direct connections through the site to the future District Centre and to Tonkin Hwy (via Taylor Rd and Bishop Rd).
7. Potential vibration and noise attenuation requirements associated with existing railway lines.
8. Higher order access streets proposed adjacent Manjedal Brook providing additional support to the central east-west connector and optimising views to and across the Brook.
9. Opportunity to provide pedestrian crossings across the Manjedal Brook to optimise north-south connections.
10. No road connections to Bishop Road west of Taylor Road and no direct lot access to Bishop Road and Taylor Road north of the central east-west connector due to potential conflicts with vehicles on existing roads with high forecast traffic volumes in the future.

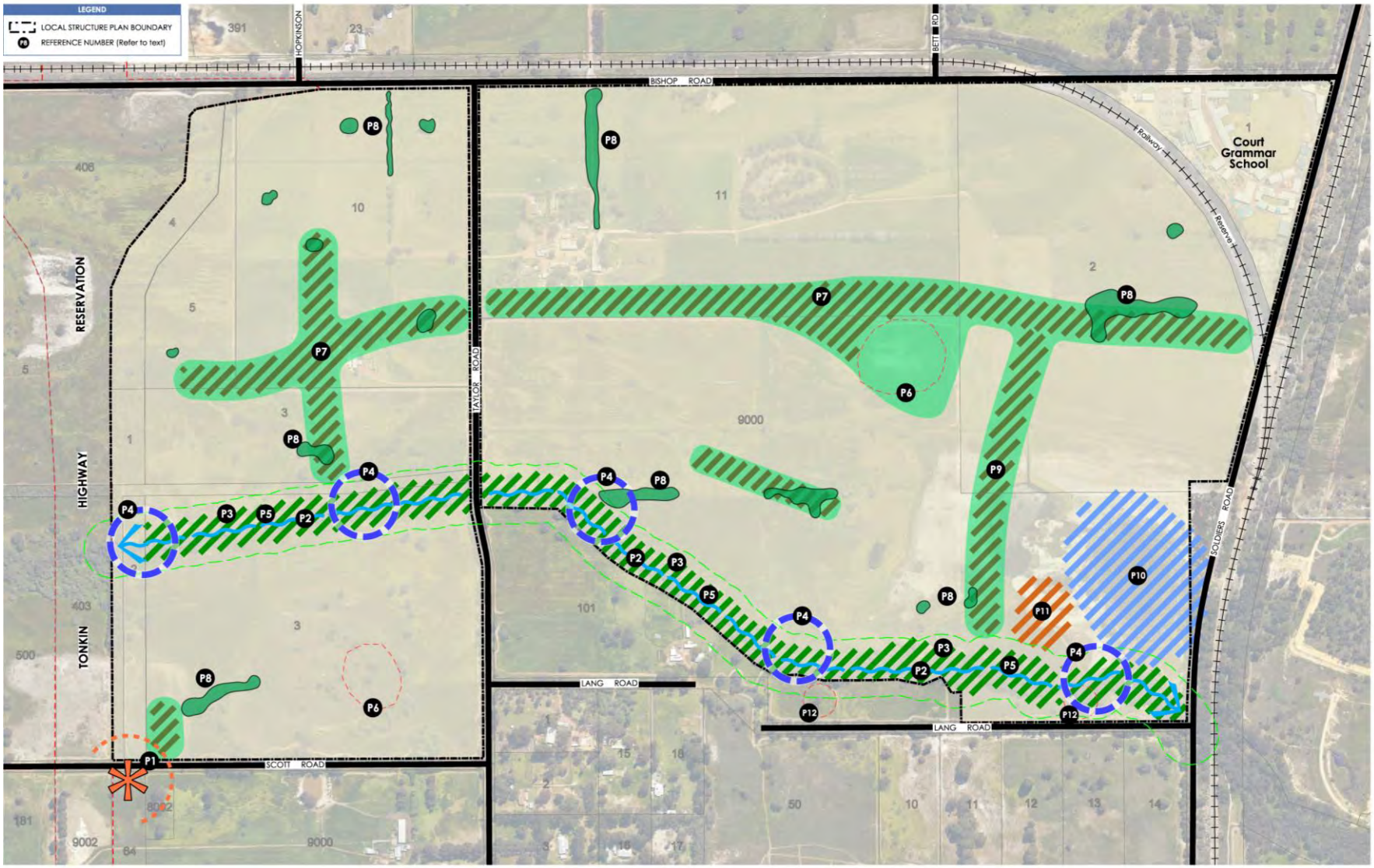


Figure 11 Public Realm Opportunities and Constraints

3.1.1.3 Public Realm

1. Interim Pump station site. Opportunity for portion of POS to be utilised for drainage.
2. Manjedal Brook dissects the development site with the potential to restrict north-south movements.
3. Manjedal Brook required 50m buffer area (based on CCW classification) is large and may have significant ongoing management requirements. Opportunity to reclassify Brook to REW and reduce buffer to 30m based on ability to retain floodway within the reduced buffer, and subject to biophysical assessment.
4. Opportunity to rationalise Manjedal Brook foreshore buffer to retain existing stands of trees and provide larger pockets of open space abutting the Brook.
5. Optimise and promote the natural beauty of Manjedal Brook and its foreshore providing for the dominant landscape and amenity feature of the development.
6. Opportunity to locate Primary School ovals and POS over 'Other Heritage Places' (MJ01 & 02) retaining identified artefacts in situ.
7. Key east-west POS corridor centrally located within development providing excellent visual and pedestrian linkages through development.
8. Opportunity to retain existing mature trees across the site within POS and road reserves.
9. Key north-south POS corridor connecting east-west POS corridor with Manjedal Brook providing for excellent visual, pedestrian and efficient drainage linkages.
10. CCW and associated 50m buffer provides a large, consolidated area of natural beauty in the south-eastern quadrant.
11. Integrate Hallam's site (DAA Id 3648) with conservation and POS areas and/or provide for public interpretation, in response to Section 18 approval of the Aboriginal Heritage Act 1972.
12. Opportunity to retain Scar Trees (MJ-08 & MJ-09) within foreshore buffer to Manjedal Brook, in response to Section 18 approval of the Aboriginal Heritage Act 1972.

3.2 Land Use

The SP area will form part of a discrete urban cell with clearly defined boundaries. As a consequence of this, the SP is focused on residential land uses and the supporting open space network, neighbourhood centre and primary school sites in accordance with the Mundijong-Whitby DSP. A summary of the land uses and their areas are provided in **Table 6.**

Table 6 Land Use

SP ZONE / RESERVE	AREA (HA)
Residential	96.6702
Roads	45.0787
Conservation areas & Public Open Space (including drainage)	42.1700
Neighbourhood Centre	0.7149
Private School (existing)	6.9600
Primary Schools (proposed)	7.5362
Service Corridor	7.1910

3.2.1 Residential

Development proposed within the SP is primarily residential, and provides a range of housing choices through the provision of low and medium density single lots, as well as potential for grouped housing sites, ranging from R25 to R40.

The density code range is outlined on the SP. The allocation of residential densities to be submitted to the WAPC at the subdivision stage through the provision of a Residential Code Plan shall be in accordance with the following criteria:

a) R10:
R10 density shall apply in areas abutting major road and rail corridors to help alleviate and/or manage noise, in addition to noise mitigation measures through quiet house requirements as identified in the Noise and Vibration Assessment prepared by Herring Storer (dated December 2015) and Addendum (dated April 2023), as amended.

d) R40/R60:
R40/R60 density shall apply in areas of high amenity, being lots located within 400m of public open space (POS) and conservation areas, schools or a neighbourhood centre and lots abutting higher order streets (i.e. neighbourhood connector roads) and public transport routes.

b) R25:
R25 density shall apply for the remainder of residential land in the SP area.

3.2.1.1 Density Targets

The estimated dwelling yield for the SP area, based on the Concept Plan and residential density code range is 2,897 dwellings (**Table 7** below). This could accommodate a total population of up to 8,546 people based on 2.95 people per dwelling.

Element 1 of Liveable Neighbourhoods and the calculations required under the Mundijong-Whitby *I* equates the measurement to *"22 dwellings per site hectare"* (encompassing land purely zoned for residential purposes). In addition to this, the Perth and Peel @3.5million recommends that new urban areas implement a minimum average residential density target of 15 dwellings per gross hectare of urban-zoned land and a residential site density of 26 dwellings per residential site hectare and requires that this be measured as a means of determining whether the residential densities proposed in an SP will deliver the dwelling aspirations under the State planning framework.

The applicable density targets under the SP as measured in accordance with Liveable Neighbourhoods and Perth and Peel @3.5million are 14.53 dwellings per gross Urban zoned hectare and 29.96 dwellings per net site hectare; based on 2,897 lots.

The density codes applied and the resultant lot typology will accommodate maximum flexibility for the developer, whilst addressing the needs of the local residential housing market. There are a number of different lot types which will provide ample opportunities for purchasers to select their lot and a project home to meet their needs. Final yields will be determined during the detailed subdivision design process.

Table 7 Estimated Dwelling Yield

DENSITY CODING	AREA (HA)	YIELD
R10 (1,000m² average)	7.3017	73
R25 (350m² average)	73.2502	2,092
R40 (220m² average)	16.1183	732
TOTAL	**96.6702**	**2,897**

3.2.2 Other Land Uses

Supporting the residential land use is the relevant open space reserves, neighbourhood centre, community site, primary school sites and utility reserves, which will be discussed in detail in later sections of this report.

3.3 Open Space

More than 20ha of public open space is provided on the SP of differing forms and functions. The open space network, as detailed on **Figure 12**, consists of POS, the CCW and Manjedal Brook.

3.3.1 Public Open Space

The provision of POS is distributed throughout the site to provide accessibility to residents and respond to the existing drainage lines present in the area. The POS network comprises a mixture of linear parks, consolidated POS of varying sizes, and a network of attractive and well-utilised POS 'green links' have been incorporated throughout the SP area, east-west and north-south culminating at the Manjedal Brook.

The provisions of Liveable Neighbourhoods require a range of site responsive urban parklands in order to address the district, neighbourhood and local needs of residents, and should be a mixture of unrestricted and restricted open space. The POS layout allows access for all residents in the area, encouraging the usage of these spaces by the community. The central POS, co-located with the primary school, will provide a shared sized oval, providing active recreational facilities for students of the school and the wider community and provide a central focal point for the community.

A POS calculation has been prepared in accordance with Liveable Neighbourhoods, as detailed in **Table 9**. The POS calculation identifies a surplus of POS in comparison to the minimum 10% requirement under Liveable Neighbourhoods. The total POS provided will be refined at the subdivision stage by the developer to meet its obligations.

The Integrated Landscape and Management Strategy (ILMS) (refer **Appendix G**) identifies various facilities and treatments of the POS areas. This design is provided as a guide and will be further informed by detailed site planning, engineering design and discussions with the Shire at subdivision stage.

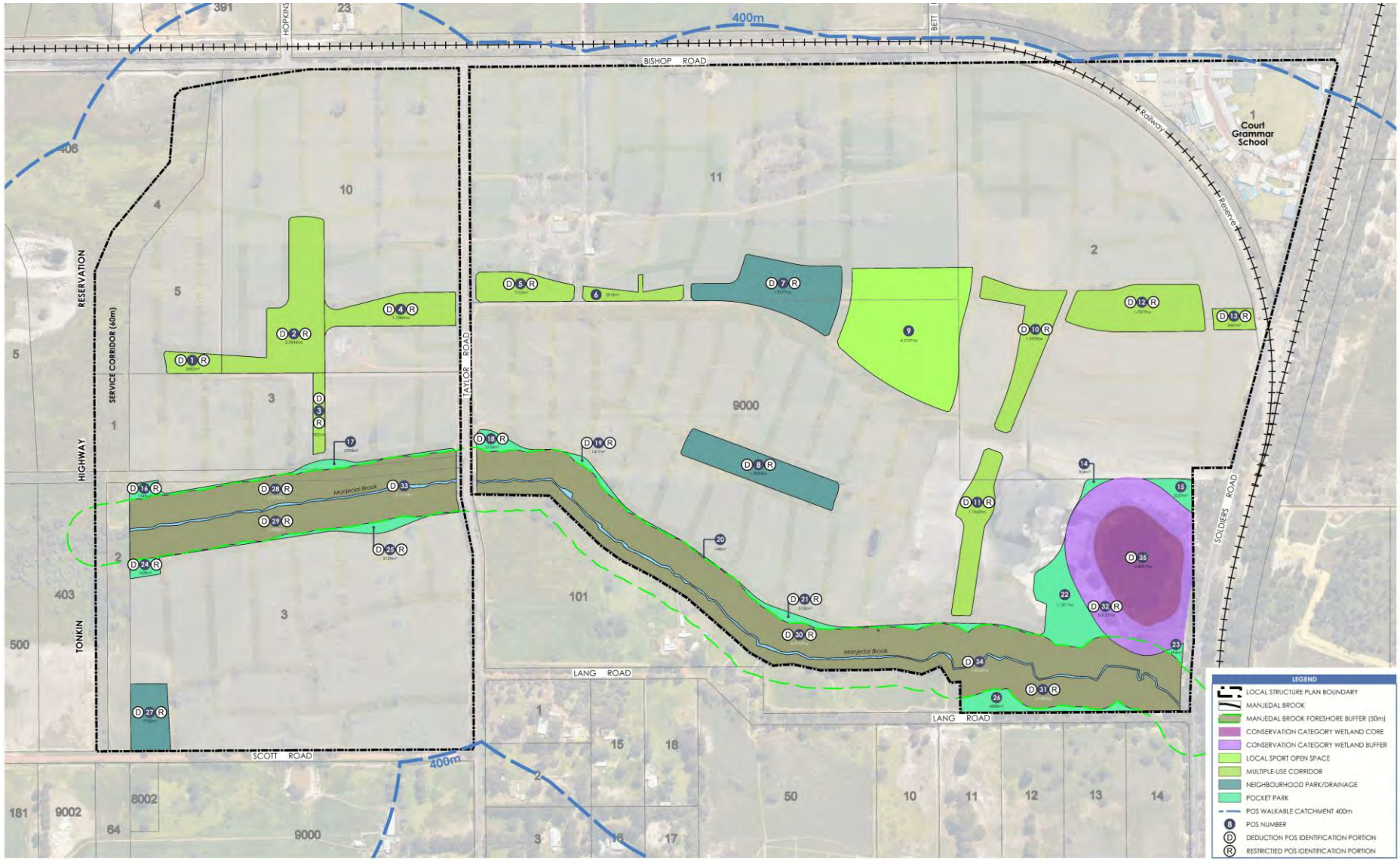


Figure 12 Public Open Space Plan

Table 8 Public Open Space table

PUBLIC OPEN SPACE TABLE			
Number	**Size (ha)**	**Deduction (ha)**	**Restricted (ha)**
1	0.3482	0.0367	0.1931
2	2.3546	0.2163	0.8368
3	0.2931	0.0758	0.0526
4	1.1086	0.1799	0.2483
5	0.7703	0.1250	0.2560
6	0.3918		
7	1.9277	0.3300	0.5094
8	1.3930	0.1070	0.1128
9	4.2737		
10	1.3533	0.1880	0.1669
11	1.1662	0.2734	0.1132
12	1.7577	0.1856	0.2524
13	0.2661	0.0358	0.0283
14	0.0704		
15	0.2237		
16	0.1345	0.0520	0.0155
17	0.2598	0.0970	0.0388
18	0.2124	0.0360	0.0658
19	0.1417	0.0383	0.0989
20	0.0148		
21	0.3150	0.0650	0.1138
22	1.1311		
23	0.0494		
24	0.1638	0.0590	0.0239
25	0.3139	0.0620	0.0698
26	0.4888		
27	0.7732	0.0670	0.3223
28	2.9009	16.6735	
29	2.9085		
30	6.9157		
31	3.9484		
32	3.0137	3.0137	
33	0.2103	0.2103	
34	0.4536	0.4536	
35	2.4057	2.4057	

Table 9 Public Open Space schedule

PUBLIC OPEN SPACE SCHEDULE		
Gross Site Area – Excluding Existing Roads & School (ha)		**199.3311**
Deductions		
Service Corridor	7.1910	
Primary Schools (proposed)	7.5063	
Neighbourhood Centre	0.7149	
Conservation Category Wetland Core	2.4057	
Drainage Basins (1:1)	2.2298	
Drainage Reserves (Manjedal Brook)	0.6639	
Surplus Restricted Public Open Space (Manjedal & CCW Buffers)	19.5872	
Total Deductions	**40.2988**	
Gross Subdivisible Area		159.0323
Required Public Open Space (10%)		**15.9032**
Public Open Space Requirements		
Unrestricted public open space – minimum 80%	12.7226	
Restricted public open space – maximum 20%	3.1806	
Total		**15.9032**
PUBLIC OPEN SPACE PROVISION		
Unrestricted Public Open Space		
Formalised POS	16.0893	
Total Unrestricted Public Open Space		**16.0893**
Restricted Public Open Space		
Conservation / Passive POS (Manjedal Brook Buffer & CCW Buffer)	19.6872	
Restricted POS (1:5)	3.0806	
Total Restricted Public Open Space	**22.7678**	
Total Credited Restricted Public Open Space		**3.1806**
Total Credited Public Open Space		**19.2699**
Percentage of Public Open Space Provided (Unrestricted and Restricted POS Contribution)		**12.1%**
POS Oversupply		**3.3667**

Assumptions:

- All areas are in hectares.
- Total credited restricted POS is 20% minimum
- Assumes provision of 50m buffer to Manjedal Brook
- Assumes no 1 year drainage in Manjedal Brook buffer

3.3.2 Manjedal Brook and Wetland

As discussed, a 50m buffer has been provided to the Manjedal Brook, which may be subject to a future reclassification of the Brook to a REW through a biophysical assessment.

The Brook and Wetland buffers are predominately cleared and do not present a fire hazard. Management of the conservation areas and associated buffers will focus on the maintenance of hydrological processes and functions associated with the wetlands, and the enhancement of native vegetation within the buffer, to minimise the potential impacts that may occur as a result of the future development.

Final management of the Brook, Wetland core and buffers are to be determined by the DPLH. It is understood, at this stage, that the Brook and Wetland core will be ceded as a Reserve for Conservation and a management order established under the control of the State Government. It is likely that the buffers will be managed by the Shire of Serpentine-Jarrahdale in line with their standard responsibilities for the management of local parks.

Further detail with respect to management measures is outlined in the ILMS (refer **Appendix G**) and will be addressed as part of a future Wetland/Landscape Management Plan(s) to be prepared at the appropriate stage.

3.3.3 Landscape Design

An ILMS has been prepared by Emerge Associates to provide guidance on the management of environmental values within POS and conservation areas and outline management requirements for various environmental values and landscape considerations (refer **Appendix G**).

The landscape treatments for the development will occur over a series of distinct open space categories or 'management elements' as outlined below. Further detailed landscape design will be undertaken as part of future planning stages and subject to preparation and approval of detailed landscaping plans.

3.3.3.1 Multiple Use Corridors

MUCs have been designated to align with existing agricultural drainage lines through the subject land in an integrated landscape design approach that provides for usable informal passive and active POS. These open space areas will contain the swales and overland flow path that will be created, contoured and stabilised where necessary to provide a multiple use drainage/landscaped response. To facilitate multiple uses, it is proposed that 1:1 year and 1:10 year stormwater events will be contained within landscaped drainage channels within the multiple use corridors and the 1:100 year stormwater event contained within the adjacent drainage basins. The drainage channels will typically be planted with side slopes no greater than 1:3 or grassed areas with maximum side slopes of 1:6 grade. Some sections of the arterial drainage system will comprise of piped connections.

The MUCs will incorporate dual use and pedestrian path systems with built in vehicular crossing and access points for maintenance purposes. Dual use and pedestrian systems shall provide smooth and easy access to all features of the open space and link accordingly into residential and other areas adjacent as part of a greenbelt system across the development. Disability access will be given a high priority and will be designed in accordance with relevant Australian Standards.

Pedestrian crossings over the drainage channels will be incorporated into the overall footpath network which will be constructed of timber or composite decking products as agreed with the Shire. Balustrading will be provided where the fall heights exceed the requirements of the Building Code of Australia (typically 900mm in height). All associated landscape infrastructure will be constructed above the 1:5 year stormwater flood levels. **Figure 13** illustrates a number of ways the MUCs could be developed.



Figure 13 Multiple Use Corridor Indicative Concept

3.3.3.2 Neighbourhood Parks

Neighbourhood parks are proposed to act as a ‘destination park’ either along the MUCs or in their own right. Neighbourhood parks will link to the adjoining residential streets and to the overall network of footpaths, providing ease of access and legibility.

Shrub plantings are planned within strategic areas to provide spatial definition and colour where required. Shrub planting shall primarily consist of lower growing species to enable clear vision and security through passive surveillance. It is proposed that the shrubs will consist of native species, with consideration and adherence to Waterwise principles.

Drainage areas may be catered for within the neighbourhood parks. Where these are included, the drainage basins will be landscaped, for both recreational and amenity functions. **Figure 14, Figure 15 and Figure 16** illustrate an indicative neighbourhood park concept, cross-section and senior sized oval concept adjacent to a primary school for shared use and demonstrating sufficient area for facilities outside of the area required for the playing field (ie clubhouse, car parking etc.



Figure 14 Neighbourhood Park Indicative Cross-Section



Figure 15 Neighbourhood Park Indicative Concept

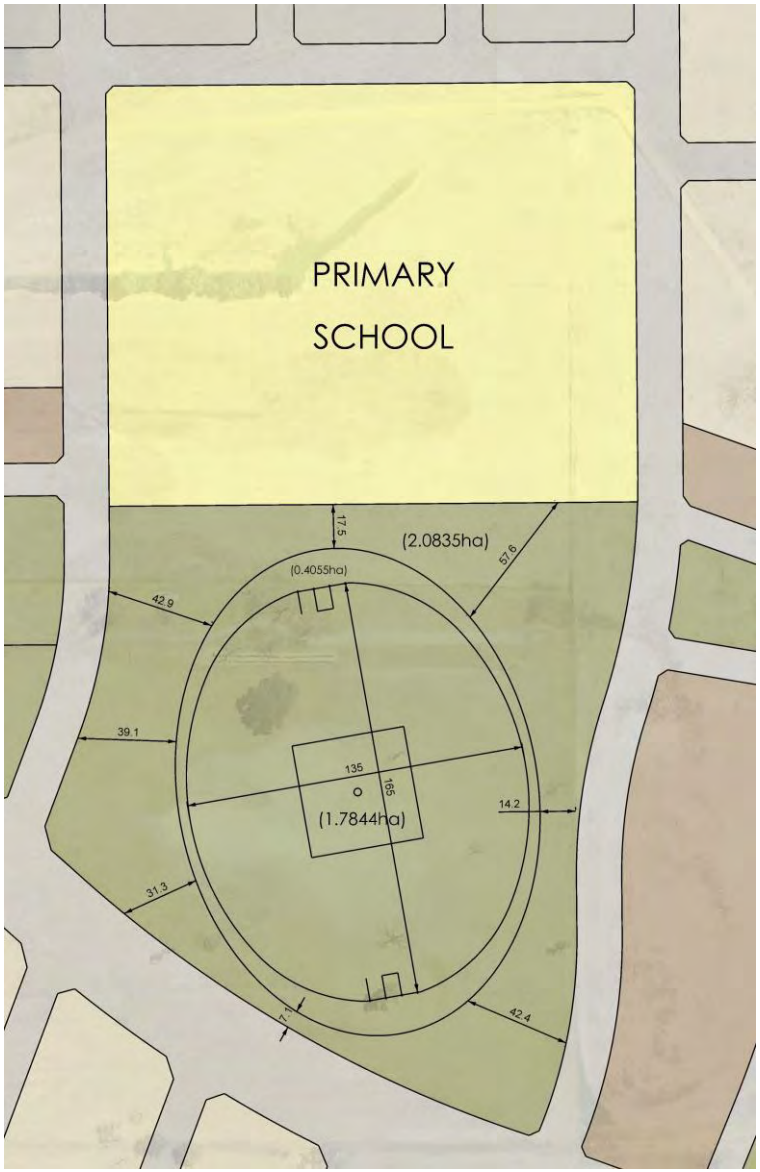


Figure 16 Senior Sized Oval

3.3.3.3 Conservation Category Wetland Buffer

A 50m buffer from the mapped CCW has been accommodated within the LSP design. To enhance the condition of the vegetation and protect these areas from current and potential future impacts from adjacent land uses, partial revegetation will be undertaken within the buffer areas. The revegetation will consist of local native flora species and those wetland and dryland species considered suitable for revegetation and will be undertaken in a way that considers future bushfire implications.

Given the highly degraded nature of the majority of the buffer area, some amenity landscaping is proposed to provide a spill out space or activity node, (refer **Figure 17** and **Figure 18**).

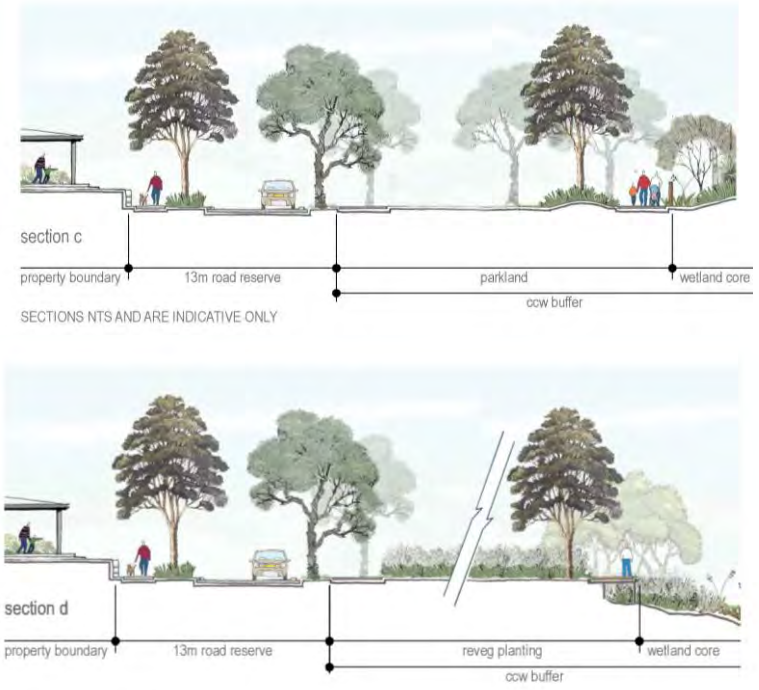


Figure 17 CCW Indicative Cross-Section



Figure 18 CCW Indicative Concept

3.3.3.4 Manjedal Brook Foreshore Reserve

A 50m foreshore reserve has been provided on either side of the existing Manjedal Brook waterway channel, and is considered appropriate to encompass the existing ecological and hydrological values of the Manjedal Brook, and provide an appropriate buffer between the waterway and adjacent development. As discussed, this will be subject to a biophysical assessment in order to seek a potential reclassification from CCW to REW category.

As proposed for the CCW buffer, to enhance the condition of the vegetation, revegetation will be undertaken consisting of local native flora species where appropriate, and those wetland and dryland species considered suitable for revegetation. **Figure 19** and **Figure 20** illustrate an indicative concept and cross-section for the Manjedal Brook foreshore reserve.

Passive recreation opportunities within the foreshore reserve will include dual-use footpaths, boardwalks and shelters, which will link in with the wider open space network. Interpretative signage will be located along the footpath and boardwalk network informing the community and users of the waterway, highlighting local flora and fauna values.

Bio-filtration and detention basins will be included in some locations. These basins will be landscaped for both recreational and amenity purposes, to provide ease of maintenance and to maintain the current predevelopment flows into the brook, particularly the incorporation for requirements from the 1:100 YR ARI events.



Figure 19 Manjedal Brook Indicative Cross-Section



Figure 20 Manjedal Brook Indicative Concept

3.3.3.5 Streetscapes

Streetscapes throughout the development shall incorporate a variety of treatments in response to the road hierarchy system. In all cases landscape works shall incorporate tree planting in accordance with accepted traffic standards on the standard street tree alignment in relation to the service utility corridor and the Shire's LPP 4.16 Tree Retention and Planting. Treatments may include soft works such as street trees and groundcovers.

The retention of existing trees where possible will enhance the project's landscape theme, and the trees will serve an important visual buffer and amenity function in reinforcing the rural character of Mundijong.

3.3.3.6 Drainage

Drainage will be managed through a variety of treatment typologies including bio retention areas and flood storage areas.

Runoff from storm events will be directed into outlet basins located within the open space areas. These basins will be located in a manner which considers the environmental values of the area and generally avoid further clearing of native vegetation wherever possible. Generally these will include:

- Bio-retention areas – vegetated swales and/or basins designed to retain the 1:1YR ARI rainfall events and to strip nutrients.
- Flood storage areas – detention basins to ensure that post-development stormwater flows are equivalent to pre-development flows, and may include vegetated, turfed, or other treatments.

3.4 Movement Network

A Traffic Report has been prepared by Riley Consulting (dated 2016) in support of the LSP (refer **Appendix H**). The purpose of the Traffic Report was to assess traffic generation and distribution, road reserve requirements, intersection capacity, foot and dual use path alignments and public transport needs. A further Traffic Report was prepared by Riley Consulting (dated 2022) (refer **Appendix H**) to respond specifically to the Schedule of Modifications required by the WAPC and based on district road planning and modelling undertaken by the Shire, DPLH and MRWA since preparation of the original report in 2016. Key aspects of the reports are outlined below.

3.4.1 Road Network and Traffic Volumes

The LSP incorporates a highly permeable modified grid movement network influenced by the existing road network and recommendations of the Mundijong-Whitby DSP (2021) and South Metropolitan Peel Sub-regional Planning Framework. Based on and approximate dwelling yield of 3,000, and a daily trip rate of 8 trips per day, ultimate development of the subject land is expected to generate in the order of 24,000 trips per day. The two proposed primary schools and neighbourhood centre have also been factored into these calculations.

Based on the expected distribution of that traffic, having regard for the attraction of internal and external facilities (schools, local centres and access to regional destinations), the anticipated road hierarchy for the district structure planning, the following outlines the forecast traffic movements and indicative cross-sections for each internal road type in accordance with Liveable Neighbourhoods.

Figure 21 shows the suggested road hierarchy for the LSP, involving a combination of laneways, access streets and neighbourhood connectors.

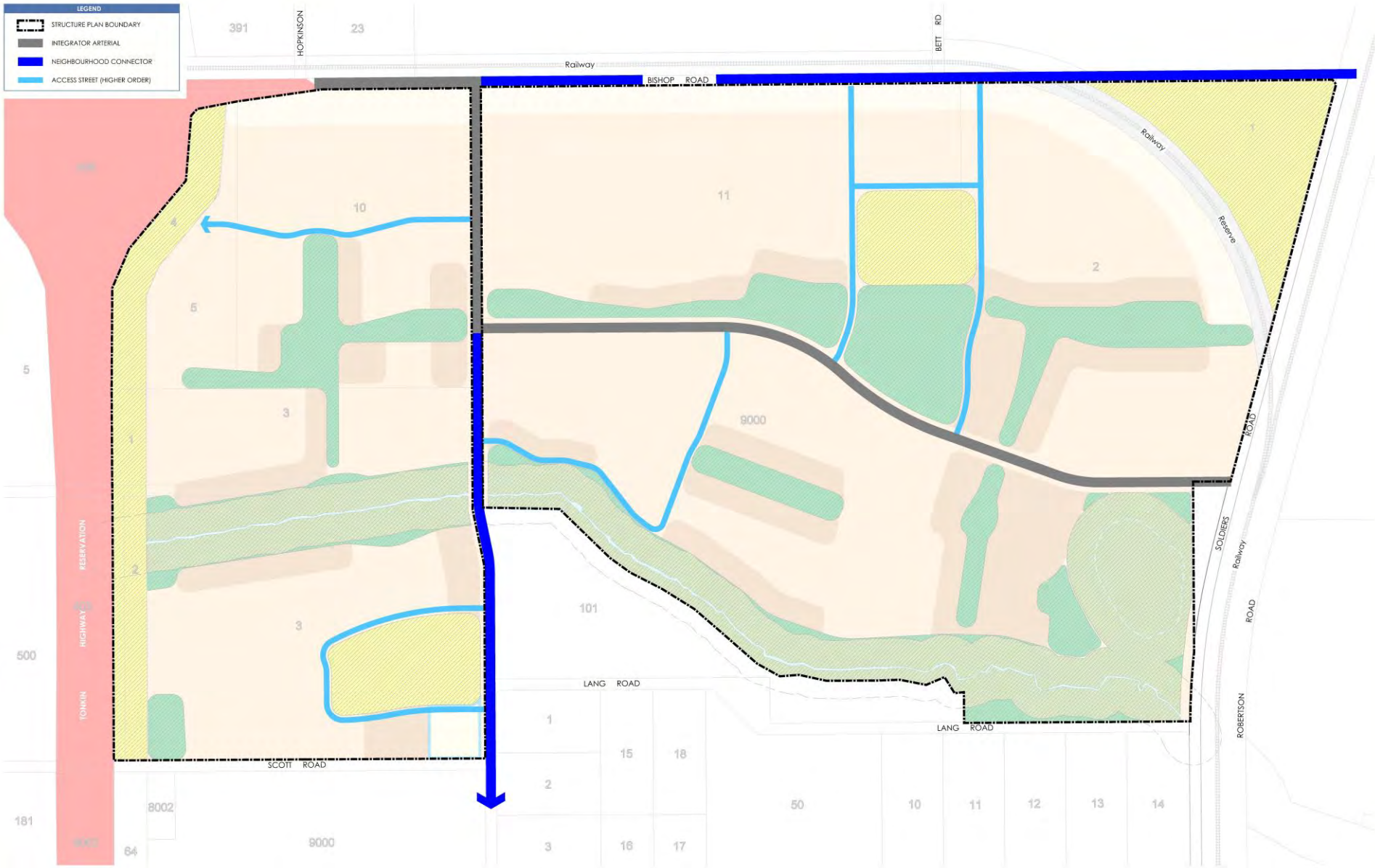


Figure 21 Proposed Movement Network

3.4.1.1 Integrator Arterials

As required by district road planning and modelling, Taylor Road (northern portion), Bishop Road (western portion) and the proposed East-West Connector are identified as Integrator Type A roads. Under Liveable Neighbourhoods the forecast traffic demands would require a road reservation of 31.2 metres to accommodate 10,000-2,000vpd.

A 6.0m median and pavements of 5.0m would be suited to this road to provide a standard traffic lane and an on-street cycle lane of 1.5m. Residual verges of 7.6m would be provided and allow for future duplication of the traffic lanes if deemed appropriate. With ultimate pavements of 8.5m for each direction (7.0m traffic lane plus 1.5m cycle lane), the verges would be reduced to 4.1m. If standard verge configurations are deemed to be required (5.1m) at full development a further 2.0m would be required to achieve a reservation of 33.1m. However, as required by district road planning and modelling, the SP allows for a road reservation of 35.6m for those portions of Taylor Road, Bishop Road and the proposed East-West Connector identified as Integrator Arterial roads.

Proposed connections of integrator arterials to Bishop Street and Soldiers Road / Robertson Road will result in the creation of four-way intersections requiring the construction of appropriate traffic management treatments in response to Austroads guidelines. Internally, the proposed connection between Taylor Road and the east-west neighbourhood connector is also proposed as a roundabout. All other access locations along Taylor Road have been suitably spaced to accommodate priority intersections.

3.4.1.2 Neighbourhood Connectors

Daily traffic flows on roads shown as neighbourhood connectors on **Figure 21** are well within the 7,000 vpd recommended. The northern portion of Taylor Road (identified as an Integrator Arterial) is expected to experience an increase in traffic volume due to the primary access with Bishop Road and east-west connector, however the southern portion (identified as a Neighbourhood Connector) is well within the capacity of the existing road.

These streets can be provided with a standard 7.2m carriageway, which is suited to bus movements. A footpath on both sides of the street is required, although one side may be designated as a shared use path. At intersections, median islands of 2.0m width would be desirable to provide safer pedestrian crossing points and to highlight the intersection. A residual verge width of 4.1m will occur where such medians are provided. A minimum 20.0m road reserve is recommended for neighbourhood connectors, however the southern portion of Taylor Road and eastern portion of Bishop Road classified as a 'Neighbourhood Connector' will feature a 30m road reserve as required by district road planning and modelling.

3.4.1.3 High Order Access Streets

Access streets carrying between 1,000 vpd to 3,000 vpd are considered to be higher order access streets (Local Access Street 'C') and a slightly wider road reservation is suitable. Liveable Neighbourhoods suggests that these streets would be considered as 'typical residential streets' and a carriageway width of 7.0m within a 15.4m to 16.0m road reservation is appropriate. However, the 7.0m wide carriageway is not supported in residential areas as it will tend to encourage a higher traffic speed. A 6.0m carriageway within a 15.0m wide road reservation is preferred to encourage a 40 kilometres per hour (kph) target speed and should restrict volumes to less than 3,000 vpd, maintain appropriate residential amenity. A wide carriageway is only recommended where buses or large vehicles are expected. In higher density areas, the provision of parking embayments is a preferred treatment rather than an increased carriageway width.

3.4.1.4 Lower Order Access Streets

Almost all other roads are classified as lower order access streets on the basis they are expected to cater for volumes below 1,000 vpd. To encourage a slower speed environment, a 5.0m to 5.6m carriageway (within a 14.2m reservation) is suggested. In order to accommodate parking embayments, a 15.0m road reservation is suggested.

3.4.1.5 Roads Abutting Public Open Space

Where roads (of all types) abut POS, a reduced reservation width involving an offset verge on the POS side to a minimum of 1.0m will be provided, on the basis that a full verge width will not be required for parking and/or servicing purposes. Footpaths are not required adjacent to the road where POS is provided. Reserve widths will be documented at the subdivision stage of development, with carriageway designs to be reviewed by the Shire's engineers at the detailed engineering stage of development.

3.4.1.6 Roads Abutting Schools

Where roads abut the proposed primary schools, an 18.0m road reservation is recommended to provide for future on street parking. The reservation allows ample width to provide embayed parking, in addition to a dual use path abutting the school and a footpath on the opposite side.

3.4.1.7 Traffic Management Devices

Street blocks within the development generally conform to Liveable Neighbourhood standards, with access streets typically less than 200m long, and intersections appropriately controlled. There are no road sections that require the introduction of traffic management to control traffic movements.

To further reduce the opportunity for speeding, it is recommended that corner radii outlined in Liveable Neighbourhoods be adopted during construction, being:

- 6m – access street / access street intersections
- 9m – access street / neighbourhood connector.

Where larger vehicles are expected (such as buses accessing a school) larger radii may be required and should be considered at the detailed design stage of development.

Access to Bishop Road will accord with the intersection spacing requirements set out in Liveable Neighbourhoods. Based on Integrator A standards, intersection spacing of 130m (junctions on same side of street) is required. Direct lot access is not permitted, although service lanes maybe used.

3.4.1.8 District Structure Plan and Road Planning Implications

As discussed, the Shire, DPLH and MRWA has undertaken a number of traffic studies for the Mundijong-Whitby locality and wider district and regional areas heavily informed by the Shire's district structure planning (2021) and Sub-regional Planning Framework. Significant consultation with these agencies has occurred which has informed the proposed movement network of this SP, however there still remain uncertainties around road and rail planning requirements, specifically the realignment of the freight rail along the northern boundary and the intersection of the east-west connector and

Of specific relevance to the subject land, the road hierarchy of the SP (specifically Taylor Road, Bishop Road, Soldiers Road and east-west connector) are cognisant of the road network planning by DPLH.

Table 10 below shows the anticipated road network impacts in the context of the forecasts outlined in the Mundijong-Whitby DSP (2021) and shows that the Riley Consulting Saturn modelling of the SP (2016) generally retains traffic forecasts to levels identified in the DSP. There are some external roads that are shown to carry greater traffic demands (Bishop Road and Soldiers Road).

Table 10 DSP and actual traffic forecasts

ROAD	DSP (2021) FORECASTS (VPD)	LSP (RILEY CONSULTING) FORECASTS (VPD)
Watkins Road (at Mundijong Road)	4,200	5,980
Mundijong Road west of Paterson St	12,381	11,510
Mundijong Road east of Tonkin Highway (between Tonkin Hwy and Paterson St)	7,000	22,221
South Western Highway	18,270	14,590
Paterson Street (at Mundijong Road)	2,810	7,270
Soldiers Road	3,420	4,380
Taylor Road (south of Bishop Road)	5,962	17,580
Taylor Road (south of Scott Road)	1,740	6,390
Bishop Road (at Tonkin Highway)	7,010	23,410
Bishop Road (at Soldiers Road)	3,590	3,190
Tonkin Highway	15,650	19,420
East-West Connector (mid)	2,200	15,790
East-West Connector (at Whitby)	-	21,850

The proposed road network of the SP accommodates district road planning, however as notated on the SP the ability to accommodate a future grade separation of the rail crossing at Soldiers Road requires further investigation.

3.4.2 Pedestrian and Cycling Network

The Shire's Walking and Cycling Plan (February 2020) sets out an interim and long-term aspirational walking and cycling network for the Shire and includes an implementation program for individual projects that will support the realisation of the Plan's vision and objectives. The strategy and path alignment generally follows the Department of Transport's Perth and Peel Long Term Cycle Network Plan and identifies 'primary' routes along the future Tonkin Highway extension to be completed as part of large State infrastructure projects and 'local' routes aligning with Taylor Road, east-west connector road and adjacent to the proposed primary school. This is reflected in the proposed walking and cycling network for the subject land (refer **Figure 22**).

A highly interconnected path network is proposed, inclusive of paths on both sides of high volume roads (in excess of 1,000 vpd) and key connections to the broader pedestrian/cyclist network and key attractions such as the proposed primary schools. Adjacent to the school and on identified walking routes, it is desirable to provide a footpath to both sides of the street.

Paths are also proposed along the Manjedal Brook within each key POS areas providing a permeable walking network. There is also the potential for a shared path to be provided across the brook providing a dedicated walking and cycling link to/from proposed schools within, and to the south of, the subject land. The exact location and the provision of footpaths will be determined at the detailed design stage, to the satisfaction of the Shire of Serpentine-Jarrahdale.

Shared paths along neighbourhood connectors will be provided to provide a safe cycle network. A principal shared path is identified on the DSP adjacent to the future Tonkin Highway. The cycle network proposed under the SP will be designed to connect to the broader cycle network (principal shared path) adjacent the future Tonkin Highway (to be constructed by others).

3.4.3 Public Transport

As discussed, the Mundijong Train Station is located within close proximity and the Armadale Train Station is located approximately 21km to the north of the subject land.

As part of the State Government's METRONET, the Byford Rail Extension project will extend the Armadale line to Byford. An elevated rail through Armadale is proposed and the extension project will result in the removal of eight level crossings at Armadale Road, Forrest Road, Church Avenue, Seventh Road (pedestrian level crossing), Byron Road, Eleventh Road, Thomas Road and Larsen Road.

The project will also deliver a new ground-level Byford Station approximately 400m north of Abernethy Road with around 400 parking bays, a bus interchange, and pedestrian connections. Works are already underway on the Thomas Road project to configure the level crossing to a road-over-rail bridge and main works for the Byford Station will likely commence from late-2023 for approximately 18 months.

The Mundijong DSP (2020) advocates for passenger rail extension from Byford to the Mundijong with a further train station in the Mundijong Town Centre and a 'transit node' identified east of the Whitby District Centre as a high frequency transit corridor.

As discussed, there are two bus services (Routes 252 & 253) operating within the locality. The DSPs (2011 and 2020) identify a potential bus route along Taylor Road / Soldiers Road that would terminate on the northern side of Mundijong Road.

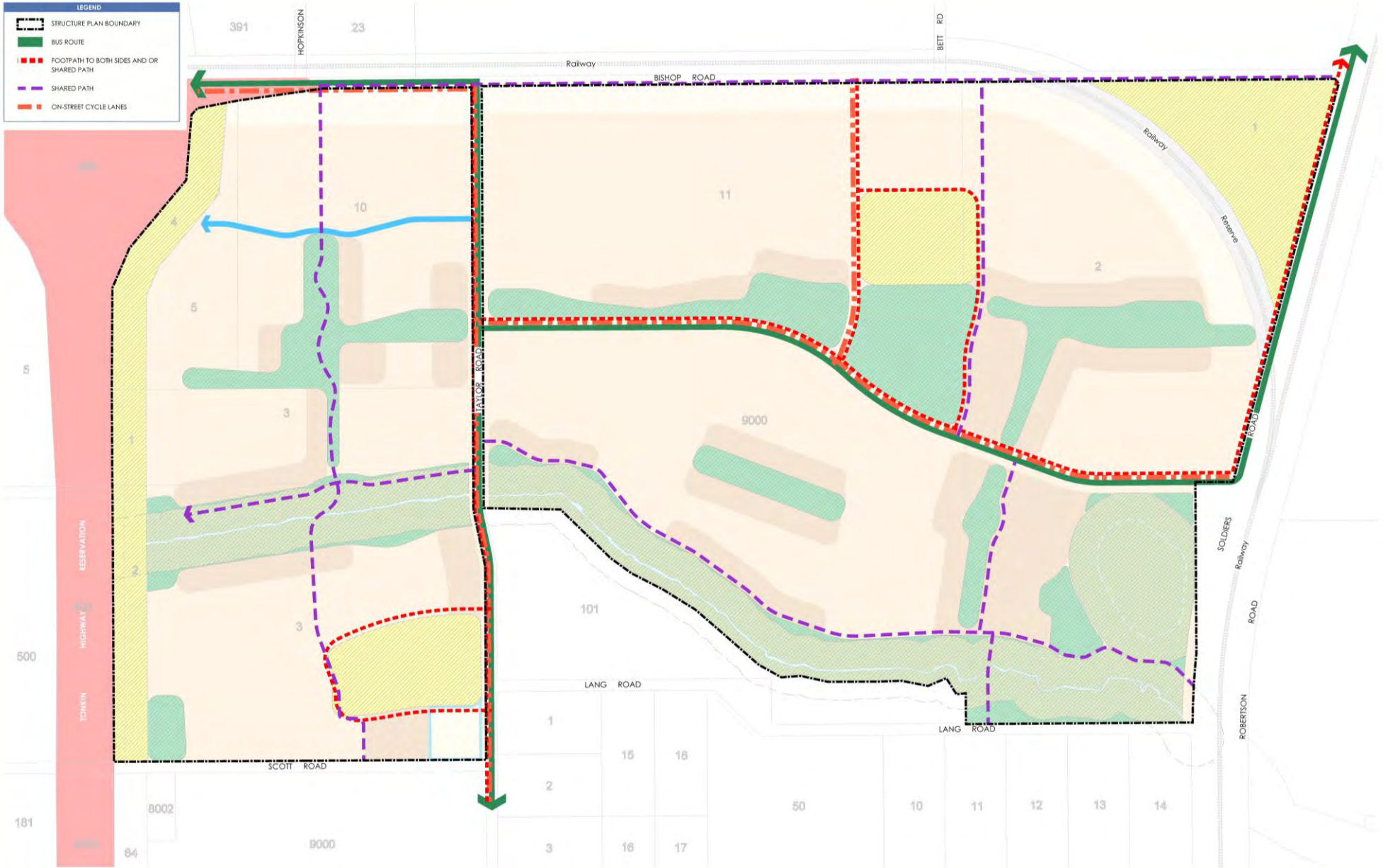


Figure 22 Proposed Pedestrian and Cycling Network

3.5 Water Management

3.5.1 Local Water Management Strategy

A LWMS has been prepared by Wave International in support of the SP (refer **Appendix C**). The purpose of the LWMS was to analyse local hydrological site conditions and establish the concepts and broad level design measures for flood mitigation and stormwater management necessary to facilitate urban development of the site.

Key aspects of the report are summarised below.

3.5.2 Stormwater Management

The stormwater management strategy for the subject land is to generally maintain the pre-development flow paths where practical, which follow the subject land's natural topography. Storage basins and swales will be integrated into the POS to attenuate post-development runoff and ensure that runoff discharging from the subject land is within pre-development flow rates.

Key elements of the stormwater management strategy include:

A proposed central drainage system traverses the subject land from east to west, parallel with the Manjedal Brook. Perpendicular north-south drains allow water to be discharged into the Manjedal Brook.

- The proposed buffer to the Manjedal Brook will be used for attenuation basins for the 1:5YR ARI events. All 1:1YR ARI events are located in POS outside the buffer.
- No stormwater flow from the development will discharge into the CCW and subsoil drainage will not drain water from this wetland area.
- The SP area is divided into sub-catchments, each of which will consist of a bio-retention basin and attenuation basin to manage post-development for up to 100YR ARI events.
- Roof runoff from residential lots will be retained and infiltrated in soak-wells for storm events up to 1YR 1hr ARI.
- Road runoff from events up to 1YR 1hr ARI will be directed into bio-retention swales which will be located in POS areas and road reserves (in medians or inactive lot frontages where practicable).
- The separation of the 1YR ARI bioretention areas from the 5YR and 100YR flood storage areas should be adopted as a preferred option in the subdivision drainage design to minimise the flushing of entrapped nutrients.

3.5.3 Water Conservation

The LWMS seeks to achieve the objectives for water use and conservation as outlined in the DWMS:

- Ensure the efficient use of all water resources in the newly-developing urban form and aim to achieve highest value use of fit-for-purpose water.
- Maintain opportunities for future generations by using water more efficiently.

The proposed development will be designed to minimise potable water use, and to ensure fit-for-purpose water use. 'Fit-for- purpose' refers to the use of water that is of a suitable quality for the intended use. The use of high-quality drinking water for garden irrigation, for example, is not a fit-for-purpose use and lower-quality water (e.g. rainwater, groundwater etc.) would be more suitable for this purpose. The Shire of Serpentine-Jarrahdale is investigating potential alternative water sources that could be used for a third-pipe scheme throughout the greater Mundijong area. The road reserves within the development are wide enough to accommodate a third pipe network within the verges, should an alternative water source be available at the time of subdivision.

Future UWMPs for the precinct will outline the specific water conservation measures that will be taken to ensure that the consumption targets are achieved.

3.5.4 Groundwater Management

It is proposed that the following criteria be applied to setting a localised CGL for the subject land, which would set the minimum level for subsoil drainage or open drainage inverts:

- For areas adjacent to water dependent ecosystems (i.e., Manjedal Creek and the CCW), CGL should be equivalent to the pre-development perched winter water levels. The design of the subsoil drainage system will need to show that no drawdown of pre-development perched water levels will occur within wetlands or their buffers.
- In all other areas, the level of the underlying clay material will dictate the minimum subsoil drainage invert levels and grades. Living streams and bio-retention areas should be designed to ensure that baseflow during winter months is contained within defined areas that will be planted with sedges and appropriate plant species.

- Subsoil drainage invert levels at the outfall locations should be at least 0.65m above the invert of the closest open drain, to ensure sufficient separation of bio-retention areas below the drain outlet and above stream baseflow levels. Unless approved by the local authority, all subsoil drains should discharge to bio-retention treatment areas.

3.6 Education Facilities

3.6.1 Primary Schools

The Mundijong-Whitby DSPs (2011 and 2020) identifies two primary school sites within the LSP area. The northernmost primary school site is 3.5 ha in area and is co-located with POS for shared use by the school and surrounding community. The southernmost primary school is 4 ha in area and is located along the western boundary of Taylor Road in accordance with the location as shown on the DSPs.

Both Element 8 of Liveable Neighbourhoods and Operational Policy 2.4 – School Sites (OP 2.4) provide a guide to facilitate the responsive design of school sites in new subdivision areas. Both documents state that primary schools should be located on a neighbourhood connector with good accessibility for walking, cycling and public transport together with vehicular access. Shared ovals with local government and school sites are encouraged to improve land efficiency, and allow the provision of smaller school sites, as is the case with the proposed primary school site within the subject area. In such cases, a minimum site area of 3.5 ha is required for a primary school in cases of co-location with adjoining POS.

It is of note that an existing high school site, Court Grammar School private K-12 school, is situated within the north-eastern corner of the subject land, which services a large portion of the Mundijong existing community.

3.7 Activity Centres and Employment

Precincts E & G of the Mundijong-Whitby DSP (2011) contain portion of a local neighbourhood centre which will provide for the convenience needs of the local community. The location of this neighbourhood centre is within Sub-Precinct E1 and proposed Sub-Precinct G2, and is outside the responsibility of the subject SP.

In addition, the Mundijong DSP (2020) identifies two neighbourhood centres for the SP area, being at the intersection of Taylor Road and the east-west connector road and along the southern boundary of the SP area abutting Taylor Road.

However, subsequent discussions with the Shire of Serpentine-Jarrahdale have indicated that there is a preference for the local centre to be accommodated within proposed Sub-Precinct G1 subject to this SP. In line with the requirements of the WAPC approved DSP (2011), the SP proposes a neighbourhood centre of 0.71ha, comprising 2,500 square metres (sqm) of retail floorspace (1,500sqm small supermarket and 1,000sqm speciality retail) wholly within the Sub-Precinct G1 SP area.

In addition to the proposed neighbourhood centre, the future Whitby District Centre, located to the east of the subject land, will provide higher order retail and commercial uses.

3.8 Infrastructure Coordination, Servicing and Staging

Wave International was engaged to prepare an Infrastructure Servicing Report in support of the SP. An addendum has been prepared by TABEC Civil Engineering Consultants (2023) to supplement the Infrastructure Servicing Report (Wave International, 2015) in light of current wastewater and water scheme planning information and updated preliminary servicing advice from the Water Corporation and Wester Power. A full copy of both reports, which concludes that all the necessary services are readily available (with sufficient capacity) in close proximity to the development, is included at **Appendix I**. Key aspects of the report based on current information and advice is summarised below.

3.8.1 Water Supply

The main water supply to Mundijong is currently supplied via the Serpentine Trunk Main on Summerfield Road 5.5km south of Mundijong Road, consisting of 150 millimetres (mm) and 300mm diameter (dia) water main pipes. A 600mm dia distribution main has recently been constructed along Paterson Road between Keirnan Street and Mundijong Road.

In order to service the initial stages of development (i.e. 400 lot capacity), water supply can be obtained from the staged construction of a 250mm dia reticulation main from Keirnan Street northwards along Soldiers Road which connects with the existing 600 dia at the intersection of Keirnan and Paterson Streets. Alternatively, a 250mm dia reticulation main could be constructed via Paterson Street, Cockram Street and Taylor Road.

The Water Corporation has advised that developers and other landholdings west of Taylor Road/Adams Street would need to coordinate and fund the cost of water reticulation main extensions from the terminus of the existing 600 dia distribution main.

3.8.2 Wastewater

The subject land, and wider Mundijong area, is not currently serviced by a sewer reticulation network.

As an interim measure to service the immediate Mundijong gravity sewer catchment, the Water Corporation has constructed a Type 90 interim sewer pump station at Scott Road and pump sewage approximately 8km northwards to an existing pump station (PS086-02) off Hopkinson Road in Byford. The odour buffer associated with the WWPS does not extend within the subject land. The Water Corporation is in the process of revised sewer concept planning to incorporate additional flows from proposed development in the area and potential freight rail realignment options, which will likely result in an increase in the side of the gravity collection main traversing the western side of the subject land.

The Water Corporation has advised that the development will need to connect to the interim Type 90 pump station at Scott Road via a gravity sewer extension.

Current Water Corporation planning includes the construction of a permanent Type 1000 sewer pump station at the Scott Road site. This WWPS will be developed as multiple Type 350 and Type 500 units located on two separate sites, east and west of the future Tonkin Highway extension, and will be developed to the ultimate capacity.

3.8.3 Power Supply

The existing Western Power distribution infrastructure in the vicinity of the subject land comprises of several three phase 22kV HV aerial feeder lines, which are supplied from the existing Byford Zone Substation.

These are present in the following locations:

- Bishop Road - The three phase overhead power line crosses Bishop Road from the east side of Hopkinson Street. This aerial line runs eastwards along the southern side of Bishop Road where it terminates prior to the intersection with Soldiers Road to serve the Serpentine Jarrahdale Grammar School.
- Taylor Road - A three phase overhead power line connects from the Bishop Road system and runs southwards along the eastern side of Taylor Road. This overhead line runs the full length of Taylor Road and Adams Street to serve the residential area to the southern side of the subject land.
- Scott Road - A three phase overhead power line connects from the Taylor Road overhead lines and runs westwards before connecting to the Kargotich Road overhead power lines.
- Robertson Road - An underground HV cable runs along the eastern side of Robertson Road from the Byford substation to Keirnan Street.

As the subject site is located towards the end of the 22kV feeder network the ability to utilise the overhead network cables to service the development will need to be assessed by Western Power. The feeder may need to be extended as a HV ring to the proposed development areas. There is another existing HV overhead power line at the intersection of Paterson Street and Keirnan Street which could potentially be connected to, and extended as part of the HV ring to serve the development. However, confirmation should be obtained upon commencement of design of the first stage of work(s) due to other development within the area that may utilise this spare capacity in the interim.

Western Power were unable to provide a timeframe for the construction of a new major zone substation to allow part of the load of the Byford Zone Substation to be offloaded.

3.8.4 Telecommunications

The subject land is within National Broadband Network (NBN) Co's fibre footprint and can be serviced with optic fibre under their NBN roll-out scheme for Greenfield developments.

3.8.5 Gas Supply

There is an existing ATCO Gas 150mm dia high pressure gas main which runs along Soldiers Road and travels westbound along Bishop Road, terminating prior to Taylor Road. ATCO Gas has advised that connection into the existing high- pressure main will be required and that there is sufficient capacity in the network.

It is acknowledged that portion of the subject site is located within 300m of the Maximum Allowable Operating Pressure (MAOP) 1900+ pipeline located within the Bishop and Soldiers Road reserves. As per Draft DC Policy 4.3 – Planning for High-Pressure Gas Pipelines, any sensitive land uses within this trigger distance will require the preparation of a Pipeline Risk Management Plan (PRMP) at the subdivision/development stage to assess and control the risk.

Where development is not a sensitive land use or where works are carried out by others (e.g. as part of any future district and regional rail or road works) the responsibility and costs of works and modifications required to protect the pipeline shall be borne by the landowner/applicant.

3.8.6 Water Corporation Service Corridor

A 60m wide service corridor is proposed along the western boundary of the subject land in accordance with the requirements of the DSP. The service corridor will contain a Water Corporation pressure main that will discharge from the proposed Byford Main Pump Station to the proposed East Rockingham Waste Water Treatment Plant (WWTP).

3.9 Developer Contribution Arrangements

The Shire has prepared a Development Contribution Arrangement for the Mundijong-Whitby DCA for the provision of traditional and community infrastructure, inclusive of the LSP area. Landowners will be required to make a contribution towards a shared funding arrangement for both traditional and community infrastructure at the time of subdivision/development.

Appendix A

Pre- Lodgement Consultation

PRE LODGEMENT CONSULTATION

The following table summarises the outcomes of pre-lodgement consultation with the Local Authority and relevant government agencies.

Agency	Date of Consultation	Method of Consultation	Summary of Outcomes
Shire of Serpentine-Jarrahdale	12 December 2011	Meeting	• Mundijong Whitby Main Landowners Group – discussion regarding precinct boundary changes and progression of local structure plan over portion of Precinct G.
	19 December 2011	Meeting	• Project update including the following matters: - Outline of vision workshop (November 2011) and opportunities and constraints mapping - Shire preference to explore water reuse, incorporating Third Pipe, community bores etc. in accordance with the previous requirements of the DSP - Confirm with Water Corporation use and development in the Service Corridor, including temporary or interim uses - Review vegetation survey work undertaken for Soldiers Rd road reserve for the Whitby LSP - Requirement for Bushfire Management Plan and discuss fire friendly vegetation with Shire
	9 January 2012	Letter	• Formal request to seek Council's support for a minor variation to the Mundijong-Whitby DSP Precinct E & G boundaries.
	6 April 2012	Meeting	• Provide update on preliminary development concept plans, including lot yield, POS and drainage calculations.
	2 May 2012	Meeting	• Discussion on Local Water Management Strategy and the reported inflows from the upstream catchments. • The Shire advised that the recent work undertaken as part of the LWMS for the Whitby site to the east has shown that the flows into the subject land from the upstream catchments are much lower than reported in the DWMS. As such, the lower flows in Manjedal Brook are much more easily managed through the subject land and allow use of the brook's buffer for drainage purposes.
	September 2015	Meeting / Email	• Circulation of draft Concept Plan and discussion regarding Soldiers Road realignment.
	30 October 2015	Meeting	• Discussion on Local Water Management Strategy, in particular the following items: - Minor comments on water quality targets, groundwater yield and revised bio-filtration construction details - Recent changes to the upstream hydrology of the Whitby project that will need to be taken into consideration for the subject land - Likely volumes from the superficial aquifer - Piping of drainage through primary school site
	3 December 2015	Meeting	• Provide update on progression of draft Concept Plan. The following items were discussed: - Consider location of aboriginal heritage sites west of CCW and potential to apply for s18 clearance under the Aboriginal Heritage Act. - Consider reclassification of Brook (possible downgrading from CCW) and potential reduction in buffer as vast area of land poses significant management issues for Shire - Consider retention of trees where possible

Agency	Date of Consultation	Method of Consultation	Summary of Outcomes
Department of Education	16 November 2011	Email	• Confirmation that current student enrolments at Mundijong Primary School equates to a total of 175 students (K-7) and the school is currently operating at its full accommodation potential.
	December 2013	Meeting	• Confirm no encumbered cultural heritage land within primary school site and demonstrate all facilities can be built in presence of artefacts.
Department of Parks and Wildlife	17 January 2012	Meeting	• Discussion regarding Conservation Category Wetland (UFI 7835) and Multiple Use Wetland, Manjedal Brook and Aboriginal Heritage; pre and post development hydrology; and management of wetlands.
Department of Water	18 January 2012	Email	• Comments relating to Manjedal Brook suggest that the DoW would consider a buffer of less than 50m, however this would depend on the results of a biophysical assessment in line with Foreshore Policy 1. The buffer would be measured from the top of the bank. The DoW would consider retention basins and other infrastructure within the buffer, however this would depend what is being proposed and how close it is to the watercourse.
	6 April 2015	Letter	• Provision of comments on Local Water Management Strategy.
Water Corporation	30 January 2012	Email	• Provision of advice relating to ultimate design of service corridor and confirmation of the following: - 60m wide service corridor - Corridor could be used for public open space and drainage purposes for overflow during a major storm event, including floodways and drainage basins structures straddling the edge of the corridor - Up to two internal access roads will need to be accommodated within the service corridor - No limitations on landscaping and similar within the corridor - Local government responsible for maintenance of public access across the corridor
	20 January 2013	Email	• Discussions regarding Water Corporation planning for interim and ultimate waste water pump station (WWPS).
	2 November 2015	Email	• Current Water Corporation planning suggests that the buffers associated with the interim Type 90 WWPS (30m buffer) and ultimate Type 350 WWPS (50m buffer) will not extend into the subject land. Both WWPS will likely be located south of Scott Road.
Department of Aboriginal Affairs	29 February 2012	Meeting	• The data elicited by the research strategy would assist the ACMC with the deliberations in respect to the presence of archaeological Aboriginal sites within the subject land under Section 5(a) of the AHA and the significance of those sites under Section 39(2) and (3). • It would be beneficial for any section 18 Notice to have information about possible subsurface material in other areas of the subject land given the location of archaeological sites DIA ID 3648 and DIA IDA 450, particularly the ridge immediately west of DIA ID 3648. • DAA suggested testing areas considered to be of low potential on the clays, in order to ground truth the archaeological predicative model regarding the location of sites within the subject land.
Main Roads WA	February 2012	Email	• Various discussion regarding future Tonkin Highway extension

Appendix B

Environmental Assessment & Management Strategy

ENVIRONMENTAL ASSESSMENT & MANAGEMENT STRATEGY

TAYLOR ROAD, MUNDIJONG LOCAL STRUCTURE PLAN

Project Number EP15-036(01)

Prepared for Peet Mundijong Syndicate Ltd
May 2023



Document Control

DOC NAME	ENVIRONMENTAL ASSESSMENT & MANAGEMENT STRATEGY – TAYLOR ROAD, MUNDIJONG LOCAL STRUCTURE PLAN				
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C	May 2023	Kirsten Knox	KK	Kirsten Knox	KK
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Executive Summary

Taylor Burrell Barnett (TBB), on behalf of Peet Mundijong Syndicate Ltd (Peet), have prepared a Local Structure Plan (LSP) for urban development within Lot 2 Bishop Road, and lots 3, 5, 10, 11 29, 52 and 9000 Taylor Road, in the locality of Mundijong, within the Shire of Serpentine Jarrahdale. This area is herein referred to as "the site".

The LSP for the site has been prepared by TBB to provide a framework for the future implementation of residential land use. The LSP design incorporates the inputs from a multi-disciplinary project team and the outcomes from various technical studies.

Emerge Associates have been engaged to provide a suite of environmental consultancy services to support the preparation of the LSP, which has included numerous investigations to identify and assess the environmental attributes and values within the site. This included review of existing information and historic environmental assessments, and undertaking further site specific assessments and reporting, including:

- *Bushfire Management Plan* (Emerge Associates 2023a)
- *Integrated Landscape Management Strategy* (Emerge Associates 2023b)
- *Spring Flora and Vegetation Survey (Emerge Associates 2017).*

Based on the above, the environmental attributes and values identified within the site include:

- The majority of the site was historically cleared for agricultural purposes, primarily cattle grazing.
- Based on a detailed flora and vegetation survey undertaken in 2017 there are no Threatened Flora (TF) or Priority Flora (PF) species, Threatened Ecological Communities (TECs) or Priority Ecological Communities (PECs) present within the site.
- Vegetation within the site is generally in "Completely Degraded" or "Degraded" condition (based upon the flora and vegetation survey (Emerge Associates 2017). A small portion of vegetation in the south-east of the site, associated with an area of Conservation Category Wetland, is considered to range from "Good - degraded" to "Excellent – very good" condition.
- Bush Forever Site 350 occurs immediately east of the site, within the Soldiers Road and railway reserve. This Bush Forever Site is known to support significant flora and vegetation values. There are no Bush Forever sites within the site.
- Environmentally Sensitive Areas (ESAs) extend into the east of the site, associated with the flora and vegetation values known to occur within Bush Forever Site 350, and south associated with Manjedal Brook.
- Based on the flora and vegetation survey for the site (Emerge Associates 2017), the site potentially has value as habitat for threatened or priority fauna species, specifically suitable foraging and potential breeding habitat for black cockatoo species, however, would largely be restricted to the vegetation associated with Manjedal Brook.
- Manjedal Brook runs through the southern portion of the site. This creekline conveys surface flows through the site to the west, and joins with Cardup Brook and eventually the Serpentine River west of the site.
- The majority of the site is covered by Multiple Use Wetlands (MUW), and there are three Conservation Category Wetlands (CCW) in the south of the site, two of which are associated with Manjedal Brook.

- An existing railway line occurs adjacent to the northern and eastern site boundary, while a Primary Regional Road reserve associated with the Tonkin Highway extension and Water Corporation service corridor lies adjacent to the western boundary of the site. These existing and future adjacent land uses will pose acoustic and potential vibration implications to residential development within the site, however site specific assessments indicate impacts can be managed can be managed appropriately in the context of the policy framework.
- Vegetation surrounding the site, as well as that associated with Manjedal Brook and the CCWs which is proposed to be retained, presents a permanent bushfire hazard to residential development.

The environmental values and attributes of the site will be addressed or managed through the management framework outlined in this report, in accordance with the requirements of the planning framework, to be implemented as part of future residential development. This includes retention of remnant vegetation associated with the CCWs and Manjedal Brook, and provision of 50 m buffers to these features. As such, the proposed future development of the site is not expected to significantly impact on the environmental values and attributes of the site and region.

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Taylor Road, Mundijong Local Structure Plan

Appendix B
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Appendix C
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Appendix D
Copy of EPA Report on MRS Amendment No. 966/13

1 Introduction

1.1 Background

Taylor Burrell Barnett (TBB), on behalf of Peet Mundijong Syndicate Ltd (Peet), have prepared a Local Structure Plan (LSP) for urban development within Lot 2 Bishop Road, and Lots 3, 5, 10, 11 29, 52 and 9000 Taylor Road, in the locality of Mundijong. This area is herein referred to as "the site". The site is approximately 199 hectares (ha) in size, located in the Shire of Serpentine Jarrahdale, approximately 37 km south-east of the Perth Central Business District (CBD), as shown in **Figure 1**.

The site is bound by Bishop Road to the north and east, Manjedal Brook and Scott Road to the south, and rural landholdings to the west, as shown in **Figure 2**. The site is zoned "Urban" under the Metropolitan Region Scheme (MRS) and "Urban Development" under the Shire of Serpentine Jarrahdale's Town Planning Scheme (TPS) No. 2.

1.2 Purpose of report

This report provides a synthesis of information regarding the environmental attributes and values of the site. It is based on a range of information sources including local and regional reports, databases and publicly available mapping, and where necessary, site specific surveys and investigations. Together, this information has been used to inform the LSP and the preparation of the LSP supporting documentation.

The primary purpose of this report is to present the information that was used to inform the LSP, outline the potential environmental impacts that could arise from the implementation of the LSP, and in response to this and where required, outline responses in the LSP to accommodate the environmental values and attributes, and collectively provide an environmental management framework for the future residential subdivision and development process.

1.3 Scope of work

Emerge Associates have been engaged to provide a suite of environmental services to support the preparation of the LSP. This has included site specific technical investigations to identify and assess the environmental attributes and values/constraints present within the site and those areas for which the LSP formally covers.

To date, these services include:

- Desktop environmental investigation and review of historic investigations to inform this report.
- Preparation of a *Bushfire Management Plan* (BMP) (Emerge Associates 2023a)
- Preparation of an *Integrated Landscape Management Strategy* (ILMS) (Emerge Associates 2023b).

1.4 Environmental and site specific investigations

In addition to the above, there has been a significant body of investigations undertaken historically to understand the site. This has included:

- *Level 2 Flora and Vegetation Survey* (PGV 2012)
- *Spring Flora and Vegetation Survey* (Emerge Associates 2017)– attached in **Appendix B**.
- *Level 1 Fauna Survey* (Terrestrial Ecosystems 2011)
- *Fauna Survey of wetland and waterway* (Terrestrial Ecosystems 2012)
- *Habitat and targeted vegetation assessment* (Strategen 2015b)
- *EPBC Act significance assessment* (Strategen 2015a)
- *Preliminary Site Investigation of Lot 2 Bishop Road and Lot 11 Taylor Road* (Aurora Environmental 2014a)
- *Sampling and Analysis Plan for Lot 2 Bishop Road and Lot 11 Taylor Road* (Aurora Environmental 2014b)
- *Groundwater monitoring* (BGE 2009)
- *Addendum to the Local Water Management Strategy* (RPS 2023)
- *Local Water Management Strategy* (Wave International 2016)
- *Report on Geotechnical Study* (Galt Geotechnics 2011)
- *Noise Report (Herring Storer Acoustics 2023)*

2 Planning and Environmental Assessment Context

2.1 Planning context

The long term planning for the urbanisation of Mundijong and Whitby commenced in 1994 through the identification of the area for urban purposes within the Serpentine Jarrahdale Shire Rural Strategy. Subsequent to this, the area surrounding the Mundijong rural village was rezoned to “Urban” through MRS Amendment no. 966/13 in 1995, and rezoned to “Urban Development” through the Shire of Serpentine Jarrahdale TPS No. 2 Amendment in 2006.

The site is located within the Mundijong District Structure Plan (DSP), which aims to create a viable and liveable town for around 35,000 residents over the next 30 years, to be a well-connected community that is appropriate to the rural setting of the wider area and the natural landscape values (Hames Sharley 2021). A copy of the Mundijong DSP is provided in **Appendix C**. The site forms part of Precinct G of the Mundijong DSP area (as shown in **Appendix C**), and the LSP prepared for the site provides the sequential and more detailed level of land use planning required to deliver the vision of the Mundijong DSP.

The Mundijong DSP was adopted by the Shire of Serpentine-Jarrahdale in 2021 (Hames Sharley 2021) to provide overall guidance on the structure, vision and objectives for the planning and development of the Mundijong and Whitby areas.

2.2 Previous environmental assessment

The Amendment of the MRS (Amendment no. 966/13) was referred to the Environmental Protection Authority (EPA), which provided a strategic assessment and advice relating to the implementation of development in accordance with the MRS amendment, in place of a formal assessment under Part IV Division 3 of the EP Act (Government of WA 1995). This is discussed further in **Section 4**. A copy of the EPA’s advice and recommendations regarding a number of environmental issues is attached in **Appendix D**.

3 Existing Environment

3.1 Local context

The site is approximately 200 ha in size, and is bound by Bishop Road to the north and east, Manjedal Brook and Scott Road to the south, and rural landholdings to the west, as shown in **Figure 1**. The site is zoned "Urban" under the Metropolitan Region Scheme (MRS) and "Urban Development" under the Shire of Serpentine Jarrahdale's Town Planning Scheme (TPS) No. 2. The current MRS zoning across the site is shown in **Figure 2**.

The site is bound by "Urban" zoned land to the east and south, with a Railway reserve associated with the existing railway line adjacent to the eastern and northern site boundaries, and a "Primary Regional Road" reserve immediately west of the site, associated with the future Tonkin Highway extension (see **Figure 2**). Landholdings further west of the site are currently zoned for "Rural" land uses, and are intended for future industrial land uses under the West Mundijong Industrial Area Structure Plan (SoSJ 2022) (Shire of Serpentine Jarrahdale 2022).

Landholdings east of the site are currently undergoing separate residential subdivision processes in line with the endorsed Whitby Local Structure Plan (Roberts Day 2012) and will form an urban district centre and residential neighbourhood along with the site, in accordance with the Mundijong DSP.

3.2 Climate

The climate of the site which applies to the broader south west region of Western Australia is described as Mediterranean with hot, dry summers and moderately wet, mild winters. The majority of rainfall within the region occurs between May and October each year, and on average is between 600 to 1000 mm per year. However, in the last 40 years there has been a marked decrease in rainfall (between 10 to 15% decrease), with a noticeable shift to a drier climate across the south-west of Western Australia (CSIRO 2009).

The closest inland weather station to the site is the Karnet weather station, located approximately 18 km south-east of the site. Average climate statistics recorded at the Karnet weather station between 1963 and December 2022 (BoM 2023) is summarised in Table 1: Rainfall and temperature averages for the Karnet weather station (1983 to December 2022) (BoM 2023)**Table 1** below.

Table 1: Rainfall and temperature averages for the Karnet weather station (1983 to December 2022) (BoM 2023)

STATISTICS	J	F	M	A	M	J	J	A	S	O	N	D
Mean Maximum Temperature (°C)	30.6	30.4	27.8	23.3	19.2	16.5	15.5	16.0	17.7	20.8	24.4	28.3
Mean Minimum Temperature (°C)	15.3	15.8	14.4	11.8	9.0	7.3	6.4	6.4	7.3	9.0	11.4	13.6
Mean Rainfall (mm)	18.1	20.9	25.2	64.6	139.8	205.1	220.3	182.7	131.1	74.7	44.7	18.1

3.3 Landform and soils

3.3.1 Topography

The site is generally flat, with a westerly aspect. Topography ranges from approximately 40 metres Australian Height Datum (m AHD) in the north-east, and slopes down to approximately 25 m AHD in the west. Available topographic contours for the site are shown in **Figure 3**.

3.3.2 Regional geomorphology

The site is located on the Swan Coastal Plain, which forms the central portion of the Perth basin. The Perth basin extends from the Darling Fault in the east to the continental slope west of Rottnest Island, and from the Murchison River in the north and the Southern Ocean in the south. The Perth basin is sedimentary in original and is marginal to the west of the Australian Shield (Seddon 2004).

The Swan Coastal Plain is generally flat and is approximately 20 – 30 km wide, consisting of a series of geomorphic entities running parallel to the coastline. The youngest and most western of these geomorphic entities is the Quindalup Dunes, followed by the Spearwood Dunes and at the most eastern extent the Bassendean Dunes. The site is located on the eastern side of the Swan Coastal Plain, and falls within the Pinjarra, Bassendean Dunes, and Forrestfield Systems.

3.3.3 Landform and soils

Environmental geology (surface soils) across the site has been mapped by the Geological Survey of Western Australia (Gozzard 1986). The site is largely comprised of sandy clay of the Guildford Formation (Cs), with pockets of Bassendean Sand over clay (S_{10}) throughout the site. A small portion of clayey sandy silt (Msc_1) and peaty sand (Sp_1) occur in the south-east of the site, associated with the Alluvium soils of areas of CCW and Manjedal Brook. Landform and soil mapping for the site is shown in **Figure 4**.

A geotechnical survey (Galt Geotechnics 2011) was undertaken across the site which found soils within the site are consistent with the regional mapping. Based on the geotechnical survey of the site (Galt Geotechnics 2011), soil conditions across the site can be described by two typical soil profiles:

- Sand, comprising of the following:
  - Sand (SP) – Medium to coarse grained, sub-rounded to sub-angular material with occasional 5mm to 15mm weakly to moderately cemented ferruginised modules. (between 0.5m and 2.5m, however average thickness 1.4m); overlaying
  - Ferricrete Gravels (GP/GC) – Located in 9 out of 18 test pits at depths below 1.0m. Fine to medium gravels in sand and clayey sand, becoming cemented in areas. Refusal encountered between 0.9m to 2.0m.
  - Clayey sand (SC) – Located in 2 out of 18 test-pits and present below sand layer. Localised layer/lenses of medium to course sub-rounded to sub-angular varying between 10-30% low to medium plasticity clay fines with occasional 5mm to 15mm weakly to moderately cemented ferruginised modules. (0.4m thick).
- Clayey sand, comprising of the following:
  - Sand (SP) – Medium to coarse grained, sub-rounded to sub-angular material between 0.0m and 1.3m. (average thickness 0.7m); overlaying
  - Clayey sand (SC)/Sandy Clay (CL) –Medium to course grained sub-rounded to sub-angular varying between 20-60% low to medium plasticity clay fines (localised high plasticity) with

occasional weakly to moderately cemented ferruginised modules present between 1.2m to 2.6m.

3.3.4 Acid Sulfate Soils

Acid Sulfate Soils (ASS) is the name commonly given to naturally occurring soils and sediment containing iron sulphide (iron pyrite) materials. In their natural state ASS are generally present in waterlogged anoxic conditions and do not present any risk to the environment. When oxidised, ASS produce sulphuric acid, which can pose risks to the surrounding environment, infrastructure and human health.

The Department of Water and Environmental Regulation (DWER) provides broad-scale mapping indicating areas of potential ASS risk (DWER 2023a). Available information indicates that the majority of the site has been classified as having 'moderate to low' risk of ASS occurring within three metres of the natural soil surface. Two areas in the south-east portion of the site have a 'high to moderate' risk of ASS occurring, generally associated with wetlands in this area, as shown in **Figure 5**.

A geotechnical assessment was undertaken for the site by Galt Geotechnics in 2011, which determined that there is a low likelihood of ASS occurring within the site (Galt Geotechnics 2011).

3.4 Biodiversity and natural assets

3.4.1 Flora and vegetation

3.4.1.1 Regional vegetation context

The site lies within the Swan Coastal Plain Interim Biogeographic Regionalisation for Australia (IBRA) region (Thackway and Cresswell 1995). The Swan Coastal Plain IBRA region is broadly compatible with the Swan Coastal Plain (Drummond Botanical Subdistrict) Phytogeographical Subregion as described by (Beard 1990). This region is characterised by *Banksia* low woodlands on leached sands, woodlands of tuart (*Eucalyptus gomphocephala*), jarrah (*Eucalyptus marginata*) and marri (*Corymbia calophylla*) on less leached soils and *Melaleuca* swamps.

At a local level, vegetation complex mapping for the Swan Coastal Plain undertaken by (Heddle *et al.* 1980) indicates that the site is mapped within the Beermullah complex, the Forrestfield complex, and the Guildford complex, as shown in **Figure 6**.

The Beermullah complex is described by Heddle *et al.* (1980) as consisting of a mixture of low open forest of *Casuarina obesa* and open woodland of *C.calophylla - Eucalyptus wandoo - Eucalyptus marginata*. Components include closed scrub of *Melaleuca* spp. Minor components include closed scrub of *Melaleuca* spp. and occurrence of *Actinostrobus pyramidalis*. DBCA and DWER provided statistics regarding pre-European and current extent of the vegetation complexes in the south-west of Western Australia (Government of Western Australia 2019). Remnant vegetation calculations undertaken in 2018 determined that approximately 6.7% of the pre-European extent of the Beermullah complex remains on the Swan Coastal Plain (Government of Western Australia 2019). Approximately 2.1% formally protected within Bush Forever or conservation reserves.

Vegetation of the Forrestfield complex ranges from open forest of *Coryimbia calophylla - Eucalyptus wandoo*, *Eucalyptus marginata* to open forest of *Eucalyptus marginata - Corymbia calophylla*, *Allocasuarina fraserana - Banksia* spp. Fringing woodland of *Eucalyptus rudis* in the gullies that dissect this landform (Heddle *et al.* 1980). Approximately 10.5% of the pre-European extent of this

vegetation complex remains on the Swan Coastal Plain, with approximately 1.6% under formal conservation protection (Government of Western Australia 2019).

The Guildford complex is described as a mixture of open forest to tall open forest of *Corymbia calophylla - Eucalyptus wandoo - Eucalyptus marginata* and woodland of *Eucalyptus wandoo* (with rare occurrences of *Eucalyptus* l*ane-poolei*). Minor components include *Eucalyptus rudis - Melaleuca rhaphiophylla* (Heddle *et al.* 1980). Approximately 5.0% of the pre-European extent of the Guildford complex remains on the Swan Coastal Plain, with approximately 0.3% under formal conservation protection (Government of Western Australia 2019).

The EPA's *Environmental Guidance for Planning and Development* (EPA 2008) states that the loss of biodiversity caused by habitat fragmentation is significantly greater once a habitat type falls below 30% of its original extent. The Guidance also references the biodiversity conservation national objective and target of retaining 30% of the original extent of each vegetation complex, and the states' minimum target of 10% for constrained urban areas such as the Swan Coastal Plain. The Beermullah and Guildford vegetation complexes have less than 10% remaining, while the Forrestfield has approximately 10.5% is below the 30% retention objective and marginally above or equal to the 10% minimum retention target for the Swan Coastal Plain.

3.4.1.2 Extent and condition of remnant vegetation

A spring flora and vegetation surveys (Emerge Associates 2017) was undertaken in order to understand the extent of remnant vegetation values within the site and is in addition to early surveys including *Mundijong North- Spring Flora and Vegetation Survey* (PGV 2012). Based on these detailed surveys, the majority of remnant vegetation across that site was found to be in "Completely Degraded" condition, as shown in **Figure 7**. Remnant vegetation associated with Manjedal Brook in the south of the site is in "Degraded" condition due to the high degree of disturbance of the understorey through historic clearing and cattle grazing.

The site is devoid of large areas of intact remnant vegetation due to the long history of cropping and stock grazing. Non-native pasture species are dominant across the site with scattered native trees such as *Corymbia calophylla, Eucalyptus rudis* and *Melaleuca preissiana* (see **Figure 8**). The vegetation interpreted from aerial imagery was confirmed during the field survey. A small rise in the south-western corner of the site (within Lot 3 Taylor Road) contains a variety of different scattered native trees such as *Banksia ilicifolia*, *Eucalyptus marginata* and *Xylomelum occidentale* over similar non-native pasture grasses. Stands of non-native planted trees also occur across the site, particularly in the north of the site and surrounding the dairy located in Lot 11 Taylor Road.

Limited remnant vegetation occurs in the south of the site associated with Manjedal Brook and an area of Conservation Category Wetland (CCW). Vegetation within Manjedal Brook is comprised mainly of *Corymbia calophylla*, *Melaleuca preissiana* and *Melaleuca rhaphiophylla* over pasture grasses, as shown in **Plate 2**. Due to the extent of disturbance from cattle grazing within the waterway, vegetation associated with Manjedal Brook is considered to be in "Degraded" condition.

The CCW (UFI 7835) retains the highest quality vegetation in the site and is located between the easternmost wetland feature and the site boundary and is in 'excellent - very good' condition. Native species diversity was relatively low but this is expected for this type of dense inundated wetland vegetation. The remaining vegetation surrounding this feature is altered from its original form and is in 'degraded' condition. The CCW supports a large area of remnant vegetation consisting mainly of *Melaleuca preissiana*, *Melaleuca rhaphiophylla* and planted Eucalypt species over *Baumea articulata*,

Lepidosperma longitudinale and *Juncus pallidus,* as shown in **Plate 3** and **Plate 4.** The majority of remnant wetland vegetation in this area was found to be in "Excellent – very good" condition, with areas of "Very good – good", "Good" and "Degraded" vegetation at the perimeter of the wetland (shown in **Figure 7** and **Plate 5**), due to the extensive clearing of overstorey and understorey species (Emerge Associates 2017).



Plate 1: Scattered paddock trees over pasture grass, dominant across the site



Plate 2: Remnant riparian vegetation within Manjedal Brook in the south of the site



Plate 3: Remnant wetland vegetation within the CCW in the south-east of the site



Plate 4: Area of CCW in the south-east of the site



Plate 5: Vegetation within the CCW buffer area in the south-east of the site

3.4.1.3 Significant flora

Certain flora species that are considered to be rare or under threat warrant special protection under federal and/or state legislation. At a federal level, flora species may be listed as 'threatened' pursuant to the EPBC Act. Threatened flora species listed under the EPBC Act are assigned a conservation status according to attributes such as population size and geographic distribution. Any action likely to have a significant impact on a taxon listed under the EPBC Act requires Ministerial approval.

At a state level, plant species may also be classed as 'threatened' under the BC Act. Similarly, it is an offence to 'take' or 'disturb' threatened flora listed under the BC Act without Ministerial approval.

Flora species that do not currently meet the criteria for listing as threatened but are potentially rare or threatened may be added to the DBCA's *Priority Flora List*. These species are classified into 'priority' levels based on threat. Whilst priority species are not under direct statutory protection, they are considered during State approval processes.

Based on the findings of the *Flora and Vegetation Survey* (Emerge Associates 2017) one regionally significant flora species (but is not identified as threatened or priority flora), *Dielsia stenostachya*, was recorded in vegetation between the easternmost wetland feature and the site boundary. This species is identified in *Significant Flora of the Foothills and Pinjarra Plain in the Perth Metropolitan Region* as it is endemic to the Swan Coastal Plain (Government of WA 2000b).

3.4.1.4 Plant communities

Eleven plant communities were identified within the site from the detailed flora and vegetation survey undertaken by Emerge Associates (2017), as shown in **Figure 8**, and include in **Table 2** below:

Table 2: Plant communities identified within the site

Plant community	Description	Area (ha)
ErCcMr	**Manjedal Brook** Low open forest *Eucalyptus rudis* and *Corymbia calophylla* over low open woodland *Melaleuca rhaphiophylla* over isolated forbs *Juncus pallidus* and *Alternanthera nodiflora* over closed grassland non-native pasture grasses. Pools of standing water were present in the brook at the time of the survey.	7.12
MpTlBaLl	**Far eastern sumpland – eastern side** Low woodland *Melaleuca preissiana* over tall shrubland *Taxandra linearifolia* over sedgeland *Baumea articulata* and *Lepidosperma longitudinale* over open forbland *Cycnogeton lineare.* Most of this community was waterlogged at the time of the survey.	0.94
BaJp	**Far eastern sumpland – remaining perimeter** Closed sedgeland *Baumea articulata* and *Juncus pallidus*. The majority of this community was inundated at the time of the survey.	0.37
MpTl	**Sumpland west of the far eastern sumpland – north-eastern corner** Low woodland *Melaleuca preissiana* over closed shrubland *Taxandra linearifolia* over isolated sedges *Juncus pallidus* over forbland *Lemna dispersa* and **Briza minor.* Some *Melaleuca preissiana* canopy trees in this community were inundated.	0.13

Table 2: Plant communities identified within the site (continued)

Plant community	Description	Area (ha)
CcJp	**Sumpland west of the far eastern sumpland – eastern side** Low open woodland *Corymbia calophylla* over sparse sedgeland *Juncus pallidus* over open grassland of non-native pasture species such as **Ehrharta calycina* and **Pennisetum clandestinum*. The two areas of this community were moist to dry at the time of the survey.	0.06
MpJfAf	**Swales between the two sumplands** Open low woodland *Melaleuca preissiana* over Tall open shrubland *Jacksonia furcellata* over shrubland *Astartea fascicularis*. The lower lying areas of this community were waterlogged at the time of the survey.	0.36
Non-native vegetation	Heavily disturbed areas comprising scattered planted trees and shrubs over closed grassland of scattered introduced pasture weeds such as **Ehrharta calycina* and **Bromus diandrus* (**Plate 2**).	188.85

3.4.1.5 Threatened and/or Priority Ecological Communities

In Western Australia, Threatened Ecological Communities (TECs) are defined by the Western Australian Threatened Ecological Communities Scientific Advisory Committee. Generally these can be described as vegetation communities that are assemblages of species that occur together in a particular type of habitat. They are the sum of species within an ecosystem and, as a whole provide many of the processes which support a specific ecosystem. TECs are recognised as specific ecological communities that are rare or under threat.

Selected TECs are afforded statutory protection at a federal level under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). TECs listed under the EPBC Act are assigned a conservation status. Any action likely to have a significant impact on a community listed under the EPBC Act requires Ministerial approval.

TECs are also listed within Western Australia under the *Biodiversity Conservation Act 2016* (BC Act) and the Biodiversity Conservation Regulations 2018 (BC Regulations). Their significance is also acknowledged through other state environmental approval processes such as 'environmental impact assessment' pursuant to Part IV of the *Environmental Protection Act 1986* (EP Act) and the *Environmental Protection (Clearing of Native Vegetation) Regulations 2004.*

In addition to a listing as a TEC, a community may be listed as a Priority Ecological Community (PEC). This is an ecological community that is under consideration for listing as a TEC, but does not yet meet survey criteria or has not been adequately defined.

Based on the detailed spring survey undertaken for the site, no TECs or PECs occur within the site. Vegetation within the CCW in the south-east of the site and within Manjedal Brook in the south of the site are considered to have once represented Floristic Community Type (FCT) 13 and FCT 11 respectively, neither of which are listed as TECs or PECs at a state or federal level (Emerge Associates 2017).

Bush Forever Site 350 east of the site is known to support several TECs (Government of WA 2000b), as discussed further below, however this TEC does not extend within the site.

3.4.2 Bush Forever and conservation reserves

The Government of Western Australia's *Bush Forever Policy* is a strategic plan for conserving regionally significant bushland within the Swan Coastal Plain portion of the Perth Metropolitan Region. The objective of Bush Forever is to protect comprehensive representations of all original ecological communities by targeting a minimum of 10 % of each vegetation complex for protection (Government of WA 2000a). Bush Forever Sites are representative of regional ecosystems and habitat and have a key role in the conservation of Perth's biodiversity.

There are no Bush Forever sites located within the site, however Bush Forever Site 350 "Byford to Serpentine Rail/Road Reserves and Adjacent Bushland" (Bush Forever Site 350) is located immediately east of the site, and is known to contain Threatened Flora species and TECs in need of protection (Government of WA 2000b). The location of Bush Forever Site 350 is shown in **Figure 9**.

3.4.3 Environmentally Sensitive Areas

'Environmentally sensitive areas' (ESAs) are prescribed under the *Environmental Protection (Clearing of Native Vegetation) Regulations 2004* to protect native vegetation values of areas surrounding significant, threatened or scheduled flora, vegetation communities or ecosystems. Within an ESA none of the exemptions under the *Environmental Protection (Clearing of Native Vegetation) Regulations 2004* apply. However, exemptions under Schedule 6 of the EP Act still apply, including any clearing in accordance with a subdivision approval under the *Planning and Development Act 2005* (a recognised exemption under the Schedule 6 of the EP Act).

ESAs cover portions of the site in the east and south, as shown in **Figure 9**, generally associated with the CCW, Bush Forever Site 350, and the associated flora and vegetation values known to occur in these areas.

3.4.4 Ecological linkages

Ecological linkages support the movement of fauna, flora and genetic material between areas of fragmented remnant habitat. The movement of fauna and the exchange of genetic material between vegetation remnants improve the viability of those remnants by allowing greater access to breeding partners, food sources, refuge from disturbances such as fire, and maintenance of genetic diversity of plant communities and populations. Ecological linkages are often continuous or near-continuous as the more fractured a linkage is, the less ease flora and fauna have in moving within the corridor (Molloy *et al.* 2009).

Ecological linkages have been generally identified by the State Government in Bush Forever, Perth's Greenways and the System 6 study and have been published by the Perth Biodiversity Project. These identified linkages reflect the on-ground linkages throughout the Perth Metropolitan area (Molloy *et al.* 2009). The dataset is employed as a conservation tool aimed to conserve and enhance our regional biological linkages.

Part of a mapped ecological linkage occurs within the eastern extent of the site, associated with Bush Forever Site 350 and the vegetation values known to occur in this area. This ecological linkage is shown in **Figure 9**. The connectivity of this linkage will be maintained through the long term retention of vegetation within Bush Forever east of the site, and is not dependent on the retention of vegetation within the site, nor will it be impacted by the proposed development of the site.

3.4.5 Terrestrial fauna

Fauna species that are considered to be rare or under threat warrant special protection under state and/or federal legislation. At a federal level, fauna species may be listed as 'threatened' pursuant to the EPBC Act and any action likely to have a significant impact on a listed threatened species requires approval from the federal Minister for the Environment.

At a state level, fauna species are listed as 'threatened' under section sections 13, 19 and 26(2) of the BC Act. It is an offence to 'take' or 'disturb' threatened fauna without Ministerial approval. In addition to this, the Department of Biodiversity Conservation and Attractions (DBCA) maintains a list of priority fauna species which, while not considered threatened under the BC Act and therefore not protected directly, involve some concern over their long-term survival.

Due to the significant historic disturbance that has occurred within the site, and the overall condition of remnant vegetation, it is unlikely that the site supports any significant fauna habitat values other than some opportunistic values for mobile fauna species.

A targeted black cockatoo habitat assessment for three species of black cockatoo was undertaken for the site (Strategen 2015b) which concluded that while the site supports some scattered habitat species that are considered suitable potential foraging or breeding habitat for black cockatoos, there is no evidence that vegetation within the site is being actively used by black cockatoos (Strategen 2015b).

Potential black cockatoo foraging and breeding habitat within the site is illustrated in **Figure 10** (DBCA 2019), however due to the completely degraded nature of vegetation within the site, and the large area of intact habitat vegetation reserved in Bush Forever Sites 354 and 361 approximately 650 m north-east of the site, it is unlikely that the site supports any significant foraging and/or breeding activities.

3.5 Hydrology

3.5.1 Groundwater

Information on groundwater from the *Water Register* (DWER 2022) indicates that groundwater beneath the site is a multi-layered system comprised of the following:

- Perth – Superficial Swan (allocation available)
- Perth – Cattamarra Coal Measures (allocation available)
- Perth – Leederville (allocation available)
- Lower Serpentine (limited information)

Groundwater data from the DWER Perth Groundwater Map (DWER 2023b) shows minimum groundwater levels across the site occur approximately 1 to 2 metres below ground level (m BGL), with groundwater flowing in a westerly direction.

The Local Water Management Strategy (LWMS) and addendum to the LWMS (addendum) prepared for the site (Wave International 2016; RPS 2023) outlines groundwater levels of the underlying superficial aquifer occur at depths of approximately 19 to 32 m BGL. However, monitoring has shown that the site is hydrologically distinct and isolated from the underlying superficial aquifer by localized low permeability soils (i.e. clay), which causes the seasonal peak groundwater levels to be perched (i.e. unable to permeate through clay layer underlying the site) to a maximum of 2 m BGL (Wave

International 2016; RPS 2023), which is consistent with the mapping provided by the DWER outlined above.

Groundwater quality at the site was monitored by Brown Geotechnical (BGE 2009) and samples were analysed for physical parameters and nutrients. Groundwater was found to be slightly acidic, and Nitrogen and Phosphorous levels were found to be slightly higher than the ANZECC and ARMCANZ (2000) Guidelines for Southwest Australian Aquatic Ecosystems, however this is not uncommon in agricultural land (Wave International 2016; RPS 2023).

Further information and relevant data is provided in the LWMS and addendum (Wave International 2016; RPS 2023) prepared to support the LSP.

3.5.2 Surface water

Manjedal Brook traverses the south of the site, as shown in **Figure 13**, and flows in an east to west direction. A number of agricultural drains disect the site, associated with the historic rural land uses, which convey flows through the site to Manjedal Brook in the south of the site.

The Manjedal Brook has a defined channel through the site, however extensive disturbance through cattle grazing has resulted in significant damage to the waterway banks and riparian vegetation (see **Plate 6**). Based on extensive site observations by Emerge Associates botanists, vegetation along the Manjedal Brook was found to be in a “Degraded” to “Completely Degraded” condition, and in a large portion of the waterway consists of only a single row of native trees over pasture grass (see **Plate 7**). This is consistent with the outcomes of the *Spring Flora and Vegetation Survey* (Emerge Associates 2017).

Based on the requirements of the Western Australian Planning Commission (WAPC) *Schedule of Modifications (WAPC and DPLH 2022)*, a foreshore reserve of 50 m on either side of the waterway is proposed and the foreshore encompasses the existing ecological and hydrological values of the Manjedal Brook, and provides an appropriate buffer between the waterway and adjacent development.



Plate 6: Degraded riparian vegetation over pasture grass within Manjedal Brook



Plate 7: Manjedal Brook, degraded by extensive cattle grazing in and around the waterway

3.5.3 Wetlands

Based on the DBCA Geomorphic Wetland series mapping (DBCA 2022), the majority of the site is mapped as Multiple Use wetlands (MUW), with areas of Conservation Category wetlands (CCW) in both the south-east and south of the site, as shown in **Figure 11**. Areas of CCW in the south of the site (UFI 14945 and UFI 15446) are associated with Manjedal Brook, while a large circular CCW (UFI 7835) is located in the south-eastern corner of the site, as shown in **Plate 8** below. This CCW (UFI 7835) is a seasonally inundated basin or 'sumpland' wetland which supports a large area of remnant vegetation consisting mainly of *Melaleuca preissiana*, *Melaleuca rhaphiophylla* and planted Eucalypt species over *Baumea articulata*, *Lepidosperma longitudinale* and *Juncus pallidus,* in generally 'Very Good' condition (Emerge Associates 2017).

Due to the significant historic disturbance of Manjedal Brook through extensive livestock grazing and weed invasion, UFI 14945 and UFI 15446 are no longer considered representative of the current conservation status, and support very limited remaining riparian vegetation.



Plate 8: CCW (UFI 7835) located in the south-eastern portion of the site

3.5.4 Public Drinking Water Source Areas

Public Drinking Water Source Areas (PDWSAs) are surface water catchments or groundwater recharge areas that have been identified as drinking water sources, proclaimed as water reserves by the DWER (DoW 2009b), and protected by government legislation. PDWSAs provide the majority of Western Australia's drinking water supplies and can be vulnerable to contamination from a range of

land uses and water based activities (DoW 2009a) therefore consideration needs to be given to the intended land use and associated activities to ensure that they are appropriate in meeting the water protection quality objectives of the area.

The site does not fall with a declared PDWSA.

3.6 Health and amenity

3.6.1 Mosquitos

In the context of southwest Western Australia, mosquitos are known to constitute a potential risk to human health as a vector for serious diseases such as Ross River Virus, Barmah Forest Virus and Murray River Encephalitis (DoH 2010). Apart from acting as disease vectors, when present in sufficiently high numbers, biting female mosquitoes can also cause nuisance to the public and reduce the ability of residents to enjoy outdoor living areas. Similarly, non-biting Chironomid midges can also cause nuisance to residents of areas adjacent to wetland areas when present in large numbers by accumulating under eaves and entering the home.

The site contains wetland areas that are permanently or seasonally inundated which provide suitable breeding habitat for mosquitos. The flight range of adult mosquitoes is five kilometres; as a result, there is some potential for future homeowners within the site to be adversely affected.

3.7 Heritage

3.7.1 Indigenous heritage

Based on a review of the Department of Planning, Lands and Heritage (DPLH) 'Aboriginal Heritage Places' online database (DPLH 2023) there is one registered Indigenous heritage site mapped within the site in the south-east, and several Other Heritage Places mapped throughout the site, as shown in **Figure 14**. The details for the registered heritage sites and other heritage places are as follows:

Table 3: Registered Indigenous heritage sites within or in close proximity to the site

SITE ID	DESCRIPTION
Registered sites	
3648	Soldiers Road, Mundijong – Artefacts/Scatter
37116	Soldiers Road, Mundijong – Modified Tree
Other Heritage Places	
32591	MJ-01 – Artefacts/Scatter, Arch Deposit
32615	MJ-04 – Artefacts/Scatter, Arch Deposit
32616	MJ-03 – Artefacts/Scatter, Arch Deposit
32619	MJ-02 – Artefacts/Scatter, Arch Deposit

Peet Ltd has engaged the services of ethnography and heritage consultant Ethnosciences to provide additional advice in relation to the heritage and cultural values of the site. Ethnosciences have conducted two separate archaeological investigations of the site in 2012 and 2014, in consultation with

representatives of the relevant traditional owners and Aboriginal elders, in order to understand the extent of the heritage values of the site. These investigations identified a number of values within the site, generally aligning in location with the 'other heritage places' identified within the AHIS dataset, while Ethnosciences (TCHM 2014) also identified that the registered site (ID No. 3648) was incorrectly mapped, concluding that the values actually occurred north of this location, directly adjacent to the western boundary of the Conservation Category Wetland.

An application was made under Section 18 of the *Aboriginal Heritage Act 1972* (AHA) on 12 December 2019 and consent granted by the Minister for Aboriginal Affairs on 26 April 2020 (subject to conditions). Archaeological sites identified as meeting the requirements of section 5 of the in the AHA and proposed to be disturbed through development of the subject land are outlined in the Aboriginal Archaeological Assessment prepared by Thomson Cultural Heritage Management (April 2014) .

Furthermore, an Aboriginal Heritage Management Plan shall be prepared and implemented prior to subdivision.

3.7.2 Non-Indigenous heritage

A desktop search of the Australian Heritage Database (DCCEEW 2022), the State Heritage Office database (Heritage Council WA 2022) and the Shire of Serpentine Jarrahdale's local municipal heritage list indicated there are no registered heritage sites within or in close proximity to the site.

3.8 Land use considerations

3.8.1 Historic land uses and potential contamination

The site was historically cleared and used for rural purposes; predominantly livestock grazing as part of dairy farm operations. A Preliminary Site Investigation (PSI) was undertaken for the site (Aurora Environmental 2014a) which identified several sources of potential contamination associated with the historic agricultural land uses across the site, primarily within Lot 2 and Lot 11, including:

- Silage pads
- Cattle graveyard
- Drainage channel lined with red mud
- Effluent ponds
- Storage of industrial cleaning products
- Storage of fertilisers, pesticides/herbicides/insecticides
- Storage of fuels and farm machinery/equipment
- Redundant fuel storage tanks and drums
- Building structures potentially with Asbestos Containing Material (ACM)
- Pesticides beneath building pads
- Cattle pens and feed lots

Following the preparation of the PSI, a Sampling and Analysis Plan (SAP) was prepared (Aurora Environmental 2014b) to facilitate the implementation of a future Detailed Site Investigation (DSI) to be undertaken prior to the commencement of development within the site. The SAP (Aurora Environmental 2014b) outlines the requirement for further soil and groundwater testing to determine the extent of potential contamination within the site. This is discussed further in **Section 5**.

3.8.2 Surrounding land uses

3.8.2.1 Freight railway line

The site is bordered by a freight railway line to the east, as shown in **Figure 13**. Noise emissions and vibrations from this transport corridor have the potential to impact upon the future urban land use of the site.

A noise management plan, *Taylor Road, Mundijong, Local Structure Plan Addendum, SPP 5.4 Noise Management Plan* (Herring Storer Acoustics 2023) was prepared to facilitate the revised LSP and provides noise modelling with regard to road traffic and rail (discussed further in **Section 5**).

Potential mitigation strategies for development within the site may include the provision of an acoustic barrier/wall, and/or architectural treatments to new buildings in the vicinity of the railway line. These mitigation options can be used to meet "Noise Target" levels for residential development (as outlined in the noise management plan (Herring Storer Acoustics 2023) and WAPC's *State Planning Policy 5.4 Road and Rail Noise* (SPP 5.4) (WAPC 2019)), if determined to be required. This is discussed further in **Section 5**.

3.8.2.2 Tonkin Highway extension

The site is bordered by a "Primary Regional Road" reservation, associated with the future Tonkin Highway extension, to the west, as shown in **Figure 13**. Noise emissions from this transport corridor may have the potential to impact upon urban land uses within the site. Construction is expected to commence in 2025 with target completion in late 2027, subject to regulatory approvals. This is discussed further in **Section 5**.

3.9 Natural hazards

3.9.1 Flooding

Based on detailed flood modelling undertaken for Manjedal Brook in the south of the site (Wave International 2016; RPS 2023) flood levels for Manjedal Brook have been modelled to be fully contained within 30 m flow width of the waterway. This will be accommodated by the foreshore reserve of 50 m on either side of the waterway, proposed to encompass the existing ecological and hydrological values of the Manjedal Brook, and provide an appropriate buffer between the waterway and adjacent development.

3.9.2 Bushfire hazard

The site has been identified as a bushfire prone area under the M*ap of Bush Fire Prone Areas* (OBRM 2021), as shown in **Figure 14**. The identification of a site within an area declared as bushfire prone necessitates further assessment of the determined bushfire risk affecting the site in accordance with *Australian Standard 3959:2018 Construction of buildings in bushfire prone areas* (AS 3959) (Standards Australia 2018), and the satisfactory compliance of the proposal with the policy measures described in *State Planning Policy 3.7 Planning in Bushfire Prone Areas* (SPP 3.7) (WAPC 2015a) and the *Guidelines for Planning in Bushfire Prone Areas Version 1.4* (the Guidelines) (DPLH & WAPC 2021). The Bushfire Management Plan (BMP) aims to address bushfire management issues within the LSP and through this, minimise the impact of bushfires within and surrounding the site, thereby reducing the threat to life, property and the environment.

A bushfire management plan (BMP) has been prepared (Emerge Associates 2023a) to meet the requirements of SPP 3.7, to identify bushfire risk and the bushfire protection measures that will make the land suitable for its intended purpose. As part of this, a Bushfire Attack Level (BAL) assessment involving the classification and condition of vegetation within 150 m of the site has been undertaken.

The permanent bushfire hazard features which are relevant for the site include remnant vegetation within Bush Forever Site 350 adjacent to the eastern site boundary, and areas of remnant vegetation to be permanently retained within Manjedal Brook and CCW areas in the southern portion of the site 9and the associated buffers proposed to be revegetated). The bushfire hazard assessment is outlined in detail within the BMP (Emerge Associates 2023a).

4 Local Structure Plan and Planning Approval Framework

4.1 Historic planning and environmental approvals

The long term planning for the urbanisation of Mundijong and Whitby commenced in 1994 through the identification of the area for urban purposes within the Serpentine Jarrahdale Shire Rural Strategy. Subsequent to this, the area surrounding the Mundijong rural village was rezoned to “Urban” through MRS Amendment no. 966/13 prior to 2006.

The MRS amendment for the site was referred to the Environmental Protection Authority (EPA), which determined that the proposed amendment was environmentally acceptable subject to several recommendations relating to the retention of regionally significant wetland values. Wetland values identified within the site, while of conservation significance, are not considered regionally significant under the EPA’s advice, a copy of which is provided in **Appendix D**.

4.2 Taylor Road, Mundijong Local Structure Plan (TBB 2023)

A LSP has been prepared for the site by TBB and is provided in **Appendix A**, and incorporates the inputs from a multi-disciplinary project team, and the outcomes from various technical studies. The LSP provides the sequential level of land use planning detail associated with implementing the Mundijong DSP.

The environmental planning principles outlined within the Mundijong DSP and to be considered as a part of LSP are that:

- The natural environment will be protected, repaired, enhanced and respected within the natural context;
- Urban development will promote green power initiatives;
- The total water cycle will be sustainably repaired, maintained and enhanced;
- Feasible water cycle management approaches will be promoted; and
- Existing landform must be respected and maintained and be utilised to enhance the built form.

The LSP area includes a total land area of approximately 199 ha and the proposed land uses include:

- Residential lots of varying density, to provide a range of lot sizes and lifestyle options
- Two primary school sites
- A neighbourhood centre
- Public road reserves
- Areas of public open space, incorporating appropriate drainage basins
- Remnant waterway and wetland areas with the accommodation of associated buffer areas
- A 60 m wide service corridor for the future Tonkin Highway extension west of the site.

The EAMS is consistent with the EPA’s current *Guidance Statement No. 33 Environmental Guidance for Planning and Development* (EPA 2008) and the WAPC’s *Structure Plan Framework* (WAPC 2015b) and includes:

- Identification of significant environmental features.
- Management strategies specific to each environmental feature within the LSP area.
- Opportunities for enhancement of the environmental features and issues to address at later stages of development.

4.3 Future planning approval process

Following the approval of the LSP, subdivision and development of areas generally in accordance with the LSP will be progressed. It is usual for this process to involve the imposition of subdivision conditions, in accordance with the WAPC's *Model Subdivision Conditions Schedule* (WAPC and DPLH 2022) and these generally cover the following relevant areas:

- Amenity
- Buildings and use
- Drainage and site works
- Electricity and gas pipelines
- Environmental conditions
- Fire and emergency
- Heritage (indigenous, state, local, etc.)
- Lot design
- Reserves
- School sites
- Transport roads and access
- Water and sewers.

This condition framework provides a future environment management framework for the site and is discussed further in **Section 5**.

4.4 Relevant environmental factors and considerations

Table 4 below lists the full suite of environmental factors that have been investigated for the site, and summarises those that require further specific attention in **Section 5**.

Table 4: Relevant environmental factors and considerations for LSP

ENVIRONMENTAL FACTOR	RELEVANT CONSIDERATIONS
Climate	No issues posed and therefore no further consideration is required.
Topography	No issues posed and therefore no further consideration is required.
Geology	No issues posed and therefore no further consideration is required.
Landforms and soils	No issues posed and therefore no further consideration is required.
Acid Sulfate Soils	"Moderate to Low" and "High to Moderate" risk of ASS occurring within three metres of the natural soil surface. This is a relevant consideration for future excavation for any deep services e.g. sewers. This is addressed further in **Section 5**.
Flora and vegetation	Remnant wetland vegetation is to be retained within public open space in the south of the site. The ongoing management of flora and vegetation is addressed further in **Section 5**.
Bush Forever and conservation reserves	No Bush Forever sites occur within the site, therefore no further consideration is required.
Ecological Linkages	No Ecological Linkage issues are posed, and therefore no further consideration is required.

Table 3: Relevant environmental factors and considerations for LSP (continued)

ENVIRONMENTAL FACTOR	RELEVANT CONSIDERATIONS
Environmentally Sensitive Areas (ESAs)	The site falls within a declared ESA, therefore exemptions under the *Environmental Protection (Clearing of Native Vegetation) Regulations 2004* do not apply. This may require consideration as part of future subdivision stages, however no further consideration is required to support the LSP progression.
Terrestrial Fauna	The site contains potential black cockatoo habitat. This is addressed further in **Section 5**.
Groundwater	Pre-development groundwater levels and quality will need to be managed post-development. This is addressed further in **Section 5**.
Surface water	Manjedal Brook flows through the south of the site. Surface water conditions are addressed further in **Section 5**.
Wetlands	A number of CCWs occur in the south of the site, while MUWs cover the majority of the site. This is addressed further in **Section 5**.
Public Drinking Water Source Areas (PDWSAs)	The site is not located within a declared PDWSA, therefore no further consideration is required.
Mosquitos	The site contains suitable breeding habitat for mosquitos. This is addressed further in **Section 5**.
Indigenous Heritage	One registered heritage site and several Other Heritage Places occur within the site as per the DPLH(WAPC and DPLH 2022)s AHIS in addition, a number of other heritage values have been identified within the site. This is discussed further in **Section 5**.
Non-Indigenous Heritage	No issues posed and therefore no further consideration is required.
Historic Land Uses	Historic land uses may pose potential contamination issues, and further investigation is required prior to subdivision to determine future remediation requirements (if any). This is discussed further in **Section 5**.
Surrounding Land Uses	There are potential noise and vibration considerations presented by surrounding land uses. This is addressed further in **Section 5**.
Flooding	Potential flood risk is posed by Manjedal Brook in the south of the site. This is addressed further in **Section 5**.
Bushfire Hazard	Classified vegetation within and surrounding the site poses Moderate to Extreme bushfire hazards for future residential development. This is addressed further in **Section 5**.

5 Environmental Assessment and Management

5.1 Landform and soils – Acid Sulfate Soils

5.1.1 Policy framework and management objective

In the context of environmental impact assessment, the EPA's objective for ASS is *'to maintain the quality of land and soils so that environmental values are protected'* (EPA 2016a). The application of the mitigation hierarchy should be applied to avoid or minimise impacts to terrestrial environmental quality where possible.

The DWER, through the WAPC, ensures ASS are adequately managed during the land use planning and development process. The objective of the DWER's ASS policy framework is to manage ASS appropriately to prevent the release of metals, nutrients and acidity into the soil and groundwater system that may adversely affect the natural and built environment and human health.

The regional mapping produced by DWER indicates that the majority of the site has been classified as having 'moderate to low' risk of ASS occurring within three meters of the natural soil surface. Two areas in the south-east portion of the site have a 'high to moderate' risk of ASS occurring, generally associated with wetlands in this area (as shown in **Figure 5**).

The principal management objective for ASS within the site is to ensure that any future development that may disturb ASS is appropriately managed to avoid impacts on the environment.

5.1.2 LSP considerations for Acid Sulfate Soils

ASS management does not require any spatial consideration within the LSP.

5.1.3 Future Acid Sulfate Soil management requirements

ASS is only likely to be a consideration if excavation (primarily for services, and in particular sewer) extends below the permanent groundwater table. It is possible, depending upon the extent of cut and fill within the site and location of services, that excavation could occur below the permanent groundwater table and if this is the case, additional ASS investigations may be required and could include the preparation of an Acid Sulfate Soils and Dewatering Management Plan. This is a well-established process which appropriately manages ASS risk.

Where a risk of ASS is identified in the regional mapping, the WAPC will apply a standard subdivision condition (model subdivision condition EN8 (WAPC and DPLH 2021)), which states:

An acid sulphate soils self-assessment form and, if required as a result of the self-assessment an acid sulphate soils report and an acid sulphate soils management plan shall be submitted to and approved by the Department of Water and Environmental Regulation (DWER) before any subdivision works or development are commenced. Where an acid sulphate soil management plan is required to be submitted, all subdivision works shall be carried out in accordance with the approved management plan (Department of Water and Environmental Regulation).

A geotechnical assessment was undertaken for the site in 2011 (Galt Geotechnics 2011) which determined that, based on screening tests across the site to various depths; there is a low likelihood of ASS occurring within the site (Galt Geotechnics 2011). Based on this assessment it is not considered likely that further detailed ASS investigations will be required as part of future subdivision. However,

should ASS be found to occur within the site an ASS Management Plan will be prepared according to WAPC standards and DWER's policy framework.

5.1.4 Predicted environmental outcomes

Any future ASS considerations will be identified and managed during the subdivision process according to DWER's standards and policy framework.

5.2 Biodiversity and natural assets – flora and vegetation

5.2.1 Policy framework and management objective

The EPA objective for flora and vegetation is '*to protect flora and vegetation so that biological diversity and ecological integrity are maintained*' (EPA 2016c). Where a proposal may potentially impact upon flora and vegetation values, the following mitigation hierarchy should be applied to minimise potential impacts:

1. **Avoid** impacts
2. Minimise impacts
3. Offset impacts.

The objective for future management of flora and vegetation within the site will be principally focused around maximising the retention and revegetation of the CCW buffer and Munjedal Brook foreshore reserve in public open space areas.

5.2.2 LSP considerations for flora and vegetation

Due to the significant historic disturbances within the site associated with agricultural land uses, remnant vegetation values are limited within the site. Remnant vegetation within Manjedal Brook and the area of CCW in the south-east of the site are to be retained permanently within public open space for conservation purposes, as shown in the LSP shown in **Appendix A**.

In addition the retention of remnant vegetation within these areas, a 50 m wetland buffer has been provided from the mapped CCW boundary in the south-east of the site (UFI 7835) and a 50 m foreshore reserve for Manjedal Brook. These areas will provide an interface between the waterway and wetland values and the proposed development, and will incorporate revegetation, public amenities, and some drainage infrastructure. The ILMS (Emerge Associates 2023b) outlines the proposed treatment and ongoing management requirements of the Manjedal Brook foreshore reserve and the CCW buffer area.

From a bushfire hazard perspective, it is assumed that Manjedal Brook, the CCW and their associated buffers will be unmanaged and therefore a hazard, all other areas of public open space are assumed to be managed to achieve low threat in accordance with AS 3959. This is discussed further in **Section 5.11** and in the ILMS (Emerge Associates 2023a).

In addition, the long term retention of vegetation within the wetland and waterway areas within the site will contribute to the overall connectivity of the regional ecological linkage occurring east of the site, however as discussed in **Section 3.4.4** the integrity of the connection is not dependent on the vegetation within the site, nor will it be compromised by the implementation of the LSP.

5.2.3 Future flora and vegetation management requirements

The future management and ongoing consideration of remnant vegetation values being retained within the site will be addressed through the preparation of a Landscape Management Plan as part of future subdivision, which will provide ongoing environmental maintenance requirements including fencing, weed control, revegetation works, fauna management, landscape treatments etc. This report will be prepared to support future subdivision within the site, in accordance with the WAPC standard subdivision condition EN1 which states:

Prior to the commencement of subdivisional works an environmental protection management plan is to be prepared and approved to ensure the protection and management of the sites environmental assets with satisfactory arrangements being made for the implementation of the approved plan. (Department of Water and Environmental Regulation)

A revegetation plan being prepared, approved and implemented for the revegetation of [INSERT VALUE] or the area shown on the dated [INSERT VALUE] (attached) [DELETE AS APPLICABLE] with appropriate native species to the specifications of the Department of Water and Environmental Regulation. (Department of Water and Environmental Regulation)

5.2.4 Predicted environmental outcomes

Remnant vegetation will be retained where possible within areas of public open space, and within conservation reserves associated with areas of CCW in the south-east of the site and the foreshore/buffer areas associated with Manjedal Brook. The restoration and enhancement of vegetation values in this portion of the site will aim to address the EPA's policy objective, while providing an overall environmental benefit to the site.

5.3 Biodiversity and natural assets – terrestrial fauna

5.3.1 Policy framework and management objective

The *Environment Protection and Biodiversity Conservation Act* 1999 (EPBC Act) provides a legal mechanism for the Commonwealth government to play a role in the protection and management of nationally and internationally important flora, fauna, ecological communities and heritage places, defined in the EPBC Act as Matters of National Environmental Significance (MNES). Under the EPBC Act, a person must not take an action that has, will have, or is likely to have a significant impact on any MNES without approval from the Australian Government Environment Minister.

At the State level, the EPA's *Environmental Factor Guideline – Terrestrial Fauna* objective for terrestrial fauna is *'to protect fauna so that biological diversity and ecological integrity are maintained'* (EPA 2016b). The application of the mitigation hierarchy should be applied to avoid or minimise impacts to terrestrial fauna where possible.

5.3.2 LSP considerations for terrestrial fauna

As previously discussed, due to significant historic disturbance, remnant vegetation within the site is generally in "Completely Degraded" to "Degraded", and is not considered likely to support significant habitat for terrestrial fauna. The presence of large areas of suitable habitat reserved within Bush Forever north-east of the site (and proposed to be protected and retained) means it is unlikely that the scattered paddock trees proposed to be removed to accommodate development would be considered significant habitat.

A targeted black cockatoo habitat assessment was undertaken for the site (Strategen 2014) and concluded that while the site supports scattered trees species that are considered suitable for black cockatoos, there was no evidence that vegetation within the site was being actively used by black cockatoos (Strategen 2015).

While approximately 1.78 ha of potential black cockatoo habitat is proposed to be cleared from the site to support urban development (Strategen 2015), approximately 10.5 hectares of remnant vegetation is to be retained within Manjedal Brook and areas of CCW in the south-east of the site, with potential revegetation works proposed for these areas (and the associated buffers) providing potential future fauna habitat (as outlined in the ILMS (Emerge Associates 2023b)). These areas will to be reserved within public open space for conservation purposes, and will, in the long term, be ceded to the Shire of Serpentine Jarrahdale for ongoing management. In addition to this, mature trees will be retained throughout the site within public open space and streetscapes, where engineering requirements permit.

5.3.3 Future terrestrial fauna management requirements

Due to the limited occurrence of suitable fauna habitat species within the site, there will be no future management requirements for terrestrial fauna and fauna habitat, and as such no Fauna Management Plan is deemed to be required.

Notwithstanding this, these species are protected under the EPBC Act and the proponent is aware of their potential obligations pursuant to this Act prior to the commencement of civil works within the site.

Existing trees will be modified or removed as part of the proposed development and fauna may be disturbed as part of this process. Management of fauna as part of the detailed design and construction for the proposed development will be based on minimising harm to fauna (particularly the black cockatoos) and can be addressed through the preparation and implementation of a fauna management plan as part of subdivision. Measures to be implemented may include:

- Bunting/flagging of trees to be retained so that it is clear which trees are to be avoided.
- Undertaking preclearing inspections of tree/vegetation proposed for removal/modification. This may include a trapping and relocation program for western ringtail possums.
- Using a fauna spotter during demolition and clearing works to avoid impacts to fauna wherever possible and to rescue trans-locatable fauna that are disturbed during clearing works to assist them to disperse safely or capture them for later translocation as appropriate.
- Application of correct fauna handling procedures to reduce stress on any captured animals.

It is likely that this will be a condition of future subdivision approval, based on application of model subdivision condition EN1, EN2, EN 3 and EN7 (WAPC and DPLH 2022), which requires:

EN1 - Prior to the commencement of subdivisional works a foreshore/ environmental/ bushland/tree/ wetland/wildlife protection [DELETE AS APPLICABLE] management plan for [INSERT VALUE] is to be prepared and approved to ensure the protection and management of the sites environmental assets with satisfactory arrangements being made for the implementation of the approved plan. Department of Water and Environmental Regulation) OR (Local Government) OR (Department of Biodiversity, Conservation and Attractions) [DELETE AS APPLICABLE]

EN2 - Prior to the commencement of subdivisional works, measures being undertaken to identify any vegetation on the site worthy of retention, including any potential habitat or foraging trees for

threatened fauna species, and protection measures implemented to ensure such vegetation is not impacted by subdivisional works. (Local Government)

EN3 - A revegetation plan being prepared, approved and implemented for the revegetation of [INSERT VALUE] or the area shown on the dated [INSERT VALUE] (attached) [DELETE AS APPLICABLE] with appropriate native species to the specifications of the Department of Water and Environmental Regulation OR Department of Biodiversity, Conservation and Attractions OR Local Government (DELETE AS APPLICABLE). (Department of Water and Environmental Regulation) OR (Local Government) OR (Department of Biodiversity, Conservation and Attractions) [DELETE AS APPLICABLE]

EN7 - Prior to subdivisional works in the foreshore/waterway area, a plan is to be submitted and approved, detailing the waterway crossing and indicating how design and construction will minimise detrimental impacts on the waterway form and function. The waterway crossing plan is to be implemented as part of the subdivisional works. (Department of Water and Environmental Regulation)

5.3.4 Predicted environmental outcomes

Remnant vegetation including mature trees will be retained within Manjedal Brook and the area of CCW in the south-east of the site, and within Bush Forever Site No. 350 east of the site, and where possible within areas of public open space. This will contribute to the EPA's objective above and will create ecological/fauna corridors to facilitate the movement of fauna through the site.

5.4 Hydrology – groundwater

5.4.1 Policy framework and management objective

The EPA's objective for inland waters (and applied to the land use planning process) is *'to maintain the hydrological regimes and quality of groundwater and surface water so that environmental values are protected'* (EPA 2018).

In addition, the *State Water Strategy for Western Australia* (Government of WA 2003b) and *Better Urban Water Management* (WAPC 2008a) endorses the promotion of integrated water cycle management and application of water sensitive urban design (WSUD) principles to provide improvements in the management of stormwater, and to increase the efficient use of other existing water supplies. Of particular relevance to the floodplain feature that occurs within the site is the *Better Urban Water Management* criteria for ecological protection, which requires management to maintain or restore desirable environmental flows and/or hydrological cycles.

The principal management objective for hydrology in the site will be to ensure that groundwater and surface water is appropriately infiltrated and treated to not impact on the broader area based on water sensitive design.

5.4.2 LSP considerations for groundwater

The LSP provides a framework for the removal of nutrients from groundwater through the implementation of surface and groundwater management in the form of stormwater infiltration on site, as practicable with the subsoil condition (Wave International 2016; RPS 2023).

5.4.3 Future groundwater management requirements

Future groundwater level and quality monitoring will be required at the site to ensure that there is no significant impact on groundwater within the site as a result of the proposed development.

An Urban Water Management Plan (UWMP) will be prepared for each stage of subdivision within the site, in order to address WAPC's standard model subdivision condition D2 (WAPC and DPLH 2022) which states:

D2 - Prior to the commencement of subdivisional works, an urban water management plan is to be prepared and approved, in consultation with the Department of Water and Environmental Regulation, consistent with any approved Local Water Management Strategy.

The UWMP will provide information on the implementation of the LWMS through detailed civil and landscape design.

5.4.4 Predicted environmental outcomes

The LWMS provides the framework for the LSP to manage groundwater levels and quality in a contemporary best-practice approach utilising WSUD objectives, and in accordance with the WAPC and EPA guidelines and policy frameworks. The preparation of a UWMP to satisfy subdivision approval will provide design details that will ensure the sustainable use of groundwater resources.

5.5 Hydrology – surface water

5.5.1 Policy framework and management objective

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

The key principles of integrated water cycle management include:

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

The EPA's *Environmental Factor Guideline – Inland Waters* (EPA 2018) outlines the following key objectives for the management of surface water *'to maintain the hydrological regimes and quality of groundwater and surface water so that environmental values are protected'*.

State Planning Policy 2.9 Water Resources (WAPC 2006a) outlines the following key policy objectives:

- Protect, conserve and enhance water resources that are identified as having significant economic, social, cultural and/or environmental values.
- Assist in ensuring the availability of suitable water resources to maintain essential requirements for human and all other biological life with attention to maintaining or improving the quality and quantity of water resources.

- Promote and assist in the management and sustainable use of water resources.

5.5.2 LSP considerations for surface water

5.5.2.1 Waterway considerations

Manjedal Brook traverses the southern extent of the site, flowing east to west. The LSP proposes to fully retain Manjedal Brook and existing riparian vegetation within an approximate 100 m-wide foreshore reserve (50 m either side of the banks), as shown in **Appendix A**. Based on flood modelling (Wave International 2016; RPS 2023) the hydrological values of the waterway can be accommodated within a 30 m-wide corridor, and therefore is addressed through the proposed foreshore reserve.

The foreshore reserve will ensure development does not encroach on the remaining waterway values, and provides sufficient allowance for flood levels in future large rainfall events.

An ILMS (Emerge Associates 2023b) has been prepared to support the LSP, and outlines the preliminary landscape treatments for areas of public open space and conservation reserves within the site. The ILMS provides further advice on the treatment of wetland and foreshore areas. The Manjedal Brook foreshore reserve will be incorporated into public open space, and will incorporate revegetation for conservation purposes, public amenity and access options, and some drainage infrastructure, as outlined in the ILMS (Emerge Associates 2023b).

5.5.2.2 Stormwater considerations

The stormwater management strategy for the site is detailed in the Local Water Management Strategy (LWMS) and addendum (Wave International 2016; RPS 2023) prepared to support the LSP. The principle behind the stormwater management strategy for the site is to mimic the existing hydrology. The 1 exceedance per year (EY) - 1 hour event runoff from the site will be retained as close to source as possible using a combination of soakwells, roadside swales and bio-retention areas within public open space and wetland buffer areas. Stormwater runoff greater than the 1 EY - 1 hour event will be conveyed to Manjedal Brook, as currently occurs in the pre-development environment. The design of stormwater management infrastructure ensures overall peak discharge from the development does not exceed the pre-development peak discharge rates for up to the 1% annual exceedance probability event. Stormwater quality will be addressed using a treatment train approach, utilising the storage provisions discussed above (Wave International 2016; RPS 2023).

Further information is provided in the LWMS and addendum (Wave International 2016; RPS 2023).

5.5.3 Future surface water management requirements

A Landscape Management Plan will be prepared to support subdivision within the site and will outline all environmental management requirements including those associated with Manjedal Brook and its associated foreshore reserve. Management requirements addressed will include fencing, weed control, revegetation works, fauna management, landscape treatments etc. and will be prepared to support future subdivision within the site, in accordance with the WAPC standard subdivision condition EN1 which states:

EN1 - Prior to the commencement of subdivisional works an environmental management plan is to be prepared and approved to ensure the protection and management of the sites environmental assets with satisfactory arrangements being made for the implementation of the approved plan. (Department of Water Environment and Regulation)

A UWMP will be required for each stage of subdivision within the site, in order to address WAPC's standard model subdivision condition D2 (WAPC and DPLH 2022) which states:

D2 - Prior to the commencement of subdivisional works, an urban water management plan is to be prepared and approved, in consultation with the Department of Water and Environmental Regulation, consistent with any approved Local Water Management Strategy. (Local Government)

The UWMP will provide information on the implementation of the LWMS through detailed civil and landscape design.

5.5.4 Predicted environmental outcomes

The implementation of the LSP will enable the removal of existing disturbances to the waterway and wetland area (i.e. livestock) and will allow for the retention and enhancement of ecological values within Manjedal Brook and its associated wetlands. Future development within the site will also allow the waterway and wetland values within Manjedal Brook to be consolidated and vested with the local government, rather than remaining within private landownership.

The LWMS provides the framework for the LSP to manage surface water within the site in accordance with the WAPC and EPA guidelines and policy frameworks. Implementation of the LSP will see that stormwater flows discharge into Manjedal Brook to reflect the natural historic drainage of the site.

The preparation of a UWMP utilising *Better Urban Water Management* practices to support subdivision will ensure the sustainable use of surface water resources.

5.6 Hydrology – wetlands

5.6.1 Policy framework and management objective

State Planning Policy 2.9 Water Resources (WAPC 2006b) outlines the following key policy objectives for the management of wetlands:

- Protect, conserve and enhance water resources that are identified as having significant economic, social, cultural and/or environmental values;
- Assist in ensuring the availability of suitable water resources to maintain essential requirements for human and all other biological life with attention to maintaining or improving the quality and quantity of water resources; and
- Promote and assist in the management and sustainable use of water resources.

Of particular relevance for the site, key policy measures for Multiple Use (MU) wetlands outlined in *State Planning Policy 2.9* include to '*ensure use of best management practices in the development and use of multiple use wetlands, consistent with the principles of total water cycle management' (DPLH 2021)*

Ensure adequate and appropriate buffering of wetlands, waterways and estuaries to maintain or enhance the environmental attributes, functions and values of the water resource and minimise the impact of nearby land uses, both existing and future.

5.6.2 LSP considerations for wetlands

An ILMS (Emerge Associates 2023b) has been prepared to support the LSP, and outlines the preliminary landscape treatments for areas of public open space and conservation reserves within the site. The ILMS provides further advice on the treatment of wetland and foreshore areas.

Spatial consideration for wetlands within the site has been provided through the retention and placement of public open space over remnant vegetation in the south of the site associated with Manjedal Brook and its wetlands, and the area of CCW in the south-east of the site, as shown in **Appendix A**.

A 50 m foreshore reserve has been provided for the Manjedal Brook (and previously discussed in **Section 5.5**), as shown in **Appendix A** and **Figure 15**, and will act as an appropriate buffer to ensure development does not encroach on the waterway and wetland values. The Manjedal Brook foreshore reserve is assumed to be revegetated (incorporating existing remnant vegetation), providing separation between the Manjedal Brook waterway and proposed development. The foreshore reserve will incorporate remnant vegetation and revegetation, drainage, and landscaped public amenity elements, as outlined in the ILMS (Emerge Associates 2023b).

A 50 m buffer has been accommodated within the LSP from the mapped CCW located in the south-east of the site, as shown in **Appendix A**. This wetland buffer will incorporate remnant vegetation, revegetation works and drainage, and some landscaped public amenity elements to provide an appropriate environmental buffer between the waterway and the adjacent development. Further information regarding the proposed treatment and ongoing management of these areas is provided in the ILMS (Emerge Associates 2023b).

5.6.3 Future wetland management requirements

A Landscape Management Plan will be prepared for future subdivision stages, and will address the future environmental management requirements for the site, including the Manjedal Brook foreshore reserve and the CCW and buffer area. This Landscape Management Plan will also address the WAPC standard model subdivision condition EN1(WAPC and DPLH 2022), and will outline details on items including planting, design of public use/pathways, weed control, ongoing management and maintenance, handover etc. to ensure the protection and management of wetland values within the site. This is also outlined within the ILMS (Emerge Associates 2023b).

5.6.4 Predicted environmental outcomes

Wetland values within the site will be retained as part of future development. Weed management and proposed planting regimes within the foreshore and buffer areas will contribute to the protection, conservation and enhancement of wetland values, as per the management objective outlined in *State Planning Policy 2.9*.

Areas of MUW present within the site will be utilised in the total water cycle management for the site, outlined in the LWMS and addendum (Wave International 2016; RPS 2023), and will be addressed in future UWMP/s at future subdivision stages.

5.7 Health and amenity – mosquito management

5.7.1 Policy framework and management objective

Mosquitos and other nuisance insects (midges, etc.) are a concern for local governments and health authorities, given they can spread disease (such as Ross River virus with mosquitos), cause nuisance to the community, and affect both health and lifestyle.

The site is located within the eastern portion of the Swan Coastal Plain, and is located in proximity to wetland/waterway features that have the potential to support mosquito breeding areas. Mosquitoes are a concern for the community not only due to their potential to transmit debilitating diseases but also due to their nuisance value which can impact on the ability of future residents to enjoy the amenities and natural values of the area. However, mosquitoes are also a valuable part of the natural ecosystem, providing food for birds, bats, amphibians, fish and insects. The challenge is creating a balance between these factors and managing mosquitoes to reduce the risk of the community being exposed to mosquito borne diseases whilst minimising impacts on the environment.

The Department of Health Mosquito Management Manual outlines considerations for mosquitoes and mosquito management, including provision of appropriate buffers between areas of potential mosquitoes breeding and areas inhabited by humans. The key objective for the LSP will be ensure that mosquitoes do not adversely affect the health, welfare or amenity of future residents through appropriate design and management.

5.7.2 LSP consideration for mosquito management

Vegetation can provide a barrier between mosquito (and midge) movement. Spatial provision has been made in the LSP for public open space to be located to enable the retention of existing vegetation around the wetland and waterway features, as well as buffers that will be revegetated. These features will assist with management movement of mosquitoes, as per the Department of Health Mosquito Management Manual.

5.7.3 Future mosquito management requirements

Wetland values to be retained within the south-east of the LSP provides potential mosquito habitat in the vicinity of future development. In order to adequately address the impact of the potential mosquito risk, further assessment will be undertaken as part of future subdivision for those development stages located in the vicinity of potential mosquito habitat. The WAPC may impose conditions of approval on a subdivision application, utilising the *Model Subdivision Conditions Schedule* (WAPC and DPLH 2022). These conditions include provisions for ensuring the management of mosquitoes and their associated risks such as placing a notification on the certificates of title of proposed lot(s) and/or a requirement to prepare a Mosquito and Midge Management Plan.

5.7.4 Predicted environmental outcome

Any future mosquito management considerations will be identified and implemented during the subdivision process according to WAPC's and the Shire of Serpentine Jarrahdale's requirements.

5.8 Heritage – Indigenous heritage

5.8.1 Policy framework and management objective

Indigenous heritage values in Western Australia are protected under the *Aboriginal Heritage Act 1972* (Aboriginal Heritage Act) which will be shortly transitioning to the *Aboriginal Cultural Heritage Act 2021*, which make provision for the preservation of cultural values, including places and objects customarily used by, or traditional to, the original inhabitants of Australia or their descendants, on behalf of the community. The Aboriginal Cultural Heritage Act provides a modern framework for the recognition, protection, conservation and preservation of Aboriginal cultural heritage while recognising the fundamental importance of Aboriginal cultural heritage to Aboriginal people. Consultation will be a key part of the new act.

5.8.2 LSP considerations for Indigenous heritage

As outlined in **Section 3.7.1**, there is one registered Indigenous heritage site and several Other Heritage Places mapped within the site, as shown in **Figure 12**. Peet Ltd have engaged the services of ethnography and heritage consultant Ethnosciences to provide additional advice in relation to the heritage and cultural values of the site. Ethnosciences have conducted two separate archaeological investigations of the site in 2012 and 2014 in consultation with representatives of the relevant traditional owners and Aboriginal elders, in order to understand the extent of the heritage values of the site.

Spatial consideration for two ‘registered sites’ (ID 3648 and 37116) has been given to the heritage values within the CCW buffer and Mundijong Brook foreshore public open space to retain these where possible.

5.8.3 Future Indigenous heritage management requirements

As outlined previously, an application was made under Section 18 of the *Aboriginal Heritage Act 1972* (AHA) on 12 December 2019 and consent granted by the Minister for Aboriginal Affairs on 26 April 2020 (subject to conditions). Archaeological sites identified as meeting the requirements of section 5 of the in the AHA and proposed to be disturbed through development of the subject land are outlined in the Aboriginal Archaeological Assessment prepared by Thomson Cultural Heritage Management (April 2014).

5.8.4 Predicted environmental outcomes

This Section 18 approval will be valid under the new *Aboriginal Cultural Heritage Act 2021* as part of transition provisions, and values will be managed in accordance with all relevant requirements. An Aboriginal Heritage Management Plan shall be prepared and implemented as part of the subdivision process, when ground disturbance will occur.

5.9 Land use considerations – potential contamination

5.9.1 Policy framework and management objective

Potential site contamination is addressed under the *Contaminated Sites Act 2003* which aims to protect human health, the environment and environmental values by providing for the identification, recording, management and remediation of contaminated sites in the State.

5.9.2 LSP considerations for potential contamination

The existing or potential contamination of land within the site does not require spatial consideration in the LSP, but will be addressed at future subdivision and development stages where applicable.

5.9.3 Future management requirements for potential contamination

The future subdivision approval process will provide the trigger for the site to enter the formal Contaminated Sites process for those areas identified as requiring further investigation within the SAP (Aurora Environmental 2014b) and will therefore tie the remediation of any contamination within lots to subdivision and/or development approval.

Where subdivision is proposed, the WAPC includes a standard condition on all subdivision applications (model subdivision condition EN9, (WAPC and DPLH 2022)) which states:

a) *Prior to commencement of subdivision works, investigation for soil and groundwater contamination is to be carried out to determine if remediation is required.*

b) *If required, remediation, including validation of remediation, of any contamination identified shall be completed prior to the issuing of titles on advice from the Department of Water and Environmental Regulation, to ensure that the lots created are suitable for the proposed use.*

Investigations and remediation are to be carried out in compliance with the Contaminated Sites Act 2003 and current Department of Water and Environmental Regulation Contaminated Sites Guidelines. (Department of Water and Environmental Regulation).

5.9.4 Predicted environmental outcomes

Potential soil and groundwater contamination sources identified through the PSI (Aurora Environmental 2014a) and SAP (Aurora Environmental 2014b) prepared for the site will be addressed as a condition of future subdivision and/or development approval in those lots designated as having a medium or high risk of contamination. If required, site contamination will be remediated to meet acceptable standards before development commences.

5.10 Land use considerations – freight railway and future Tonkin Highway

5.10.1 Policy framework and management objective

The WAPC's *State Planning Policy 5.4 Road and Rail Noise* (SPP 5.4) (DPLH 2019b) recognises that excessive noise has the potential to affect the health and amenity of a community as a whole, as well as the wellbeing of individuals. The policy aims to protect people from unreasonable levels of transport noise by establishing a standardised set of criteria to be used in the assessment of development proposals.

Table 4 below outlines the outdoor noise criteria applicable to new noise-sensitive development as specified in SPP 5.4 (DPLH 2019b).

Table 5: Summary of noise targets for new noise sensitive proposals from SPP 5.4 (DPLH 2019))

	OUTDOOR		INDOOR	
Type of use	**DAY** (L_{Aeq}(Day) dB)	**NIGHT** (L_{Aeq}(Night) dB)	**DAY** (L_{Aeq}(Day) dB)	**NIGHT** (L_{Aeq}(Night) dB)
Noise sensitive land use and/or development	55 (6 am to 10 pm)	50 (10 pm to 6 am)	40 (living and work areas)	35 (bedrooms)

Where the targets are exceeded, an assessment is required to determine the likely level of transport noise and management/mitigation required.

The application of SPP 5.4 is to consider anticipated traffic volumes for the next 20 years from when the noise assessment is undertaken. In the application of the noise targets, the objective is to achieve the following:

- Indoor noise levels specified in **Table 5** in noise-sensitive areas (e.g. bedrooms and living rooms of houses and school classrooms).
- A reasonable degree of acoustic amenity for outdoor living areas on each residential lot. For non-residential noise-sensitive developments, for example schools and childcare centres, the design of outdoor areas should take into consideration the noise target.

The site is located adjacent to the freight railway and future Tonkin Highway, which is identified as an 'significant freight and major traffic route' and 'other significant freight/traffic route' in *Section 4 Table 1* of State Planning Policy 5.4 *Road and Rail Noise* (SPP 5.4) (DPLH 2019a). Therefore, where development is located within the 200 m trigger value, road noise impacts on sensitive land uses and/or development should be considered. This means noise will be a relevant consideration for future development in the western portion of the site.

The principle management objective for acoustic impacts is to protect future residents from unreasonable levels of transport noise.

5.10.2 LSP considerations for the freight railway and future Tonkin Highway

The proponent commissioned Herring Storer Acoustics to undertake a noise management plan (Herring Storer Acoustics 2023). This has considered potential noise impacts from both the freight railway and future Tonkin Highway.

There have been no spatial considerations provided within the LSP to address the future Tonkin Highway extension or the existing freight railway line. Portions of the development cells along the freight railway and future Tonkin Highway may exceed the noise target but can be addressed through quiet house design, specifically Package A or Package B.

The noise mitigation methods (provision of an acoustic barrier/wall, and/or architectural treatments to new buildings) available to the site, as discussed in **Section 3.8.2**, will be determined as part of future detailed design and subdivision.

5.10.3 Future management requirements for the freight railway and future Tonkin Highway

The acoustic implications of the future Tonkin Highway extension will be addressed as part of the development of this road reserve. Those lots in the vicinity of the future highway will require notification on titles alerting prospective buyers of the adjacent future noise source. The standard subdivision condition relating to notification on title as outlined by the WAPC (model subdivision condition T24 (WAPC and DPLH 2022)) states:

"This lot is situated in the vicinity of a transport corridor and is currently affected, or may in the future be affected by transport noise. Additional planning and building requirements may apply to development on this land to achieve an acceptable level of noise reduction."

Further acoustic assessment may be undertaken to support future subdivision in the vicinity of the freight railway line east of the site, to enable the accurate determination of specific lots requiring architectural noise mitigation strategies, and will detail the treatments required to ensure development meets the requirements of SPP 5.4 (DPLH 2019b). There would be a requirement to provide notification on titles for those lots that are determined to require acoustic architectural treatments, as per the above standard subdivision condition (WAPC and DPLH 2022).

5.10.4 Predicted environmental outcomes

As outlined, the requirements of SPP can be achieved through implementation of the structure plan. It should be noted that the provided noise contours in the noise management report are a worst case scenario (Herring Storer Acoustics 2023). Detailed noise modelling can be undertaken to support the future subdivision processes when more detailed site-specific information (e.g. proposed final development layout, finished lot levels) is available.

Noise mitigation requirements will be finalised and implemented once the subdivision design is complete and will be applied with any conditions imposed on the affected lots.

5.11 Natural Hazards – bushfire management

5.11.1 Policy framework and management objective

State Planning Policy 3.7 Planning in Bushfire Prone Areas (SPP 3.7) (WAPC 2015a) stipulates that any development proposal which occurs partly or wholly within a designated bushfire prone area is required to be accompanied by a bushfire management plan (BMP). The preparation of a BMP is required to incorporate the following tasks:

- Classification of existing vegetation and effective slope within the site and surrounding 150 m, in accordance with AS 3959 (Standards Australia 2018).
- Assessment of bushfire hazard levels within the site and surrounding 150 m, in accordance with the Guidelines (DPLH & WAPC 2021).
- Completion of an indicative Bushfire Attack Level (BAL) assessment and preparation of an associated BAL contour plan.
- Assessment of the structure plan design against the bushfire protection criteria, in accordance with the Guidelines (DPLH & WAPC 2021).

Policy objective 5.4 of SPP 3.7 specifies that development is required to:

"…*achieve an appropriate balance between bushfire risk management measures and biodiversity conservation values, environmental protection and biodiversity management and landscape amenity."*

This policy objective ensures that future development appropriately considers the bushfire risks, and provides appropriate separation from any identified risks without negatively impacting existing environmental values.

Bushfire hazards have been identified external to the site (discussed in **Section 0** and the BMP (Emerge Associates 2023a)), and for the purposes of the assessment to support the scheme amendment and structure plan process, it has been assumed any hazards identified external to the site will remain in the long-term. The majority of the proposed public open space areas within the site have been assumed to be a managed to achieve low threat in accordance with Section 2.2.3.2 of AS 3959 and are not identified as a bushfire hazard. Manjedal Brook and the CCW (and associated foreshore reserve/buffers) have been assumed to be a bushfire hazard (and therefore effectively means 'no management' is assumed for the purposes of the bushfire assessment), with classified forest (Class A) and scrub (Class D) vegetation respectively.

The principal management objective for the bushfire risk to the site is to ensure that the risk to future people, property and infrastructure is appropriately minimised without negatively impacting on environmental values within or surrounding the site.

5.11.2 LSP considerations for bushfire management

In accordance with the BMP (Emerge Associates 2023a) prepared for the site, the LSP has provided an appropriate spatial response to bushfire risk through:

- Ensuring future development areas will be able to accommodate the separation necessary to enable habitable buildings to achieve a bushfire attack level (BAL) rating of BAL-29 or less without requiring clearing or modification of remnant native vegetation retained in or surrounding the site. This has been achieved through the location of proposed roads between future lots and areas of bushfire hazard and/or providing lots of an appropriate size to accommodate necessary separation. Areas within the site assessed as being subject to BAL-FZ and BAL-40 (and able to support habitable building) are shown in **Figure 15**.
- An integrated internal road network that connects with the existing external public road network and provides access to multiple destinations, supporting appropriate emergency evacuation and response.

5.11.3 Future bushfire management requirements

The BMP (Emerge Associates 2023a) demonstrates that SPP 3.7 and the bushfire protection criteria (outlined within the Guidelines (DPLH & WAPC 2021)) can be satisfied through an 'acceptable solution' approach without compromising environmental values within or nearby to the site. No fuel load management of remnant native vegetation outside the site has been assumed as part of addressing bushfire risk, nor has fuel load management within Manjedal Brook, the CCW and associated foreshore reserve/buffer been assumed.

Going forward and based on satisfying the bushfire protection criteria, detailed design and construction will need to consider the following:

- Providing appropriate separation between bushfire hazards and future habitable buildings to achieve a bushfire attack level (BAL) rating of BAL-29 or less, with portions of the site likely to be subject to BAL-LOW. This is through the use of perimeter public roads and in-lot setbacks.
- Providing access to multiple destinations via Bishop Road, Scott Road, Soldiers Road and Taylor Road.
- Meeting water supply requirements through a reticulated water scheme and provision of hydrants.

A revised BMP may be required to support future subdivision applications, particularly if vegetation management assumptions are different, or the development layout is different to that assessed as part of the BMP. The BMP will need to respond to the subdivision design (and/or stage of development). It is likely that the WAPC will include a number of standard conditions on the subdivision approval, including F1, F2 and F3 (DPLH & WAPC 2021) which states:

F1- Information is to be provided to demonstrate that the measures contained in the bushfire management plan [NAME/DATE] that address the following [LIST AS REQUIRED] have been implemented during subdivisional works. This information should include a notice of 'Certification by Bushfire Consultant'.

F2 – Notification, pursuant to Section 165 of the Planning and Development Act 2005, is to be placed on the certificate(s) of title of the proposed lot(s) with a Bushfire Attack Level (BAL) rating of 12.5 or above, advising of the existence of a hazard or other factor. Notice of this notification is to be included on the diagram or plan of survey (deposited plan). The notification is to state as follows:

"This land is within a bushfire prone area as designated by an Order made by the Fire and Emergency Services Commissioner and is/ may be subject to a Bushfire Management Plan [RENAME/DELETE AS APPLICABLE]. Additional planning and building requirements may apply to development on this land" (Western Australian Planning Commission)

F3 – A plan is to be provided to identify areas of the proposed lot(s) that have been assessed as BAL-40 or BAL-Flame Zone.

A restrictive covenant to the benefit of the local government, pursuant to section 129BA of the Transfer of Land Act 1893, is to be placed on the certificate(s) of title of the proposed lot(s) advising of the existence of a restriction on the use of the land within areas that have been assessed as BAL-40 or BAL-Flame Zone. Notice of this restriction is to be included on the diagram or plan of survey (deposited plan). The restrictive covenant is to state as follows:

"No habitable buildings are to be built within areas identified as BAL-40 or BAL-Flame Zone". (Local Government).

5.11.4 Predicted environmental outcomes

By utilising the BMP at this early stage of planning process, the LSP has been able to incorporate bushfire hazard management considerations into the design of the development, ensuring that, if there is a bushfire within or near the site, the threat to residents, property and emergency response personnel will be reduced.

6 Summary and Conclusions

TBB, on behalf of Peet, has prepared a LSP for the proposed urban development of the site. Emerge Associates have been engaged to provide a suite of environmental consultancy services to support the preparation of the LSP, which has included various investigations to identify and assess the environmental attributes and any constraints within the site.

The LSP (attached in **Appendix A**) provides a framework for the implementation of the urban development including residential lots, two primary schools, community use facilities, and areas of public open space and conservation reserves. The LSP incorporates the inputs from a multi-disciplinary project team and the outcomes from various technical studies.

The environmental attributes and values identified within the site have been outlined in **Section 2** and include:

- The majority of the site was historically cleared for agricultural purposes, primarily cattle grazing.
- Based on a flora and vegetation survey undertaken in 2017, there are no Threatened Flora (TF) or Priority Flora (PF) species, Threatened Ecological Communities (TECs) or Priority Ecological Communities (PECs) present within the site.
- Vegetation within the site is generally in “Completely Degraded” or “Degraded” condition (based upon the flora and vegetation survey (Emerge Associates 2017)). A small portion of vegetation in the south-east of the site, associated with an area of CCW, is considered to range from “Good - degraded” to “Excellent – very good” condition. This vegetation may also provide habitat for fauna species, including black cockatoos, but is not considered significant.
- Bush Forever Site 350 occurs immediately east of the site, within the Soldiers Road and railway reserve. This Bush Forever Site is known to support significant flora and vegetation values. There are no Bush Forever sites within the site.
- ESAs extend into the east of the site, associated with the flora and vegetation values known to occur within Bush Forever Site 350.
- Manjedal Brook runs through the south of the site. This creekline conveys surface flows through the site to the west, and joins with Cardup Brook and eventually the Serpentine River west of the site.
- The majority of the site is covered by MUWs, and there are three CCWs in the south of the site, two of which are associated with Manjedal Brook.
- An existing railway line occurs adjacent to the northern and eastern site boundary, while a Primary Regional Road reserve associated with the Tonkin Highway extension and Water Corporation service corridor lies adjacent to the western boundary of the site. These existing and future adjacent land uses will pose acoustic and potential vibration implications to residential development within the site.
- Vegetation associated with Manjedal Brook and the CCWs, as well as that surrounding the site presents a permanent bushfire hazard to residential development.
-

The LSP has responded to the environmental values and attributes of the site, in particular with spatial provision provided for the protection and retention of Manjedal Brook and the CCW (which contain the majority of the vegetation and fauna habitat values), and this report outlines an environmental management framework that will be implemented either as part of the future residential planning and development process.

The WAPC's *Model Subdivision Conditions Schedule (WAPC and DPLH 2022)* provide a planning framework for the management of environmental factors throughout the implementation of the LSP at future subdivision and development stages, including:

- Preparation of an ASS self-assessment form, and subsequent ASS Management Plan if required, in accordance with model subdivision condition EN8 *(WAPC and DPLH 2022)*.
- Preparation of a Landscape Management Plan in accordance with model subdivision condition R4 *(WAPC and DPLH 2022)* and the ILMS.
- Preparation of Urban Water Management Plans in accordance with model subdivision condition DA1 Urban Water Management Plans.
- Notification on titles regarding proximity of lots to adjacent future noise source/s associated with the future Tonkin Highway extension west of the site. Additional requirements may be applied to development under *SPP 5.4 Road and Rail Noise* if noise reduction levels cannot be achieved.
- Preparation of relevant soil and groundwater contamination investigations (where required), in accordance with model subdivision condition ENa2 *(WAPC and DPLH 2022)*.
- Preparation of further detailed bushfire hazard and risk assessment and management plan/s as part of future subdivision or detailed design.

These mechanisms will ensure that there are no significant impacts on the environmental values and attributes of the site and that an appropriate planning and development framework exists to respond to, and manage, the environment. Overall, the environmental attributes and values/constraints of the site have been accommodated within the LSP layout or can be managed through the future subdivision and development stages in accordance with relevant federal, state and local government legislation, policies and guidelines and best management practices. As such, the proposed future development of the site is not expected to significantly impact on the environment.

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Figure 11: Hydrology and Geomorphic Wetlands

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Figure 14: Designated Bushire Prone Areas

Figure 15: Key Management Considerations

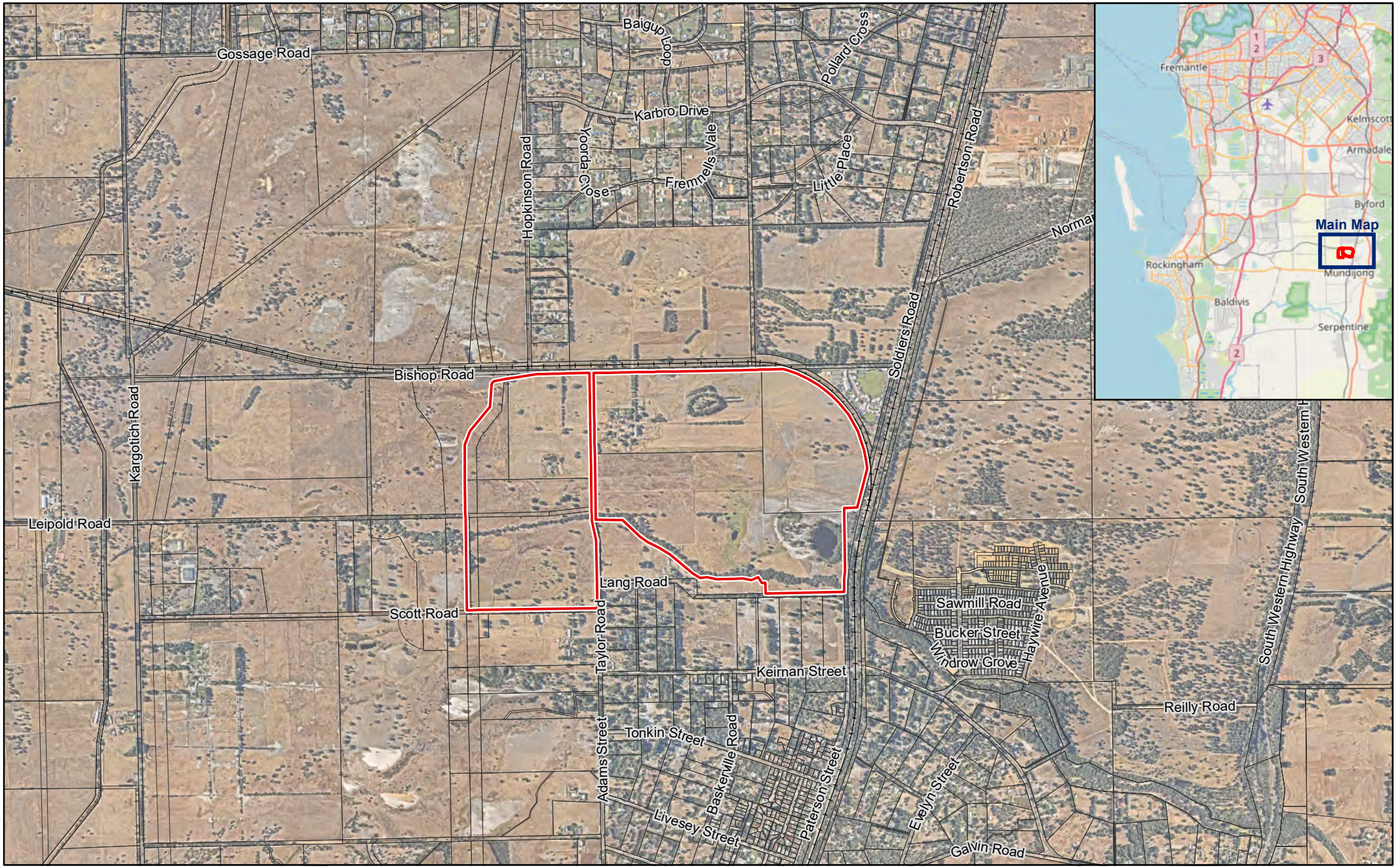


Figure 1: Location Plan

Project:	Environmental Assessment and Management Strategy Taylor Road, Mundijong
Client:	Peet Mundijong Syndicate Ltd

Legend

- Site boundary
- Cadastral boundary
- Railway

Plan Number: EP15-036(01)--F85			
Drawn:	WJC	Date:	01/05/2023
Approved:	KK	Date:	05/05/2023
Checked:	SAM	Scale:	1:25,000@A4

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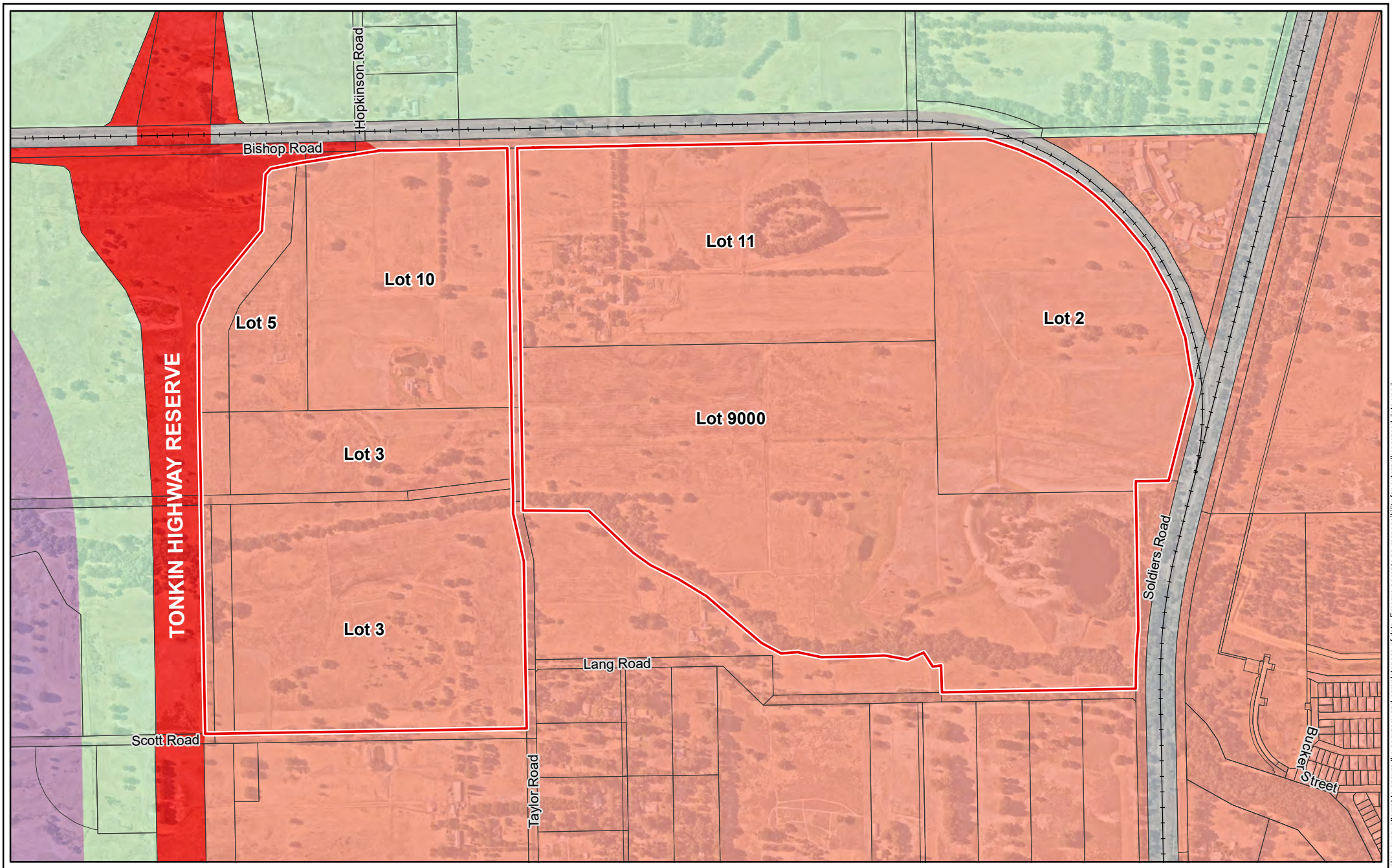


Figure 2: Current Metropolitan Region Scheme

Project:	Environmental Assessment and Management Strategy Taylor Road, Mundijong
Client:	Peet Mundijong Syndicate Ltd

Legend

- Site boundary
- Cadastral boundary
- Railway

Region Schemes (DPLH 2023)

- Industrial
- Primary regional roads
- Railways
- Rural
- Urban

Plan Number: EP15-036(01)--F87			
Drawn:	WJC	Date:	01/05/2023
Approved:	KK	Date:	05/05/2023
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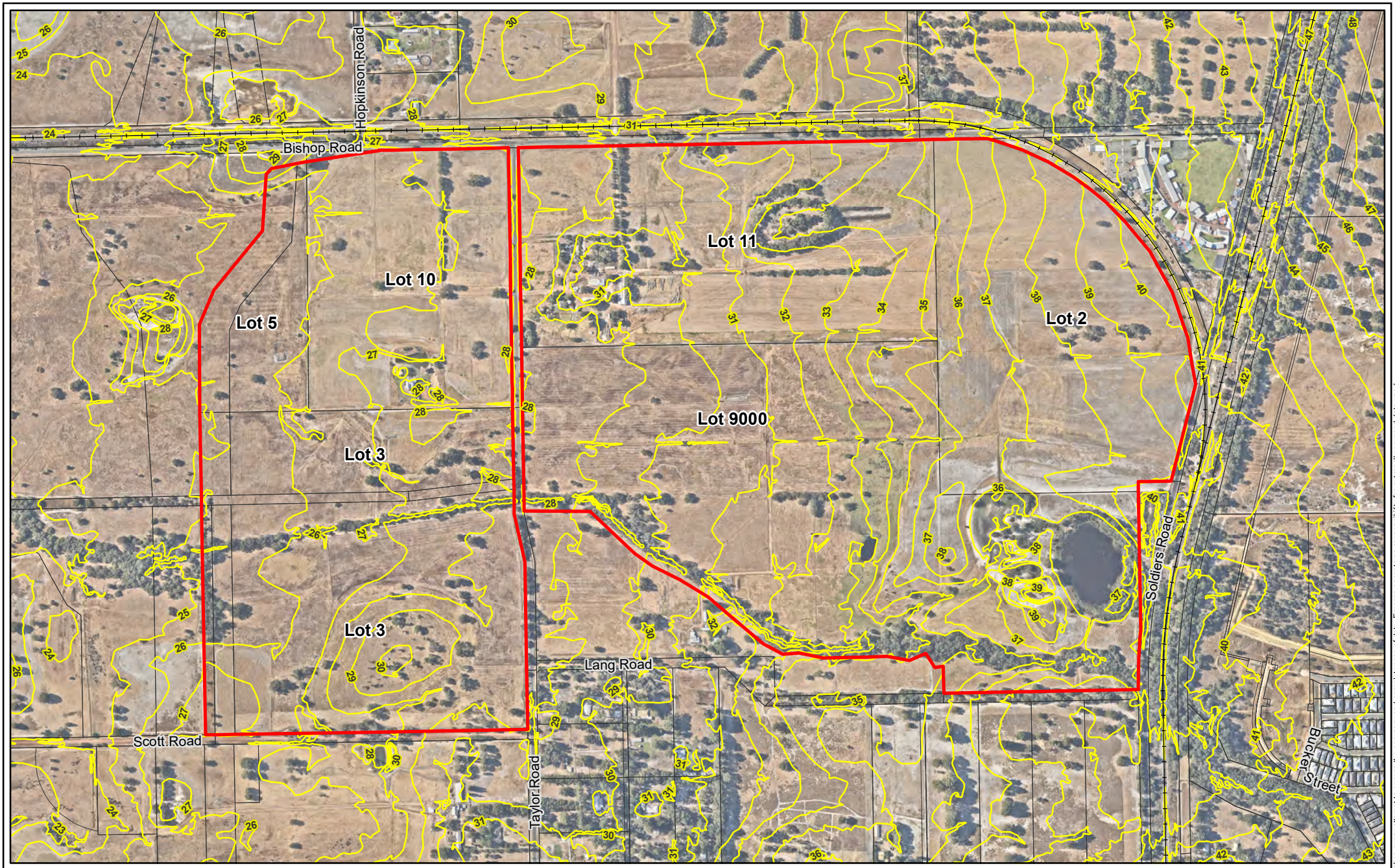


Figure 3:	**Topography**
Project:	Environmental Assessment and Management Strategy Taylor Road, Mundijong
Client:	Peet Mundijong Syndicate Ltd

Legend

- Site boundary
- Cadastral boundary
- Railway
- Elevation contour (DWER)

Plan Number: EP15-036(01)--F88			
Drawn:	WJC	Date:	01/05/2023
Approved:	KK	Date:	05/05/2023
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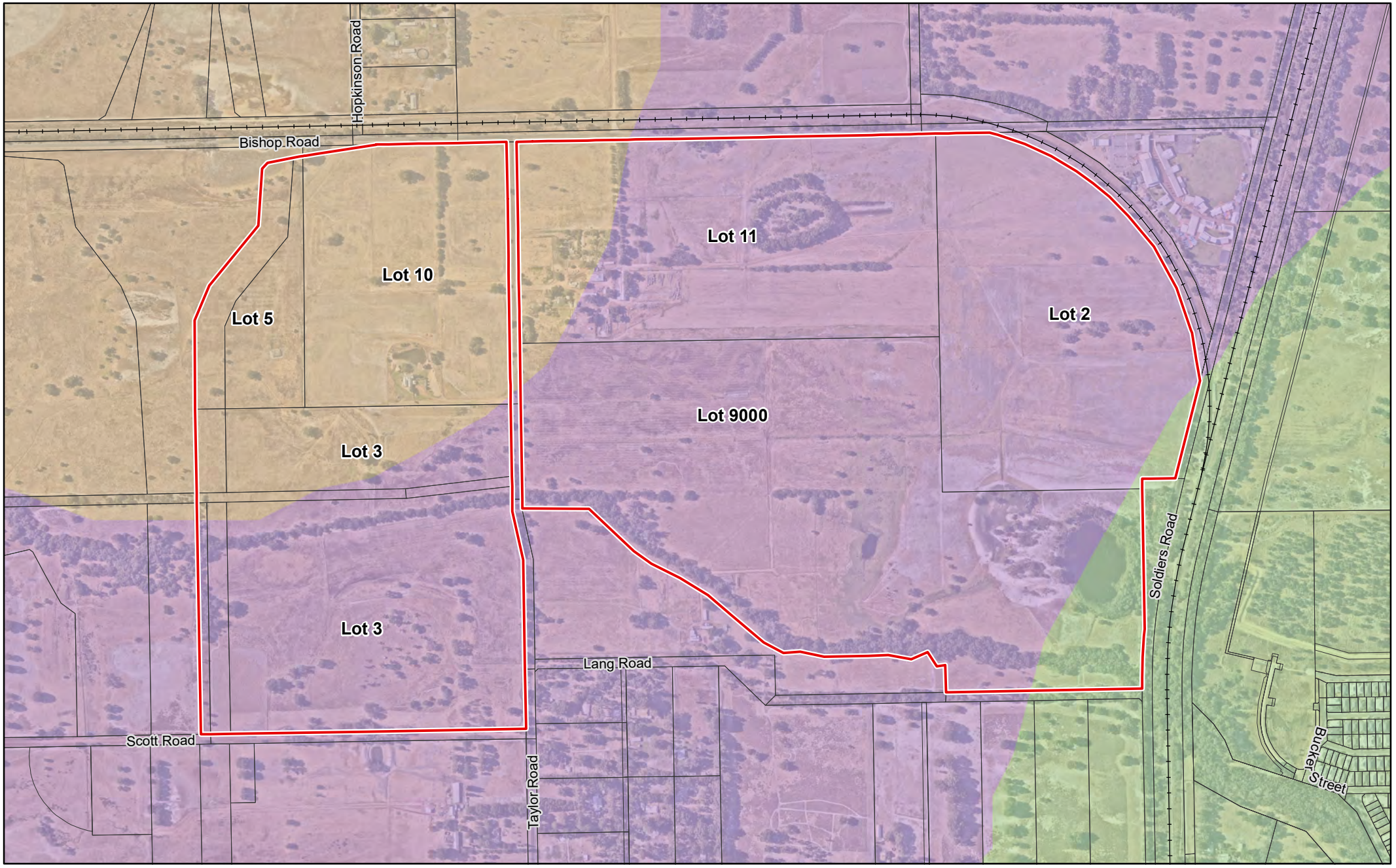


Figure 4: Landforms

Project:	Environmental Assessment and Management Strategy Taylor Road, Mundijong
Client:	Peet Mundijong Syndicate Ltd

Legend

- Site boundary
- Cadastral boundary
- Railway

Landforms (Churchward and McArthur)

- Beermullah
- Forrestfield
- Guildford

Plan Number: EP15-036(01)--F89			
Drawn:	WJC	Date:	01/05/2023
Approved:	KK	Date:	05/05/2023
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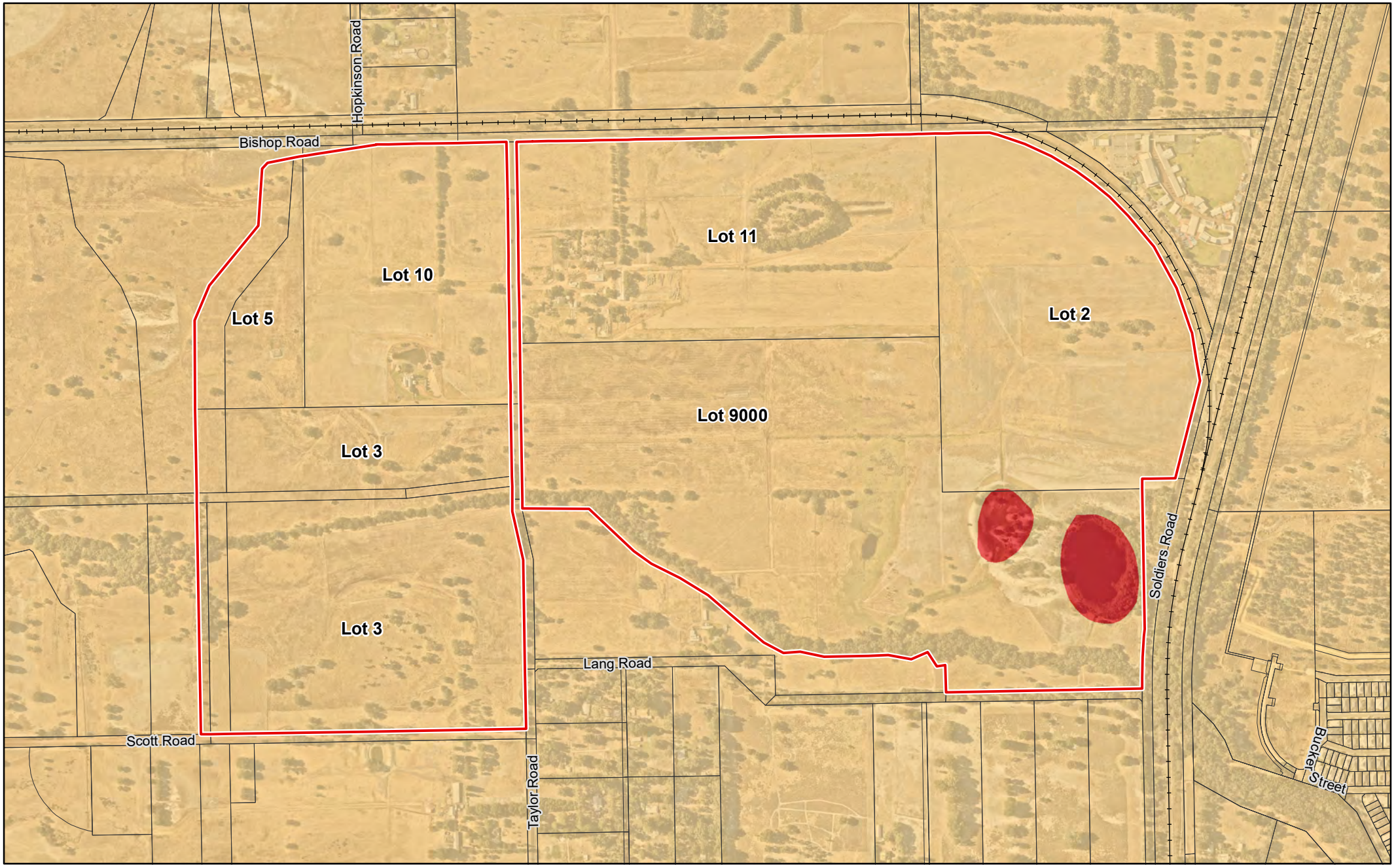


Figure 5: Acid Sulfate Soils

Project:	Environmental Assessment and Management Strategy Taylor Road, Mundijong
Client:	Peet Mundijong Syndicate Ltd

Legend

- Site boundary
- Cadastral boundary
- Railway

Acid Sulfate Soils (DWER)

- High to moderate risk
- Moderate to low risk

Plan Number: EP15-036(01)--F90			
Drawn:	WJC	Date:	01/05/2023
Approved:	KK	Date:	05/05/2023
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0 100 200 400 Metres

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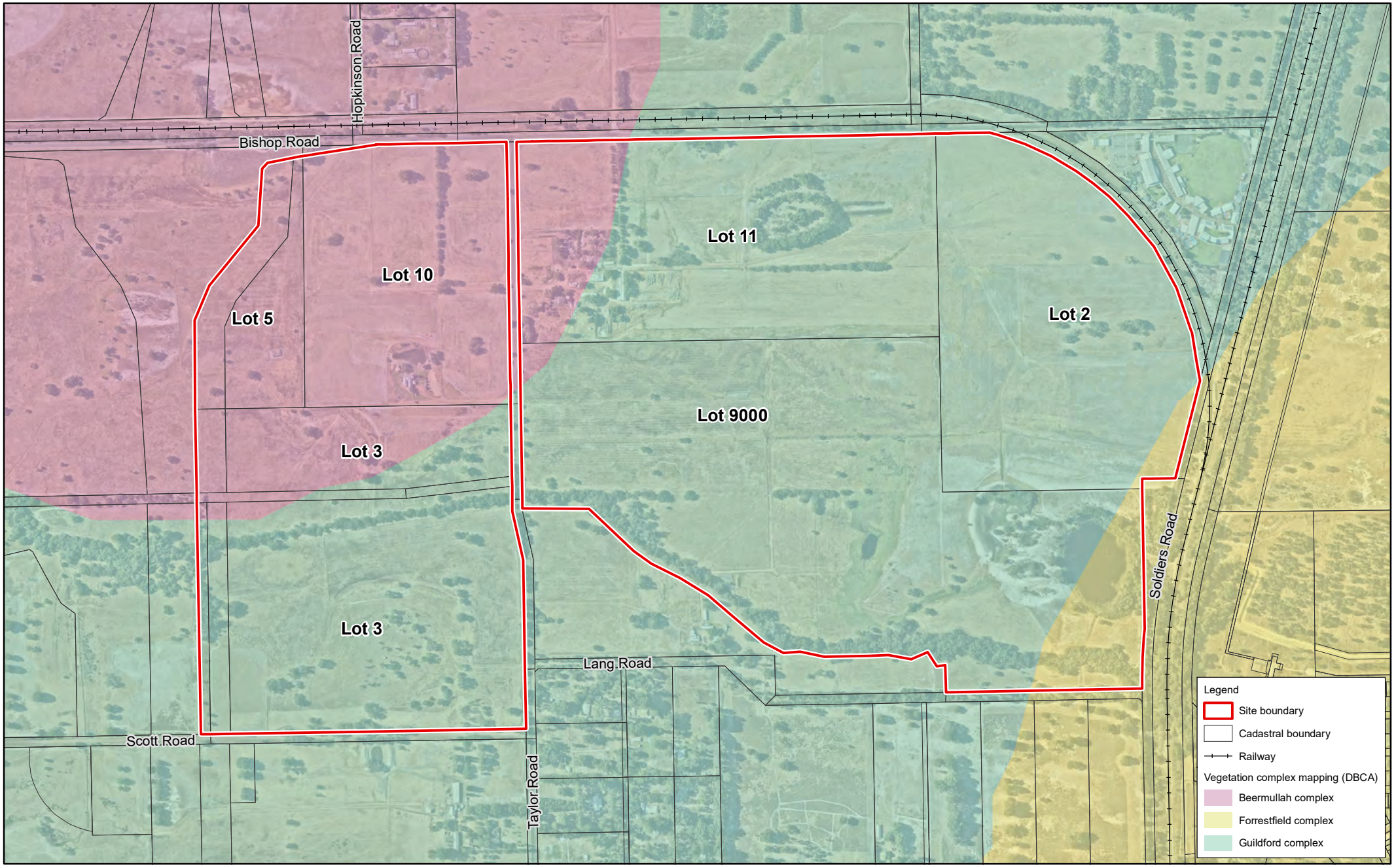


Figure 6:	**Regional Vegetation Complex Mapping**
Project:	Environmental Assessment and Management Strategy Taylor Road, Mundijong
Client:	Peet Mundijong Syndicate Ltd

Plan Number: EP15-036(01)--F91			
Drawn:	WJC	Date:	01/05/2023
Approved:	KK	Date:	05/05/2023
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0 100 200 400 Metres

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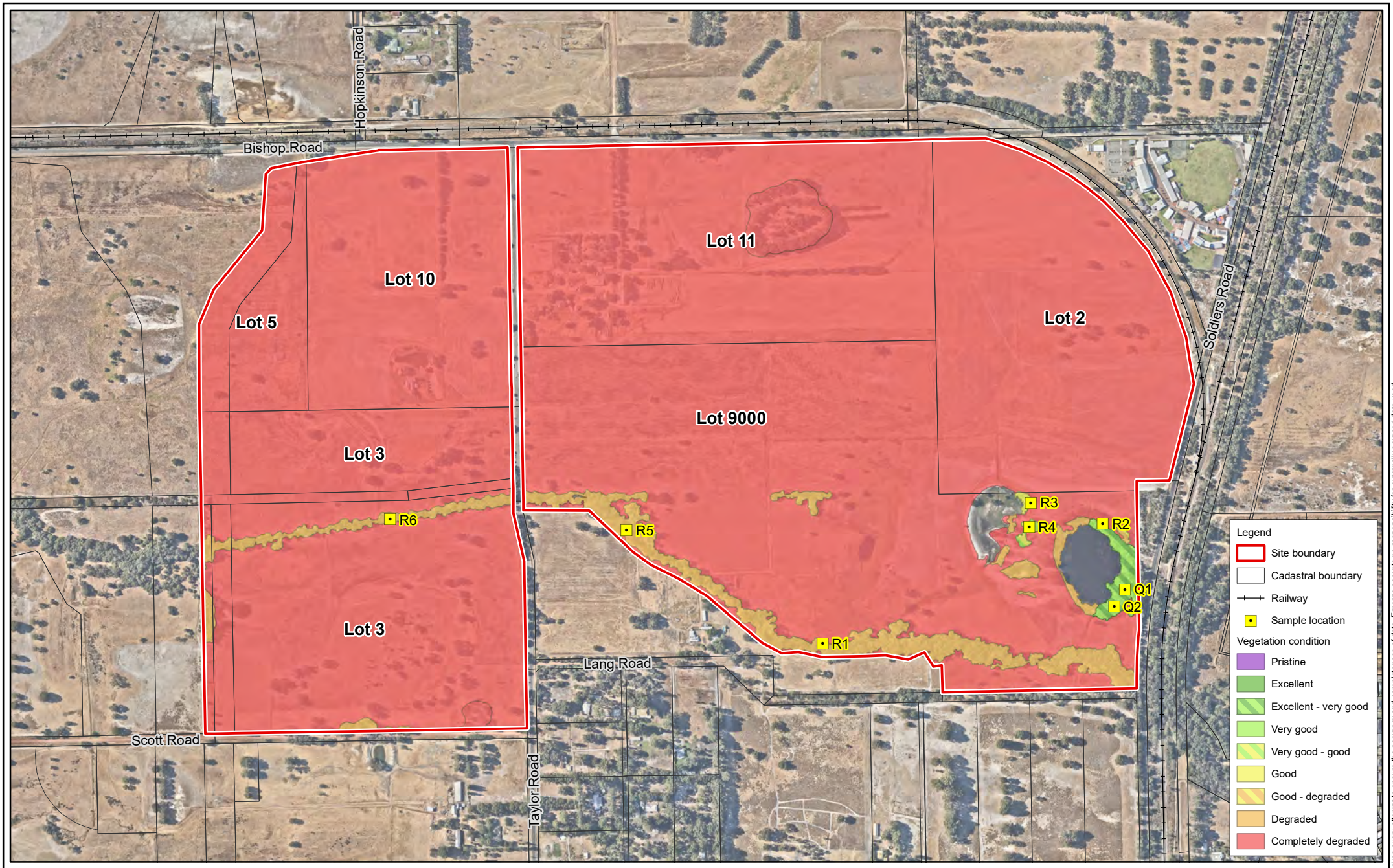


Figure 7: Vegetation Condition

Project:	Environmental Assessment and Management Strategy Taylor Road, Mundijong
Client:	Peet Mundijong Syndicate Ltd

Sourced: Emerge Associates (2017) *Spring Flora and Vegetation Survey - Taylor Road, Mundijong* (EP15-036(07)--008 RAO)

Plan Number: EP15-036(01)--F92

Drawn:	WJC	Date:	01/05/2023
Approved:	KK	Date:	05/05/2023
Checked:	SAM	Scale:	1:10,000@A4

0 100 200 400 Metres

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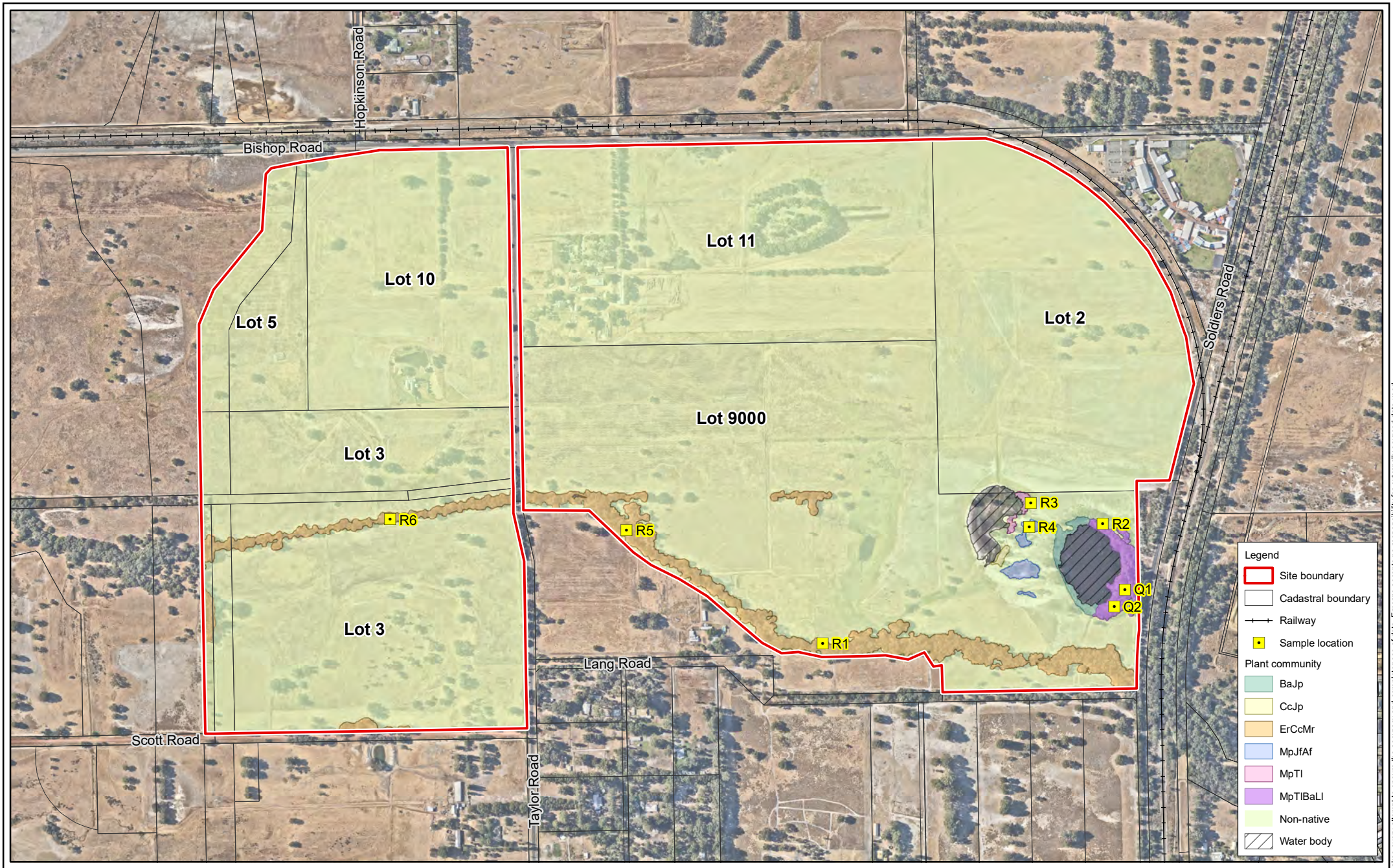


Figure 8:	**Plant Communities**
Project:	Environmental Assessment and Management Strategy Taylor Road, Mundijong
Client:	Peet Mundijong Syndicate Ltd

Sourced: Emerge Associates (2017) *Spring Flora and Vegetation Survey - Taylor Road, Mundijong* (EP15-036(07)--008 RAO)

Plan Number: EP15-036(01)--F93			
Drawn:	WJC	Date:	01/05/2023
Approved:	KK	Date:	05/05/2023
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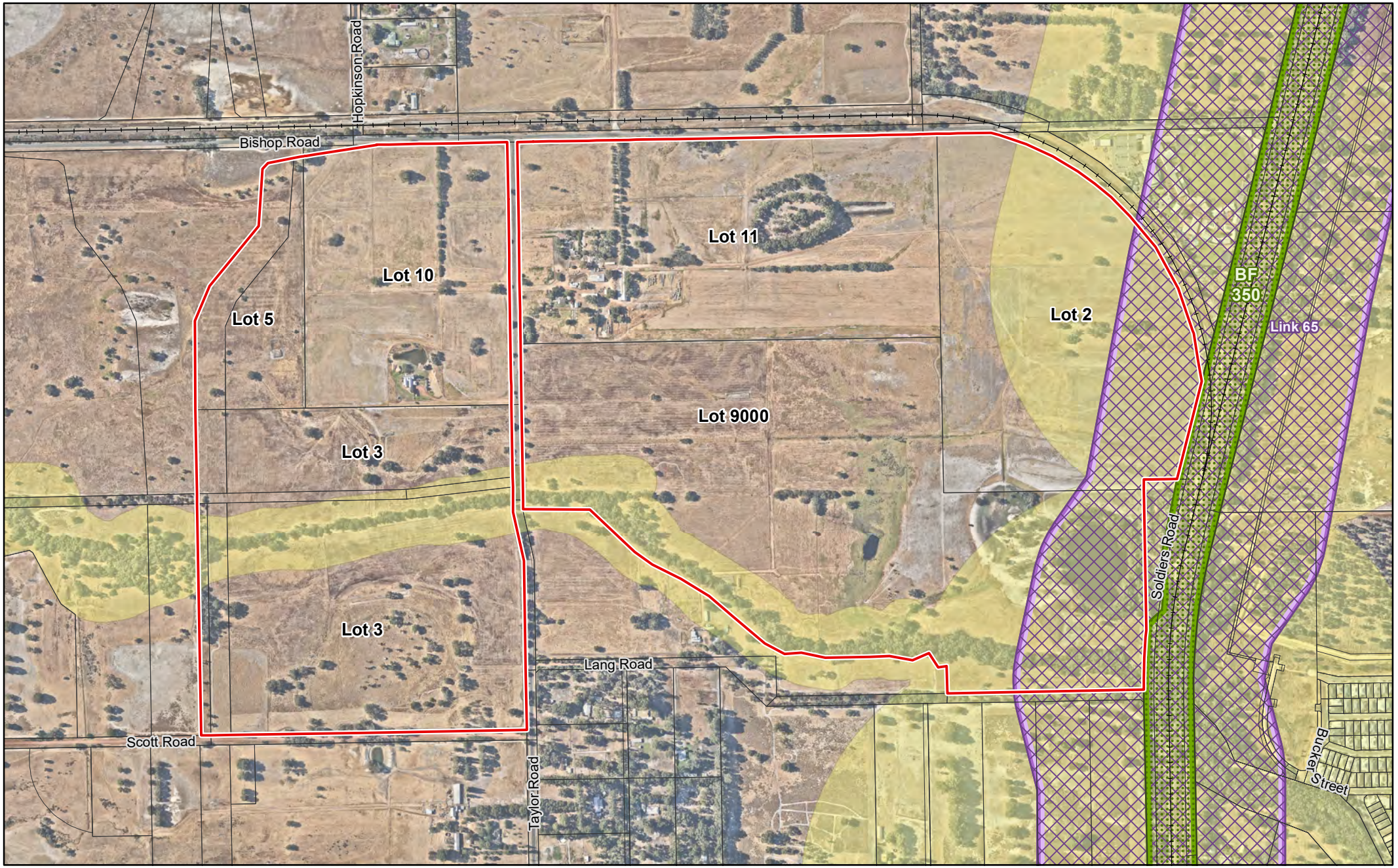


Figure 9: Bush Forever, ESAs and Ecological Linkages

Project:	Environmental Assessment and Management Strategy Taylor Road, Mundijong
Client:	Peet Mundijong Syndicate Ltd

Legend

- Site boundary
- Cadastral boundary
- Railway
- Bush forever
- Environmentally sensitive area
- Biodiversity linkage

Plan Number: EP15-036(01)--F94			
Drawn:	WJC	Date:	01/05/2023
Approved:	KK	Date:	05/05/2023
Checked:	SAM	Scale:	1:10,000@A4

0 100 200 400 Metres

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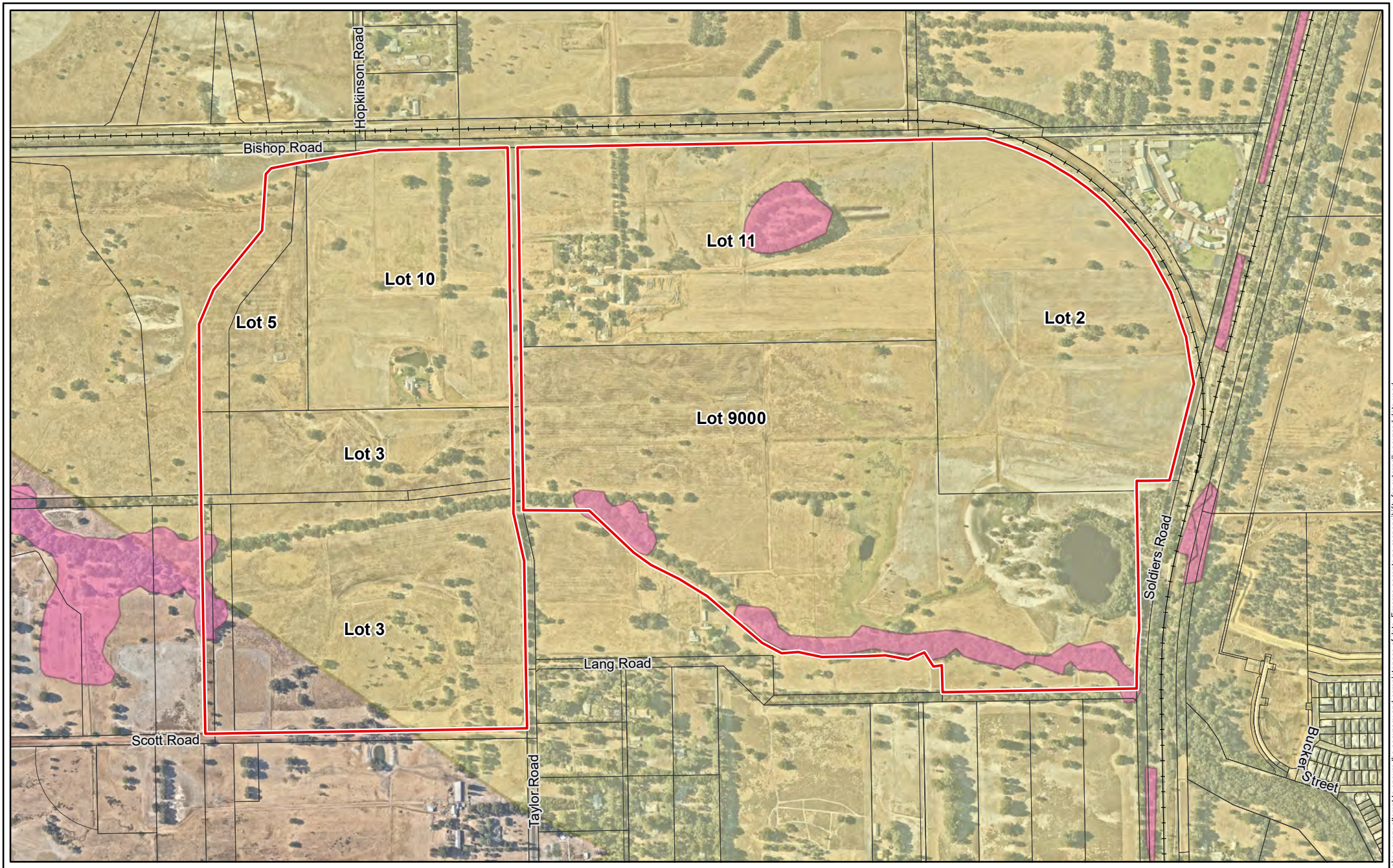


Figure 10: Potential Black Cockatoo Habitat

Project:	Environmental Assessment and Management Strategy Taylor Road, Mundijong
Client:	Peet Mundijong Syndicate Ltd

Legend

- Site boundary
- Cadastral boundary
- Railway
- Potential black cockatoo foraging habitat (DEC)
- Unconfirmed breeding areas within 6km (DEC)

Plan Number: EP15-036(01)--F95			
Drawn:	WJC	Date:	01/05/2023
Approved:	KK	Date:	05/05/2023
Checked:	SAM	Scale:	1:10,000@A4

0 100 200 400 Metres

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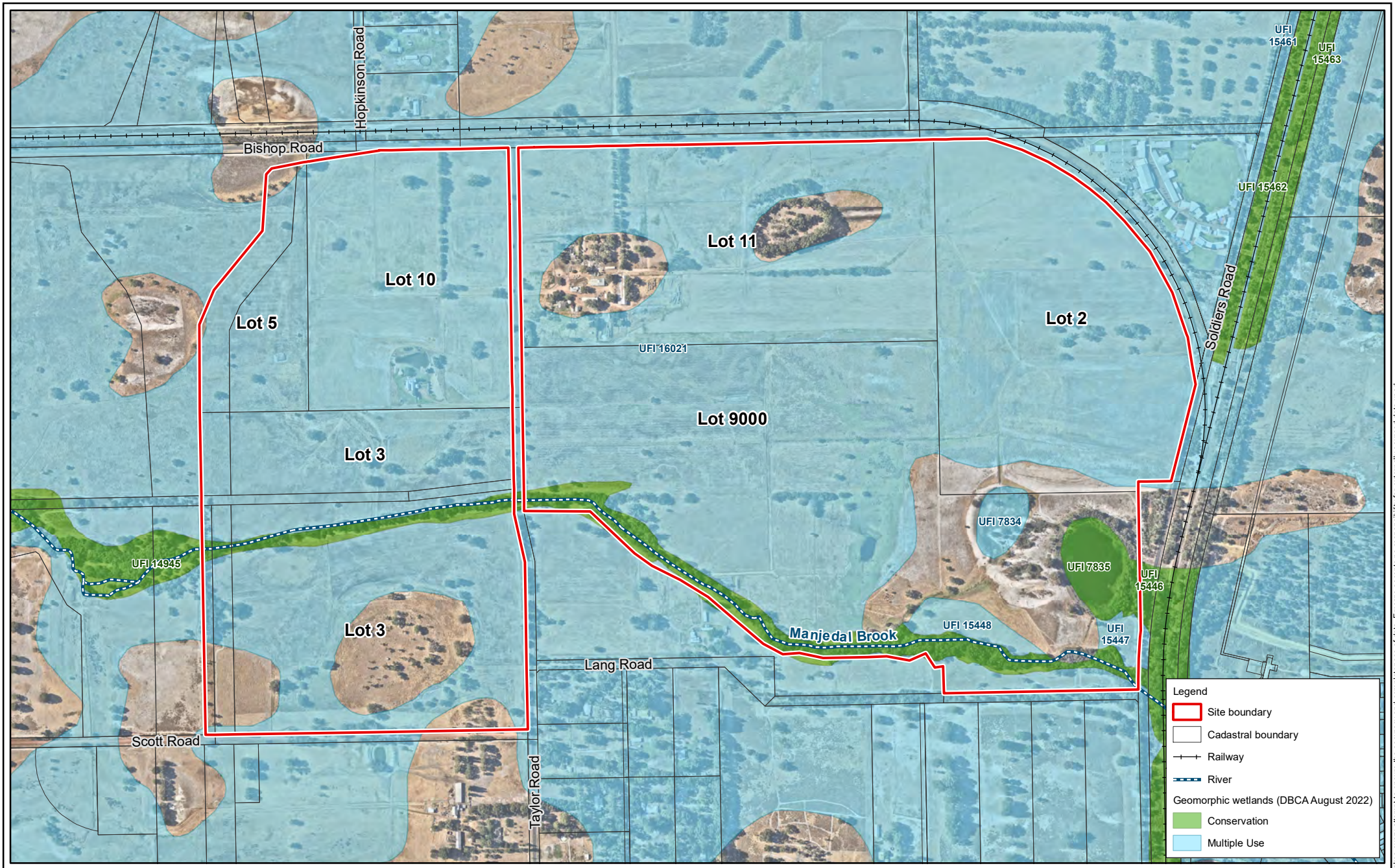


Figure 11: Hydrology and Geomorphic Wetlands

Project:	Environmental Assessment and Management Strategy Taylor Road, Mundijong
Client:	Peet Mundijong Syndicate Ltd

Plan Number: EP15-036(01)--F96

Drawn:	WJC	Date:	01/05/2023
Approved:	KK	Date:	05/05/2023
Checked:	SAM	Scale:	1:10,000@A4

0 100 200 400 Metres

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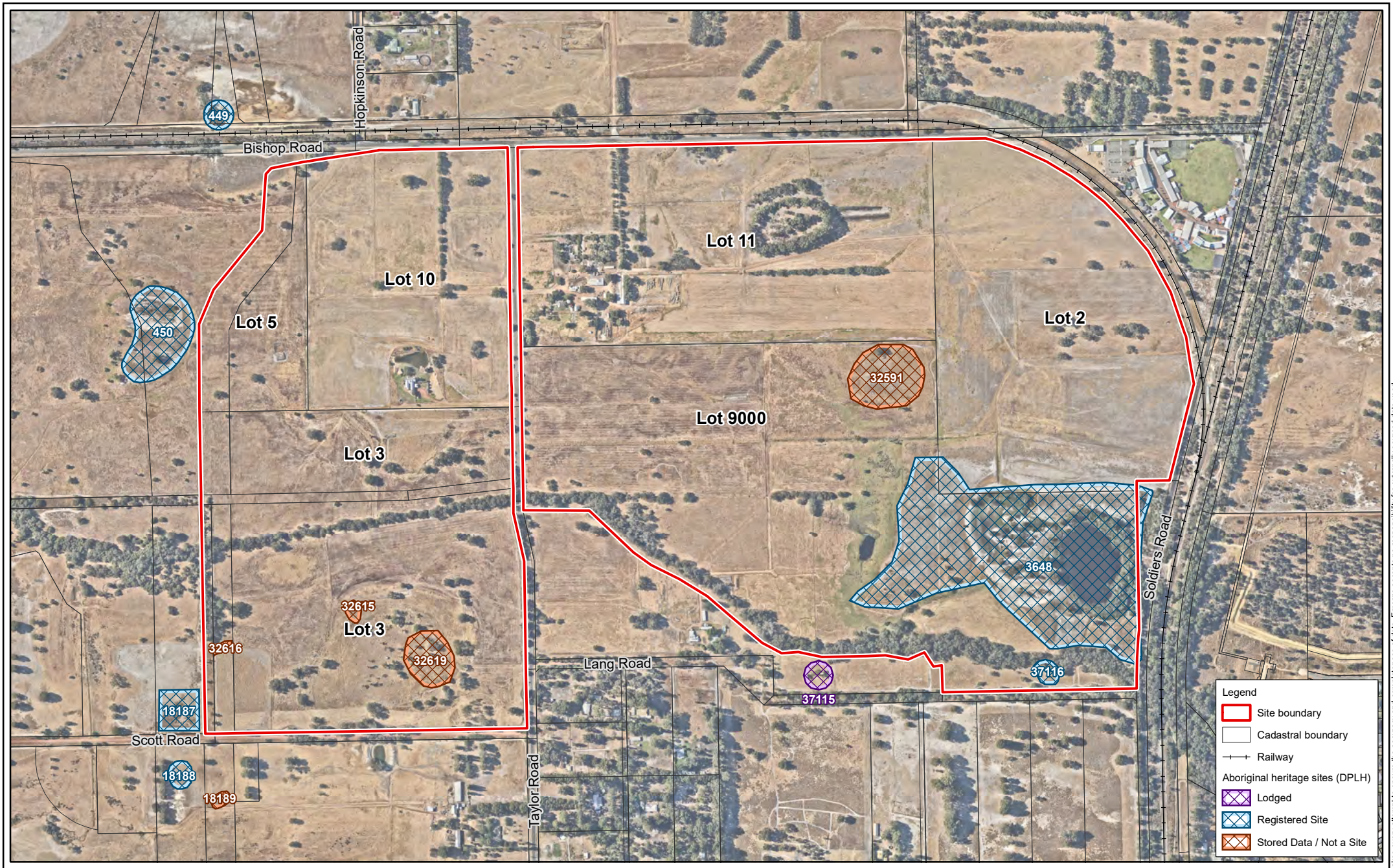


Figure 12: Indigenous Heritage Values

Project:	Environmental Assessment and Management Strategy Taylor Road, Mundijong
Client:	Peet Mundijong Syndicate Ltd

Plan Number: EP15-036(01)--F97

Drawn:	WJC	Date:	01/05/2023
Approved:	KK	Date:	05/05/2023
Checked:	SAM	Scale:	1:10,000@A4

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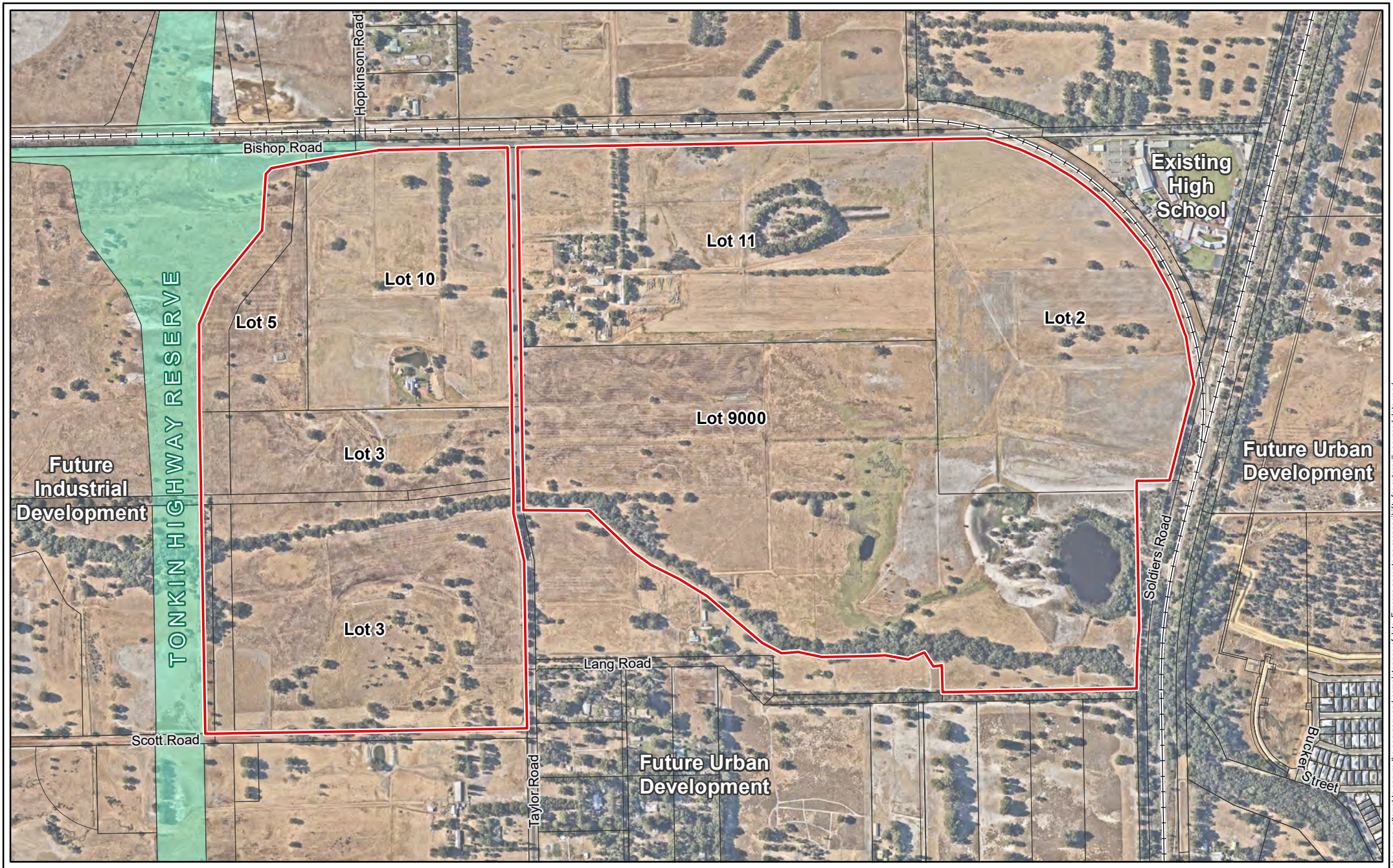


Figure 13: Surrounding Land Uses

Project:	Environmental Assessment and Management Strategy Taylor Road, Mundijong
Client:	Peet Mundijong Syndicate Ltd

Legend

- Site boundary
- Tonkin Highway reserve
- Cadastral boundary
- Railway

Plan Number: EP15-036(01)--F98			
Drawn:	WJC	Date:	01/05/2023
Approved:	KK	Date:	05/05/2023
Checked:	SAM	Scale:	1:10,000@A4

0 100 200 400 Metres

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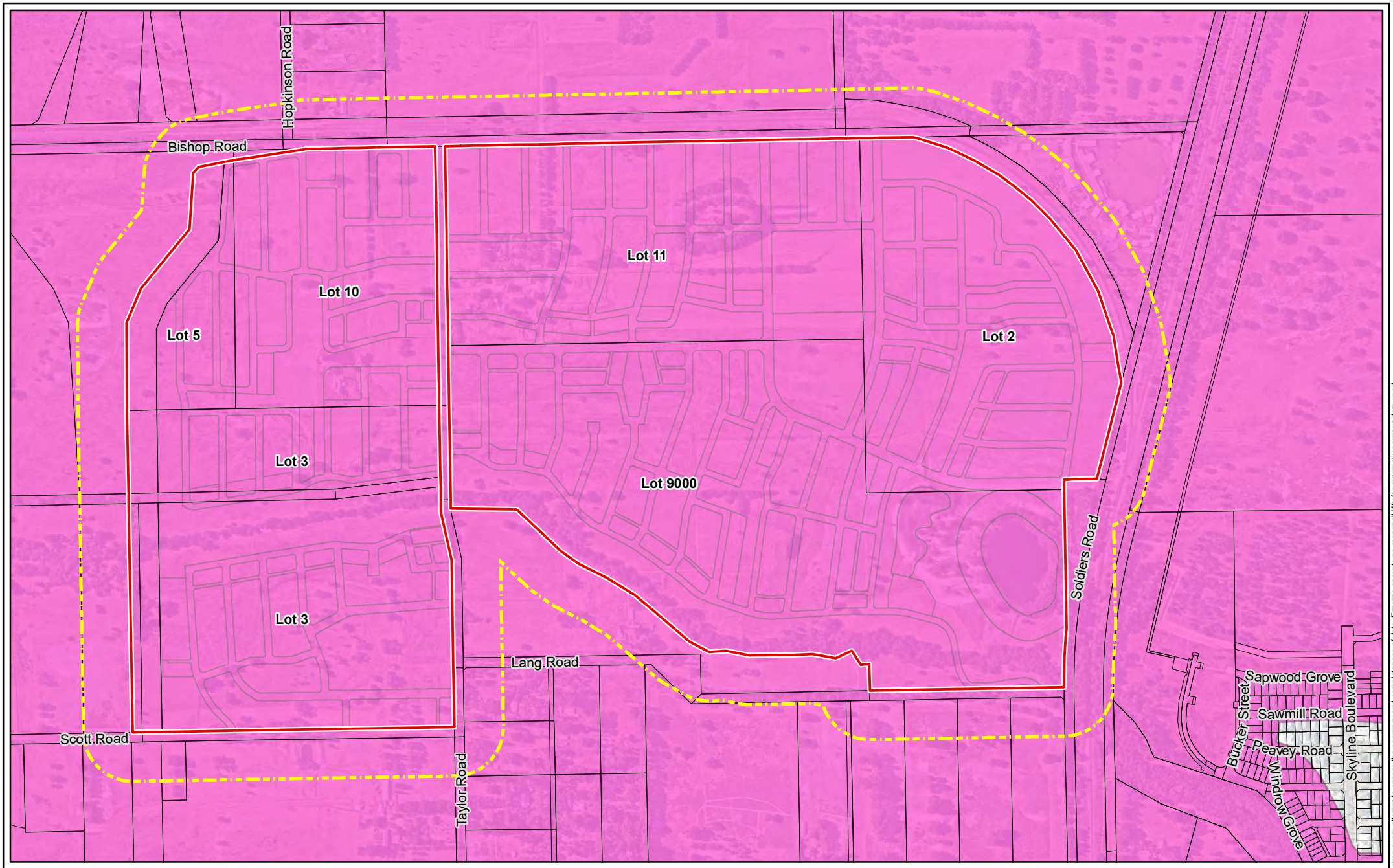


Figure 14: Designated Bushfire Prone Areas

Project:	Environmental Assessment and Management Strategy Taylor Road, Mundijong
Client:	Peet Mundijong Syndicate Ltd

Legend

- Site Boundary
- Assessment boundary
- Cadastral boundary
- LSP
- Bush Fire Prone Areas (OBRM 2021)

Plan Number: EP15-036(01)--F99			
Drawn:	WJC	Date:	01/05/2023
Approved:	KK	Date:	05/05/2023
Checked:	SAM	Scale:	1:10,000@A4

0 100 200 400 Metres

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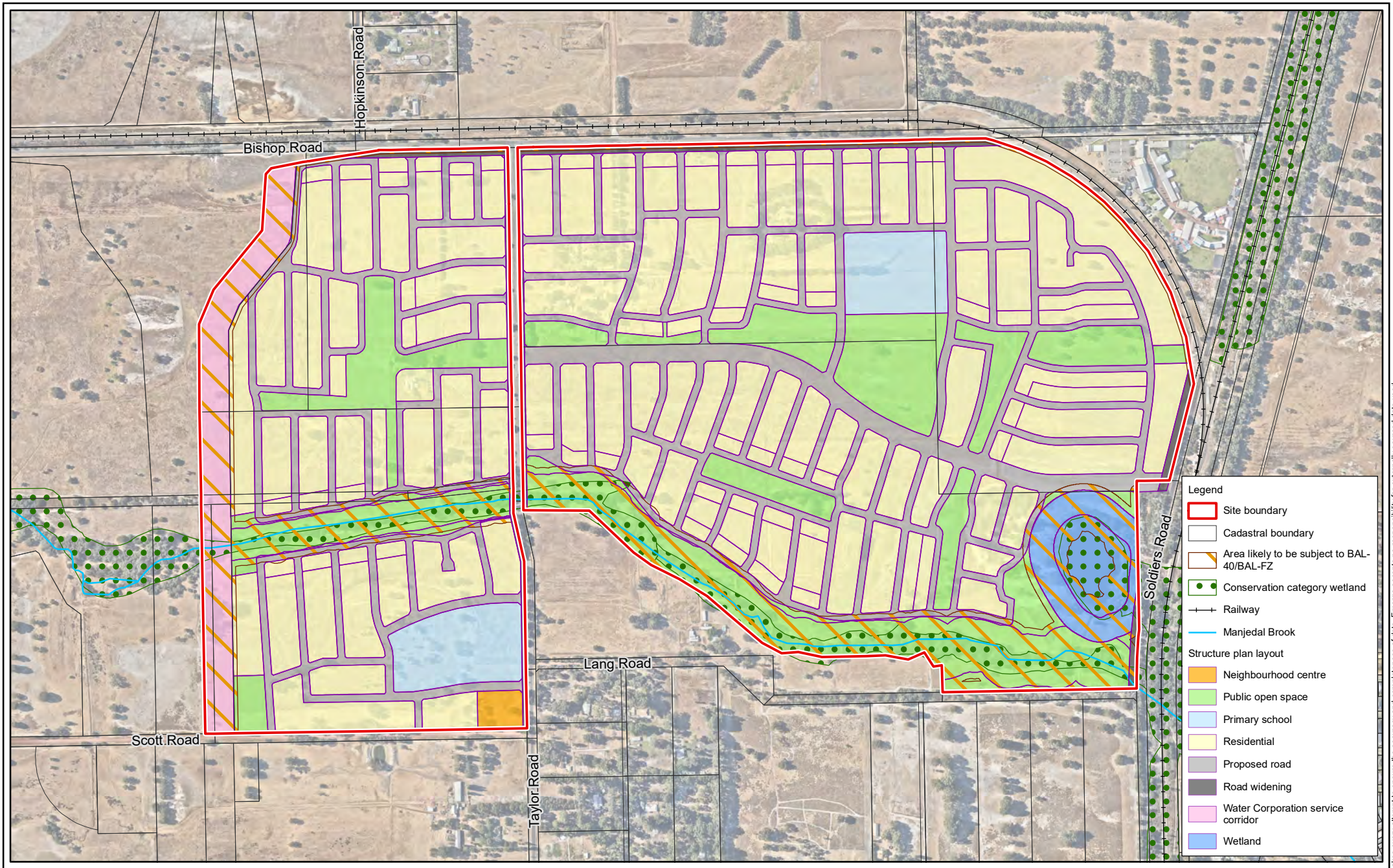


Figure 15: Key Management Considerations

Project:	Environmental Assessment and Management Strategy Taylor Road, Mundijong
Client:	Peet Mundijong Syndicate Ltd

Plan Number: EP15-036(01)--F100

Drawn:	WJC	Date:	17/05/2023
Approved:	KK	Date:	18/05/2023
Checked:	SAM	Scale:	1:10,000@A4

0 100 200 400 Metres

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APPENDIX A

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TAYLOR ROAD, MUNDIJONG LOCAL STRUCTURE PLAN

Legend

- STRUCTURE PLAN BOUNDARY
- RESIDENTIAL (R10)
- RESIDENTIAL (R25-40)
- RESIDENTIAL (R40-60)
- NC — CENTRE - NEIGHBOURHOOD
- PUBLIC OPEN SPACE AND DRAINAGE
- ENVIRONMENTAL CONSERVATION
- PUBLIC PURPOSES
  Denoted as:
  IS - Infrastructure Services
  E(PS) - Education, Primary School
  E(HS) - Education, High School
- PRIMARY REGIONAL ROAD
- INTEGRATOR ARTERIAL
- NEIGHBOURHOOD CONNECTOR
- AREA SUBJECT TO FUTURE INVESTIGATION (FREIGHT RAIL REALIGNMENT)

Notes

1. The location of local roads, public open space, civic and community sites and neighbourhood centre sites are indiciative only and subject to refinement at subdivision stage.
2. Area subject to future investigation to consider appropriate planning responses for the proposed freight rail realignment. and does not constitute a Structure Plan pursuant to the *Planning and Development (Local Planning Scheme) Regulations 2015 Schedule 2 - Deemed provisions* until such time as a subsequent Structure Plan amendment has been lodged and assessed to the satisfaction of the WAPC.
3. The Structure Plan provides for an at-grade connection to Whitby Town Centre and identifies this area as also subject to further investigation for a grade-separated railway crossing.



Structure Plan

TAYLOR & BISHOP ROAD, MUNDIJONG

A Peet Limited Project

DRAFT

scale: 1:7000@A3
0 50 100m

plan: 06/066/043H
date: 11/03/2024
aerial: n/a

Taylor Burrell Barnett Town Planning & Design
Level 7, 160 St Georges Terrace, Perth WA 6000
e: admin@tbbplanning.com.au
p: (08) 9226 4276

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ALL AREAS AND DIMENSIONS DISPLAYED ARE SUBJECT TO DETAIL SURVEY.

APPENDIX B

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SPRING FLORA AND VEGETATION SURVEY

Spring Flora and Vegetation Survey

Taylor Road, Mundijong

Project No: EP15-036(06)

PreparedforPeetMundijongSyndicateLtd
March2017



Document Control

Doc name:	SpringFl oraand Vegetati onS urvey TaylorRoad,M undijong				
Doc no.:	EP15036(06)0 08				
Version	Date	Author		Reviewer	
1	March2017	RachelOmodei	RAO	TomAtkinson	TAA

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Executive Summary

PeetMundijongSy ndicateLtd engagedEmergeAssociates(E merge)tounderta keaspringfloraand vegetationsurveywithinLot2BishopRoad, andLots 3,5,10,112 9,52and900 0TaylorRoad, Mundijong.Theselots(her einreferredtoas 'thesite')compriseapproximately 199hectares(ha)of landwiththe majorityusedfor grazing,cropping andresidential pu rposes.Manj edalBrookrunseast westthrough thesite andtwosumpland wetlandsoccurintheeastofthesite.

AbotanistfromEmergeAs sociatesvisitedthesiteon18 thNovember2016 andundertookadetailed floraandvegetationsurvey.During thesurveytargetedsearcheswerec onductedfor'thr eatened' and'priority'floraandanassessmentwas madeonthety pe,condition andvaluesofvegeta tion acrossthesite.Thisspring surveyqualifiesasade tailedsurveyunderEPA guidelines(EPA2 016).

Outcomesofthissurveyi nclude:

- Nonnativevegetationispresentacross188.85hecta res(ha)ofthesite.Nativevegetationis presentacross8.98haofthesite.Theremaining 1.42haofthesitei soccupiedbyopenwater associatedwithtwosumplandwetlands .
- Nothrea tenedorpriority flo raspecieswererecorded orare consideredlikely tooccur within thesiteduetolacko fsuitablehabitat. Oneregionallysignifica ntnativespecies, *Dielsia stenostachya,* wasrecorded inthesite invegetation aroundthefa reasternsumpland.This speciesisidentified in *SignificantFlora o ftheFoo thills andPinjarraPlainin theP erth MetropolitanRegion,* butisknowntocommonlyoccuri navariety ofwetlandv egetation communitiesacrosstheSw anCoastalPlain.
- Thenativevegetationwithinthesitew asclassifiedintosixplantcommunities: **ErCcMr**, **MpTlBaLl**, **BaJp**,**MpTl** ,**CcJp** and **MpJfAf**.Theconditio nofthese communitiesra ngedfrom 'excellent–v erygood'to' degraded'.
  - Plantcommunity **ErCcMr** occursalongManjedalBrookand consistsofnativetr eesover nonnativeunderstoreyin'degraded'condition. This communitya lignswithregionalfloristic communitytype(FCT)11' wetforestsa ndwoodlands'.
  - Plantcommunity **MpTlBaLl** containsthe highestquali tyvege tationinthe site andisin 'excellent–v erygood'condition. Thiscommunityaligns withFCT13'deeperw etlandson heavysoils'.
  - Plantcommunity **BaJp** lackscanopycoverandisana lteredformo fplantcommunity **MpTlBaLl**in' degraded'co ndition.
  - Plantcommunities **MpTl** and **CcJp** comprisesmallareasofisolatednativevegetationin 'good'and'degraded'condition.
  - Plantcommunity **MpJfAf** comprises'verygood–good'condi tionregrowthvegetation betweentheeasternsum plandsand alignedwith FCT13.
- Nothrea tenedorpriority ecologicalcom munitiesarepresentinthesite.

Regardlessof condition,thenativevegetationpr esent alongManj edalBrookandassociated with the fareasternsumpland maybeconsideredregionally andlocally significantasthesareasare categorizeda s'conservation'categorywetlandsbyDPaW andidentifiedassignificantremnants, localecologicallinkages andlocalnatura lareas bytheShire ofSerpentineJarrahdale.

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AppendixA

AdditionalBa ckgroundInformation

Appendix B

SpeciesList

AppendixC

SampleData

AppendixD

ClusterDe ndrograms

1 Introduction

1.1 Project background

TaylorBurrellBarnett(TBB),onbehalfo fPeetMundij ongSyndicate Ltd (Peet)a ndWellstrand HoldingsPtyLtd,have preparedaLo calStructurePlan (LSP) forurbandevelopmentwithin Lot2 BishopRoad,andLots3,5, 10,1129,52 and 9000Ta ylorRoad,Mundijong (her einreferredtoas'the site').

Thesiteislo catedapproximately37 kilometres(km)south eastofthePerthcent ralbusinessdistrict intheShireo fSerpe ntine Jarrahdale.Thesite i sapproximately19 9hectares(ha)in size andisbound byBishopRoadtothenorth,Soldiers Roadtotheea st,ManjedalBrookand ScottRoadtothesouth andruralla ndholdingstothewest.The locationof thesite issho wnin **Figure1.**

1.2 Purpose and scope of work

EmergeAssociates(Emerge)w ere engagedbyPeet Mundijo ngSy ndicateLtdtoprovide environmentalconsultancyservicesto supportthes tructureplanningforresid entialdevelo pment processforthesite.Thepurposeofthis surveyi sto providesufficientinformat ionontheflor aand vegetationvalueswithinthesite toinfor mthisproces s.

Thes copeofworkwasspecifically tound ertakeaspringflora andv egetationassessmentin accordancewiththeEnvironmental Protection Authority's(EPA' s)document *TechnicalGui dance–Floraan dV egetationSurveysfor Enviro nmentalIm pactA ssessment* (EPA2016).This surveyqualifies asadetailedsurveyund ertheEPAguidelines.

Aspartofthisscopeofwo rk, thefollowingtasks wereundertaken:

- Desktopreviewofrelevantba ckground informationpertainin gtothesiteands urrounds, includingdatabasesearchesforthreatened floraspeciesandecologicalco mmunities.
- Compilationofacomprehensivelistof floraspecies recordedaspartofthefieldsurvey.
- Mappingofplantcommunitie s andvegetationcondition.
- Identificationofconservationsignifica ntfloraandvegetation.
- Documentationofthedes ktopassessment,survey methodologya ndresultsintoareport.

2 Background

2.1 Climate

Climatehasastronginfluenceonthet ypesofvegetationthatgrowina regionandthelif ecyclesof theflorapresent. Itisther eforecriticalfora floraandvegetationsurveyt ores pondappropriatelyto climaticconditionstoensuretha tsurveysareconducted duringtimeswhenflo raspeciesareeasiest todetect andidentify.

ThesouthwestofWesternAustraliaexperiences aMediterranea nclimateofho tdrysummersand coolwetwinters.InMediterraneanty peclimatesso me floraspecieswilltypica lly spendpartoftheir lifecycleaseitherundergr oundstorageorgans orasseed.Thisisa nadapta tion tounfavourable environmentalconditions suchasexcessiveheata nddrough tthatoccur overthesummerperiod. Thesespecies ,knownas'geophytes'or' annuals',tendto reemer geduringwinterwhenfav ourable conditionsreturna ndaremostvisibleduring spring,which istheffloweringperiodforamaj orityof plantspecies.Therefore,s pringis theo ptimaltim etocompletefloraand vegetationsurveysinthe southwestofWA.

Longtermclimatedataobtained from nearbyweatherstationsconfirms thatthesiteis subjecttoa Mediterraneanclimate(B OM 2016).Anaverageof925.0millime tres(mm) ofrainfallisrecorded annuallyfro mtheSerpentineweather station,whichistheclosest weatherstationapproximately 7.4kmfromMundijong. Themajority ofthisrainfall isreceivedbetweenthem onthsofMayand August.Mea nmaxi mumtemperaturesa ttheMedi naresearchstation,whichi sthe nearest temperaturerecordingstationapproxim ately18 kmnorthwes to fthe site,rangefrom18.3 CinJuly to31.5CinFebruary.W hilemeanminimum te mperaturesrangefrom8.2Cin JulyandAugustto 17.6CinFebruary(BoM2016).

Atotalof656 .8mmofrain wasrecorded from MaytoOctober20 16,indica tingsufficientseasonal rainfalloccurredatthesitetopromotethegrowth o ffloraspeciespriortothis survey(see **Section 3.1**forsurveytiming).

2.2 Geomorphology and soils

Landformandsoilsinflue ncev egetationtypesatregi onalandlo calscales.Thesiteoccurso nthe SwanCoastalPlain,whichisthegeomor phicuni tthatcharacterisesmuchofthePerthmetropolitan region.

TheSwanCo astalPlainisapproximately500kmlongand2 0to3 0kmwideand isroughlyboundby theIndianOceantothew estandtheD arlingScarptothe east.BroadlytheSw anCoastalPlain consistsoftw osedimentarybelts ofdiff erentorigin. Its easternside,referredto asthePinjarraPlain, hasformedfromthedepositionofalluv ialmaterialwash eddownfromtheDarling Scarp.Itswestern sideisco mprisedofthr eedune systems that runroughlyparallel tothe India nOceancoastli ne (Seddon200 4).Thesedunesystems,referred toasQuindalup,SpearwoodandBassendean associations,representas uccessionofcoastaldepos ition thathasoccurr edsincethelate Quaternaryperiod(approximately twomillionyearsago)(Kendrick *e ta l.*1991)and,asaresult,they containsoilsatdifferents tages ofleachingandforma tion.

Examinationofbroadscalemapping placesthe majorityofthesitewithin theGuilfordassociation (ChurchwardandMcAr thur1980).A lar geportion ofthe northwesterncornerofthesiteis located withintheBeermullahassociationandthesouth easterncorneris withintheForrestfieldassociation (ChurchwardandMcAr thur1980).Finer scale mappingbyGozzard(2011)places the site in boththe PinjarraPlainandBassendeanDunes.T hePinjarraPlainconsistso falluvial soilswasheddownform theDarlingScarpthatarepredominantlyclays andsilts.TheBassendeanD unesconsistof predominantlydeepgreyquart zsands thatareparticularlyleachedand lowin nutrientsdue totheir age.

Distinctivew etlandson sands,clays,cal creteand lateritecano ccuron theinterfaceofthe BassendeanDunesandPinjarraPlain.Thesitedoes containarangeofwetland landformsincludinga palusplain,twosumplandsandManjedal Brook(discussedfurtherin **Section2.4**).Theselandforms arenotknow ntoberes trictedo runiquegeologicalfeatures.

2.3 Topography

Theelevationofthesite ranges from42 minrelationtothe AustralianHeightDatum(mAHD)onthe easternside ofthesiteto25mAHD onthewesternside ofthesite (DoW 2008).Thetopogra phyof thesiteissho wnin **Figure2** .

2.4 Hydrology and wetlands

Wetlandsinclude“areasof seasonally, intermittentlyorperma nently waterloggedsoilsorinundated land,whethernaturaloro therwise,fres hand saline,e.g.waterloggedsoils,ponds,billabongs ,lakes, swamps,tidal flats,estuari es,riversand their tri butaries”(WetlandsAdvisoryCommittee 1977). Wetlandscanfurtherberecognisedb ythepresence ofvegetationassociatedw ithwa terloggingor thepresenceofhydricsoils such aspeat, peaty sando rcarbonatemud (Hil l *et al*.1996).

Wetlandsofregional,natio nal,inter nationalo rcultur alsignificancemaybeaddedto registers,lists ordatabasesaimeda tensuringtheir protection.The followinglis tswereche ckedaspartofthis assessment:

- *RamsarListo fWetlandsof International Importance*
- *ADirectoryof ImportantW etlandsinA ustralia.*

NoRamsarorlisted‘importantwetlands’ arelocatedwithinornearthesite.

ExaminationoftheDepartmentofWater’s (DOW)hydrographydataset showseightwetla ndor waterrelatedfeaturesi nthesite including:

- aminorwatercourse(ManjedalBrook)r unningeastwestthrough thesite
- twoperennia lwetlandsinthe easternportionofthesite
- aminordrainconnecting thetwo perennialwetla ndsandManjedalBrook
- amajordrainrunningnorthandeast ofthemorewesterly perennialwetland
- amajordrain runningeast westthroughthesite
- twodamns;oneinthesouthwestand oneinthesoutheastofthesite.

ThegeomorphicwetlandclassificationsystemofSemeniuk (1987)i susedtoclas sifywetlandsonthe SwanCoastalPlainbasedonthelandfo rmshape andwaterperma nence(hydro period).The DepartmentofParksandWildlife(DPaW)maintains the *GeomorphicW etlandsoftheSwan Coastal Plain*dataset, whichfur thercate gorisesgeomorphic wetlandfeaturesinto spe cificmanage ment categoriestoguide landuseand conser vation.Fur therinformatio nongeomorphicwetla ndtypesand theirmanage mentca tegoriesisprovide din **AppendixA** .

AreviewofD PaW's *GeomorphicW etlandsof theSw anCoastal Plain* da tasetindicatedthatthe followinggeo morphicwetlandsare ma ppedwithinthesite:

- Two'conservation'categorypalusplains (UFIs14945and 15446)alongMa njedalBrookwith UFI 15446extendingnorthalo ngtheeastern siteboundarytojoinwithUFI7835.
- A'conservation'categorysumpland (UFI7835)in thefareastofthesite.
- Asmallareaof'conservation'categorypalusplain(UF I15446)a djoiningthesoutheastern cornerofUFI7835.
- A'multiple us e'categorysumpland(UFI 7834)tothewestofUFI7 835.
- A'mul tipleus e'cate gorypalusplain(uni quefea turei dentifier(UFI)15785)acro ssthemajorityof thesite.

Asthe *GeomorphicW etlandsof theSw anCoastal Plain* datasetwasdrafteda taregionalscalethe boundarieso fmappedfea turesareofteninconsistent withphysicalwetlandbo undaries.Aerial imagerysho wsthatthemapped boundariesofthegeomorphic wetlandse ncompassthemajorityof thea ctual wetlandfeaturebut arenotcompletely accurate.Themapped wetlandsinthesiteare shownin **Figure 2.**

Aerialimager yshowsthatthetwoeasternsumplands (UFIs7835 and7834)containpermanent waterthroughouttheyear.

2.5 Regional vegetation

Nativevegetationisdes cribeda ndmappeda tdiffer entscales inordertoillustra tepa tternsin its distribution.Atcontine ntalscalethe *InterimBiogeographicRegion alisationof Australia* (IBRA) dividestheSwanCoastalPlainintotw ofloristic subregions(Environment Australia2000).Thesite is containedwithinthe'SWA02'orPerths ubregion,whi chis characterisedasmainlycontaining *Banksia* lowwoodlandonleachedsandswith *Melaleuca* swampswhereilldrained;andwoo dlandof *Eucalyptusg omphocephala*(tuart), *E.marginata* (jarrah)and *Corymbiacalophylla* (marri)onless leachedsoils(Beard1990).Thissubregionisrecognised asabiodiversityhotspo tand containsawide varietyofendemicfloraa ndvegetatio ntypes.

Variationsinnativevegeta tionwithin thesite canbefurtherclassifiedbased onregionalvegetation associations.Beard *etal.* (2013)mappingshowsthesitea scompr isingvegetationassociation 'Pinjarra968'.This associationis describedas'mediumwoodland:jarrah, marriandwa ndoo'(Beard *etal.* 2013).Pinjarra968Associationhas38.9%its preEuropeanextent remainingontheSwan CoastalPlainwith19.6 %protectedfor conservationpurposes(Go vernmentofWA2014).

Studieshaveindica tedtha tthe lossofbiodiversityca usedb y habitatfragmenta tionissignificantly greateronceahabitatty pefallsbelow 30%ofitsoriginalextent(Miles 2001).However,asthisisa

purelybiodiv ersityprotectionorientatedobjectivea ndo ntheSw anCoastalPlain,whichis considereda‘constrainedarea’,theEPAhasappli edanobjectiveofretaining 1 0%ofeach v egetation complex(EPA 2006).The a rearemainingofthe Pinjarra968vegetation associationfallsabovethis retentionobjective.

2.6 Historic land use

Reviewofhistoricalima gesavailablefrom1953onwards showsthatthemajorityofthesitewas clearedofna tivevegetatio npriorto1953, likelyforgrazingand/orcropping uses.

By1965thevegetationha dbeenmostlyclearedaround thetwos umplandsintheeaster nportionof thesite(UFIs7835and783 4).A narrowf ringeofremnantvegetatio nremained aroundea ch sumplandandnoremnantvegeta tionwas presentbetweenthem.A portionofremnantvegetation remainedbe tweenthe mo steasterlysumpland and the site boundary.The areabetwee nthe two sumplandsr emainedunvegetateduntil approximatel y 1995.Thea erialimagefr om1995showsthis arealandsca pedintoaseriesofsandys walesinw hichnativevegetationhas r egenerated.Fr om1995 someregenerationandtr eeplanting hasoccurredonthefringeo fthefareasternsumpland. However,themajorityofthesurrounding areacontinued tobemanagedasgr azingla nd.A nartificial drainageli nebetweenthetwosumplands wasconstr uctedsometi mebet ween1965and197 4.

TheManjedalBrookhasbeenadjacenttonon nativepasturevegetationsince1 953.Nativecanopy treesappeartohavebeenretainedalong thebrooksincethistime.

Aerialimages from1953of Lot3TaylorRoadinth es outhwester ncornerof thesiteshowa square patchofpotentiallyfencedremnantv egetationsurro undedby pastureand/orcrops.Between1965 and1974par tofthevegetationwas clearedandtheinnerportion retained.Thisareahasgra dually declinedinnativecoversince1983 andis currentlyinsimilarconditiontothe imagefrom1 995.

2.7 Threatened and priority flora

Certainfloraspeciesthatareconsider edtobe rareorunder threa twarrantspecialprotectionunder Commonwealthand/orStatelegislation.AtaCommonwealth level,floraspeciesmaybelistedas ‘threatened’pursuanttoSchedule1 ofthe *EnvironmentProtectionandBiodiv ersityConservationAct 1999* (EPBCAct).Anyactio nlike lytoha veasignifica ntimpacton aspecieslistedunder theEPBCAct requiresapprovalfromtheCommonwealth MinisterfortheEnviro nment.

InWesternA ustraliaplantspeciesmayalsobe classedas‘threa tened’or ‘priority’speciesunderthe *WildlifeConservationAct1950* (WCAct).Thr eatenedfloraspecies aregazettedundersubsection2 ofsection23 FoftheWCA ct and itisanoffenceto“take”or damagerareflorawithoutMinisterial approval.Priorityfloraspeciesarepotentially rareorthreatenedand areclassedin orderofthreat. Furtherinfor mationonthreatenedandpriorityspecies andtheir categoriesisprovidedin **AppendixA** .

Asearchwasconductedfo r threatenedandpriority florawithin atenk mradiusofthesiteusingthe *ProtectedMatter s SearchTool* (DoEE20 17)and *NatureMap* (DPaW2017).Atotalof20thr eatened and15priorityfloraspecieswereidentif iedaspotentiallyoccurri nginthewider localareaaslistedin **Table 1**.

Ofthefloras peciespotentiallyoccurringinth elocal area,onlyfloraspeciessuitedtowetland habitatsw eredeemedlikelytooccur.Atotalof 21potentially occurring threatenedandpri orityflora speciesoccur inseasonally wetareas.Thetwo easternsumplands (**Section2.4**)providepotential habitatforthesespecies.Onthisbasisthefollowing ninethreatenedand12 priorityfloraspecies wereidentifiedaspotentially occurringwithinthesite:

- *Synaphea* sp. PinjarraPlain(T)
- *Andersoniag racilis*(T)
- *Diurispurd iei*(T)
- *Drakaeael astica*(T)
- *Diurismicrantha* (T)
- *Eleochariskei gheryi*(T)
- *Tetrariaa ustraliensis*(T)
- *Austrostipaj acobsiana* (T)
- *Synaphea* sp.Serpen tine(T)
- *Acacialasiocarpa* var.*bra cteolata* longpeduncle variant(P1)
- *Synapheao docoileops* (P1)
- *Johnsonia pubescens* subsp.*cy gnorum* (P2)
- *Angianthusd rummondii* (P3)
- *Babingtoniaurbana* (P3)
- *Dillwyniadillwynioides* (P3)
- *Jacksoniagra cillima* (P3)
- *Schoenuspen nisetis* (P3)
- *Centrolepiscaespi tosa* (P4)
- *Droseraoccidentalis* subsp*. occidentalis* (P4)
- *Stylidiumlon gitubum* (P4)
- *Verticordiali ndleyi* subsp.*lindleyi* (P4).

Table1:Signifi cantflorasp ecies knowntooccurwithin1 0kmofthesite

Species	Levelof significance		Life strategy	Habitat	Flowering period	Likelihood of occurrence
	State	EPBCAct				
Calectasia cyanea	T	CE	P	Heathlandonwhitesandor lateritegravel overlaterite.	JunOct	Unlikely
Synaphea sp.Fai rbridge Farm	T	CE	P	Lowwoodlandongrey, clayey sandwithlaterit icpebbles (PinjarraPlain)nearwinterwet flats.	SepNov	Unlikely
Synaphea sp.Pinjarra Plain	T	CE	P	Whitegreyclayeysandon edges ofseaso nallyinundatedlowlying areas.	SepOct	**Possible**
Andersoniag racilis	T	E	P	White/greysand y,sandyclay, gravellyloam.Winterwetareas, nearswamps .	SeptNov	**Possible**
Caladeniahuegelii	T	E	PG	Deepgreywhiteorcalcareous	SeptOct	Unlikely

Species	Levelof significance		Life strategy	Habitat	Flowering period	Likelihood of occurrence
				yellowsandinjarrah/banksia woodland.		
Diurispu rdiei	T	E	PG	Sandtosandy clayinwinterwet areas.	SeptOct	**Possible**
Drakaeaelastica	T	E	PG	Whiteorgreysandindense vegetationinlowlyingwinter wet areas.	OctNov	**Possible**
Eucalyptus xba lanites	T	E	P	Lightcolouredsandysoilsover laterite.Ingentlysloping heathlands;openmallee woodlandovers hrubland (Population2)o rheathlandwith emergentmallees(population1)	OctFeb	Unlikely
Grevilleacurv iloba subsp.*incurva*	T	E	P	Winterwetareasonsandover limestone,oroverironstoneat siteswithahigh watertable.	SepOct	Unlikely
Lasiopetalum pterocarpum	T	E	P	Sandoverlimest one.	SepDec	Unlikely
Lepidospermaro stratum	T	E	P	Peatysandand clayamongstlow heath,inwinterwetswamps.	MayAug	Unlikely
Synapheastenoloba	T	E	P	Swampyloamindepressionsthat areoccasionally inundate.Under heath.	SepOct	Unlikely
Thelymitra dedmaniarum	T	E	PG	Redbrownsand yloamwith doleriteandgraniteoutcrops.	OctNov	Unlikely
Thelymitras tellata	T	E	PG	Sandyloam,clayorgravel over lateriteorgravel.	SepNov	Unlikely
Diurismicranth a	T	V	PG	Darkgreyblacksandyclayloamin winterwetdepressions.	SeptOct	**Possible**
Drakaeamicrant ha	T	V	PG	Whitegreysand .	SeptOct	Unlikely
Eleochariskeigheryi	T	V	P	Clayorsandyloaminfreshwater creeksandtransientwaterbodies suchasseasonal lywetclaypans.	AugDec	**Possible**
Tetrariaaustraliensis	T	V	P	Sandoverclay, winterwet depressionsanddrainagelines.	NovDec	**Possible**
Austrostipaja cobsiana	T	-	P	Greysan dyclayinwinterwet areasand damplands.	NovJan	**Possible**
Synaphea sp.Serpentine	T	-	P	Seasonallydam pareas, loam sand.	SepOct	**Possible**
Acacia lasiocarpa var. *bracteolata* long pedunclevariant	P1	-	P	Greyorblacksandoverclayin swampyarea sa ndwinterwet lowlands.	Mayor Aug	**Possible**
Synapheaodocoileops	P1	-	P	Brownorangeloam&sandyclay, granite, inswampsandwinter - wetareas.	AugOct	**Possible**

Species	Levelof significance		Life strategy	Habitat	Flowering period	Likelihood of occurrence
Johnsoniapubescens subsp.*cygnorum*	P2	-	P	Greywhiteyellowsandson flats andseasonally wetareas.	Sep	**Possible**
Millotiatenu ifolia var.*laevis*	P2	-	A	Graniteorlateriticsoils.	SepOct	**Unlikely**
Angianthusdru mmondii	P3	-	A	Greyorbrownclaysoils, ironstone.Onseasonallywetflats.	OctDec	**Possible**
Babingtoniau rbana	P3	-	P	Winterwetdepressionsan d wetlands.	JanMar	**Possible**
Dillwyniadillwy nioides	P3	-	P	Winterwetdepressionson sandy soils.	AugDec	**Possible**
Jacksoniagra cillima	P3	-	P	Browngreysan dinwelldrained areasonedgeo f wetland.	OctMar	**Possible**
Schoenuspennisetis	P3	-	A	Greyorpeatys andinswamps and winterwetdepressions.	AugSep	**Possible**
Centrolepiscaes pitosa	P4	-	A	Whitesand,clayonsaltflatsand wetareas.	OctDec	**Possible**
Droseraocciden talis subsp.*occidenta lis*	P4	-	P	Sandy&clayeysoilsinswamps& wetdepression s.	NovDec	**Possible**
Eucalyptus rudis subsp. *cratyantha*	P4	-	P	Loamonflatsandhillsides.	JulSep	**Unlikely**
Parsonsia diaphanophleba	P4	-		Alluvialsoilsalongrivers.	JanFebor AprSep	**Unlikely**
Stylidiumlongitu bum	P4	-	A	Sandyclay,clayinseaso nal wetlands.	OctDec	**Possible**
Verticordia lindleyi subsp.*lindleyi*	P4	-	P	Sandand sandy clayinwinterwet areas.	NovJan	**Possible**

Note:T=threatened,CE=c riticallyendangered,E =endangered, V=vulnerable,P1=P riority1,P 2=Priority2,P 3=priority3,P 4=priority4 , P=perennial,PG=perennialgeophyte ,A=annual.

2.8 Threatened and priority ecological communities

Anecological communityisa naturallyoccurringgro upofna tive plants,anima lsandotherorganisms thatareinter actinginauniquehabita t.A necologicalcommunity'sstructure,co mpositionand distributiona redeterminedby environmentalfactor s suchassoiltype,position inthelandscape, altitude,climateandwater availability(DoEE2016).' Threatenedecological communities'(TECs)are ecologicalco mmunitiesthatarerecognisedasrareo runderthreat and thereforewarrantspecial protection.

SelectedTEC sareaffordedstatutoryprotectionata Commonwealthlevelundersection 181ofthe EPBCAct.Anyactionlikely tohaveasignificant impa cton acommunity listed u nderthe EPB CAct requiresapprovalfromtheCommonwealth MinisterfortheEnviro nment.TECsarealsolistedwithin WesternA ustraliabutarecurrently nota ffordeddirectstatutoryprotectionata Statelevel. Nonethelesstheirsignifica nceis acknowledgedthroughotherSta teenvironmentalapproval processessuchas'environmentalimpactassessment' pursuantto PartIVofthe *Environmental*

ProtectionAct1986 (EPA ct)a nd the *EnvironmentalProtection (Cl earingofNativeVegetatio n) Regulations2004* .Apla ntcommunitythatisunderc onsiderationforlistingasa TECinWestern Australia,butdoesnotyetmeetsurvey criteriaorha snotbeen adequately defi ned,may belistedas a'priorityecologicalcommunity'(P EC).Listingas aPECissimilarlyconsideredduring Sta teapproval processes.Further informationoncategoriesofTEC sandPECsisprovidedin **AppendixA** .

Knownloca tionsofTECsa ndPECswithin10kmof thesite weresearchedfor usingthepublicly available *Weedandnativ efloradataset* (Ke ighery20 12)and *ProtectedMattersSearch Tool* (DoEE 2017).Thesesearchresultsindica tenoTECsorPECs areknownto occurwithin thesite,butthat sevenTECsandone PECo ccurwithin1 0kmofthesiteasliste di n **Table2** .Duetothelackof vegetationapplicable totheseTECsandPECsandthe absenceofclaypans,no TECsorPECswere consideredlikelyto occurinthesite.

Table2:T ECsandPEC sknownto occurwithin10km ofthesite.

Code	Community name	TEC/ PEC	Levelofsig nificance	
			State	EPBCAct
SCP3a	*Corymbiacaloph yllaKing iaaust ralis*woodlandson heavy soilsoftheSwanCoastal Plain	TEC	Critically Endangered	Endangered *Corymbiac alophyllaKing ia australis*woodla ndson heavy soilsoftheSwan CoastalPlain
SCP3c	*Corymbiac alophyllaXantho rrhoeapreissi i* woodlandsandshrublandsoftheSwanCoastalPlain	TEC	Critically Endangered	Endangered *Corymbiac alophylla Xanthorrhoeap reissii* woodlandsandshrublandsof theSwanCoasta lPla in
SCP20b	*Banksiaattenua ta*and/or *Eucalyptusmarginata* woodlandsoftheeastern sideof theSwanCoast al Plain	TEC	Endangered	Endangered BanksiaWoodlandsofthe SwanCoastalPlain
SCP08	Herbrichshrublandsinclaypans	TEC	Vulnerable	Endangered (ClaypansoftheSwan CoastalPlain)
SCP09	Denseshrublan dsonclayflats	TEC	Vulnerable	
SCP02	Southernwetshrublands,Swan CoastalPlain	TEC	Endangered	-
SCP3b	*Corymbiac alophyllaEu calyptus marginata*w oodlands onsandyclayso ilsofthesouthernSwanCoastalPlain	TEC	Vulnerable	-
-	*Casuarinaobesa* Association	PEC	Priority1	-

2.9 Land use planning considerations

Arangeoflegislation,regulationsand policesarerelevantto theevaluationofvegetationinWestern Australia.Keyinstrumentsapplicablet o thesite aredescribed belo wandalsoshownin **Figure 3**.

2.9.1 Bush Forever

TheGovernmentofWesternAustralia's *BushFor ever* policyisa strategicplanforconserving regionallysignificantbushlandwithin theSwanCoastal PlainportionofthePerthMetropolitan Region.Theo bjectiveof *BushFor ever*is toprotectco mprehensiverepresentationsofalloriginal

ecologicalco mmunitiesby targetinga minimumof10%ofeach vegetationco mplexforpro tection (GovernmentofWA2000). *BushForever* sitesarerepresentative ofregionalecosystemsandhabitat andhavea keyroleinthe conservationofPerth'sbio diversity.

No *BushForever* sitesoccurwithinthesite. BushForeverSite 350(Byford toSer pentineRail/ Road ReservesandAdjacentBus hland)liesa djacenttothe southeaster ncorner ofthesite.Thislinearsite extendsalongtherailwayandcont ainsavarietyofreservesofwhich theSoldiersRoadsite isclosest tothesite.Threatened,pr iorityandr egionallysignificant floraspeciesareknow ntooccur inthis *BushFor ever* site.Theloca tionofthepa rtofBushForever Site350associatedwiththesiteis shown in **Figure3** .

2.9.2 Environmentally sensitive areas

'Environmentallysensitiveareas'(ESAs)are prescribedunderthe *EnvironmentalProtection(C learing ofNativ eV egetation)Regulations 2004* toprotectna tivevegeta tionvaluesofareassurrounding significant,threatenedors cheduled flora, vegetationcommunities orecosystems.WithinanESA noneoftheexemptionsunderthe *EnvironmentalProtection(Clear ingof NativeVegetation) Regulations2004* apply.However,exemptionsund erSchedule6 oftheEP Actstillapply,including anyclearingi naccordance with a subdivisionapprovalunderthe *Planningand DevelopmentAct 2005* (arecognisedexemptionunder theSchedule6o ftheEPAct).

OneESA (No.3350)islo catedw ithinthesite.T hisESAisassociated withManjedalBrookandextends beyondthesiteto thenorthandsouth alongtherailwayline.Theloc ationofthisESAis shownin **Figure3** .

2.9.3 Ecological linkages

Ecologicallinkagesarelinearlandscapeelementsthat allow themovementoffauna,floraand geneticmaterialbetw eenareasof remnanthabitat.Themovementof faunaa ndtheexcha ngeof geneticmaterialbetw eenvegetation remnantsimpr ovetheviabilityof thoseremnantsbya llowing greatera ccesstobreeding partnersandfoodsources, refuge fromdisturbancessuchasfirea nd maintenanceofgeneticdiv ersityofplantcommunitiesandpop ulations.Ecologicallinkages are ideallycontinuousornear continuousa sthemorefr acturedalinkageis,theles seasefloraand faunahaveinmovingwithinthecorridor (AlanTingayandAssociates1998).

ThePerthBio diversityProject,supportedby the Wes ternA ustraliaLocalGovernmentAssociation (WALGA),haveidentified andmapped Regional EcologicalLinkageswithinthe PerthMetropolitan Region(WAL GAandPBP2 004).Inorder toexte ndthisstudyoutsideo fthePerthMetropolitan Region,theSouthWes tBiodiversityProjectwas established,res ultingin thei dentificationand mappingoftheSouthWestR egionalEcologicalLinkages(Molloy *et al.*2009).

Therearenomappedecologicallinkageswithin thes ite.Oneregio nalecological linkage(No.65) occursontheeasternsideofthesite andextendsbeyondthesiteto thenorthandsouthalongthe railwayline.Thelo cationofthislinkageisshownin **Figure3** .

2.9.4 Local natural areas

TheShire ofSerpenti ne Jarrahdale(theShire) *LocalB iodiversity Strategy*(DelMarcoandPenna 2008)details'localnaturalareas'(LNAs). LNAsaredef inedas'na turalareasthatexistoutsideofBush Foreversites,theDECma nagedEstate andRegional Parks'andaregenerallyfoundonprivateland orlocalreser ves.The Shir ehaspropos edthe followingfourgoalstoretain,pr otectand ma nage LNAs:

- Preventfur therlossbyretaininga tleas t4000ha ofLNAs.
- Protectandmanagea portionofeachbasicty pe ofvegetationandecosystemstypicalto the Shire(approximately1690 haofLNAs).
- Protectspecif icecologicalfeaturesand processes (e.g.rarespecies,TECs,wetlandvege tation andecological linkages).
- ManageandrestoreLNAsandrevegeta tenew areastoincr easenativefaunahabitat.

The4000haofretentioni ntheShirei ncludesallverifiedLNAs tha tsupportCarnaby'sblack cockatoo,nativevegeta tiontha toccurswithin regional ecologicallinkagesanda llriparian vegetation.

2.10 Locally and regionally significant flora and vegetation

Floraspeciesandvegetatio nmaybesignificant fora number ofrea sonsirrespectiveofwhetherthey havespecial protectionunderpolicyorlegislation.Four keyreasonsthatvegeta tionwithin thesite maybesignif icantareliste dbelow.

- Thevegetationwithinthes itehas potentialvalueashabitatfor thr eatenedorpr iorityfauna speciesi ncluding,i nparticular,Carnaby'sblackcocka too andtheforestredtail edbla ck cockatoo,whicharelistedas'vulnerabl e'undertheEPBCAct and'endangered'under theWC Act(DoEE20 12)
- Thevegetationaround thefareasternsumpland (UFI 7835)isknowntosuppor ttheP4 marsupialspeciesquenda(southern br ownbandi coot)(Thompson2012).
- Floraspeciesinthesiteha vepoten tialtobelistedonthe *BushFor ever*do cument *Significant FloraoftheFoothills andP injarra PlainintheP erthMetropolitan Region* (GovernmentofWA 2000b).Thisdocumentlistsflora speciesdeemedtobepoorlyres ervedoratthenorthernor southernlimitoftheirkno wngeographical range(inadditiontothreatened andpriorityflora speciesasdiscussedin **Section 2.7**).
- ThevegetationalongManj edalBrookandassociated with t hesumplandsinthesiteislikelyto qualifyasoneormoreLNAsasoutlinedin **Section2 .9.4**.

2.11 Weeds

Theterm'weed'canrefertoany plantthatrequiress omeformof actiontoreduceitseffectonthe economy,theenvironment,human healthandamenity. Many nonnativeflor aspeciesa ndsome nativespeciesareconsidere dtobeweeds.

Aparti cularlyinvasiveordetrimentalw eedspecies maybelisted asa'declaredpest' pursuantto the WesternA ustralia's *BiosecurityandAgricultur eManagementAct2 007* (BAMAct),i ndicatingthati t

warrantsspecialma nagementtolimit itsspread.Furtherinformation ondecla redpes tsandother policyreleva nttoweeds i sprovidedi n **AppendixA.**

2.12 Previous flora surveys

AbotanistfromEmergepr eviouslyund ertookareconnaissances urveyofthes iteinAugust2015.

Aspring floraandvegetationsurveywa s undertakenbyPGV Envir onmentalon30 th September and 1stNovember2011overapproximately four hours(Va nder Moezel2012).T hestudyareawasthe sameasthecurrentsurveywith theexclusiono fLot5 andLot10TaylorRoad.ThePGV Environmentalsurveyrecordedatotalof71flora speciescompris ing29nativespeciesand4 2 introducedspecies.Nothreatenedorpriorityfloraspecieswere r ecordedinthesite.Eleven vegetationassociationswereidentifiedint hesiteofwhichninew ereassociatedwith theeastern sumplands.Comparisonofvegeta tionassociationda tatoaregionaldataset wasnotunderta kenand remnantvegetationwithinthesitew asinferredtor epresentfloristiccomm unityty pe(FCT)11and FCT13.Thevegetationco nditionrange dfrom‘excellent’to‘completelydegraded’.

Nootherflor asurveysofthesite areknown.

3 Methods

3.1 Field survey

OnebotanistfromEmergevisitedthesiteon18 thNov ember2016toconduct thefloraand vegetationassessment.

Thesitewastraversedonfootandthe compositiona ndconditionofvegetationwasrecorded. Searchesw ereconducted forthreate nedand priority floraspecies with potentialtooccurinthesite, witha parti cularlyfocuso nide ntifyingareasofsuitableha bitat.

Detailedsampling ofthev egetationwa sunder takenusingacombi nationofnon permanent 10x10mquadratsandrelevés.Thequadrats wereestablishedusingfence dro ppersboundby measuringta pe.Therelev éswere completedovera nequivalent10x10 mareawithouttheuseof physicalmarkersandwer eincluded toprovidea morerapidsampleofareasofvegetationinpoorer conditionand/orofsmallersize.Atotalofeightsa mplingpointsweresurvey ed, comprisedoftwo quadratsandsixrelevés.Thepositionof eachsamplepointwasr ecorded withahand heldGPSunit, asshownon **Figure4.**

Thedatarecordedwithin eachsampling pointi ncluded:

- sitedetails(sitena me,site number,observers,date,location)
- environmentalinformatio n(slope, aspect,baregro und,rockoutcropping soiltypeandcolour class,litter layer,topographicalposition,timesincela stfireeve nt)
- biologicalinf ormation(ve getationstructureand co ndition,degr eeofdisturbanceandspecies present).

Thespecies percentage‘fo liage projectivecover’(FPC)wasalso recordedwithineachquadrat. Additionalpl antta xanotobservedwithinsampling pointswerer ecordedopportunistically asthe botanisttraversedthesite.Photographs wereta kenthroughoutthefield visittoshowparticularsite conditions.

Allplantspecimenscollectedduringthefield survey weredried,pressedandthenna medin accordancewithrequirements oftheWesternA ustralianHerbarium .Identificationofspecimens occurredthroughcomparis onwith namedma teriala ndthrough theuseoftaxonomickeys.Flora speciesnotnativetoWestern Australia aredenotedbyanasterisk (‘*’)in textandrawdata.

Theconditionofthevegetationwasas sessedusing themethodsfromKeigher y(1994)asdescribed in **Table3** .Vegetationconditionwasas signeda tea chsamplingpointandchangesinv egetation conditionwerealsonotedand mappedacrossthesite.

Table3:Veget ationconditionscale appliedduringfiel dass essment

Condition category	Definition (Keighery1994)
Pristine	Pristineornearlyso,noobvious signsofdisturba nce.
Excellent	Vegetationstructureintact,distu rbance affecting individualspeciesandweedsare non aggressivespecies.
Verygood	Vegetationstructurealteredobvioussi gnso fdist urbance.Forexa mple,disturbanceto vegetationstructurecausedbyr epeated fires, thepresenceofso memoreaggressiveweed s, dieback,loggingandgrazing
Good	Vegetationstructuresignificantly alteredby very obvioussignso f multipledisturb ances. Retainsbasicvegetationstructureorabilityto regenerateit.For example,disturb anceto vegetationstructurecausedby veryfrequentfires, thepresence of someveryaggressive weedsathigh density,partialclearing,diebackandgrazing.
Degraded	Basicvegetationstructuresever elyimpactedby disturbance.Scopeforregenerat ionbutnot toastateapproachinggoodconditionwithoutin tensiveman agement.Forexam ple, disturbancetovegetationstructurecausedb yve ryfrequentfires,thepresenceo fvery aggressiveweeds, partialclear ing,diebackandgrazing.
Completelydegr aded	Thestructureofthevegetationisno longerintactandtheareais completelyoralmost completelywith outnativespecies.Theseare as areoftendescribedas‘parkland cleared’ withthefloraco mprisingweedo rcropspe cieswithisolatednativetreesorshrub s.

3.2 Mapping and data analysis

3.2.1 Plant community identification and description

Thelo calpla ntcommunitieswithin thesitewereidentified from thesampleda tacollectedduring thefieldsurvey.A clusteranalysiswasperformedby convertingtheFPCforea chspeciesa teach sampleloca tiontoaDominvalue(Kentand Coker19 94).Classificationwasundertakenusing hierarchicalclustering withintheanalysis packagePrimer6(ClarkeandGorley2006),withgroups definedusing theBrayCurtisdistancemeasureand furtherr efinedusing asimilarityprobability measure(significancelevelof0.05).

Onceagroupwasdefinedfromthe cl usteranalysis,thevegetatio n wasdes cribedaccordingtothe dominantspeciespr esentusing thestructural formationdes criptionsofthe *NationalVegetation InventorySystem* (NV IS)(ESCAVI2003).Theidentifiedplan tcommunitywas thenmappedonaerial photography(1:15,000) fromthesample pointsa ndboundarieswereinterpretedfromaerial photography.Vegetationconditionwasmappedona erialphotogr aphy(1:13,000)basedonthe locationsrecordedduringthefieldsurveytodefin e areaswithcha ngesin condition.

3.2.2 Floristic community type assignment

Theidentifiedplant communitywasthen comparedtotheregio nal ‘floristiccommuni tytype’(FCT) dataset *A Floristicsurvey o ftheso uthernSwan CoastalPlain* byGi bson*etal.* (1994).Thesampledata (presence/absence)wasreconciledwith Gibson *et al*.(1994)bysta ndardisingthenames ofta xawith thoseused in theearliers tudy.Thiswas necessaryduetochangesi nnomencla turein the interveningperiod.Taxa thatwereonly identifiedtogenuslevel wereexcluded,whilesome infra speciesthathavebeenidentifiedsince 1994werer educedtospecieslevel.Theco mbineddataset wasthenimportedinto thestatisticala nalysispacka gePrimer6 (ClarkeandGorley2006).Asdata

fromalocalis edsurveyis oftenspa tiallycorrelated, dataforeach samplepointwascomparedto Gibson *etal* .(1994)separately.Thisremoved theinfluenceofspatial correlatio nwhenassigninga FCT.Classificationwasthenundertakenusing agrou paveragehierarchicalclus teringtechni queusing theBrayCurtisdistancemeasure (asdescribedabove forplantcommunitydetermination).

Wherethesampletendedto clusterwithagroupingofdifferent FCTs,individualsamplepoint similaritywas assessedseparatelytodifferentiatebetweenF CTs.Ultimatelythecluster analysis,as wellascontextualinforma tionrelating tothesoils,landforms andknownloca tionso fFCTsw ithin the region,wereconsidered inthefinal determinationofanFCTforv egetationwithinthesite.

3.2.3 Species accumulation curve

Aspeciesaccumulationcurvewasplotted fromsampleda taby generatingatr endlineinMicrosoft Excel.The trendline (log)wasforecastto locatethe asymptoteofthecurve(th epointatw hichthe curveflattens indi catingfewspeciesremainunde tected).Primer 6alsooffersarangeofestimators topredictminimum speciesrichness(C larkeandGor ley2006).Both theJacknif e1andC hao2non parametrices timatorsarer eported,asthesearekno wntoperformwell inco mparisontos imulated andrealdatasetsandare alsorecommendedforsmallsamplesizes (GotelliandColwell201 1). Comparisonbetweena ctualandes timatedspecies accumulation curvesassists ineval uatingthe adequacyofsamplingeffort.

3.3 Survey limitations

Itisimportanttonotethe specificconstraintsimposedonsurveysand thedegr eetow hichthese mayhavelimitedsurvey o utcomes.An evaluationofthesurvey methodologya gainststandard constraintso utlinedi nEPA *TechnicalGuidance –FloraandVegetation SurveysforEnvironmental ImpactAssessment* (EPA2 016)isprovidedin **Table4** .

Table4:Evaluationofsurvey methodologyagainst standardconstrai ntsoutlined inEPATechnicalGuidance– FloraandVegetation SurveysforEnvironmentalImpactAs sessment

Constraint	Degreeoflimita tion	Details
Availability of contextual information	No limitation	Generally, the broad scale contextual information described in **Section 2** is adequate to place the site and vegetation in context.
	Minor limitation	Regarding assignment of FCT the authoritative Gibson *et al* 1994 dataset, was derived from a necessarily limited sample of vegetation from largely publicly owned land which is now more than 20 years out of date. Consequently, it is unknown to what degree official FCTs are appropriate reference to biodiverse vegetation across the Swan Coastal Plain. Furthermore, Gibson *et al.* (1994) collected data in the spring main flowering period and in many cases sampled plots multiple times to provide a complete species list. Although only sampled once, the site data was considered comparable given it was also collected in spring.
Experience level of personnel	No limitation	This flora and vegetation assessment was undertaken by a qualified botanist with five years of botanical experience in Western Australia. Technical review was undertaken by a senior environmental consultant with 15 years' experience in environmental science in Western Australia.
Suitability of timing / temporal coverage	No limitation	The survey was conducted in November and thus within the main flowering season. Sufficient rainfall was recorded from May to October 2016 in the months preceding the site visit. Therefore it is likely that many plant species would have been in flower and/or visible at the time of survey. It is also preferable to undertake wetland surveys towards the end of spring to coincide with germination and flowering of annual flora species that occurs as the wetland gets drier in summer. The degraded nature of the site limits the potential habitat for native geophytic plants such as orchids and the majority of threatened and priority flora species with potential to occur are perennial species. The survey timing was considered adequate to allow the detection of species for which seasonal timing is critical.
	No limitation	Comprehensive flora and vegetation assessments can require multiple visits, at different times of year, and over a period of a number of years, to enable observation of all species present. The vegetation in the site has surveyed three times: one reconnaissance survey by Emerge in August 2015, one spring flora and vegetation survey by PGV in 2011 and this survey. Due to the highly disturbed condition of the vegetation and low native species diversity in the site, these surveys were considered adequate to accurately record the flora and vegetation in the site. This survey effort is deemed sufficient to qualify as a detailed survey under EPA guidelines (EPA 2016).
Spatial coverage / sampling intensity	No limitation	Site coverage was comprehensive (and track logged).
	No limitation	A total of 82 species were recorded, of which 58 were recorded from eight sample locations and 24 were recorded opportunistically. Minimum species richness within site is estimated at between 82 (Jacknife1) and 95 (Chao2) species (refer species accumulation curve and estimates shown in **Plate 9**). The number of species recorded in the site is equal to that of the Jacknife1 estimate and, combined with the degraded nature of the majority of the site, demonstrates that survey effort was adequate to prepare a near-comprehensive species inventory for the site.
Influence of disturbance	Minor limitation	Time since fire is greater than 60 years as interpreted form aerial imagery and therefore short lived species more common after fire may not have been visible.
	No limitation	Historical ground disturbance was evident in parts of the site and some native vegetation in the site is regrowth with minimal non-native species present. Some vegetation near the CCW has evidence of disturbance and historical clearing.
Adequacy of resources	No limitation	All resources required to perform the survey were available.
Access problems	No limitation	All parts of the site could be accessed as required.

4 Results

4.1 General site features and conditions

Thesiteisfla ttogentlyun dulatingwithagentleriseapparentfrom westtoea st.Themajorityofthe sitecontainssandyclaysoils.San dyloa msoilsexistwithin Ma njedalBrookandwhitegreysandis presentaroundandinparticularbetwe enthetwosumplandsintheeastern portionofthesite(UFIs 7834and783 5).Thesoilwithin t hesumplandsconsistsofpeaty sand.

Thesiteisdevoidoflargeareaso fintactremnantvegetationduetothe long historyofcroppinga nd stockgra zing.Nonnativepastur especiesaredomina ntacrossthe sitewithscatterednativetrees suchas *Corymbiacalophy lla,Eucalyptusrudis* and *Melaleucaprei ssiana*.Thevegetationinter preted fromaerialimagerywasconfirmeddur ingthefieldsurvey.As mall riseinthes outhwester ncorner ofthesite(within Lot3 Tay lorRoad)con tainsavarietyofdifferent scatterednativetreessuch as *Banksiailicifo lia*, *Eucalyptusmarginata* and *Xylomelumoccidental e*oversimilar nonnativ epasture grasses.Standsofnonna tiveplantedtr eesalsooccur acrossthesite,parti cularly inthenorth ofthe siteandsurroundingthedairylocated inLot11 TaylorRoad.

Thelengthof ManjedalBrookwithin thesite waswalkedduringthe sitesurvey.Thebanksandbed ofManjedalBrookdisplayedsigns ofer osionlikelyd ueto historicgrounddistur bancebysto ck.Parts ofthebrookareunfenced andopentostock.Nativevegetation alongthebroo kconsistsofcanopy treesandsca tteredwetlandplantsnear thewa terw hichwasstagnantin poolsa tthetimeofthe survey.Non nativepastur egrassesaredominant under nativeca nopytrees and onthebanks.

Alargeportionofthesurveytimewass pentassessing thesumpla ndsintheea sternportion ofthe site,whichbothcontainperman entwa terbodies.Thefar easternsumpland (UFI7835)supportsa narrowfringe ofnativevegetationconsi stingofa fewnativewetla ndspecies.Alargerpatchofintact nativevegeta tionispresentb etweenthissumpland a ndthe easternsite boundary.Theadjacent smallersumpland(UFI783 4) containsscatterednativ e *Eucalyptus rudis*treeswithin thewaterbody andthreeisolatedstandso falterednativevegeta tionontheedge.An artificialdrainageline betweenthetwosumplandsis dominatedby nonna tive* *Isolepisprolifera.*

4.2 Flora

Atotalof32 nativeand49 nonnativ e(weed)species wererecordedwithin the siteduringthefield survey,representing27fa milies and66 genera.Fivespecies previouslyrecordedby PGV Environmental(VanderMoezel2012) werenotrecordedduringthe currents urveyincludi ng *Baumeaprei ssii,*Fr eesiaa lba* x*leichtlinii, Kennedia prostrata,*Oxalisglabra* and*Pterostylis* sp.An additional15 specieswer erecordedinthecurrent surveythatwer enotpreviouslyrecordedbyVan derMoezel (2012).

Thedominantfamilies containing native taxaw ereMyrtaceae(eightna tivetaxa andtwoweedtaxa) andFaba ceae(threenativ etaxa andsix weedtaxa).Themostcommongenus was *Acacia,B aumea* and *Eucalyptus* withthreetaxaeach.T hefamily containing themost taxawasPoaceae(nonative and16nonnativespecies).Ofthespecies recorded5 8wererecordedinsamplelocationsa nd24

wererecorded opportunistically.Acomplete specieslistisprovidedin **AppendixB** andsampledda ta in **AppendixC** .

4.2.1 Threatened and priority flora

Nothrea tenedorpriority flora specieswererecorded withinthes ite.

4.2.2 Locally or regionally significant flora

Oneregionallysignifica ntfloraspecies, *Dielsiasteno stachya*, wasr ecordedinvegetationbetween thefar easter nsumpland andthesiteb oundary.Thisspecies isidentified in *SignificantFlora o fthe FoothillsandPinjarraPlainin thePerthMetropolitan Region* asitisendemict otheSwanCoastal Plain(GovernmentofWA2000b).

4.2.3 Significant weed species

Threespecies thatarelistedasde claredpests(C3)undertheBAM Actw ererecordedwithin thesite: **Zantedeschiaaethio pica* (arumlily),* *Asparagusasp aragoides*(br idalcre eper)and *Rubusul mifolius* (blackberry).Thesespecies wereprimarilylocate dwithinvegetatio nalongtheManjedalBrook.

Asparagusasparagoid es (bridalcreeper)isalsolisted as aweedof nationalsignificance (WoNS).

4.3 Plant communities

Sixna tiveplantcommuniti esandone nonnative plantcommunitywerei dentifiedwithin thesite.A descriptiona ndthesizeof eachplantcommuni tyisprovidedin **Table 5**andrepresentative photographsofeachareprovidedin **Pl ate1** t o **Plate 8**.Thelo cationofeach pl antcommuni tyis shownon **Figure4.**

Table5:Plantcommunities identified withi nthesite

Plant community	Description	Area (ha)
ErCcMr	**ManjedalBrook** Lowopenforest *Eucalyptus rudis* and *Corymbiaca lophylla*overlo wopenwoodland *Melaleuca rhaphiophylla*overisolatedforbs *Juncuspallid us* and *Alternantheranodiflo ra*overclosedgrasslan d nonnativepast uregrass es. Poolsofstandingwaterwerepr esentinthe brookatthetimeofthesurvey .	7.12
MpTlBaLl	**Fareasterns umpland – eastern side** Lowwoodland *Melaleucap reissiana* overtallshrubland *Taxandralinear ifolia*ove rsedgelan d *Baumeaarticula ta*and *Lepidospermalongitud inale*overopenfo rbland *Cycnogetonlineare.* Mostofthis communitywaswaterloggedatthetimeofthesurvey.	0.94
BaJp	**Fareasterns umpland–r emainingperim eter** Closedsed geland *Baumeaarticu lata* and *Juncus pallidus*. Themajorityofthiscommunitywasinundated a tthetimeofthesurvey.	0.37
MpTl	**Sumpland west ofthefareaster nsum pland– northeast erncorner** Lowwoodland *Melaleucap reissiana*overclosedshrubland *Taxandralinearifolia* overisolated sedges *Juncuspallidus* overforb land *Lemnadispersa* and* *Brizaminor.* Some *Melaleucapreissiana* canopytreesinthiscommunitywereinundated.	0.13
CcJp	**Sumpland west ofthefareaster nsum pland– easternsi de** Lowopenwoodland *Corymbiaca lophylla*over sparsese dgeland *Juncuspa llidus*overopen grassland ofnonnativepa sturespecies suchas* *Ehrharta calycina*and* *Pennisetumclandestinum* . Thetwoareasofthis communityweremoistt odryatthetimeoft hesurvey.	0.06
MpJfAf	**Swales betweenthetwos umplands** Openlowwoodland *Melaleucap reissiana*overTallopenshrubla nd *Jacksoniafur cellata*over shrubland *Astarteafascicu laris*. Thelowerlyingareasofthis communitywere waterloggedatthetimeofthe survey.	0.36
Non native vegetation	Heavilydisturbedareascomprising scatteredpla ntedtrees a ndshrubsoverclosedgrasslando f scatteredintroducedpastureweedssuchas* *Ehrhartaca lycina*a nd* *Bromusdiandrus* (**Plate2**).	188.85



*Plate1:Plantc ommunity **MpTlBaLl**inv erygood excellent condition*



*Plate2:Plantc ommunity **BaJp**indegrad ed condition(f oreground).*



*Plate3:Plantc ommunity **MpJfAf**ingoodt overygoodcondition.*



*Plate4:Plantc ommunity **MpJfAf**indegra dedconditi on.*



*Plate5:Plantc ommunity **MpTl** ingoodcondition.*



*Plate6:Plantc ommunity **CcJp** indegrad edcondition.*



*Plate7:Plantc ommunity **ErCcMr** in degradedconditi onal ongM anjedal Brook.*



*Plate8: **Nonnative** vegetation community incompletelyd egradedcondit ion.*

4.4 Vegetation condition

ThevegetationassociatedwithManjedalBrookisin 'degraded'co nditiondueto thelackofnative understoreyvegetation.Plantcommunity **ErCcMr** alongthebrookconsistso fanativecanopyover sparsenativeplants such a s *Alternantheranodiflora* and *Juncuspal lidus*withinthechannel.The banksofthebrookcontainadensecoveringof nonnativepastur egrasses andherbs.Invasivenon nativespeciessuchas **Asparagusasparagoides,* Rubusulmifolius* (blackberry)and* *Zantedeschia aethiopica*andaresca tteredalongthebank,with thedensestpo pulationof blackberryalongthe easternportion.Small isolatedpatchesofsimilarnative canopyvegetationoccurinthesitea ndare alsoin'degra ded'conditio n.

Thehighestqualityvegetationinthe siteislocatedbetweenthefar easternsumplandandthesite boundaryandisin 'excellentvery good'condition.Plantcommunity **MpTlBaLl**,representi ngthis vegetation,containsmultiplestrata andlowweed cover.Scatter edshrubsofthewoody environmentalweed **Acacialon gifolia* arescatter edthroughout **MpTlBaLl**.Na tivespeciesdiversity wasrelatively lowbu tthisi sexpe ctedfo rthis typeofdensei nundatedw etlandv egetation.T he remainingvegetationsurrounding thissumpland isa ltered fromitsoriginalformandisin'degraded' condition.Plantcommunity **BaJp** inthisareaconsists of *Baumeaar ticulata* and **Isolepisprolif era* withsome *Taxandralin earifolia*shrubsandstanding water.

Theothereasternsumpland,tothewestofthe abov ementionedsumpland,i smostlydevoidof nativevegeta tion.Onesmall patchofintactvegetation(**MpTl**)in'good'conditionispresentonthe northeaster ncorner . **MpTl**showssignsofdisturbancewithlow nativespeciesdiversityandalow moderateco verofnonna tivespecies.Two otherareasofnativevegetationin'degraded'co ndition occuron theeasternside ofthis sumpland.Plantco mmunity **CcJp** inthis areaconsists ofna tive canopytr eesoverpredomi nantlynonnative species,with somescatterednativ eshrubsa nd *Juncus pallidus*pres ent.Isolated native *Eucalyptusrudis* treesarewithinthepermanentwaterbody.

Adrainage linebetweenthesetwosumplands containsvegeta tionwhichi sin'completelydegraded' conditionduetothe domi nanceof **Isolepisprolif era.*Thepa tchofnativevegetationadjacent tothe drainageli ne,plantcommunity **MpJfAf**, isin'verygo od–good'c ondition.Thisvegetationco nsistsof regrowthfro mhistoricclearingandappearsto beanalteredformof plantcommunity **MpTlBaLl**. Canopytreesareverysparseand nativeshrubsarethedomina ntlif eform.Nonnativespeciescover isverylowandthevegetationstructure islikelytochangeovertime.

Theartificialswalesbetweenthetwosumplands w ereformedafterhistoricland clearingand thereforeals ocontain regrowthvegeta tionin 'degraded' condition.Thisvegetationisafor mofplant community **MpJfAf** withlowcoverofnativespecies. Nonnatives peciess ucha s **Eragrostiscurvula, *Ehrhartacal ycina* and **Lotussubbiflorus* arepr esent.

Theremainderofthesite isnonnativevegetationi n'completelydegraded'conditionandconsists of adensegroundlayer ofnonnativepasturespeciess uchas* *Bromusdiandrus, * Ehrhartacal ycina*, **Lolium*spp.and* *Lotussu bbiflorus*.Groupsofplantedtre esand scatterednati vetreessuch as *Corymbiacal ophylla*, *Eucalyptusrudi s*a nd *Melaleucaprei ssii*arepresentacross thesite overthe pasturespecies.

Theextentofvegeta tionbycondi tioncategoryisdetailedin **Table6** andshownon **Figure5.**

Table6:Sizeofvegetation condition categorieswithinthesite

Condition category	Size (ha)
Pristine	0
Excellent	0
Excellent–verygood	0.89
VeryGood	0
Verygoodgoo d	0.13
Good	0.08
Gooddegraded	0.05
Degraded	7.83
CompletelyDegraded	188.85

4.5 Floristic community type assignment

Plantcommunities **MpTlBaLl**,**BaJ p** and **MpJfAf** weredeter minedtorepresentFCT13'deeper wetlandsonheavysoils'.ThisFCTislis tedas 'wellreserved'and 'lowrisk'byGibson *etal.* (1994) . In theclusteranalysissamplesQ1 andQ2(plantcommunity **MpTlBaLl**)andR4 (plantcommunity **MpJfAf**) groupedwith FCT13andR2(pl antcommuni ty **BaJp**)groupedwith FCT12.Q2andR2 groupedwith Gibson *e tal .* (1994) sitesr epresentingFCT13with1 3to25% similarity.Q1 grouped withGibson *etal.* (1994) sitesrepresentingFCTs11,12and 13a ndR4 grouped withGibson *etal.* (1994) sitesr epresentingFCT11'wetforestsandwoodlands'. The **MpJfAf** vegetationis regrowth andtherefor edifferedin structuretothe other plantcommunities. Overtimethe **MpJfAf** vegetation willlikely becomemoresi milartothatof **MpTlBaLl.** Thereforeplantcommuniti es **MpTlBaLl**,**BaJp** and **MpJfAf** weredeemedtor epresentFCT13.

Plantcommunity **ErCcMr** alongManjeda lBrookwasdetermined torepresentadegradedformofFCT 11'wetfores tsandwoodlands'.This FCTislistedas' wellreserved'and'lowris k'byGibson *etal.* (1994).Intheclusteranalysisallthree s amplesites(R1,R5 andR6) groupedw ithFC T11.R1 andR6 groupedwith Gibson *e tal .* (1994) sitesr epresentingFCT11andR 5groupedwithsitesrepresenting FCT6'weeddominatedw etlandsonheavysoils'. Clusteringwith FCT6occursw hena high proportionofnonnativ es peciesarepr esentandi si ndicativeofthedegradedconditionofthis vegetation.

Plantcommunities **CcJp** and **MpTl**comprisedsmallis olatedareaso fvegetationwith evidenceof disturbancea ndlownativespecies diver sity.These communitiesw ereconsidere dtoodegradedto assigntoanFCT.However,theyare likelytohaveoncealso resembledFCT11o r13.Â

Therelevantportionsofthecl usterdendrogramsshowingsimilarityto FCT13a ndFCT 11are providedin **AppendixD** .

Table7:Plantcommunities andlikelyFCT represented withinthesite foreachsam plep oint

Plant Community	Sample	MostsimilarGi bson *etal.* (1994)sit es	Similarity (%)	Floristicc ommunity type(FCT)	Reservationa nd conservationst atus (Gibson *etal.* 19 94).
MpTlBaLl	**Q1**	HYMUS01(FCT1 1)	25	FCT13:Deeper wetlandsonhea vysoils	Wellreserved Lowrisk
	Q2	BANK1A(FCT1 3)	13		
BaJp	**R2**	MCLART1(FCT 13)	25		
MpJfAf	**R4**	HYMUS01(FCT1 1)	20		
ErCcMr	**R1**	HYMUS05(FCT1 1)	21	FCT11:Wetforestsand woodlands	Wellreserved Lowrisk
	R5	ELLEN7(FCT6)	27		
		LOW10B(FCT11)	19		
	R6	LOW10B(FCT11)	25		

4.6 Threatened and priority ecological communities

Theintactnativevege tationin thesite r epresents FCT11andFCT 13,neitherof whichisassociated witha threa tenedorpriorityecological community. ThereforenoTECsorPECsoccur in thesite.

4.7 Other observations

Multiplematureeucalypttrees(diameter atbreastheightlargerthan 500mm)arepresentacross thesitewithinnonnativepasture andcroppingareas aswellasalo ngManjedalBrook.Thesetrees includei ndividualsof *Corymbiacalophy lla*(marri)and *Eucalyptusrudis* (floodedgum),aswellas multiplelargedeadeucalypttrees.Due totheir numberandsizeth esetreeshavethepotentialto provideforaging,roostingandnes tinghabitat forblackcocka toos(especiallyCarnaby'sblack cockatoo),alongwithotherecologicalservices.

4.8 Species richness and sampling adequacy

Atotalof58 specieswer erecordedfrom eightsamplelocations.Aspeciesaccumulationcurve derivedfromsampleda taispresentedin **Plate9** .Aftereightsamplesthecurve isstillincreas ingand hasnotrea chedits asymptote.Thisindicates thata proportionofspecies likelyr emainundetected bysampling.

Speciesrichnesswasestimatedin Primer6tobebetween82 (Jacknife1) and9 5(Chao2). B asedon thetrendofthespeciesaccum ulationcurveapproximately20 to30sampleswouldberequiredto capturethatmanyspecies .Including the28 additionalspecies recordedopportunistically, atotalof 86specieswasrecordedinthesite.Basedon thespeciesrichnessestimates, thisindicatesthat between86a nd105%ofthespeciesin thesitewer erecorded.Considering the'completely degraded'co nditionofthemajorityofthevegetatio n withinthes iteandthetimespentsampling andsearchingtheintactnativ evegetation,thesurveyeffort wasconsideredtobeadequate to prepareaco mprehensivespeciesinventory.

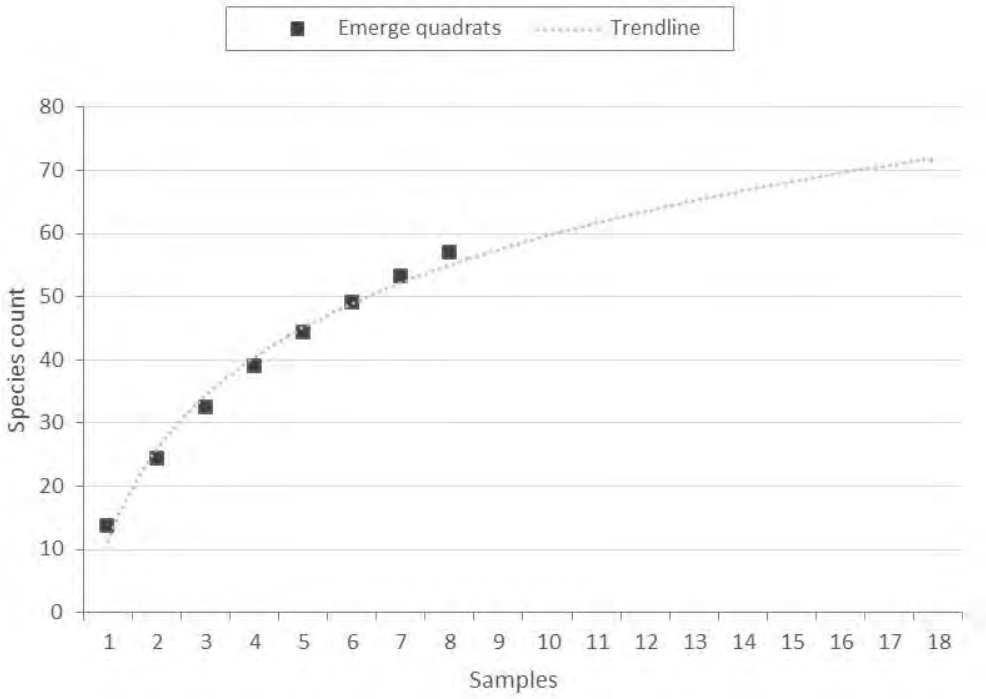


Plate9:Speciesaccumulationcurvederived fromsa mpledata(y= 21.014ln(x)+ 11.306, R^2= 0.9871)

5 Discussion

Despitetherelativelylargesize ofthes ite,the fields urveywasstr aightforwardtocomplete dueto thelimiteda mountofinta ctnativevegetationprese nt.Themajorityofsurveytimewasspent assessingthemoreinta ctnative vegetationalongMa njedalBrook andaround thesumplandsinthe easternportionofthe site.Atotal ofeighthourswa sspentin thesiteduringthecurrent survey, comparedtofourhoursovertwodays byPGVEnviro nmental.Spe ndingmoreti meon siteha slikely contributedtotherecordingofalarger species listd uringthecurrentsurvey andallowedfor a thoroughsearchforthreatenedandpri orityfloraspecies.

Nothrea tenedorpriority flo raspecieswererecorded during thecurrent surveyorthesurvey previouslyundertakenby PGVEnvironmental.The21 threatenedandpriority flora species thatw ere identifiedashavingthepotential tooccurinthe site typically gro wwithinorinassociationwith wetlandsandwinterwetareas.The vegetationalongManjedalBrook isunlikelytoprovidehabitat foranyofthe sespecies duetoi ts‘degra ded’conditio n.Therefore,theve getationassociatedwith theeasterns umplandswa sdeemedtohavethe greatestpo tentialtocontain threatenedorpriority species.

Theisolatedpatchesofwetland vegetationfringing thesumplandswere easytosearchduetotheir smallsizea ndsparsecover.Searchesin thelargerpa tchbe tweentheeasterns umplandandthesite boundary(pl antcommuni ty **MpTlBaLl**)werealsotho rough,espe ciallyinshallo wfringingareas. Accesswass omewhatlimitedinareaso fdeeper wa terandwher edensestandsof *Baumeaarticulata* werepresent. However,giventhe depthandapparent permanencyofthe openwaterandthe densityof thestandsof *B.articulata,* itishighly unli kelyanyofthe potentialthr eatenedorpr iority specieswer epresentinthesareas.Thesurvey timingwasappropriateformostofthetarget speciesandnosterileorunidentified specimenswer ecollecte dthatmighthave indicated thatan alternatives urveydate mighthavebeennecessary. Thereforeitisconsideredthatnothreatenedor priorityfloraspeciesoccur inthesite.

*Dielsiasteno stachya*islistedin *SignificantFlor aof theFoothill sandPinjarraPlain inthePerth MetropolitanRegion* asitisendemicto theSwanCoastalPlain(Go vernmentofWA2000b). As outlinedin **Section2.5** theSwanCoastalPlaincontainsa widevarietyofendemic flora.Therefore thisspeciesis significanta tabroadregionalorcontinental scale.Butits presencewithinthesite is notunusualgivenitoccursina varietyo fwetlandvege tationcommunitiesacro sstheSwanC oastal Plain.

Determinationofvegetati oncondi tioni schallenging whentheconditionofthe vegetationiscloseto theboundary oftwoclasses.Thisi s whycompoundcondition categoriessucha s‘goodtodegraded’ wereincludedin theresultsofthis survey.The vegetationin thesiteassigned compound co ndition categorieswaseither amosaicofconditionclasseso rdid notfittheKeighery(1994)condition categoriesduetoinconsistenciesr elatingtov egetationstructure,weedcovera nd/orspecies diversity.

Despitepr edominantlybeingpr esentindegradedconditionthe areas ofrelativelyinta ctnativ e vegetationalongMa njedalBrookandas sociatedwith theeasterns umplandwo uldbeconsidered locallyandregionallysignif icant. ManjedalBrookandthefar easternsumplandaremappedas

'conservation'categorywe tlands(referto **Section2.4**)andvegetationwithin thesefeaturesw illbe consideredto havehigher conservationvalue.The Shire ofSer pentineJarrahdaleisalsolikelyto considerthevegetationlocally significa ntforthefollowingreasons:

- Thevegetationislocatedw ithin theForr estfielda ndGuildford landformcomplexeswhichthe Shireidentifiesashaving beenextensivelyclearedinthelocal area(Del MarcoandPenna2008). Asoutline din **Section2.5** ,thePinjarra9 68associationisma ppedasreasonablywellretained andconserved(Beard *et al.*2013).How ever,atalo callevelthisv egetationma ybeconsider ed poorlyreserved.
- Thevegetationwould beconsideredparto falocal naturalarea(LNA).TheMa njedalBrook vegetationha sthepotentialt osupportCarnaby'sblackcocka tooandvegetatio nwithinboth areasincludesriparianvegetationandis contiguouswitha regional ecologicallinkage.
- ThevegetationalongManj edalBrookwouldalso be considereda'localecologicallinkage' under theShire's *LocalBiodiv ersityStrategy* .

6 Conclusions

Themajorityofthesiteis highlymodifiedand dominated bynonnativevegetationwithscattered nativetr ees.Relatively intactnativevegetationexists alongManjedalBrookandinassociationwith thesumplandinthefareaster nportio nofthesite.The bestconditionnativevegetationisassociated withthisfareasternsum pland,wherea sthevegeta tionalongM anjedalBrookhasbeensubj ectto extensivehistoricaldistur banceandhasanunderstorey tha tisdominatedby nonnativespecies.

Nothrea tenedorpriority flo raspecieswererecorded orconsider edlikelytooccur inthesite.

NoTECsorP ECsare presentinthesite.

Regardlessof condition,thenativevegetationpr esent alongManj edalBrookandassociated with the fareasternsumpland maybeconsideredlocally a ndregionallysignificantd uetothefollowing reasons:

- ManjedalBrookandthefa reasternsumpland arecategorizedas‘conservation’category wetlandsbyDPaW.
- Thesiteislo catedon landformassociationsthat theShireofSerpentineJarrahdalehas identifiedhavingbeen subj ectt oextensiveclearing.

TheShireofSerpentineJarrahdale islikelytoconsider vegeta tioni nthesareasaspartofa‘local ecologicallinkage’andlocalnaturalareas.

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Figures

Figure1:SiteLocality

Figure2:To pographyand Geomorphic Wetla nds

Figure3:Biodiversitylinkages,Bush ForeversitesandESAs

Figure4:PlantCommunities

Figure5:V egetationCo ndition

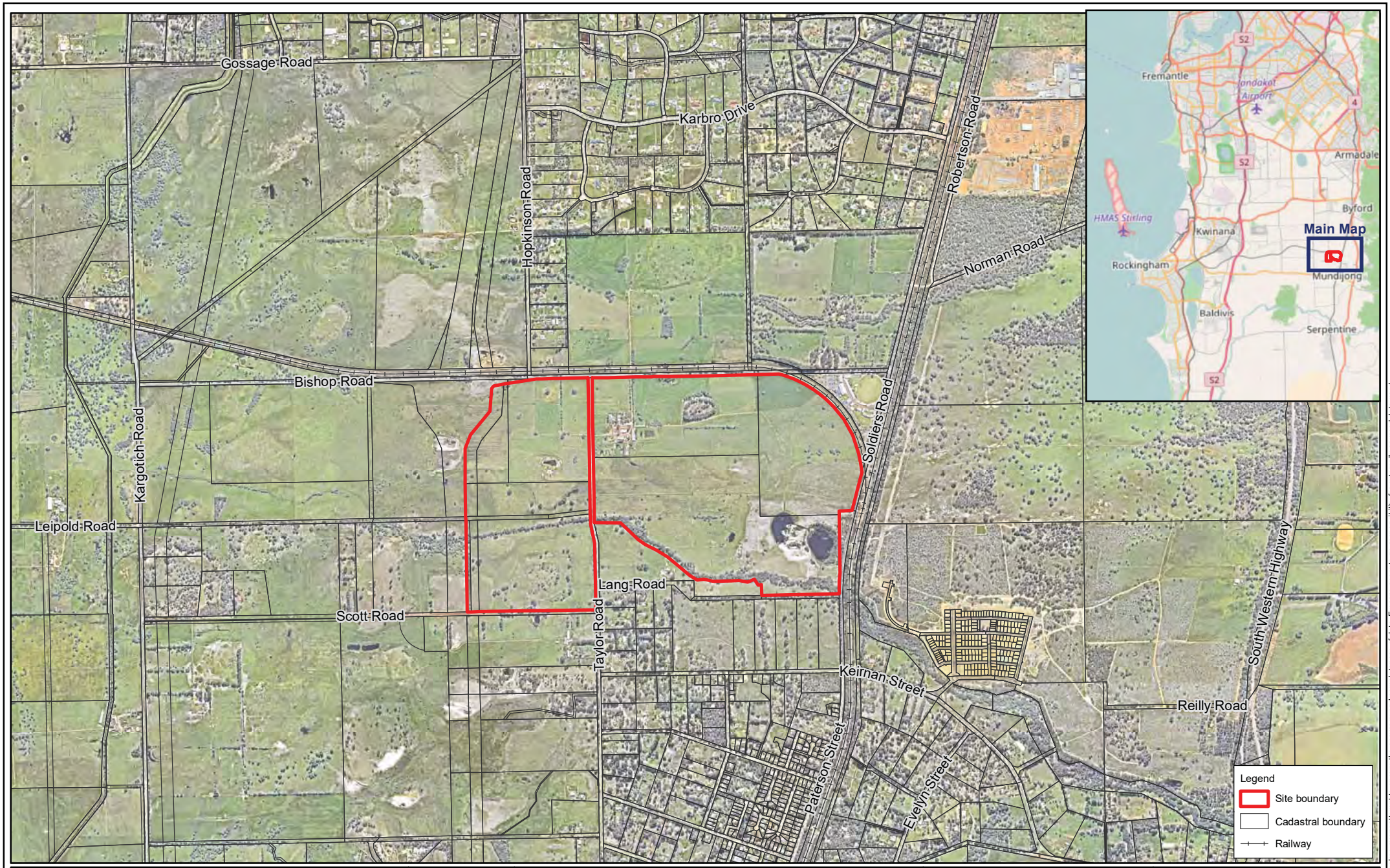


Figure 1: Site Locality

Project:	Flora and Vegetation Survey Taylor Road, Mundijong
Client:	Peet Mundijong Syndicate Ltd

Plan Number: EP15-036(06)--F55

Drawn:	RAO	Date:	12/01/2017
Approved:	TAA	Date:	20/01/2017
Checked:	TAA	Scale:	1:25,000@A4

0 250 500 1,000 Metres

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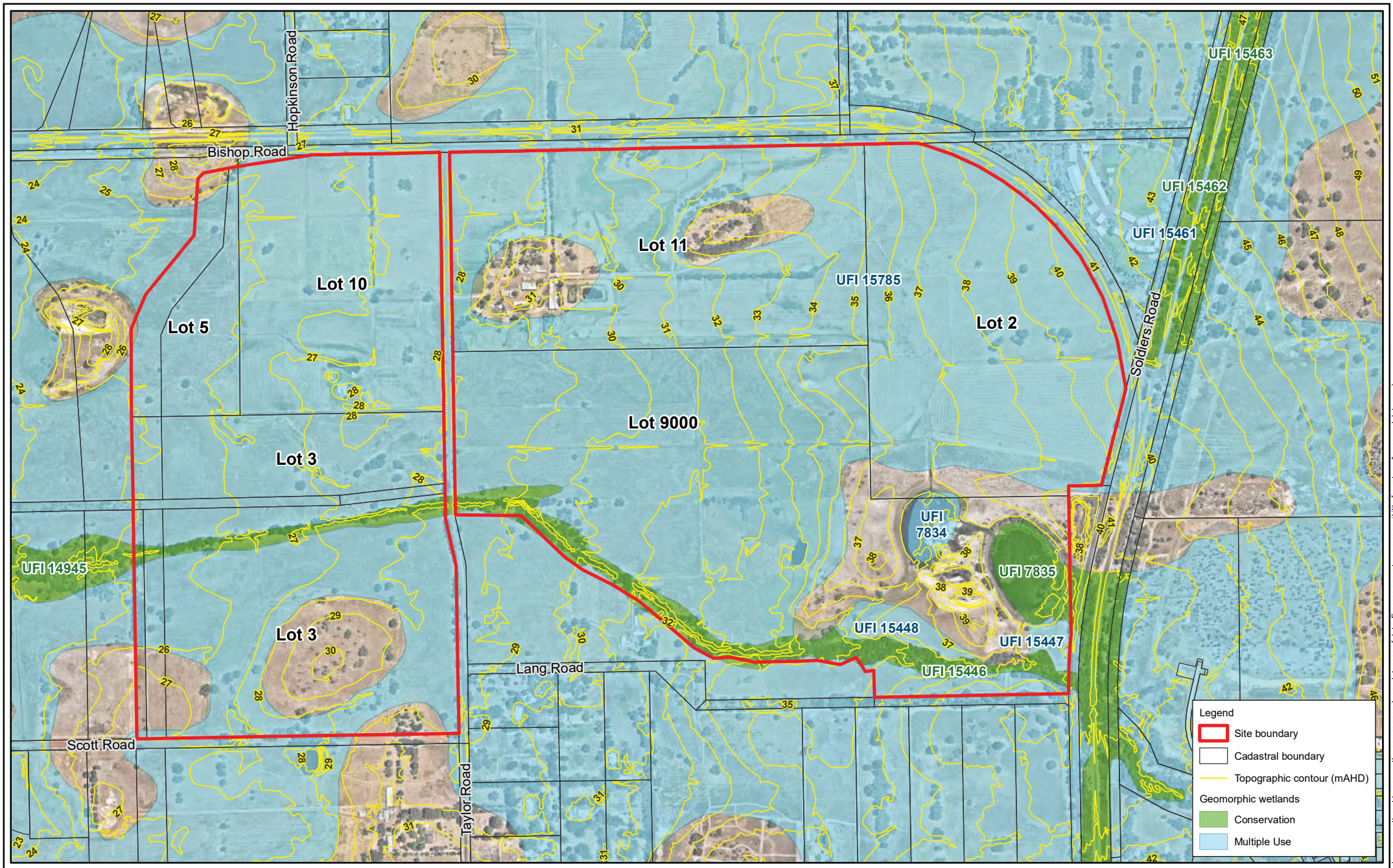


Figure 2: Topography and Geomorphic Wetlands

Project:	Flora and Vegetation Survey Taylor Road, Mundijong
Client:	Peet Mundijong Syndicate Ltd

Plan Number: EP15-036(06)--F56

Drawn:	RAO	Date:	12/01/2017
Approved:	TAA	Date:	20/01/2017
Checked:	TAA	Scale:	1:10,000@A4

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emerge ASSOCIATES
Integrated Science & Design

While Emerge Associates makes every attempt to ensure the accuracy and completeness of data, Emerge accepts no responsibility for externally sourced data used

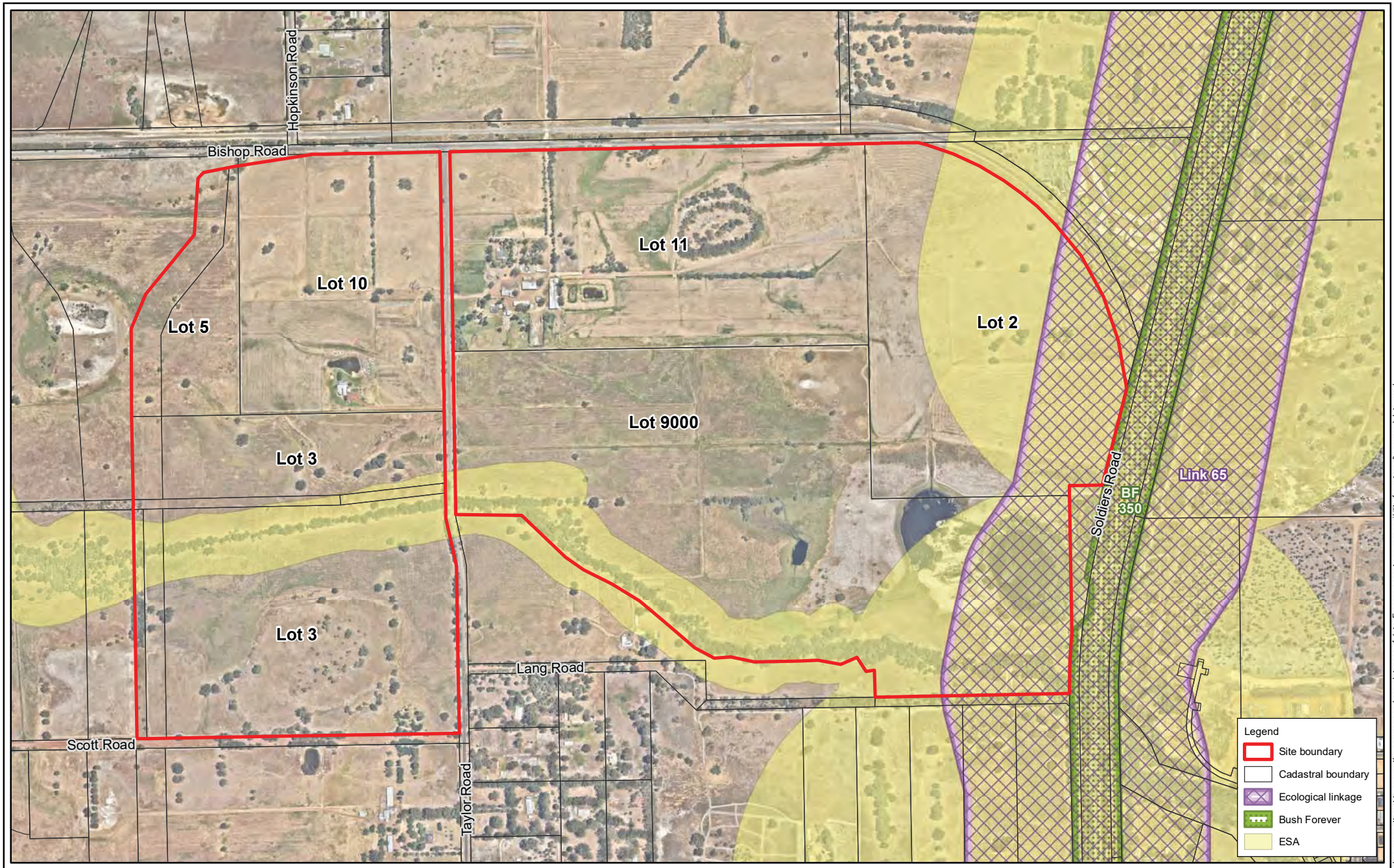


Figure 3: Ecological linkages, Bush Forever sites and ESAs

Project:	Flora and Vegetation Survey Taylor Road, Mundijong
Client:	Peet Mundijong Syndicate Ltd

Plan Number: EP15-036(06)--F57

Drawn:	RAO	Date:	22/03/2017
Approved:	TAA	Date:	22/03/2017
Checked:	TAA	Scale:	1:10,000@A4

0 100 200 400 Metres

emerge ASSOCIATES
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While Emerge Associates makes every attempt to ensure the accuracy and completeness of data, Emerge accepts no responsibility for externally sourced data used

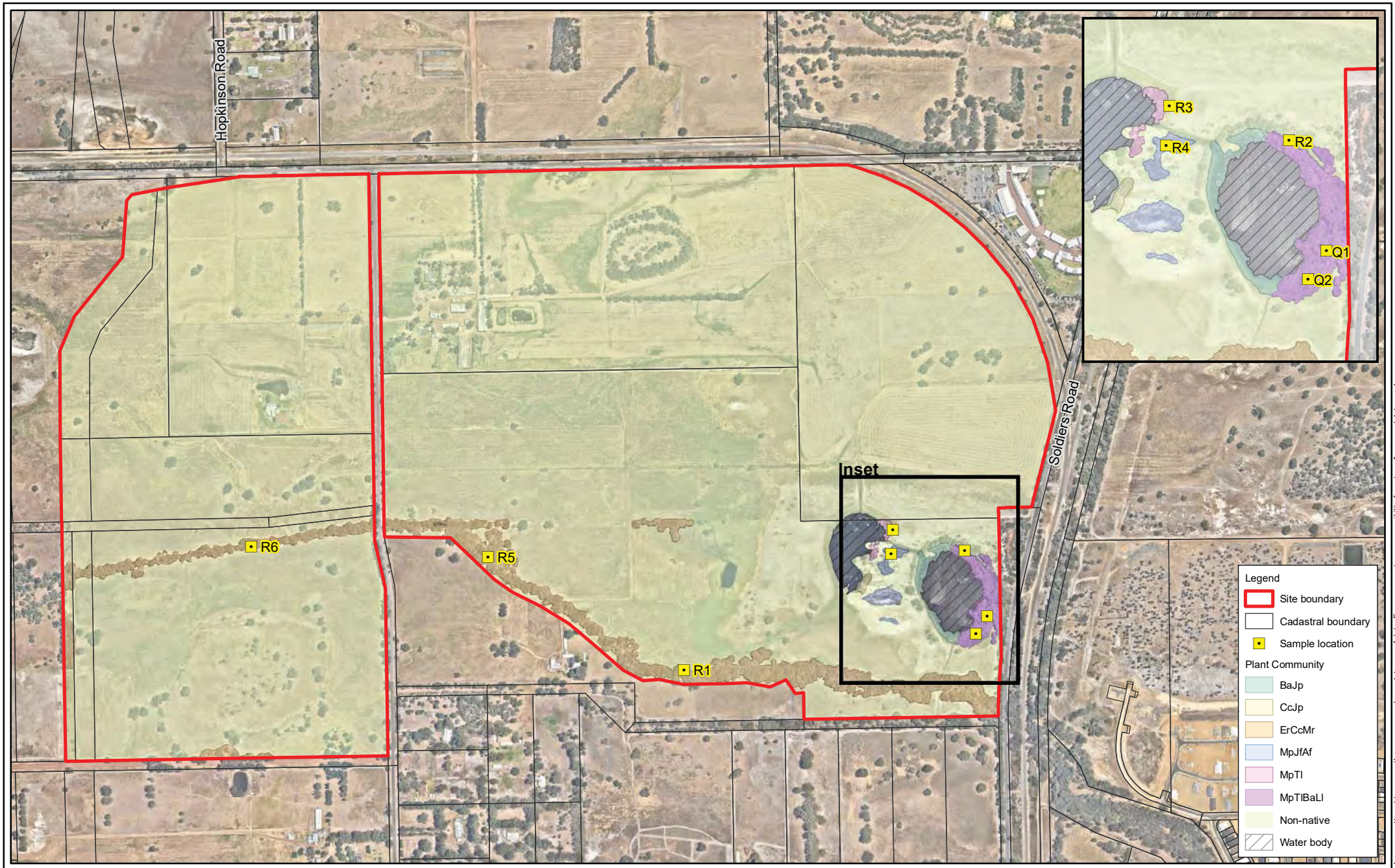


Figure 4: Plant Communities

Project:	Flora and Vegetation Survey Taylor Road, Mundijong
Client:	Peet Mundijong Syndicate Ltd

Plan Number: EP15-036(06)--F58

Drawn:	RAO	Date:	12/01/2017
Approved:	TAA	Date:	20/01/2017
Checked:	TAA	Scale:	1:10,000@A4

0 100 200 400 Metres

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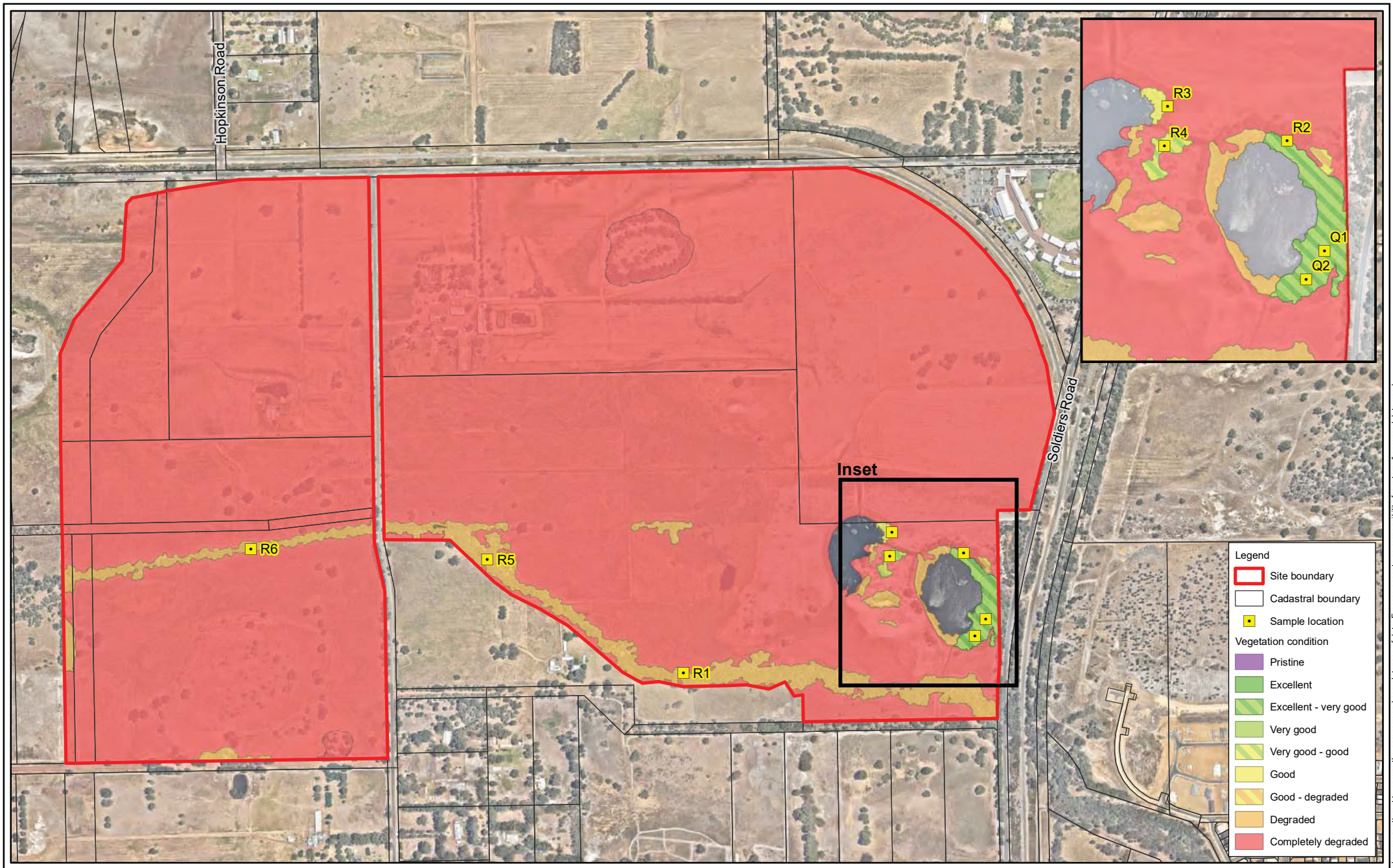


Figure 5: Vegetation Condition

Project: Flora and Vegetation Survey
Taylor Road, Mundijong

Client: Peet Mundijong Syndicate Ltd

Plan Number: EP15-036(06)--F59

Drawn:	RAO	Date:	12/01/2017
Approved:	TAA	Date:	20/01/2017
Checked:	TAA	Scale:	1:10,000@A4

0 100 200 400 Metres

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Appendix A

Additional Background Information

Conservation Significant Flora and Vegetation

Threatened and priority flora

Floraspeciesconsidered rareorunderthreat warrant specialprotectionunderCommonwealth and/orStatel egislation.Atthe Commonwealthlevel,floraspecies canbelistedunder the *EnvironmentProtection andBiodiversity ConservationAct1999* (EPBCAct).Floraspecies can be considered‘threatened’pursuanttoSchedule 1ofthe EPBCA ctandlisted aseither ‘criti cally endangered’(CE), ’endangered’(E)or‘v ulnerable’(V).

InWesternA ustralia,plantspeciesmay b eclassed‘threatened’o r‘priority’underthe *Wildlife ConservationAct1950* (WCAct),enforcedbyDepartmentof Parksa ndWildlife(D PaW).Priorityflora speciesarepotentiallyrar eorthr eatenedand areclassifiedinorderofthreat.Threatenedand priorityfloracategorydefinitions arelistedin **Table1** .Thr eatenedfloraspeciesaregaze ttedunder subsection2ofsection23 FoftheWCA ct and thereforeitisa noffenceto“take”ordamagerare florawithoutMinisterialapproval.Section23Fofthe Actdefines“totake”as“… togather,pluck,cut, pullup,destroy,digup,removeo rinjur ethefloratocauseorpermit thesametobedonebyany means”.

Table1:Defini tionofthr eatened andpriorit yfloraspeciesunder theWC Act(Smith2010).

ConservationCode	Category
T	ThreatenedFlor a–ExtantTaxa Taxawhichhavebeenadequ atelysearchedfora ndaredeemed t obeinthewildeitherrare,in dangerof extinction,orotherwis einneed ofsp ecialprote ction,andhavebeengazettedassuch.
X	ThreatenedFlor a–Presumed ExtinctTaxa Taxawhichhavenotbeencollected,orotherwise verified,overthepast50y ears despitethorough searching,orofwhichallkno wnwildpopulations havebeen destroyedmorerecently,andhave been gazetteda ssuch.
P1	PriorityOne–PoorlyKnownTaxa Taxawhichareknownfromone orafew(gener ally<5)populations whichareunderthreat,either duetosmallpop ulationsize,orb eingonlands underimmediatet hreate.g.road verges,urban areas, farmland,activemineralleasesetc.,ortheplants are underthreat,e.g.fromdise ase,grazingbyferal animalsetc.Mayincludetaxawiththreatenedpopulations onprotectedlands.Suchtaxaareunder considerationfordeclarationas‘rareflora’, buta reinurgentneedoffurthersurv ey.
P2	PriorityTwo–PoorlyKnownTaxa Taxawhichareknownfromoneor afew(generally<5)populations,atleastsomeofwhicharenot believedtobe underimmediate threat(i.e. notcurrentlyendangered).Suchtaxa areunder considerationfordeclarationas‘rareflora’, butu rgentlyneed furthersurvey.
P3	PriorityThree–PoorlyKnownTaxa Taxawhichareknownfromseveralpopulations, and thetaxaarenotbelievedto beunder immediatethreat(i.e.notcurren tlyendangered),ei therduetothenumb erofkno wnpopulations (generally>5),o rknownpopulationsbeinglarge, andeitherwidespreadorprotected.Suchtaxaar e underconsiderationfordeclarationas‘rareflora’butneed sfurth ersurvey.
P4	PriorityFour–RareTaxa Taxawhichareconsideredtoha vebeenad equatelysurveyedan dwhich,whilstbeingrare(in Australia),aren otcurrentlythre atenedby anyidentifiable factors.Thesetaxarequiremonitoring every510years.

NotethattheWCActisexpectedt oberepealedsometimein201 7andwillbereplacedby the *BiodiversityConservationAct2016* (BCAct).The BCActincl udesupdate dprov isionsforthe managementofthrea tenedfloraalongwithincre asedpenaltiesa ndre quirementsforreporting, managementprogrammes andrecoveryplans.TheBCAct wasonlyrecentlygra ntedRoyalas senton 21September2016.Currently,mostoftheprovisions of theBCActhavenot comeintoeffectand untiltheydo, theWCA ctwillc ontinuetogui de themanagementofthrea tenedflorainWestern Australia.

Threatened and priority ecological communities

'Threatened ecologicalco mmunities' (TECs)arerecognisedasecologicalcom munitiesthatarerare orunder threatandtheref orewarrants pecialprotection.SelectedTECsareaffordedstatutory protectionataCommonw ealthlevelundersection1 81of theEPB CAct.TECsnominated forlisting undertheEP BCActareco nsideredb ytheThreatened SpeciesScientific Committeeandafinal decisionis madeby the Ministerofthe Environme nt. Oncelis tedu nderthe EPB CAct,communities arecategorisedaseither'criti callyendangered','endangered' or 'vulnerable'.Anyactionlikelyto haveasignificant impa ctonacommu nitylistedunder theEPBCActrequires approvalfromthe CommonwealthMinis terfortheEnviro nment.

WithinWesternAustraliaTECsaredeter minedby theWesternAus tralianThreatened Ecological CommunitiesScientificAdvisoryCommittee (WATECSAC)andendorsedbytheMinisterforthe Environment. TheWATECSACisan independentgroupcom prisedofrepresenta tivesfrom organizationsincl udingter tiaryinsti tutions,theWesternA ustralianMuseumandDepartment of ParksandWildlife(DPaW). TECsare assignedtooneofthe categoriesoutlinedin **Table2** according totheirstatus(inrelationto thelevelofthreat). CurrentlyTECsarenotaffordeddirectstatutory protectionatastatelevela ndtheirsigni ficanceisacknowledgedthroughother stateenvironmental approvalprocessessuch a s'environmentalimpact assessment'pursuanttoPartIVofthe *EnvironmentalProtectionAct1986* (EP Act) andthe *EnvironmentalProtection(Clearin gof Native Vegetation)Regulations20 04*.Â

Table2:Categoriesofthr eatenedecol ogicalcommunities (Englisha ndBlyth1997;DEC2009a).

Conservationca tegory	Description
PD	PresumablyTotallyDestroyed Anecologicalcommunitythatha sbeenadequately searchedforb utforwhichnorepresentative occurrenceshavebeenlocated.
CE	Critically Endangered Anecologicalcommunitythatha sbeenadequately surveyed andi sfoundtob efac ingan extremelyhighr iskoftotaldestructionintheim mediatefuture.
E	Endangered Anecologicalcommunitythatha sbeenadequately surveyed andi snotcriticallyendangeredbut isfacingaveryhighriskoftotal d estructioninthenearfuture.
V	Vulnerable Anecologicalcommunitythatha sbeenadequately surveyed andi snotcriticallyendangeredor endangeredb utisfacingahighriskoftotald estructionorsignificantmodification inthemedium tolongtermfuture.

Inadditiontolisting asaTEC,a plantcommunityma ybelisted asa‘priorityecologicalcommunity’ (PEC).Thisisanecologicalcommu nitythatisunder considerationforlisting asaTEC,butdo esnot yetmeetsurveycriteriaorhasnotbeen adequatelydefined.PECs areca tegorisedaspriority category1,2 or3(thesearedescri bedi n**Table3**).Ecologicalcommunitiesthatareadequately knownandarerarebutnotthreatened, ormeet criteriafor‘nearthreatened’, orthathavebeen recentlyremovedfromthethr eatenedlist,arepla cedin‘priority 4’.Theseecologicalco mmunities requirer egularmonitoring.Conservationde pendent ecologicalco mmunitiesareplacedi n‘priority5’ (DEC2009a).

Table3:Categoriesofpriorit yecol ogicalcommunities (DEC2009a).

Prioritycategori es	Description
P1	PriorityOne Ecologicalcomm unitieswithapparentlyfew,sma lloc currences,allormostnotactivelymanagedfor conservation(e.g.withinagriculturalorpastorallands, urbanareas, activemineralleases)andfo r whichcurrentth reatsexist.Com munitiesmaybeinclude diftheyarecomparativelywellknownfrom oneormorelocalitiesbutdonotmeetadequacy ofsurveyrequirements,and/or arenotwell defined,and appeartobeund erimmediatethreatfromknownthreateningprocessesacrossthei r range.
P2	PriorityTwo Communitiesthatareknownfromfewsmalloccurrences, allor mostofwhichareactivelymanaged forconservation(e.g.withinnationalparks, conservationparks,naturereserves,Stateforest, unallocatedCrownland,waterreserve s,etc.)and notunderim minentthreatof destructionor degradation.Co mmunitiesmay beincludediftheyarecomparat ivelywellknown fromoneormo re localitiesbutdonotmeetadequ acyofsurveyr equirements,and /orarenotwell defined,and appear tobeunderthreatfromknownthreateningprocesses.
P3	PriorityThree Communitiesthatareknownfromsev eraltomany occurrences,asignificantnumberorareaof whicharenotunderthreatofhabitatdestructio nordegradationor: (i) communitiesknownfromafewwidespreadoccurrence s,whichareeitherlargeorwithin significantremainingareasof habitatinwhichother occurrencesmayoccur,muchofitnotunder imminentthreat,or; (ii)communitiesmadeupo flarge,and/orwidespread occurrences,thatmayor notberepresented inthereserve system,butareun derthreatofmo dificationacrossmuchoftheirrangefrom processes sucha sgrazingbydom estic and/orferalstock,andinap propriatefireregimes. Communitiesm aybeincludediftheyarecomparativelywell kno wnfromseveral localitiesbutdonot meetadequacy ofsurveyrequirementsa nd/orarenot welldefined,andknownt hreatening processes existthatcouldaffectthem.
P4	PriorityFour Ecologicalcomm unitiesthatareadequatelykno wn,rarebutnotthreatenedor meetcriteriafor Near Threatenedort hathaveb eenr ecentlyremoved fromthethreatenedlist.Thesecommunitiesrequire regularmonitoring.
P5	PriorityFive Ecologicalcomm unitiesthatarenotthreatened butare subj ecttoaspecificconservationprogram, thecessationof whichwouldresultin thecommunitybecomingthreatenedwithinfiveyears.

NotetheBCAct,previouslyintroduce din **Section1** , doesincl udeprovisions forthe mana gementof TECs,aswellas,penaltiesforimpacting TECSand requirementsfor reporting,management programmesandrecoveryplans.Thepr ovisionsoftheBC ActrelatingtoTECs havenotyetcome intoeffect andun til theyd othe manag ementofT ECswillcontinuetobeguidedby existing environmentalapprovalprocesses.

Weeds

Anumberof legislativeandpolicy documents existinrelationtoweedmanag ementatstateand nationallevels.The *BiosecurityandAgricultur eManagementAct2 007* (BAMAct)isthepri nciple legislationguiding weedmanagementinWester nAustralia andlis tsdeclaredpestspecies.A ta nationallevel,theAustraliangovernment hascompiledalistof 32Weedsof NationalSignificance (WoNS),ofw hich manyarealso listed undertheBAMA ct.

Declared Pests

Part2.3.23of theBAMAct requiresapersonmustnot;" *a)keep,br eedorcultivate thedeclar edpest; b)keep,br eedorcultivateananimal,pl antor otherthingthatisinfectedo r infestedwiththe declaredpest;c)releasei ntotheenviro nmentthe declaredpest,o rananimal, plantoro therthing thatisinfectedorinf estedwiththe declaredpest;or d)intentio nallyinfectorinf est,orexposeto infectionor infestation,aplant,animal o rotherthingwith adeclaredpest "*.

UndertheBAMA ct,all de claredpests areplacedi n oneofthreecategories,na melyC1(excl usion), C2(eradi cation)orC3(ma nagement).Theseca tegoriesaredes cribedf urtheri n **Table4** .TheWester n AustralianOr ganismList(WAOL)providesthestatus oforganismswhichhave beencategorised underthe BAMA ct(DAFW A2016).

Table4:Categoriesofdeclaredpestspecies und ertheBAMAct (DAFWA2016).

Category	Description
C1	Exclusion Notestablishedi nWesternAustr alia andcontrol measuresareto betaken,includingborder checks,inorder topreventthem enteri ngand establishingintheState.
C2	Eradication PresentinWesternAustraliainlowenoughnu mbersorinsufficiently limitedareasthattheir eradicationisstillapossibility.
C3	Management EstablishedinWestern Australiabutitisfeasible,or desirable, tomanage theminordertolimit theirdamage.Controlmeasures canpreventaC 3pest fromincreasinginpopula tionsizeor densityormovingfromanareai nwhichitisestablis hedintoanareawhichcurre ntlyisfreeofthat pest.

Wetland Habitat

Geomorphic wetland types

Thegeomorphicwetlandclassificationsystemof Semeniuk(1987)i sarecognisedclassificatio n systemforthesouth westof WesternA ustralia.TheSemeniuksystem usesthelandformshapeand waterper manence(hydro period)toca tegorisewetl ands.

Table5:Wetla ndt ypesdefin ed withintheg lobalg eomorphic classificationsys tem(DEC2009b).

-	Basin	Flat	Channel	Slope
Permanentlyinundated	Lake	-	River	-
Seasonallyinun dated	Sumpland	Floodplain	Creek	-
Seasonallywaterlogged	Dampland	Palusplain	-	Paluslope

Wetland management categories

DPaWmainta insthe *GeomorphicWetlandoftheSwanCoastalPlain* dataset,whichalsocategorises individualwe tlandsinto specific managemen tcategoriesasdescr ibedi n **Table6** .

Table6:Geom orphicWetlandsof the SwanCoastalPlainmanagementc ategories(Hilletal.1996).

Managementca tegory	Descriptionof wetland	Managementobjectiv es
Conservation(CCW)	Supporthighlevelsof attributes	Preservewetlandattributesand functionsthroughreservationin nationalparks, crownreservesa ndstateownedl and.Protection providedunder environmentalprotectionpolicies.
Resourceenhan cement (REW)	Partlymodified but stillsupporting substantialfunctions andattributes	Restorewetlandthroughmaintenanceand enhancementof wetlandfunctionsandattributes.Protectionvia crownreserves, stateorlocalgovernmentownedland,environmentalprotection policies andsu stainablemanag ementonprivate properties.
Multipleuse(M UW)	Fewwetland attributesbutstill provideimportant hydrological functions	Use,developm entandmana gementconsideredinthecontextof water,townandenvironmental planningthroughlandcare.

Themanage mentca tegoriesofwetlandsared eterminedbasedonhydrological,biologicaland humanusefeatures.Thisdynam icdatas etiscontinua llyupdatedwithsite specificwetlandsurveys providingnewandrelevantinformatio n.Theguid elinesforpropo singchangestothewetland boundariesa ndmanagementcate goriesstatethatrelevantinformat ionshouldbeobtainedin the optimalseas onforvegeta tionconditio nandwaterlev els,whichisusuallyspring (DEC2009 b).Each classifiedwetlandlistedinthe *GeomorphicWetlandofth eSwanC oastalPlain* datasetisgivena ‘uniquefeatureidentifier’(UFI).However inthecaseoflargerwetl andstha thav eundergone a degreeofdis turbance,as eparatemanagementcategorymay beassignedtopartsof thewetlandin ordertoreflectthecurrentvalues.

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Appendix B

Species List

FloraSpec iesListT aylorRoad,Mundij ong

Note:*denotesintroducedw eedspecies

Family		*Species*
Amaranthaceae		
		Alternantheranodiflor a
Apiaceae		
		Centellaasiatica
Apocynaceae		
	*	*Gomphocarpusfr uticosus*
Araceae		
		Lemna dispersa
	*	*Zantedeschiaaethiopica*
Asparagaceae	*	
		Asparagusaspar agoides
Asteraceae		
	*	*Arctothecacalendula*
	*	*Conyzabonar iensis*
	*	*Cotulacor onopifolia*
		Helichrysumluteoalbum
	*	*Hypochaerisglabr a*
	*	*Hypochaerisr adicata*
	*	*Lactuca serriola*
	*	*Sonchusoleraceus*
	*	*Ursiniaanthemoides*
Campanulaceae		
		Lobeliaanceps
	*	*Wahlenbergiacapensis*
Casurinaceae		
		Allocasuarinafr aseriana
Colchicaceae		
		Burchardiacongesta
Cyperaceae		
		Baumeaar ticulata
		Baumeajuncea
		Bolboschoenuscaldwelli i
	*	*Cyperustenuiflor us*
	*	*Isolepispr olifera*
		Lepidospermalongitudinale
Fabaceae		
	*	*Acacialongifolia*

FloraSpec iesListT aylorRoad,Mundij ong

Note:*denotesintroducedw eedspecies

Family		*Species*
		Acaciapulchella var. *pulchella*
		Acaciasaligna
	*	*Chamaecytisuspalmensis*
	*	*Lotussubbiflor us*
	*	*Lupinuscosentini i*
	*	*Trifoliumcampestr e*
	*	*Viciasativa*
		Jacksoniafur cellata
		Jacksoniaster nbergiana
Geraniaceae		
	*	*Geraniumdissectum*
Haemodoraceae		
		Conostylisaculeata
Iridaceae		
		Patersonia occidentalis
	*	*Romulearosea*
Juncaceae		
	*	*Juncusbufonius*
		Juncuspallidus
Juncaginaceae		
		Cycnogetonlinear e
Lythraceae		
	*	*Lythrum hyssopifolia*
Moraceae		
	*	*Ficuscar ica*
Myrtaceae		
		Astarteafascicular is
		Corymbiacalophylla
		Eucalyptusm arginata
		Eucalyptusr udis
	*	*Eucalyptussp.*
		Kunzeaglabr escens
	*	*Leptospermum laevigatum*
		Melaleucapr eissiana
		Melaleucar haphiophylla
		Taxandrialinear ifolia
Orchidaceae		
		Microtismedia

FloraSpec iesListT aylorRoad,Mundij ong

Note:*denotesintroducedw eedspecies

Family		*Species*
Orobanchaceae		
	*	*Parentucellialatifolia*
Oxalidaceae		
	*	*Oxalispescapr ae*
	*	*Oxalispur purea*
Poaceae		
	*	*Anthoxanthumodor atum*
	*	*Brizama xima*
	*	*Brizaminor*
	*	*Bromusdiandr us*
	*	*Bromushor daceus*
	*	*Cynodondactylon*
	*	*Ehrhartacalycina*
	*	*Ehrhartalongiflor a*
	*	*Eragrostiscur vula*
	*	*Holcuslanatus*
	*	*Hordeumlepor inum*
	*	*Loliumper enne*
	*	*Loliumr igidum*
	*	*Panicumcapillar e*
	*	*Paspalumdilatatum*
	*	*Pennisetumclandestinum*
	*	*Poa annua*
Polygonaceae		
		Rumexacetosella
	*	*Rumexcrispus*
Proteaceae		
		Banksia attenuata
		Banksiailicifolia
		Xylomelumoccidentale
Ranunculaceae		
	*	*Ranunculustr ilobus*
Restionaceae		
		Dielsiastenostachya
		Leptocarpusscar iosus
Rosaceae		
	*	*Rubusulmifolius*
Solanaceae		
	*	*Solanum nigrum*

Appendix C

Sample Data

SiteDetails			
Locality	EP15036	PhotoNo.	119,120
Date	18/11/2016	Photodirection	SE
Author	RAO	Geographicdatumandzone	GDA94 50
Samplingunit	Quadrat	Easting	404888
Samplenumber	1	Northing	642840

GeographicandHabitatData			
Aspect	flat	Hydrology	saturated,standingwater
Slope	-	AdjacentVegetation	same/water
Topographicposition	low	VegetationCondition	VGE
Altitude(m)	41	Timesincefire	noevidence
Bareground%	20	Disturbance	moderate
Soiltype/texture	peatysand	Rocktype	N/A
Soilcolour	brownblack	Rock%	-
Microclimate	-	Littertypeand%	leaves,twigs,branches,30%

VegetationDescription

Lowwoodland *Melaleucapreissiana* overtallshrubland *Taxandralinearifolia* oversedgeland *Baumea articulata/Lepidospermalongitudinale* overopenforbland *Cycnogetonlineare* .



Q1SpeciesData							
Coll.No.		**Species**	**Layer**	**LifeForm**	**Height**	**Habit**	**%Cover**
		Taxandrialinearifolia					50
8		*Leptocarpusscariosus*					30
		Melaleucapreissiana					40
	*	*Acacialongifoli a*					30
		Lepidospermalongitudinale					20
		Baumeaarticulata					10
		Cycnogetonlineare					10
9		*Alternantheranodiflora*					+
11	*	*Anthoxanthumodoratum*					+
12		*Astarteafascicularis*					+
		Centellaasiatica					+
10	*	*Cyperustenuiflorus*					+
	*	*Ficuscarica*					+
	*	*Rubusulmifolius*					+
		Dielsiastenostachya					opp
	*	*Hypochaerisglabra*					opp
		Microtismedia					opp
		Eucalyptusrudis					opp

Note:+=lessthan1%cover,*=nonnativespecies

SiteDetails			
Locality	EP15036	PhotoNo.	265
Date	18/11/2016	Photodirection	SE
Author	RAO	Geographicdatumandzone	GDA94 50
Samplingunit	Quadrat	Easting	404867
Samplenumber	2	Northing	6428386
GeographicandHabitatData			
Aspect	flat	Hydrology	saturated,surfacewater
Slope	-	AdjacentVegetation	same
Topographicposition	low/wetlandedge	VegetationCondition	GVG
Altitude(m)	39	Timesincefire	noevidence
Bareground%	<1	Disturbance	moderate
Soiltype/texture	peatysand	Rocktype	N/A
Soilcolour	brown	Rock%	-
Microclimate	-	Littertypeand%	leaves,logs,90%
VegetationDescription			

Lowwoodland *Melaleucapreissiana* overtallclosedshrubland *Taxandralinearifolia* oversedgeland *Baumeaarticulata/Lepidospermalongitudinale.*



Q2SpeciesData							
Coll.No.		**Species**	**Layer**	**LifeForm**	**Height**	**Habit**	**%Cover**
		Taxandrialinearifolia					70
		Melaleucapreissiana					25
	*	*Acacialongifoli a*					5
	*	*Eucalyptus* sp.					3
		Baumeaarticulata					1
		Lepidospermalongitudinale					+

Note:+=lessthan1%cover,*=nonnativespecies

SiteDetails			
Locality	EP15036	PhotoNo.	1719
Date	18/11/2016	Photodirection	multiple
Author	RAO	Geographicdatumandzone	GDA94 50
Samplingunit	Relevé	Easting	404273
Samplenumber	1	Northing	6428309

GeographicandHabitatData			
Aspect	-	Hydrology	saturatedincreek,standingwater
Slope	steepbanks	AdjacentVegetation	pasture
Topographicposition	low/creekline	VegetationCondition	D
Altitude(m)	3229	Timesincefire	noevidence
Bareground%	40	Disturbance	highcows,weeds
Soiltype/texture	sandyloam	Rocktype	N/A
Soilcolour	greybrown	Rock%	-
Microclimate	-	Littertypeand%	twigs, branches,20%

VegetationDescription

Lowopenforest *Eucalyptusrudis* and*Corymbiacalophylla* overtallopenshrubland *Melaleuca rhaphiophylla* overopenforbland* *Alternantheranodiflora* increekbedandclosedgrassland* *Ehrharta calycina* onbanksofcreek.



R1SpeciesData							
Coll.No.		**Species**	**Layer**	**LifeForm**	**Height**	**Habit**	**%Cover**
		Acaciapulchella var.*pulchella*					opp
		Alternantheranodiflora					opp
	*	*Arctothecacalendula*					opp
	*	*Asparagusasparagoides*					opp
	*	*Bromusdiandrus*					opp
	*	*Bromushordaceus*					opp
		Corymbiacalophylla					opp
	*	*Ehrhartacalycina*					opp
	*	*Ehrhartalongiflora*					opp
		Eucalyptusmarginata					opp
		Eucalyptusrudis					opp
	*	*Ficuscarica*					opp
	*	*Geraniumdissectum*					opp
	*	*Hordeumleporinum*					opp
	*	*Hypochaerisglabra*					opp
	*	*Isolepisprolifera*					opp
	*	*Juncusbufoniu s*					opp
		Juncuspallidu s					opp
		Lemnadispersa					opp
	*	*Loliumrigidum*					opp
	*	*Lotussubbiflorus*					opp
	*	*Lythrumhyssopifolia*					opp
		Melaleucarhaphiophyll a					opp
	*	*Oxalispurpurea*					opp
	*	*Poaannua*					opp
	*	*Ranunculustrilobus*					opp
	*	*Rubusulmifolius*					opp
		Rumexacetosella					opp
	*	*Rumexcrispus*					opp
	*	*Solanumnigrum*					opp

Note:+=lessthan1%cover,*=nonnativespecies

SiteDetails			
Locality	EP15036	PhotoNo.	161,162
Date	18/11/2016	Photodirection	NW/E
Author	RAO	Geographicdatumandzone	GDA94 50
Samplingunit	Relevé	Easting	404843
Samplenumber	2	Northing	6428555

GeographicandHabitatData			
Aspect	flat	Hydrology	saturated
Slope	-	AdjacentVegetation	planted *Eucalyptus* spp.
Topographicposition	low/wetland	VegetationCondition	D
Altitude(m)	45	Timesincefire	noevidence
Bareground%	3	Disturbance	moderate
Soiltype/texture	peatysand	Rocktype	N/A
Soilcolour	blackbrown	Rock%	-
Microclimate		Littertypeand%	Leaves,30%

VegetationDescription

Openshrubland *Agonislinearifolia* overclosed sedgeland *Baumeaarticulata* and*Isolepisprolifera.*



R2SpeciesData							
Coll.No.		**Species**	**Layer**	**LifeForm**	**Height**	**Habit**	**%Cover**
	*	*Acacialongifoli a*					opp
	*	*Anthoxanthumodoratum*					opp
		Baumeaarticulata					opp
		Bolboschoenuscaldwelli i					opp
	*	*Cynodondactylon*					opp
	*	*Cyperustenuiflorus*					opp
		Helichrysumluteoalbum					opp
	*	*Hypochaerisglabra*					opp
	*	*Isolepisprolifera*					opp
		Juncuspallidu s					opp
		Lepidospermalongitudinale					opp
		Lobeliaanceps					opp
	*	*Lotussubbiflorus*					opp
	*	*Paspalumdilatatum*					opp

Note:+=lessthan1%cover,*=nonnativespecies

SiteDetails			
Locality	EP15036	PhotoNo.	205208
Date	18/11/2016	Photodirection	multiple
Author	RAO	Geographicdatumandzone	GDA94 50
Samplingunit	Relevé	Easting	404698
Samplenumber	3	Northing	6428597

GeographicandHabitatData			
Aspect	flat	Hydrology	nearsaturation/inundated
Slope	-	AdjacentVegetation	pasture
Topographicposition	low/wetland	VegetationCondition	G
Altitude(m)	48	Timesincefire	noevidence
Bareground%	1	Disturbance	moderate
Soiltype/texture	peatyclay	Rocktype	N/A
Soilcolour	browm	Rock%	-
Microclimate	-	Littertypeand%	leaves,twigs,branches,70%

VegetationDescription

Openwoodland *Melaleucapreissiana* overclosedshrubland *Taxandrialinearifolia* oversparseforbland.



R3SpeciesData							
Coll.No.		**Species**	**Layer**	**LifeForm**	**Height**	**Habit**	**%Cover**
	*	*Brizamaxima*					opp
	*	*Brizamino r*					opp
	*	*Ehrhartacalycina*					opp
	*	*Ehrhartalongiflora*					opp
	*	*Isolepisprolifera*					opp
		Juncuspallidu s					opp
		Kunzeaglabrescens					opp
		Lemnadispersa					opp
	*	*Lotussubbiflorus*					opp
		Melaleucapreissiana					opp
		Taxandrialinearifolia					opp

Note:+=lessthan1%cover,*=nonnativespecies

SiteDetails			
Locality	EP15036	PhotoNo.	310
Date	18/11/2016	Photodirection	E
Author	RAO	Geographicdatumandzone	GDA94 50
Samplingunit	Relevé	Easting	404693
Samplenumber	4	Northing	6428548

GeographicandHabitatData			
Aspect	flat	Hydrology	saturated,surfacewater
Slope	-	AdjacentVegetation	openpasture
Topographicposition	low	VegetationCondition	GVG
Altitude(m)	42	Timesincefire	noevidence
Bareground%	30	Disturbance	low
Soiltype/texture	loamysand	Rocktype	N/A
Soilcolour	blackbrown	Rock%	0
Microclimate	-	Littertypeand%	leaves,twigs,2%

VegetationDescription

Isolated*Melaleuca preissiana* treesovershrubland *Agonislinearifolia* and *Astarteafascicularis* over sparserushland *Juncuspallidus.*



R4SpeciesData							
Coll.No.		**Species**	**Layer**	**LifeForm**	**Height**	**Habit**	**%Cover**
		Acaciapulchella var.*pulchella*					opp
		Astarteafascicularis					opp
	*	*Eragrostiscurvula*					opp
		Eucalyptusrudis					opp
		Jacksoniafurcellata					opp
		Juncuspallidu s					opp
		Kunzeaglabrescens					opp
	*	*Lotussubbiflorus*					opp
		Melaleucapreissiana					opp
		Taxandrialinearifolia					opp
	*	*Trifoliumcampestre*					opp
	*	*Ursiniaanthemoides*					opp

Note:+=lessthan1%cover,*=nonnativespecies

SiteDetails			
Locality	EP15036	PhotoNo.	425
Date	18/11/2016	Photodirection	E
Author	RAO	Geographicdatumandzone	GDA94 50
Samplingunit	Relevé	Easting	403872
Samplenumber	5	Northing	6428541
GeographicandHabitatData			
Aspect	flat/slopingbanks	Hydrology	creekwithstandingwater
Slope	N/A	AdjacentVegetation	pasture
Topographicposition	creekline	VegetationCondition	D
Altitude(m)	4446	Timesincefire	noevidence
Bareground%	30	Disturbance	highstock,weeds
Soiltype/texture	loamysand	Rocktype	N/A
Soilcolour	yellowbrown	Rock%	0
Microclimate	-	Littertypeand%	leaves,branches,30%
VegetationDescription			
Lowopenforest *Eucalyptusrudis* and *Melaleucarhaphiophylla* oversparserushland *Juncuspallidus* oversparseforbland* *Alternantheranodiflora* increekbedandclosedgrassland* *Ehrhartacalycina* and **Bromusdiandrus* onbanksofcreek.			



R5SpeciesData							
Coll.No.		**Species**	**Layer**	**LifeForm**	**Height**	**Habit**	**%Cover**
		Acaciasaligna					opp
		Alternantheranodiflora					opp
	*	*Bromusdiandrus*					opp
	*	*Ehrhartacalycina*					opp
	*	*Ehrhartalongiflora*					opp
		Eucalyptusrudis					opp
	*	*Hordeumleporinum*					opp
		Juncuspallidu s					opp
	*	*Loliumrigidum*					opp
	*	*Lythrumhyssopifolia*					opp
		Melaleucarhaphiophyll a					opp
	*	*Oxalispurpurea*					opp
	*	*Rumexcrispus*					opp

Note:+=lessthan1%cover,*=nonnativespecies

SiteDetails			
Locality	EP15036	PhotoNo.	518520
Date	18/11/2016	Photodirection	multiple
Author	RAO	Geographicdatumandzone	GDA94 50
Samplingunit	Relevé	Easting	403389
Samplenumber	6	Northing	6428563

GeographicandHabitatData			
Aspect	flat	Hydrology	creekwithstandingwater
Slope	gentlyslopingbanks	AdjacentVegetation	pasture
Topographicposition	creekline	VegetationCondition	D
Altitude(m)	4748	Timesincefire	noevidence
Bareground%	10	Disturbance	highstock,weeds
Soiltype/texture	loamysand	Rocktype	N/A
Soilcolour	brownblack	Rock%	0
Microclimate	-	Littertypeand%	leaves,logs,30%

VegetationDescription

Lowopenforest *Eucalyptusrudis* and *Melaleucarhaphiophylla* oversparserushland *Juncuspallidus* in creekbedandclosedgrassland* *Ehrhartalongiflora,* * *Bromusdiandrusand*Lolium* spp. onbanksof creek.

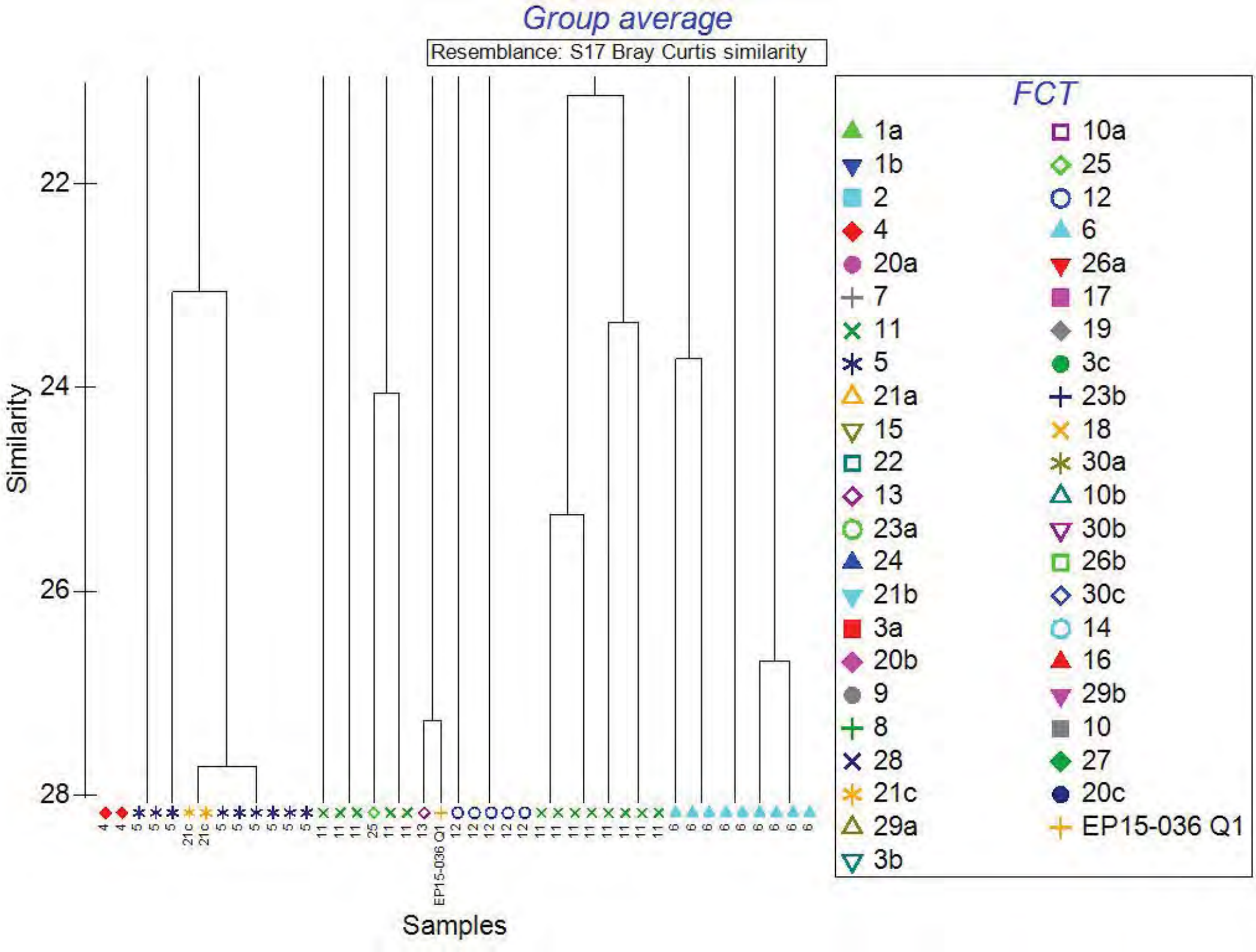


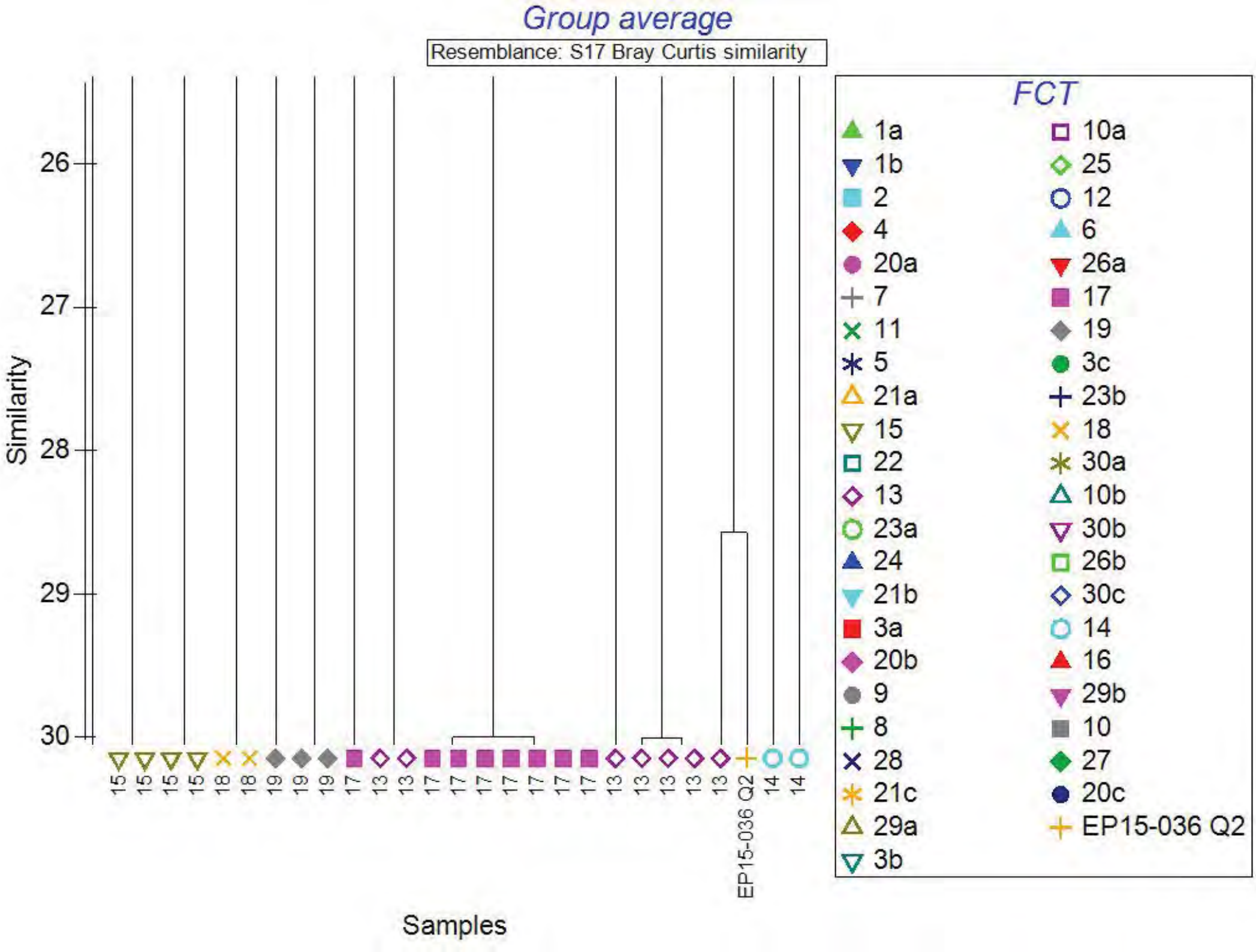
R6SpeciesData							
Coll.No.		**Species**	**Layer**	**LifeForm**	**Height**	**Habit**	**%Cover**
		Alternantheranodiflora					opp
	*	*Bromusdiandrus*					opp
	*	*Ehrhartacalycina*					opp
	*	*Ehrhartalongiflora*					opp
		Eucalyptusrudis					opp
		Juncuspallidu s					opp
		Melaleucarhaphiophyll a					opp
	*	*Oxalispurpurea*					opp
	*	*Rumexcrispus*					opp
	*	*Zantedeschiaaethiopic a*					opp

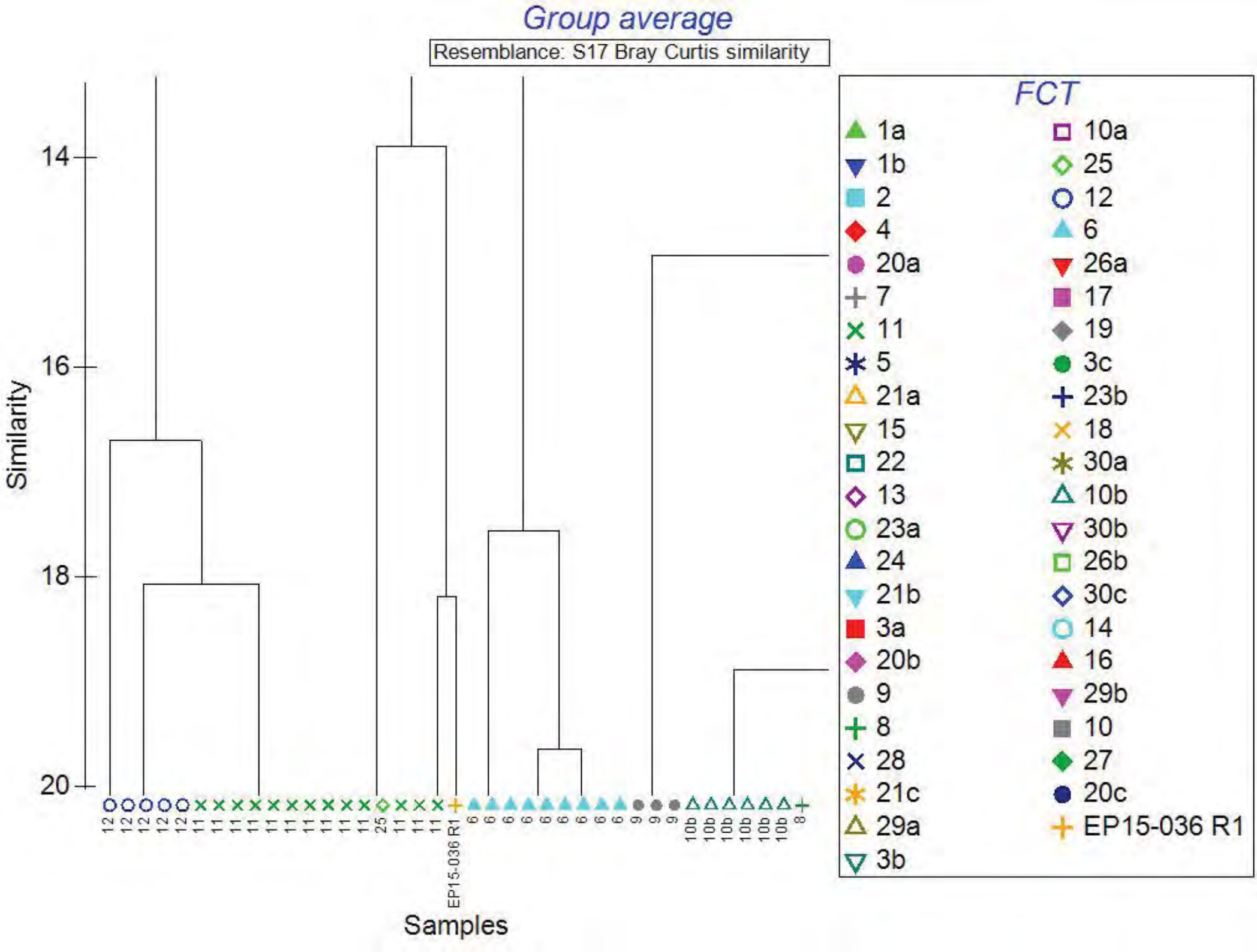
Note:+=lessthan1%cover,*=nonnativespecies

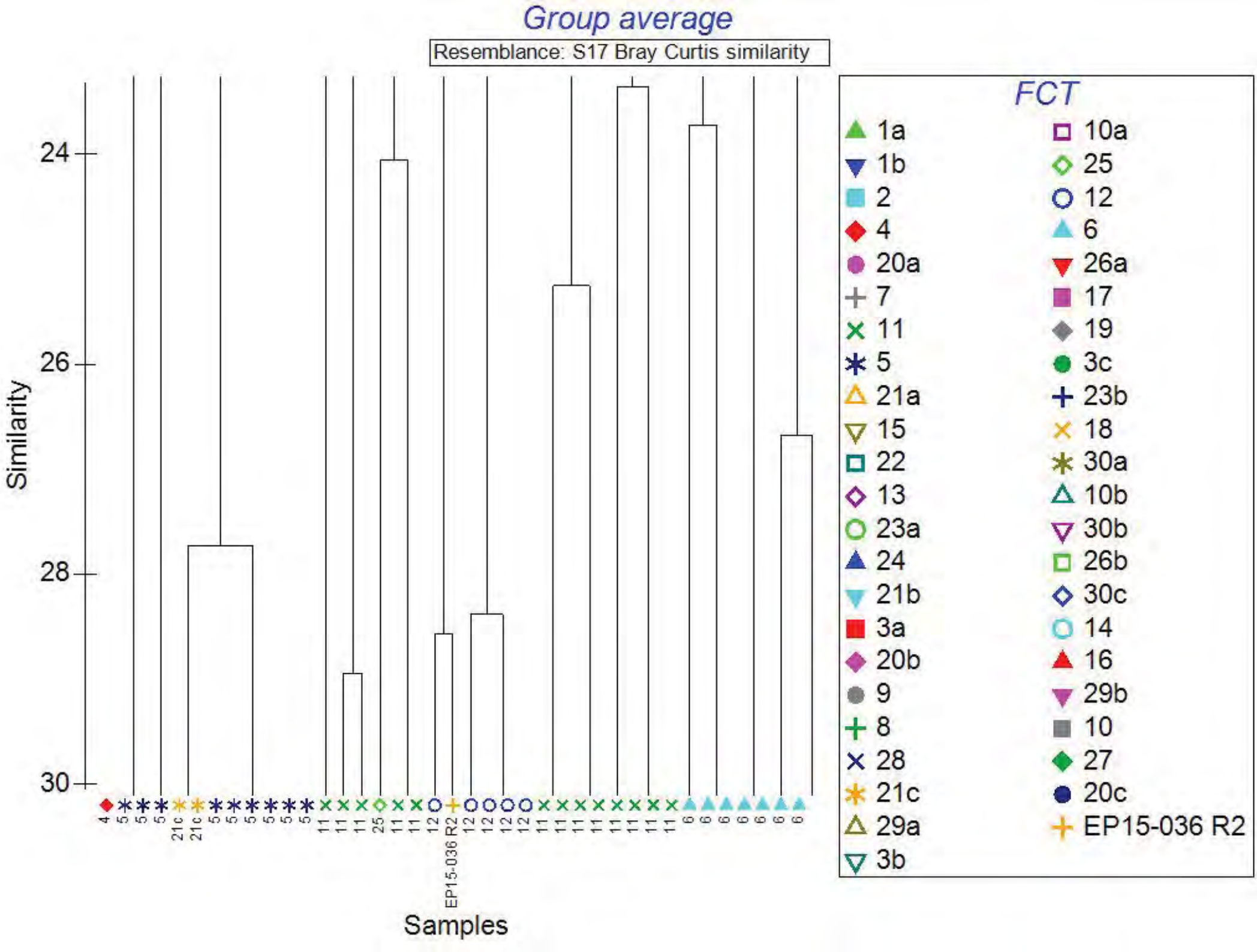
Appendix D

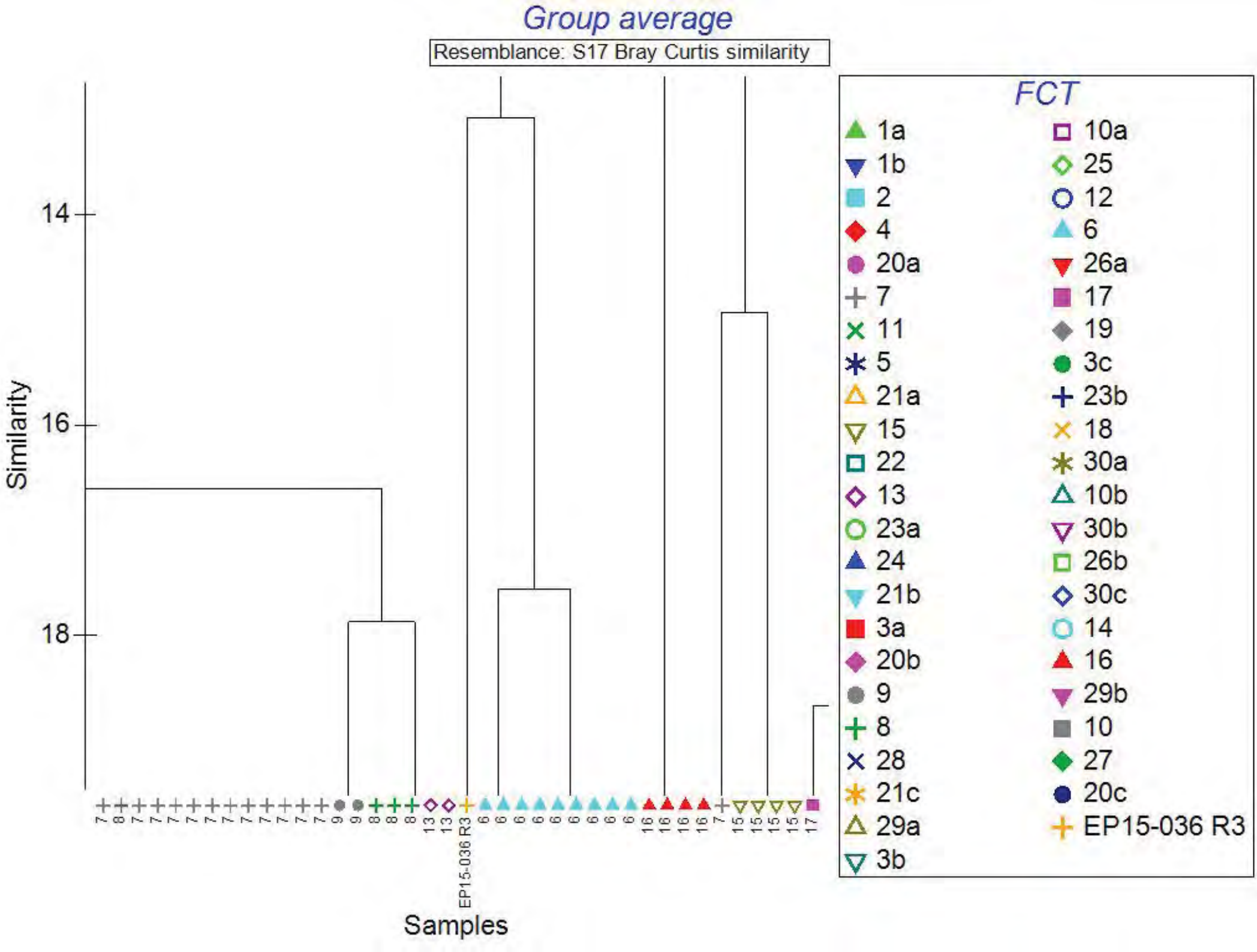
Cluster Dendrograms

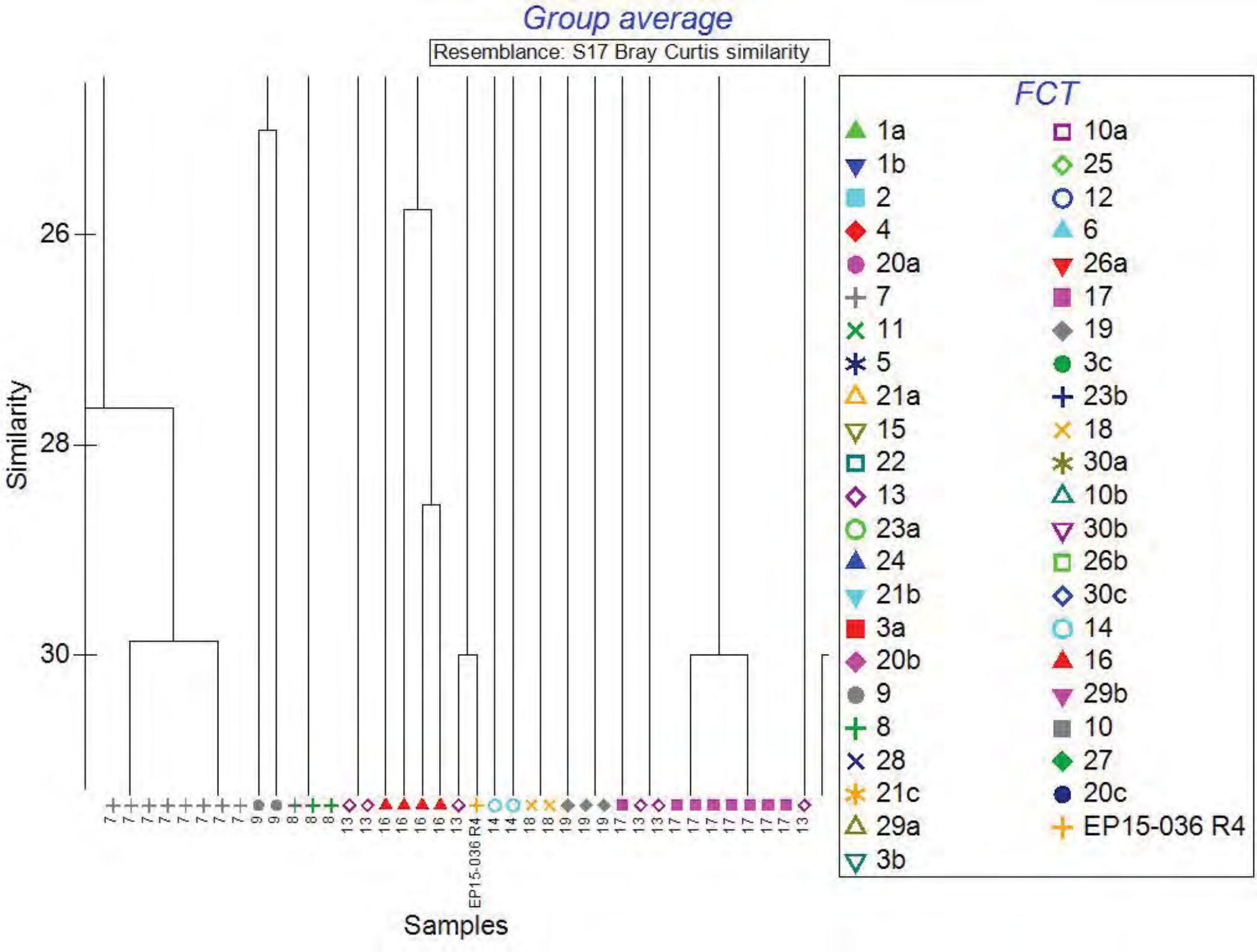

Group average
Resemblance: S17 Bray Curtis similarity
Similarity
22
24
26
28
Samples
4 4 5 5 5 21c 21c 5 5 5 5 5 5 5 11 11 11 25 11 11 13 EP15-036 Q1 12 12 12 12 12 11 11 11 11 11 11 11 6 6 6 6 6 6 6 6 6
FCT
1a
1b
2
4
20a
7
11
5
21a
15
22
13
23a
24
21b
3a
20b
9
8
28
21c
29a
3b
10a
25
12
6
26a
17
19
3c
23b
18
30a
10b
30b
26b
30c
14
16
29b
10
27
20c
EP15-036 Q1

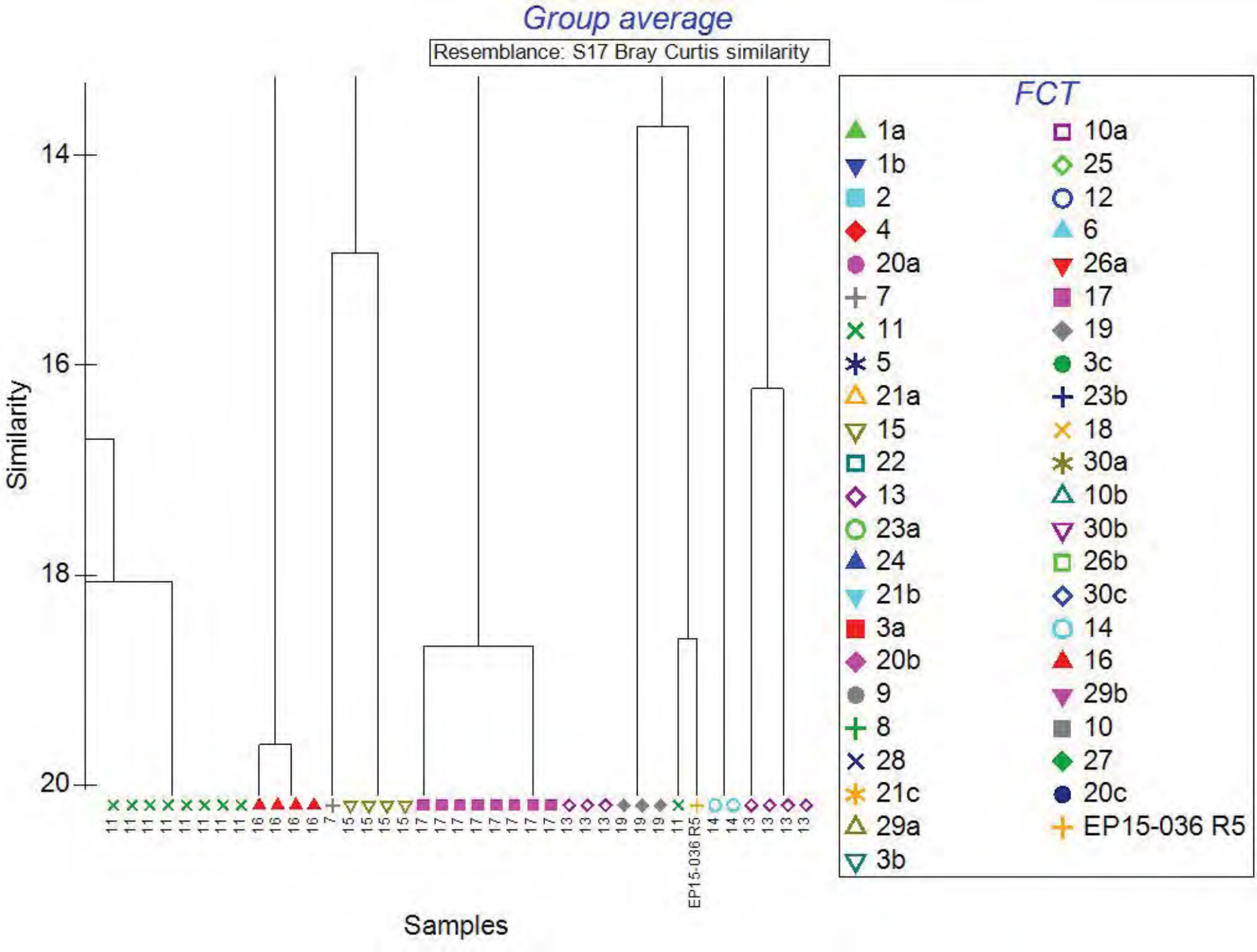

Group average
Resemblance: S17 Bray Curtis similarity
Similarity
26
27
28
29
30
15 15 15 15 18 18 19 19 19 17 13 13 17 17 17 17 17 17 13 13 13 13 13 EP15-036 Q2 14 14
Samples
FCT
1a
1b
2
4
20a
7
11
5
21a
15
22
13
23a
24
21b
3a
20b
9
8
28
21c
29a
3b
10a
25
12
6
26a
17
19
3c
23b
18
30a
10b
30b
26b
30c
14
16
29b
10
27
20c
EP15-036 Q2

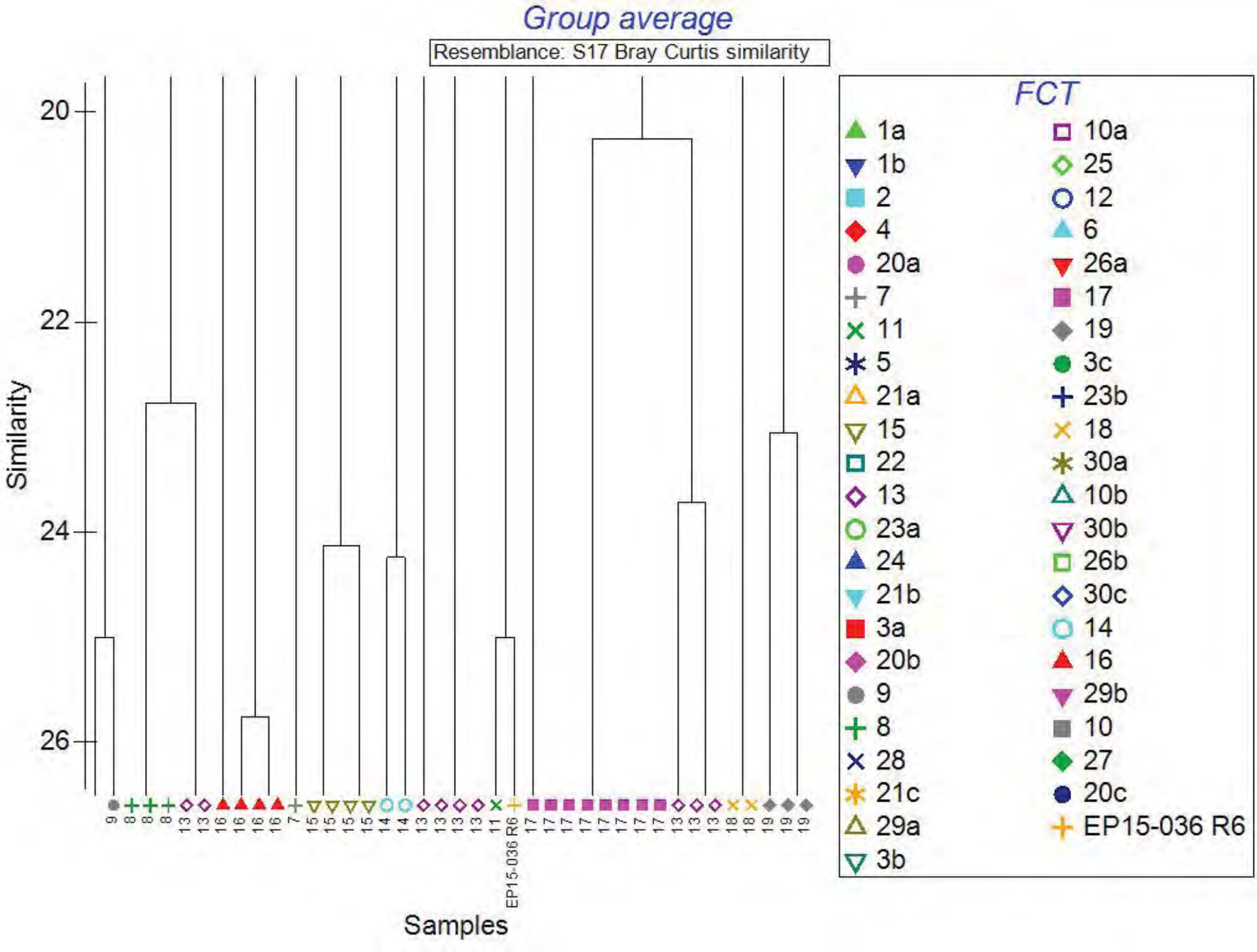

Group average
Resemblance: S17 Bray Curtis similarity
Similarity
14
16
18
20
Samples
EP15-036 R1
FCT
1a
1b
2
4
20a
7
11
5
21a
15
22
13
23a
24
21b
3a
20b
9
8
28
21c
29a
3b
10a
25
12
6
26a
17
19
3c
23b
18
30a
10b
30b
26b
30c
14
16
29b
10
27
20c
EP15-036 R1


Group average
Resemblance: S17 Bray Curtis similarity
Similarity
24
26
28
30
Samples
4
5
5
5
21c
21c
5
5
5
5
5
5
11
11
11
25
11
11
12
EP15-036 R2
12
12
12
12
11
11
11
11
11
11
11
6
6
6
6
6
6
6
FCT
1a
1b
2
4
20a
7
11
5
21a
15
22
13
23a
24
21b
3a
20b
9
8
28
21c
29a
3b
10a
25
12
6
26a
17
19
3c
23b
18
30a
10b
30b
26b
30c
14
16
29b
10
27
20c
EP15-036 R2


Group average
Resemblance: S17 Bray Curtis similarity
Similarity
14
16
18
Samples
EP15-036 R3
FCT
1a
1b
2
4
20a
7
11
5
21a
15
22
13
23a
24
21b
3a
20b
9
8
28
21c
29a
3b
10a
25
12
6
26a
17
19
3c
23b
18
30a
10b
30b
26b
30c
14
16
29b
10
27
20c
EP15-036 R3


Group average
Resemblance: S17 Bray Curtis similarity
Similarity
26
28
30
Samples
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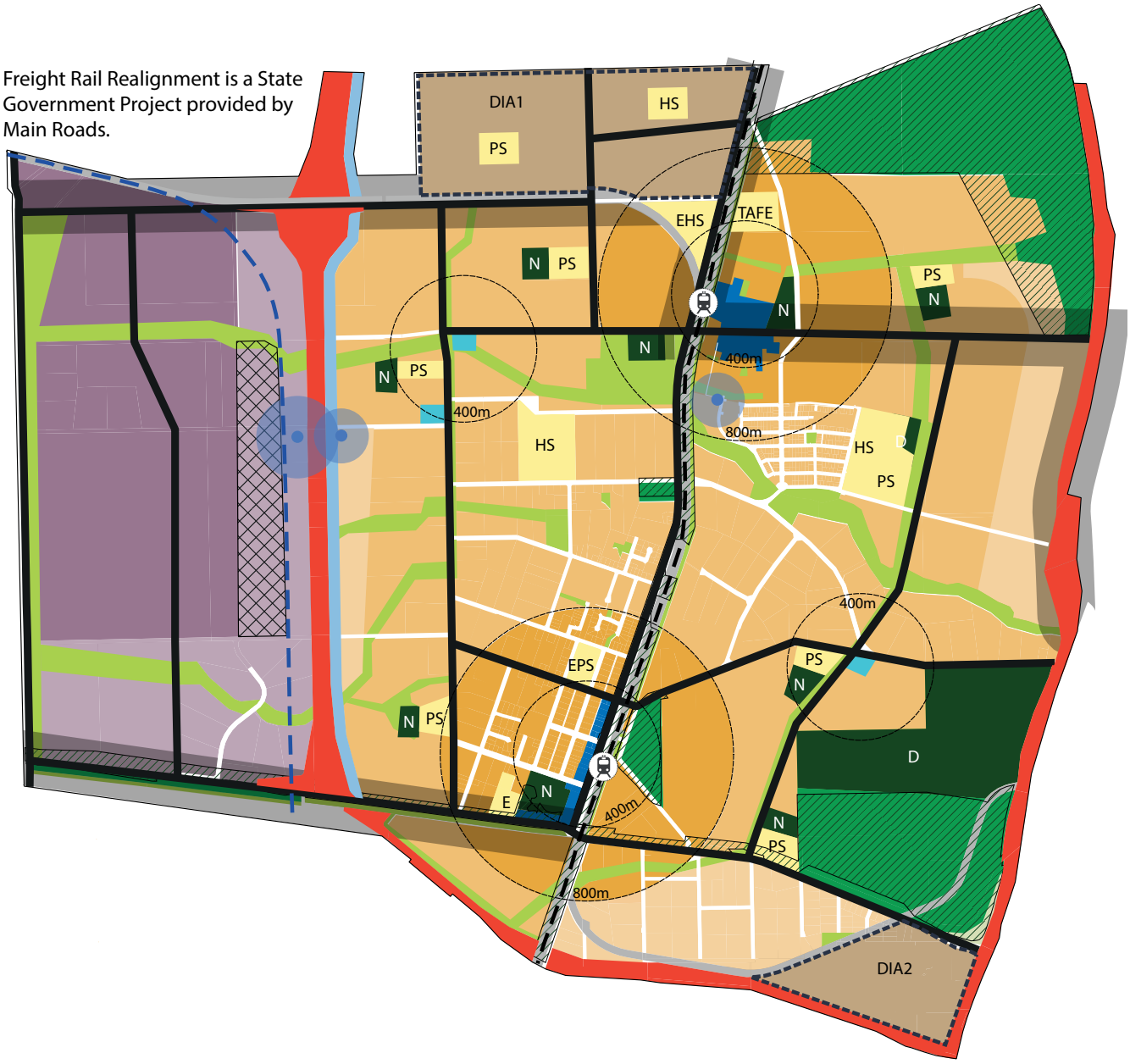

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EP15-036 R6

APPENDIX C

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MUNDIJONG DISTRICT STRUCTURE PLAN

Figure 1: Mundijong District Structure Plan



Mundijong District Structure Plan

Status : Preliminary (not to be used for feasibility purposes)
Path : P:\43874 Development Strategies for Serpentine-Jarrahdale

Scale: 1:15,000 @ A1
0 100 200 300 400
© Hames Sharley

North:

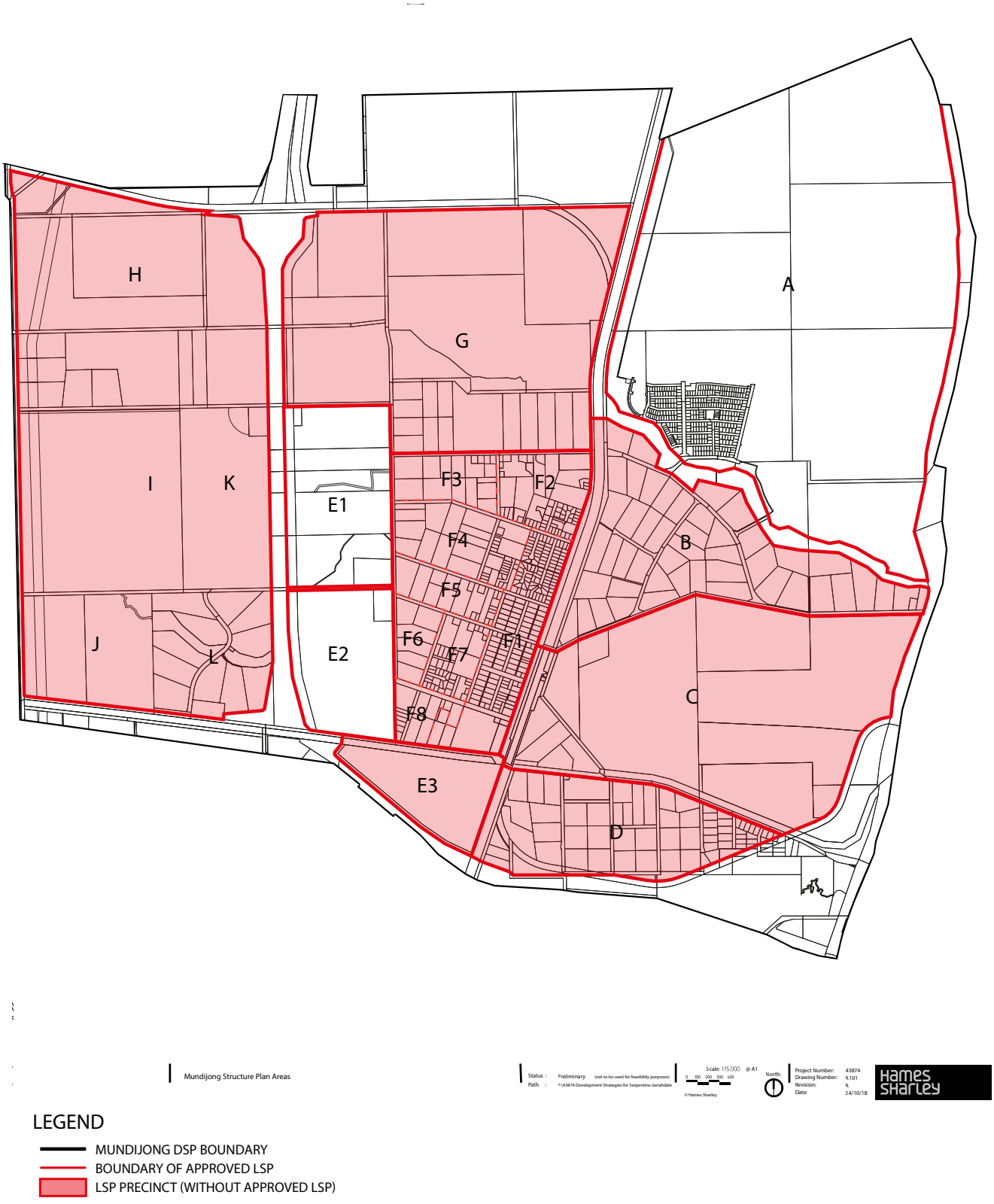
Project Number: 43874
Drawing Number: A101
Revision: A
Date: 24/10/18

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LEGEND

- MUNDIJONG DSP BOUNDARY
- DISTRICT CENTRE
- NEIGHBOURHOOD CENTRE
- PUBLIC PURPOSE - UTILITIES
- COMMUNITY AND PUBLIC PURPOSE
- LIGHT INDUSTRIAL
- INDUSTRIAL
- BUSH FOREVER
- DISTRICT/ NEIGHBOURHOOD OPEN SPACE
- RESERVE
- MULTIPLE USE CORRIDOR/LOCAL OPEN SPACE
- MEDIUM - HIGH: R40-100
- LOW (SUBURBAN): R20-35
- LOW (TRANSITIONAL): R10-15
- SPECIAL USE
- RURAL SMALL HOLDINGS
- RURAL
- URBAN EXPANSION
- PRIMARY DISTRIBUTOR
- DISTRICT DISTRIBUTOR
- RAILWAY RESERVE
- FREIGHT RAIL REALIGNMENT
- WASTE WATER PUMP STATION AND BUFFER
- DIA BOUNDARY
- DIA DEVELOPMENT INVESTIGATION AREA
- EHS EXISTING HIGH SCHOOL
- EPS EXISTING PRIMARY SCHOOL
- HS HIGH SCHOOL
- PS PRIMARY SCHOOL
- D DISTRICT OPEN SPACE
- N NEIGHBOURHOOD OPEN SPACE
- U UNIVERSITY/ INNOVATION HUB
- C CEMETERY

Figure 2: Mundijong Local Structure Plan Areas



APPENDIX D

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COPY OF EPA REPORT ON MRS AMENDMENT NO. 966/13

Draft South East Corridor Structure Plan; South East Corridor Metropolitan Region Scheme Amendment No. 966/13; and Stormwater Management Strategy and plans for new urban development at Byford and Mundijong

A submission and advice by the Environmental Protection Authority on the South East Corridor Structure Plan prepared by the Ministry for Planning, the South East Corridor Metropolitan Region Scheme Amendment prepared by the Western Australian Planning Commission and the Stormwater Management Strategy and Plans for New Urban Development at Byford and Mundijong prepared by the Water Authority of Western Australia

Environmental Protection Authority
Perth, Western Australia
Bulletin 798
December 1995

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1. Strategic environmental assessment process

Summary and recommendations

This Bulletin is the Environmental Protection Authority's advice on the:

- *Draft South East Corridor Structure Plan*;
- *Metropolitan Region Scheme Amendment No. 966/33;* and
- *Stormwater Management Strategy and Plans for New Urban Development at Byford and Mundijong.*

During the assessment the Environmental Protection Authority sought expert advice from the Department of Environmental Protection, Ministry for Planning, Water Authority of Western Australia and Shire of Serpentine - Jarrahdale and has concluded that the main environmental topics relating to the reports are:

- avoidance of environmental damage to wetlands of local and regional significance;
- protection of land that has been identified in the System 6 Report as having conservation and recreation value;
- prevention of nutrient enrichment and degradation of the groundwater and the surface water systems from on-site effluent disposal;
- protection of remnant bushland communities identified in the System 6 review;
- management of potential impact of noise, dust and odour from existing poultry farms and piggeries on proposed adjoining landuses;
- management of changes to land use within the catchment to the Peel Harvey Estuarine system to avoid environmental damage particularly in terms of nutrient export; and
- adoption of transport strategies to help meet regional air quality and greenhouse gas emission objectives.

The Environmental Protection Authority has concluded that the planning strategies are environmentally acceptable subject to the summary of recommendations outlined in Table 1.

Table 1

Summary of EPA Recommendations

Environmental Impacts to Wetlands of Regional Significance within the South West Corridor

•The South East Corridor Structure Plan should include the need to protect the Environmental Protection Policy lakes located to the east of Forrestdale Lake.

•Local structure plans should provide for the protection of the EPP lakes through the inclusion of the lakes and buffer areas in public open space.

•Management plans should be prepared for EPP and System 6 lakes prior to the land being subdivided or developed.

•Proposals adjacent to or indirectly impacting upon EPP wetlands or land identified in the System 6 report should be referred to the EPA for EIA.

•The EPA supports the proposed reservation of M83 as a Parks and Recreation reserve as recommended in the System 6 report.

Environmental Impacts to Wetlands of Local Significance within the South West Corridor

•EPA Bulletins 685 and 686 provide guidelines for protection for those wetlands not identified in the EPP or System 6 report. The protection of these wetlands would occur as part of the planning process at a local level. Proposals would normally require referral to the EPA.

•Proposals adversely affecting Categories O, C and H lakes (as defined in Bulletins 685 and 686) would most likely be environmentally unacceptable.

•Any proposal which is inconsistent with Bulletins 685 or 686 or adversely affects category, C or H wetlands should be referred to the Environmental Protection Authority for formal assessment.

Protect Land Identified as having Conservation and Recreation Value in the System 6 Report

•The EPA supports the proposed reservation in the MRS of System 6 areas M83 and M89.

•The identification of M80, M84, M85, M86 and M87 as future reserves in the Structure Plan is supported.

•The inclusion of M88 in the Private Land Conservation category of the Shire of Serpentine - Jarrahdale Rural Strategy should provide adequate protection.

•Proposals adjacent to or indirectly impacting upon land identified in the System 6 report should be referred to the EPA for EIA.

•any development proposals involving M88 should be referred to the Environmental Protection Authority for formal assessment.

Waste Water Disposal

•Proposals for on-site waste water disposal including local treatment plants or broad scale use of alternative treatment plants must be referred to the EPA for EIA.

Protect Remnant Bushland Communities Identified in the System 6 Review

•The reservation of Brickwood and Norman 3 sites in the MRS is supported. The WAPC should explore options to revise the boundaries of the Parks and Recreation reserve to be as close as possible to that shown on the maps showing the Threatened or Poorly Reserved Plant Communities Requiring Interim Protection.

•Punrack 1 and Page 30 sites should be identified as local open space in the Structure Plan.

•The significance of the Mundijong remnant bushland should be acknowledged in the Structure Plan and methods explored by the WAPC to reserve these areas for conservation purposes. The remnant bushland is currently located within the Mundijong Road reserve.

•Road construction and batters should not impact on the Mundijong remnant bushland.

•Proposals adjacent to or indirectly affecting land identified in the System 6 review should be referred to the EPA for EIA.

Impact of Noise, Dust and Odour from Existing Poultry Farms and Piggeries on Proposed Adjoining Landuses

•New residential lots should be separated at least 500m from existing poultry farms.

•New residential lots should be separated from piggeries in accordance with the buffer distance recommended in the Environmental Management Guidelines for Animal Based Industries - Piggeries (Department of Agriculture, 1989)

•The onus shall be on the developer to demonstrate that existing poultry farms and piggeries will not affect proposed residential lots.

•If residential areas encroach within the buffer area the poultry farm or piggery should be relocated.

Nutrient Export into the Peel Harvey Estuarine Catchment

• The Stormwater Strategy meets with the EPA's objective to reduce the export of nutrients into the Peel Harvey Inlet.

•The Water Authority of Western Australia should develop a monitoring programme and criteria to measure nutrient levels in the stormwater runoff in accordance with the environmental quality objectives set out in the Environmental Protection (Peel Inlet - Harvey Estuary) Policy 1992 prior to the local authority Town Planning Scheme being amended.

•Provisions should be made to implement the following contingency procedures should the Stormwater Management Strategy fail to reduce the export of nutrients:

- provision of additional detention basins within the multiple use corridors;
- provision of regional detention basins; and
- revision of the drainage plan.

•Prior to the land identified as Urban and Urban Deferred in the Structure Plan and MRS Amendment being rezoned for urban purposes in the local authority's Town Planning Scheme, the decision making authorities should adopt an agreed implementation strategy for the multiple use drainage corridors.

•Defer further development if the monitoring of nutrient levels finds that the management strategy is ineffective.

Air Quality and Greenhouse Gas Emissions

•The urban village concept would improve air quality and lower green house gas emissions in comparison to typical urban growth patterns in the Metropolitan Region.

1. Introduction and background

1.1 The purpose of this report

This report is a Strategic Environmental Assessment of the following plans:

- *Draft South East Corridor Structure Plan;*
- *Metropolitan Region Scheme Amendment No. 966/33;* and
- *Stormwater Management Strategy and Plans for New Urban Development at Byford and Mundijong.*

The advice in this Bulletin is provided as a strategic assessment and not as a formal environmental impact assessment under Part IV of that Act. Assessments under Section 16 of the Act do not lead to the setting of legally binding environmental conditions. However, the advice should be used by planning agencies in dealing with environmental issues when drawing up subsequent statutory planning proposals. The EPA will use the advice in the Bulletin when deciding on the level of assessment to be set in these subsequent statutory planning proposals.

Metropolitan Region Scheme Amendment Recommendations

A number of the recommendations contained in this report relate specifically to the Metropolitan Region Scheme Amendment. These recommendations were presented to the Western Australian Planning Commission prior to the publication of this report. It is hoped that the report will be e a useful background to the Environmental Protection Authority's recommendations with respect to the Metropolitan Region Scheme.

1.2 Background

1.2.1 Study area

The three reports considered in this Bulletin focus on land development within the Shire of Serpentine-Jarrahdale. The study area is shown in Figure 1.

The existing town sites in the study area are Byford, Mundijong, Serpentine, Jarrahdale and Keysbrook. The Metropolitan Region Scheme Amendment and Stormwater Management Strategy focus predominantly on the towns of Byford and Mundijong.

Natural drainage is a critical issue for urban development in the South - East Corridor. Approximately 75% of the study area is seasonally waterlogged. The natural drainage system comprises the channels, creeks, streams, rivers and wetlands in the area whether permanently wet or seasonally inundated (refer to Figure 3).

Many of the natural drainage lines have been modified and waterlogged areas are artificially drained. The existing Water Authority drainage network was originally constructed to facilitate drainage of agricultural land. A series of major trunk drains now traverse the area considerably modifying the natural drainage of the coastal plain.

The major river in the area is the Serpentine River. There are also a number of small streams including Beenyup, Cardup, Manjedal and Medulla Brooks. These streams generally flow east - west draining into the Serpentine River. Winter rainfall frequently exceeds the capacity of these streams and local flooding results.

1.2.2 Draft South East Corridor Structure Plan

The draft South East Corridor Structure Plan (refer to Figure 2) is a non-statutory document which was released for public comment in November 1994 and will be finalised after the Metropolitan Region Scheme (MRS) Amendment has been adopted.

The structure plan has been prepared to ensure the future development of the corridor is effectively managed and coordinated (SPC 1994). The Structure Plan focuses on accommodating future urban growth in a regional context examining matters such as employment, transport, infrastructure, services, recreation and protection of the environment.

The structure plan is essentially a review of the *Planning Strategy for the South East Corridor Stage B Report* (MRPA 1980). The structure planning for the South East Corridor was initially carried out in two stages (Stage A and Stage B), followed by the release of a consolidated strategy in 1980. The Stage A area covered development areas in Canning, Gosnells and Armadale; Stage B covered the Shire of Serpentine - Jarrahdale.

The recommendations of the *Planning Strategy for the South East Corridor Stage B Report* were confirmed in the *Report of the Review Group to the State Planning Commission on the Corridor Plan* (State Planning Commission 1987) and *METROPLAN* (State Planning Commission 1990).

The structure plan has also been based on the *Shire of Serpentine - Jarrahdale Rural Strategy* (1994) for land outside of the defined townships.

1.2.3 Metropolitan Region Scheme Amendment South East Corridor — south of Armadale

The *Metropolitan Region Scheme (MRS) Amendment* (refer to Figure 4) is part of a program of major amendments to the Metropolitan Region Scheme. The amendment reflects some of the proposals in the *draft South East Corridor Structure Plan* and the *Shire of Serpentine-Jarrahdale Rural Strategy* with the focus being on ensuring that sufficient residential land is available for an anticipated increase in population of 60,000 people in the Byford and Mundijong townships over the next thirty years.

The amendment proposes to rezone land for Urban and Urban Deferred purposes, and reserve land for Parks and Recreation, Public Purposes, Controlled Access Highway and Important Regional Roads.

1.2.4 Stormwater Management Strategy and plans for new urban development at Byford and Mundijong

This Strategy and plans (refer to Figure 5a & 5b) were produced for the Water Authority of Western Australia and the Western Australian Planning Commission as an input to the structure planning process. The purpose of the strategy is to describe a water sensitive stormwater management strategy and design concept for the proposed urban expansion around the towns of Byford and Mundijong.

The soil types of the proposed urban expansion areas of Byford and Mundijong are typically clay over sand. During winter these areas are subject to regular surface inundation with high rates of surface runoff rather than infiltration into the groundwater. If the area is urbanised and drained by conventional means the stormwater is likely to carry high levels of nutrients into the already nutrient enriched Peel - Harvey Estuary. The drainage network would also require significant upgrade to contain peak flows from proposed urban development if conventional drainage is required.

The Stormwater Management Strategy proposes to reduce these impacts by retaining peak storm flows at pre-urban rates and by ensuring that groundwater levels are maintained to protect valuable wetlands and to restrict nutrient movement.

The Strategy, therefore, proposes that stormwater be retained as close as possible to its source, generally by means of detention basins and/or artificial wetlands in a series of linked multiple use stormwater drainage corridors which also serve as recreational and wildlife corridors within the urban area. The width of the corridors will vary according to natural characteristics, but a nominal width of 100 metres will be sought on the major drainage lines.

1.3 Report format

1.3.1 Local and regional key environmental issues

The implementation of the *South East Corridor Structure Plan, Metropolitan Region Scheme Amendment and Stormwater Management Strategy* could cause environmental impacts both locally within the corridor and regionally outside of the corridor. The *Key Environmental Issues* are divided into local and regional issues in the following manner:

(a) Local environmental issues

- avoidance of environmental damage to wetlands of local and regional significance within the South East Corridor;
- protection of land that has been identified in the System 6 report as having conservation and recreation value;
- prevention of nutrient enrichment and degradation of the groundwater and the surface water systems from effluent disposal systems;
- protection of remnant bushland communities identified in the System 6 review;
- management of the potential impact of noise, dust and odour from existing poultry farms and piggeries on proposed adjoining landuses;

(b) Regional environmental issues:

- management of changes to land use within the catchment to the Peel - Harvey Estuarine System are controlled to avoid environmental damage particularly in terms of nutrient export; and
- adoption of transport strategies to help meet regional air quality and greenhouse gas emission objectives.

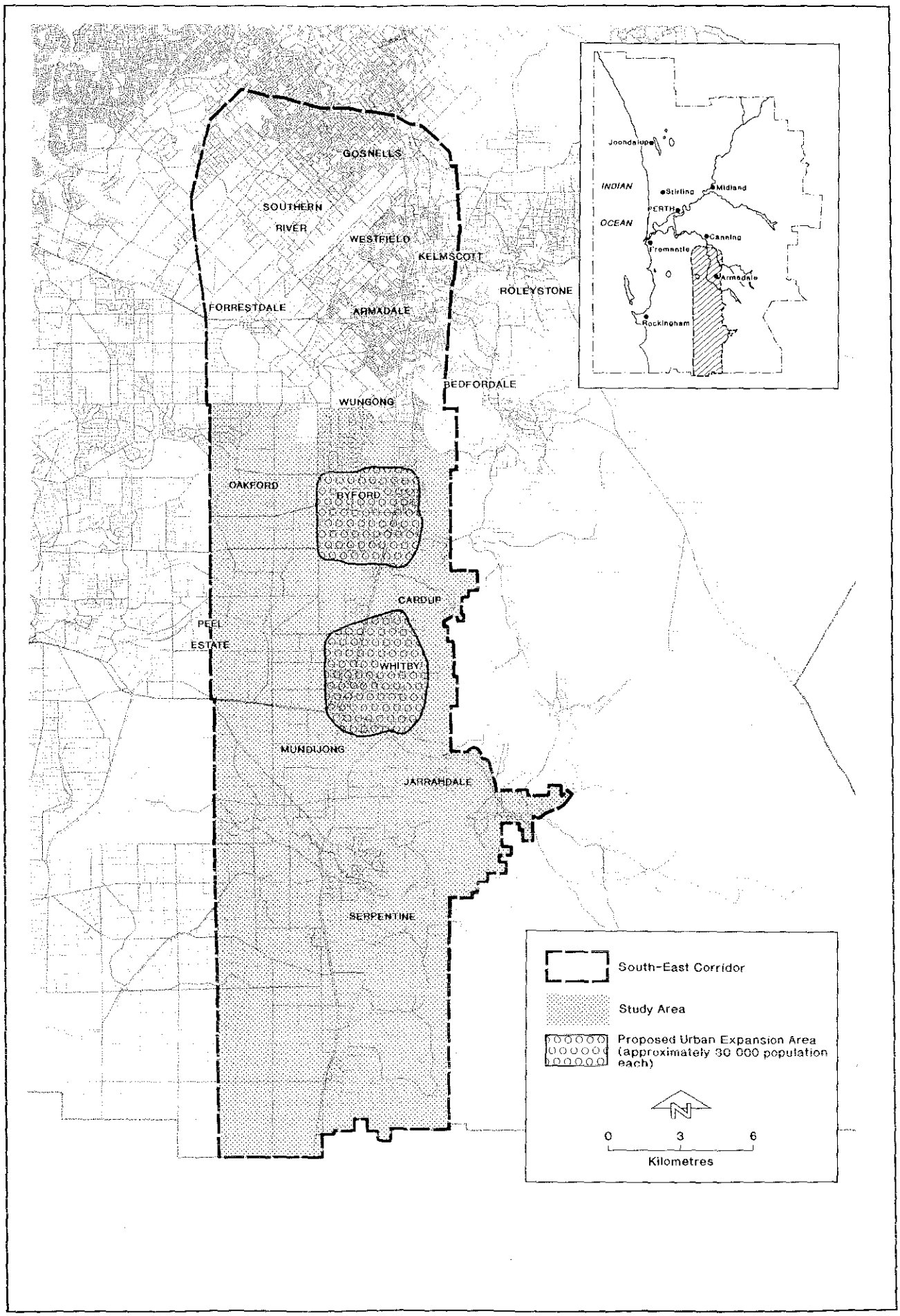


Figure 1. Draft South East Corridor Structure Plan — Study Area Boundary. (Source: Department of Planning and Urban Development, 1994)

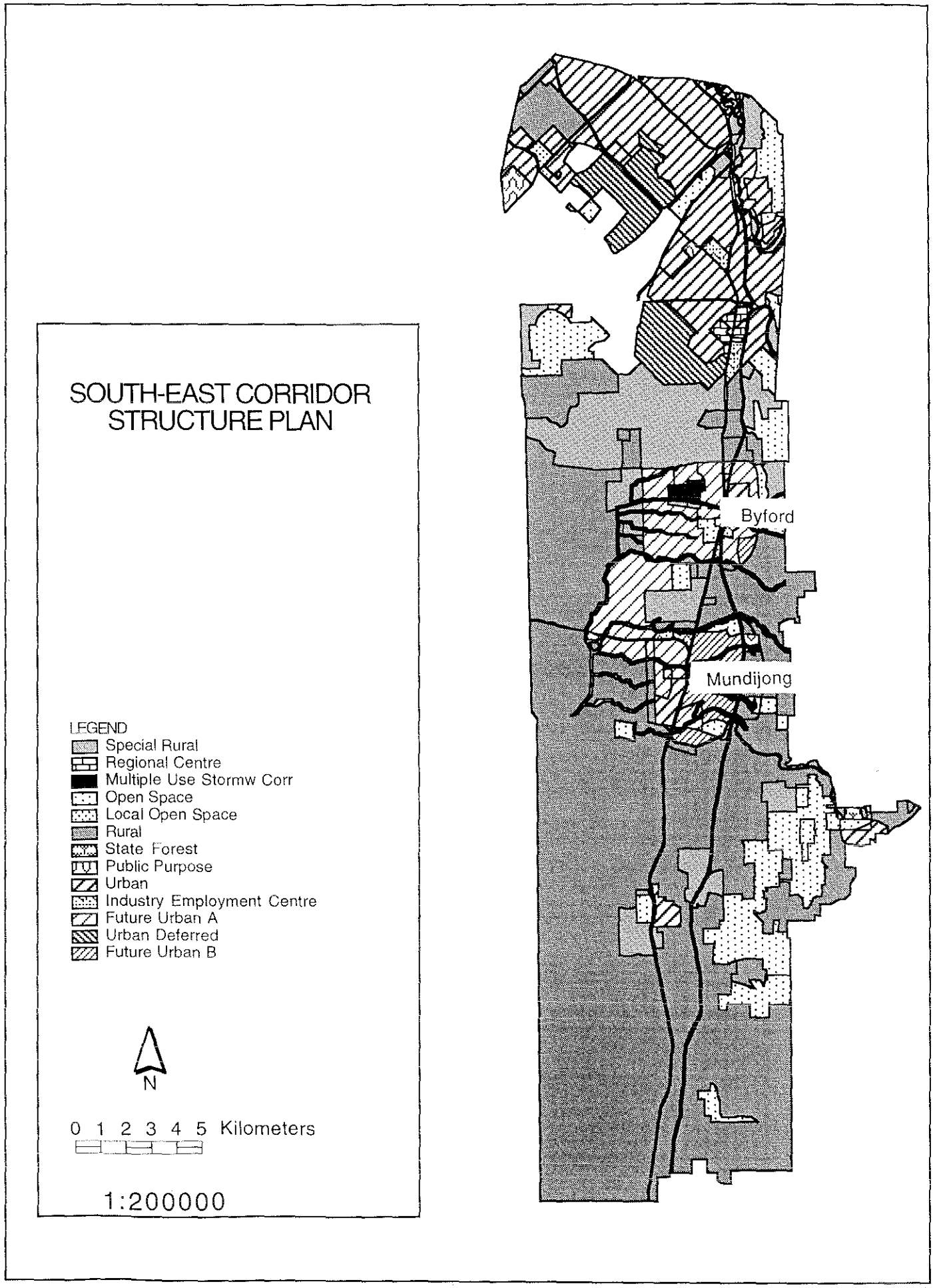


Figure 2. South East Corridor Structure Plan.

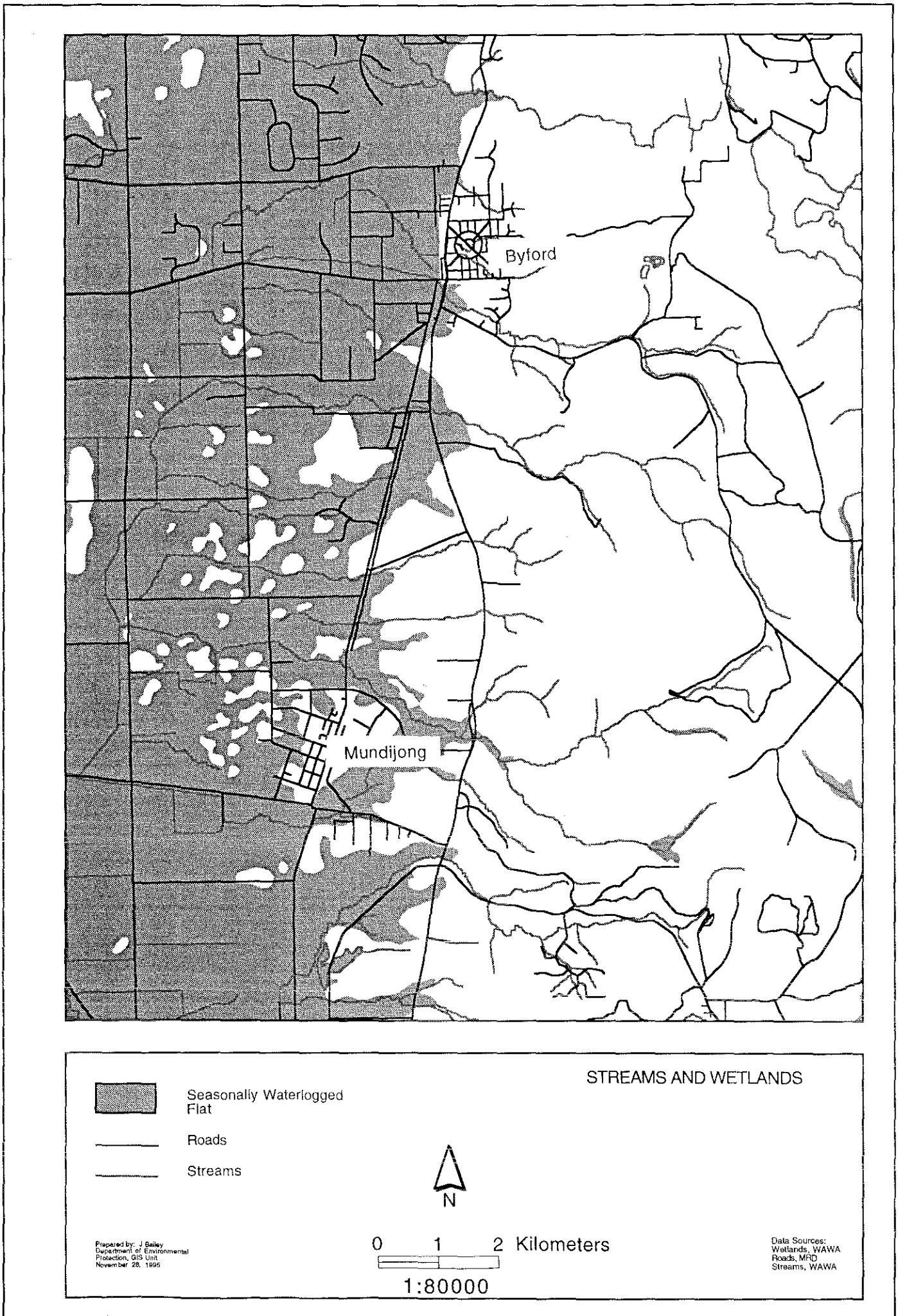


Figure 3. Streams and wetlands.

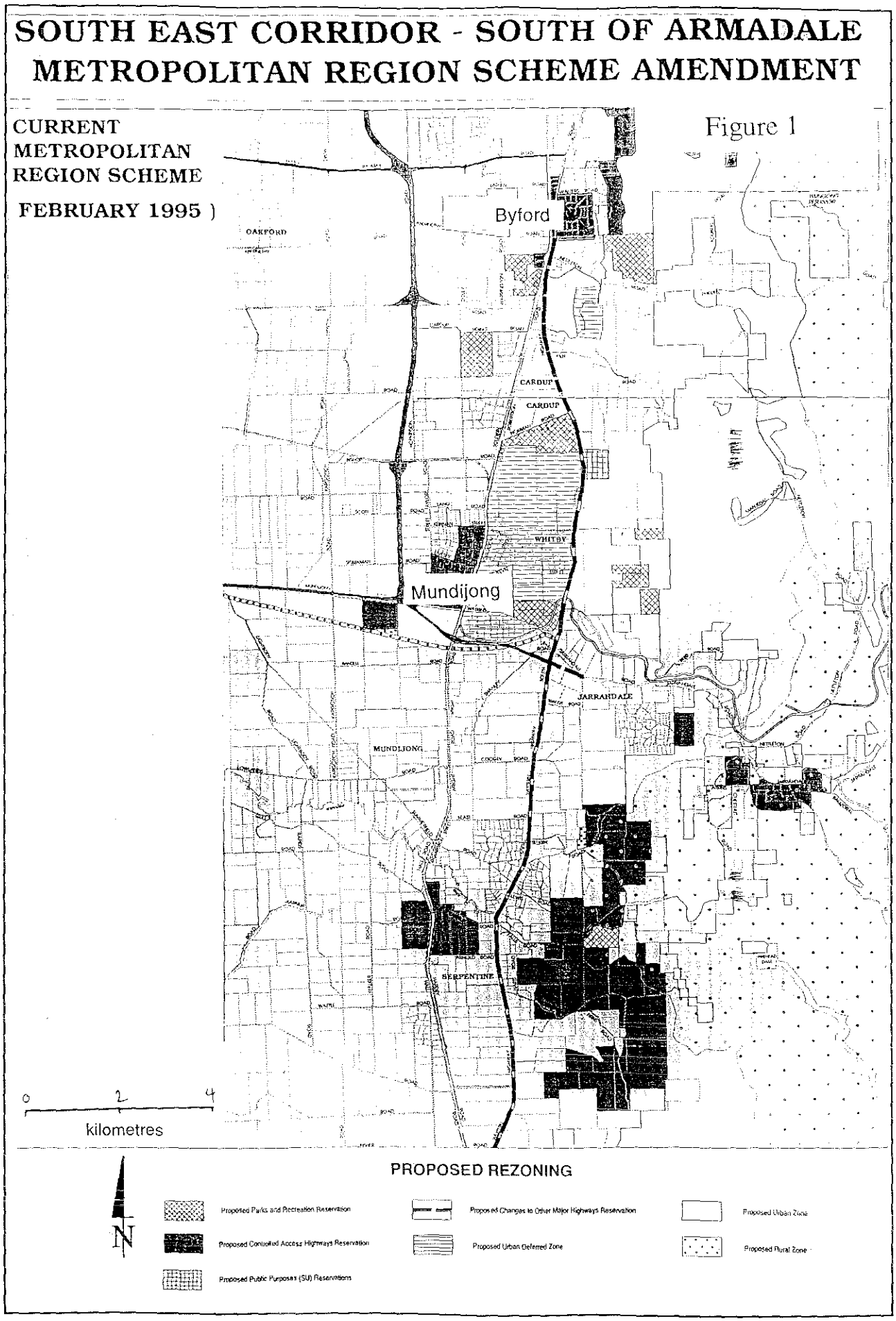


Figure 4. South of Armadale Metropolitan Region Scheme Amendment.

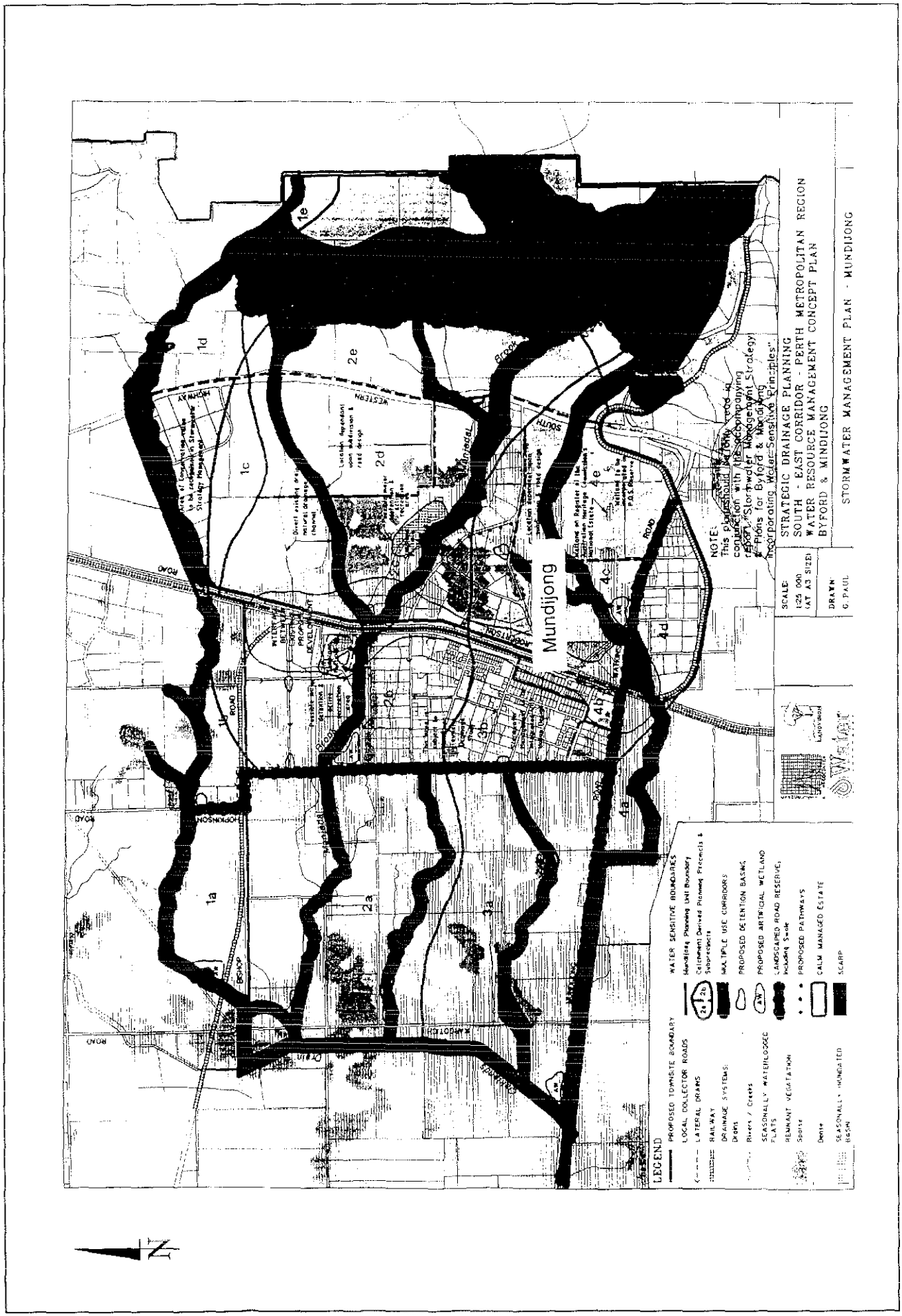


Figure 5b. Stormwater Management Plan – Mundijong. (Source : Evangelisti and Associates, 1994)

Where an aspect of the reports if implemented would have unacceptable environmental impacts the Environmental Protection Authority has advised how that matter should be addressed and whether future assessment by the Authority is required at a later stage in the planning process.

Limitations

This evaluation has been undertaken using information currently available. The information has been provided by the government agencies and consultancies preparing the reports, by Department of Environmental Protection officers utilising their own expertise and reference material, by utilising expertise and information from other State government agencies, and by contributions from Environmental Protection Authority members. The Environmental Protection Authority recognises that further studies and research may affect the conclusions.

3. Policy framework

The following is a list of relevant Environmental Protection Authority documents and policies which set the broad framework to assess the reports the subject of this Bulletin.

3.1 Previous EPA policies

Environmental Protection (Swan Coastal Plain Lakes) Policy 1992

The purpose of this policy is to protect the environmental values of lakes on the Swan Coastal Plain and identify those lakes to which the policy applies. The policy prohibits filling, mining, drainage into or out of, and effluent discharge into lakes without specific authorisation.

Environmental Protection (Peel-Harvey Estuary) Policy 1992

The purpose of this policy is:

- to set out environmental quality objectives for the Estuary which, if achieved, should rehabilitate the Estuary and protect the Estuary from further degradation; and
- to outline the means by which the environmental quality objectives for the Estuary are to be achieved and maintained.

Environmental Codes of Practice for the Poultry Industry and Piggeries (DEP 1991, 1991)

The Codes are intended to encourage an environmental ethic within the industry. Of particular relevance to this Bulletin are the recommended buffers to abutting landuses which may be affected by the odours produced by poultry farms and piggeries.

A Guide to Wetland Management in the Perth and Near Perth Swan Coastal Plain Area (Bulletin 686)

The objectives of Bulletin 686 (EPA, 1993) are to:

- outline broad management objectives for wetlands on the Swan Coastal Plain in the near Perth region; and
- provide an evaluation method so that individual wetlands can be allocated a specific management category.

Perth Photochemical Smog Study (1995)

A study of Perth's air quality verifying that the city is on the threshold of a significant air quality problem.

Strategy for the Protection of Lakes and Wetlands of the Swan Coastal Plain (Bulletin 685)

The purpose of Bulletin 685 (EPA, 1993) is to clearly define the current position taken by the Environmental Protection Authority about the protection and management of lakes and wetlands on the Swan Coastal Plain.

System 6 Report (1983)

The System 6 report contains the recommendations of the Environmental Protection Authority for reserving land for the purposes of conservation and recreation in and around the Perth Metropolitan Region.

Threatened or Poorly Reserved Plant Communities Requiring Interim Protection (Interim Plan)

This is the interim plan produced in 1994 as part of the review of the System 6. Areas of remnant bushland on the Swan Coastal Plain that contain plant communities which are considered to be threatened or poorly reserved are identified for inclusion as System 6 areas.

3.2 Previous EPA assessments

The *Shire of Serpentine Jarrahdale Rural Strategy (Shire of Serpentine - Jarrahdale)* was informally assessed by the Environmental Protection Authority.

The Draft South East Corridor Structure Plan reinforces the intent of the Rural Strategy by confining urban expansion around Byford and Mundijong and recommending a significant rural corridor between these two urban areas.

3.3 Other government agency policies

The following is a list of documents produced by other government agencies which also form the framework to assess the reports the subject of this Bulletin.

Environmental and Landscape Audit of the South West, North West, North East, South East and Foothills Corridors, Perth Metropolitan Area - Stage 4 Interim Report The South East Corridor Study (V & C Semeniuk Research Group, 1993)

This report presents the results and recommendations for the environmental audit for the South East Corridor and provides an outline of the procedures and justification for the recommendation.

Revised Greenhouse Strategy for Western Australia 1994 (Greenhouse Coordination Council, 1994).

The Western Australian Government first established the Greenhouse Coordination Council in 1989 following a major greenhouse conference. This document reviews the 1991 Greenhouse Strategy for Western Australia with reference to developments in science and policy at the local, national and international level.

Jandakot Land Use and Water Management Strategy (Western Australian Planning Commission, 1995)

The strategy establishes the physical and policy framework for the long term planning, management and development of land over the Jandakot water mound.

Metropolitan Rural Policy . A Policy Statement For Rural Land In The Perth Metropolitan Region (Department of Planning and Urban Development, 1994)

This policy provides a framework for the future planning of Perth's rural areas.

Proposals for the Jandakot Botanic Park (Ministry for Planning, 1995)

The purpose of this report is to provide protection to the banksia vegetation and wetlands around Jandakot .

Statement of Planning Policy No 2 The Peel Harvey Coastal Plain Catchment (Western Australian Planning Commission, 1992)

This policy ensures that land use changes within the Peel - Harvey Estuarine System likely to cause environmental damage to the estuary are brought under planning control based on the objectives and principles of the Environmental Protection (Swan Coastal Plain Lakes) Policy.

4. Evaluation of key site specific environmental issues in the South East Corridor

4.1 Wetlands with regional significance

4.1.1 Objective

The Environmental Protection Authority's objective is to ensure that the proposed land use changes within the *South East Corridor Structure Plan, Metropolitan Region Scheme Amendment* and *Stormwater Management Strategy* do not cause environmental damage to wetlands of regional significance.

4.1.2 Evaluation framework

Policy framework

The Environmental Protection Authority is concerned with the filling, draining, mining and polluting of the following regionally significant wetlands:

- lakes nominated for protection in the Environmental Protection (Swan Coastal Plain Lakes) Policy gazetted in December 1992;
- representative wetland areas recommended for protection in the System 6 report, other conservation reserves, areas recommended for reservation by the Department of Conservation and Land Management, and regional open space set aside for conservation;
- wetlands with rare vegetation communities not adequately represented in reserves, or rare flora and fauna (and their habitats); and
- wetlands recognised by international agreement because of their importance primarily for waterbirds and their habitats.

Environmental Protection (Swan Coastal Plain Lakes) Policy 1992

The *Environmental Protection (Swan Coastal Plain Lakes) Policy* (Lakes EPP), was proclaimed following extensive consultation with community groups and private landholders. The Lakes EPP prohibits unauthorised filling, mining, drainage or effluent discharge into nominated lakes. Lakes listed in the policy have the highest level of protection under the Environmental Protection Act and there is a presumption against approving developments that are likely to breach the intent of the policy. Authorisation under the Environmental Protection Act to disturb an EPP lake generally requires the approval of the Minister for the Environment, on advice from the Environmental Protection Authority, after a proposal has been assessed.

There are a number of EPP lakes within the study area, in the vicinity of Forrestdale Lake (refer to Figure 6).

System 6 Wetland Areas

In 1972, the Environmental Protection Authority established the *Conservation Through Reserves Committee* to make recommendations for the reservation of land for conservation and recreation purposes. The State was divided into 12 regions or Systems with the most intensively used areas in and around the Perth metropolitan area known as System 6 (Environmental Protection Authority, 1983 a & b).

There are two System 6 wetland areas contained within the study area. These are M95 (Forrestdale Lake), and M83 south of Byford which contains a wetland and remnant bushland (refer to Figure 7).

Rare Flora and Fauna and International Agreements

There are no other wetlands with the South East Corridor that contain known rare species of flora and fauna, or wetlands that form part of an international agreement such as RAMSAR that have not already been identified in System 6 or in the Lakes policy.

Planning proposal

The majority of the EPP lakes in the South East Corridor are included within the existing Parks and Recreation reserve around Forrestdale Lake. However, there are a number of EPP lakes to the east of Forrestdale Lake located within an area identified as Urban Deferred in the Structure Plan. The Urban Deferred zoning implies that this area would eventually be zoned Urban in the MRS.

The Metropolitan Region Scheme provides adequate protection to the two wetlands that have been identified in the System 6 Report. Forrestdale Lake (M95) is currently reserved for Parks and Recreation purposes and it is proposed to reserve M83 for Parks and Recreation as part of the current Metropolitan Region Scheme Amendment.

4.1.3 EPA evaluation

The EPP wetlands east of Forrestdale Lake, are within an area identified as Urban Deferred in the Structure Plan. It is considered that compliance with the EPP policy would provide adequate protection to these lakes from the impacts of future urban development in the area. Nevertheless, the Structure Plan should also reinforce the need to protect these lakes. Local structure plans should provide for the protection of the EPP lakes through the inclusion of the lakes and buffer areas in public open space.

Management plans should also be prepared prior to the land being subdivided or developed.

The System 6 wetlands within the study area are adequately protected by existing and proposed reserves. The management of landuses adjacent to these wetlands may require referral to the Environmental Protection Authority for environmental impact assessment.

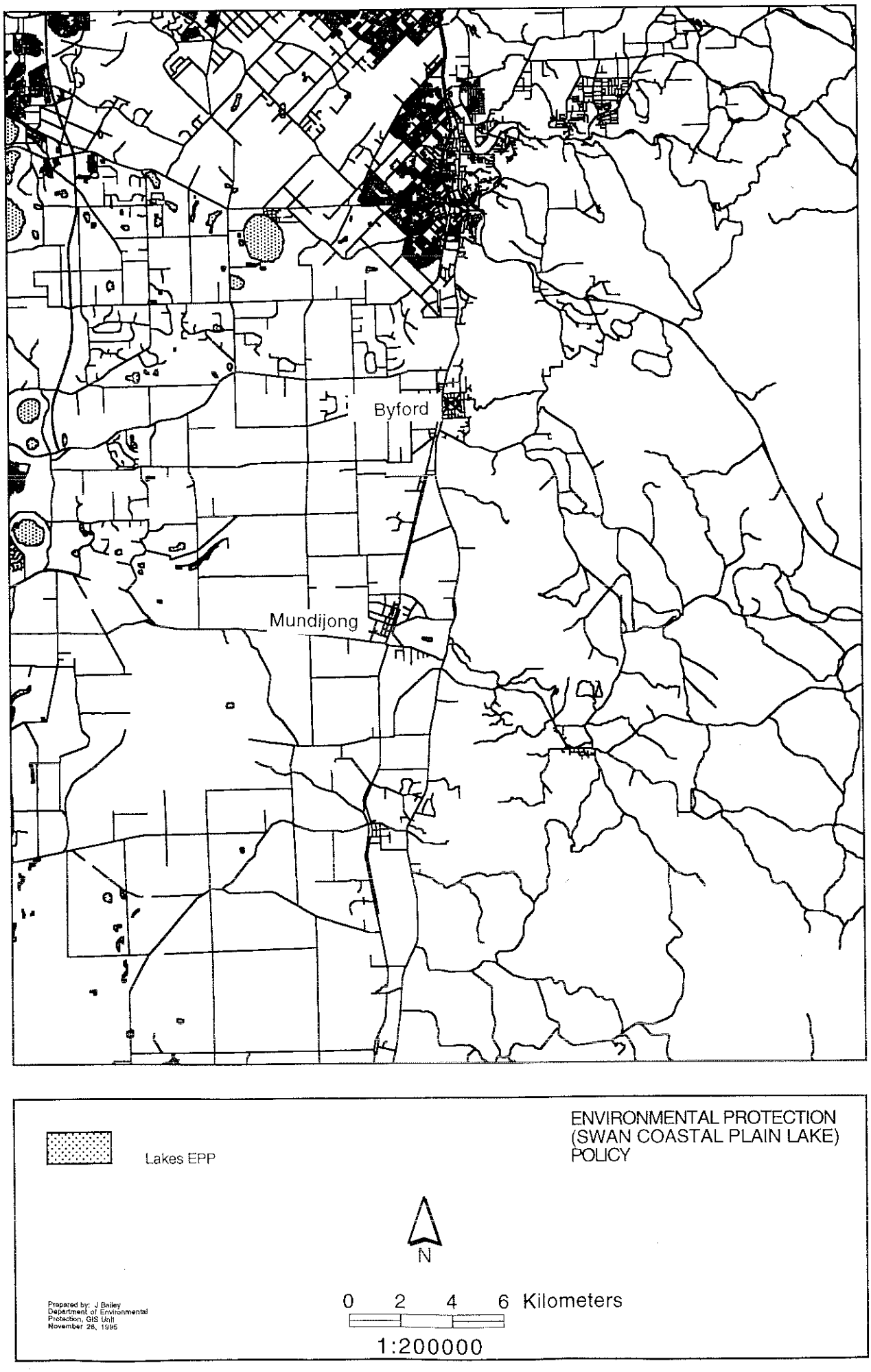


Figure 6. Environmental Protection (Swan Coastal Plain Lake) Policy.

4.2 Wetlands with local significance

4.2.1 Objectives

A significant proportion of the land in the South East Corridor is subject to inundation and is considered to be wetland. These wetlands are not identified in the Lakes Policy or the System 6 Report, but are recognised as having local significance. The Environmental Protection Authority's objectives with regard to these wetlands are:

- to ensure that the proposed land use changes within the *Structure Plan, Metropolitan Region Scheme Amendment* and *Stormwater Management Strategy* are assessed to avoid and minimise environmental damage to wetlands of local significance within the framework of the Environmental Protection Authority's report *A Guide to Wetland Management in the Perth and Near Perth Swan Coastal Plain Area. (Bulletin 686) :* and

- to prevent the export of nutrients into wetlands.

4.2.2 Evaluation framework

Policy framework

Strategy for the Protection of Lakes and Wetlands of the Swan Coastal Plain (Bulletin 685); and *A Guide to Wetland Management in the Perth and near Perth Swan Coastal Plain Area (Bulletin 686).*

The Environmental Protection Authority considers that local wetlands should be protected and managed in accordance with the principles outlined in Environmental Protection Authority Bulletins 685 and 686.

There are five management categories identified in Bulletin 686 which are based on the importance of wetlands in terms of natural ecosystems and human use. Proposals which adversely affect wetlands categorised as either Conservation and Recreation (Category O), Conservation (Category C) or High Conservation (Category H) would likely be considered environmentally unacceptable.

Many of the wetlands in the Shire of Serpentine-Jarrahdale have been cleared of natural vegetation and the water levels and quality have been altered (Department of Planning and Urban Development 1994). Bulletin 686 also recommends how wetlands that have been substantially modified and have no significant human use should be managed. These wetlands are categorised as Resource Enhancement (Category R) or Multiple Use (Category M).

Planning proposal

There are many wetlands of local significance within the study area. However, these wetlands have not been identified in the Structure Plan or MRS Amendment as it is not generally the role of regional structure plans or the Metropolitan Region Scheme to provide protection to these lakes. It is the role of local structure plans and town planning schemes to identify areas of local significance warranting management and protection. The Environmental Protection Authority considers that these wetlands can be managed under the guidelines of Bulletins 685 and 686 through the preparation of local structure plans, subsequent rezonings and subdivisions.

The *Landscape and Environmental Audit for the South East Corridor* identified all natural channels as significant for conservation. Many of the channels have been identified as multiple use stormwater corridors in the *Stormwater Management Strategy* and the *Structure Plan*. The Western Australian Planning Commission has recommended that the channels be protected through reservation in the local town planning scheme in accordance with the Structure Plan. Further reference is made to this matter in Section 5.1.2.

4.2.3 EPA evaluation

The Environmental Protection Authority considers that :

- the *Strategy for the Protection of Lakes and Wetlands of the Swan Coastal Plain (Bulletin 685)* and *A Guide to Wetland Management in the Perth and near Perth Swan Coastal Plain Area (Bulletin 686)* provide the basis for adequate protection to lakes of local significance;

- implementation of Bulletin 685 and 686 should occur through local structure plans and zoning and subdivision controls.

- proposals which adversely affect wetlands categorised as either Conservation and Recreation (Category O), Conservation (Category C) or High Conservation (Category H) should be considered environmentally unacceptable; and

- any proposal which is inconsistent with Bulletins 685 or 686 or adversely affects category), C or H wetlands should be referred to the Environmental Protection Authority for formal assessment.

4.3 System 6 areas (other than wetlands)

4.3.1 Objectives

The Environmental Protection Authority's objective is to protect land that has been identified in the System 6 Report as having regional conservation and recreation value.

4.3.2 Evaluation framework

Policy framework

System 6 Areas (other than wetlands)

There are seven System 6 (other than wetlands) areas within the study area (refer to Figure 7). These areas are M80 (Darling Scarp), M83 (Mundijong), M84 (Gooralong), M85 (Serpentine National Park), M87 (Serpentine), M88 (Keysbrook) and M89 (East of Keysbrook).

Planning proposal

There are no proposed land use changes within the boundaries of the System 6 areas in either the Structure Plan or MRS amendment.

The Structure Plan provides for the future reservation of four System 6 areas for Parks and Recreation purposes. These areas are M80, M84, M85, M87.

Two of the System 6 areas (M83 and M89) are included in Metropolitan Region Scheme amendment as Parks and Recreation reserves.

M88 has not been recommended for future inclusion in a Parks and Recreation reserve in the Structure Plan or MRS amendment. This land has been included in the *Private Land Conservation* category of the *Shire of Serpentine - Jarrahdale Local Rural Strategy* . Private land identified for conservation in the Rural Strategy is not intended for acquisition by the Local Authority or the State Government. The general aim is to encourage and make it easier for landowners to protect and manage the conservation values of the property. Any development or land use proposal will be assessed on its compatibility with the conservation values present on the site and approved or rejected accordingly.

4.3.3 EPA evaluation

The Environmental Protection Authority considers that:

- the Structure Plan and proposed Metropolitan Region Scheme Amendment provide satisfactory protection to six of the seven System 6 areas located within the study area;
- inclusion of M88 in the Private Land Conservation category of the Shire of Serpentine - Jarrahdale Local Rural Strategy is capable of providing adequate protection; and
- any development proposals involving M88 should be referred to the Environmental Protection Authority for formal assessment.

4.4 Waste water disposal

4.4.1 Objectives

To prevent nutrient enrichment and degradation of groundwater and surface water systems from on-site effluent disposal.

4.4.2 Evaluation framework

Policy framework

Government Sewerage Policy - Perth Metropolitan Region 1995

The policy requires that :

- all subdivision or density development to be provided with reticulated sewerage, except where certain discretionary provisions may apply; and
- subdivision or density development exceeding R5 in the outer metropolitan area to be subject to the provision of reticulated sewerage.

Guidance Notes from Environmental Protection Authority Reports 1971-1992, Western Australia, Bulletin 625.

This Bulletin advises that on-site effluent disposal should be appropriately located to prevent pollution and nutrient enrichment of groundwater and surface water.

Nutrient rich groundwater would not only pose a risk to public water supplies but could also impact on downstream wetlands.

Nutrients entering the surface drainage system could flow into the Peel - Harvey Estuary.

Planning proposals

Mundijong and Byford are located a considerable distance from existing sewerage infrastructure making it difficult and expensive to provide connection.

The Structure Plan presents a number of options for waste water disposal including:

- the use of local treatment and local land disposal options on a permanent or temporary basis;

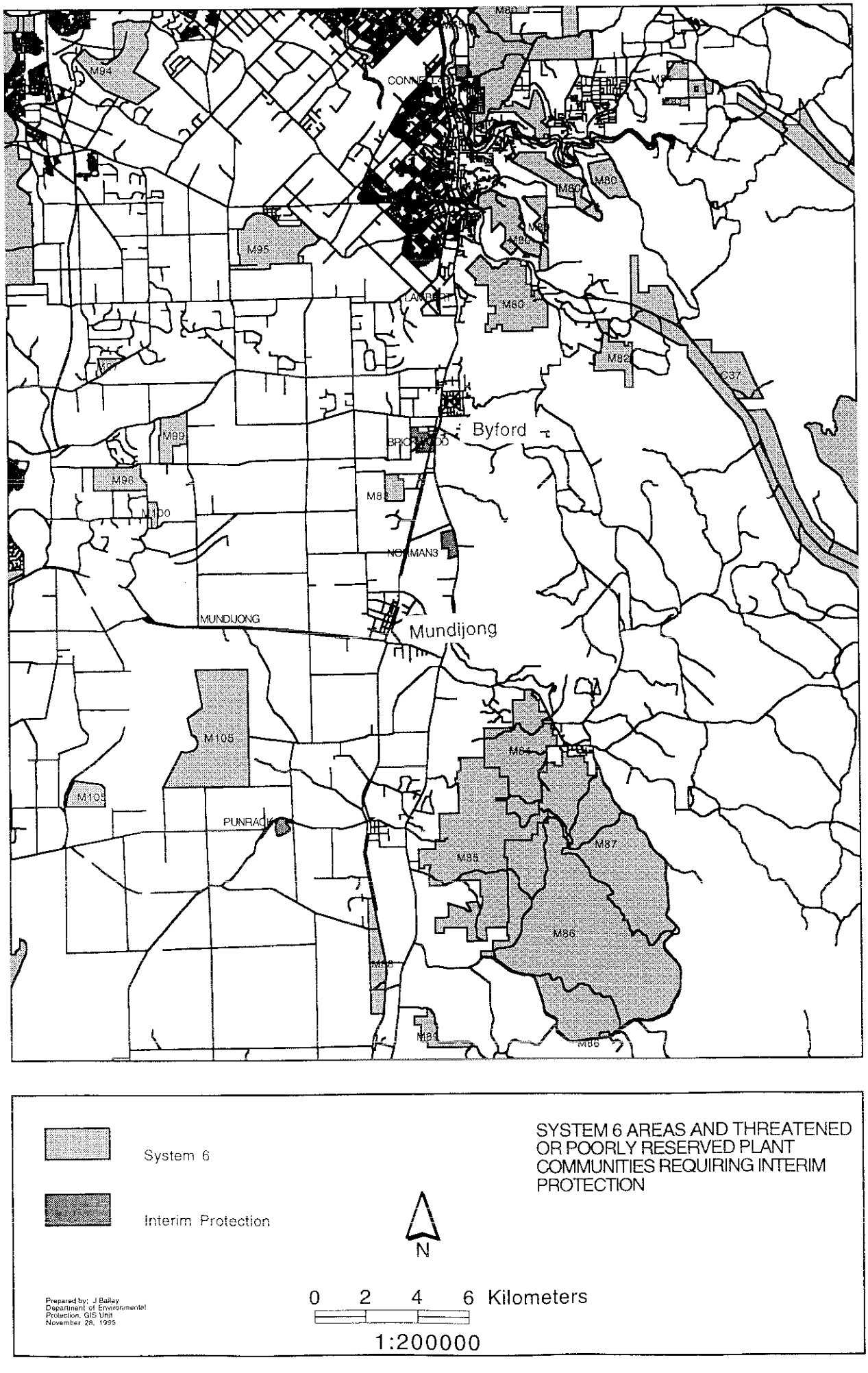


Figure 7. System 6 Areas and Threatened or Poorly Reserved Plant Communities Requiring Interim Protection

- provision of temporary pumping to Wesfield Septage Treatment Plant for on - going pumping to Woodmans Point, pending provision of permanent infrastructure.

The Ministry for Planning and Water Authority of Western Australia have advised that the provision and method of waste water disposal in Byford and Mundijong will be developer driven and dependent on options presented at the time of rezoning and subdivision.

An assessment of the options will be left until the landowners/developers in the area have presented preferred options.

4.4.3 EPA evaluation

It should be stated in the the Structure Plan that any proposals for on-site waste water disposal including local treatment plants or broad scale use of alternative treatment units must be referred to the Environmental Protection Authority for environmental impact assessment.

4.5 Threatened or poorly reserved plant communities requiring interim protection.

4.5.1 Objectives

To protect the remnant bushland communities that have been identified in the update of System 6 Report.

4.5.2 Evaluation framework

Policy framework

Threatened or Poorly Reserved Plant Communities Requiring Interim Protection (Interim Plan) (System Six update)

The System 6 update identifies 36 areas of remnant bushland on the Swan Coastal Plain between Gingin and Dunsborough that contain plant communities which are considered to be threatened or poorly reserved.

Planning proposals

There are five areas of remnant bushland identified in the System 6 review located in the South East Corridor (refer to figure 7). These are known as Brickwood, Norman 3, Mundijong, Punrack 1 and Page 30 (south of M88 outside figure 7 map area).

It is proposed to reserve the majority of Brickwood and Norman 3 for Parks and Recreation purposes in the MRS Amendment.

Punrack1 and Page 30 are not identified as local open space in the Structure Plan. These sites are located outside of the proposed urban areas.

The remnant bushland located in the Mundijong Road reserve is identified in the System 6 review as worthy of retention. It is proposed to reserve Mundijong Road as a Controlled Access Highway in the MRS Amendment which may result in future road construction adversely affecting on this area of remnant bushland.

4.5.3 EPA evaluation

The Environmental Protection Authority considers that the *Structure Plan* and *Metropolitan Region Scheme Amendment* provide some protection to the remnant bushland areas identified in the System 6 review except for the bushland along Mundijong Road. The significance of this bushland should be acknowledged in the Structure Plan. Road construction and batters should not impact upon the Mundijong remnant bushland and any proposal to construct a road in this area should be referred to the Environmental Protection Authority for assessment prior to construction.

The proposal to reserve a major portion of Brickwood and Norman 3 in the MRS for Parks and Recreation purposes is supported. The Western Australian Planning Commission should explore options to revise the boundaries of the Parks and Recreation reserve to be as close as those shown in the System 6 review.

The Structure Plan should be modified to identify Punrack 1 and Page 30 sites as local open space.

The significance of Mundijong remnant bushland should be acknowledged in the Structure Plan.

Proposals to clear or develop land identified in the System 6 update should be referred to the Environmental Protection Authority for environmental impact assessment.

4.6 Poultry farms and piggeries

4.6.1 Objectives

To avoid potential conflicts over noise, dust and odour between existing poultry farms and piggeries and proposed nearby landuses.

4.6.2 Evaluation framework

Policy framework

Environmental Code of Practice - Poultry Farm. Environmental Protection Authority (1991)

Existing poultry farms can adversely affect adjoining existing and proposed landuses due to the generation of odour, noise, visual amenity, dust and traffic.

The Environmental Protection Authority normally recommends that residential areas be separated from poultry farms by a 500m buffer. Experience in other residential areas shows that where residential development is allowed to proceed within 500 metres of a poultry farm, affected residents may complain about the odour nuisance and other impacts from the poultry operations.

The Code states that residential development should not be permitted within 500m of a poultry farm unless appropriate studies have been carried out, including proper air dispersion modelling and dynamic olfactometry to determine the specific conditions of the site to determine acceptable standards of odour. After site specific studies have been undertaken, the width of the buffer zone could be amended.

Environmental Code of Practice - Piggeries. Environmental Code of Practice (1991)

In a similar manner to poultry farms, piggeries can also have an adverse impact on existing and proposed adjoining landuses due to the generation of odour, noise, visual amenity, dust and traffic. The Environmental Protection Authority recommends that the Department of Agriculture's *Environmental Management Guidelines for Animal Based Industries - Piggeries.*

should be consulted to ensure that the site complies with the recommended minimum separation distances to towns, single residences, waterways and bores.

Environmental Management Guidelines for Animal Based Industries - Piggeries. Department of Agriculture (1989)

The guidelines aim to provide guidance to those involved in the establishment and management of piggeries, to ensure that they can be established and managed in an environmentally acceptable manner. Particular emphasis is given to preventing water pollution.

The guidelines also recommend buffer distances for a number of landuses. Buffer distances vary depending on the size of the piggery and the nature of the adjoining land use.

Poultry Farm Policy No. DC 3.5. Western Australian Planning Commission

This Policy has been prepared by the Commission to assist in determining rezoning, subdivision and development applications for poultry farms. The policy also identifies matters to be taken into account in determining residential and other forms of development in the vicinity of poultry farms.

In considering proposals for the zoning, subdivision and development of land for residential purposes (closer than 500 metres to any existing or approved poultry shed) and rural residential purposes (closer than 300 metres to any existing or approved poultry shed) the Commission and/or local authority may require an assessment to show that the operation of the poultry farm will not adversely affect the amenity of the new residents in the proposed residential and rural/residential area.

Planning proposals

Four poultry farms and piggeries are located in the areas proposed to be zoned Urban or Urban Deferred in the MRS Amendment. These areas are also identified as Urban in the Structure Plan (refer to figure 8).

4.6.3 EPA evaluation

The Environmental Protection Authority considers that the Environmental Codes of Practice for Poultry Farms and Piggeries provide planning agencies with adequate guidelines to ensure that suitable buffer distances are provided between existing poultry farms and proposed urban development.

The poultry farms and piggeries within the proposed urban areas should be separated by at least 500m from residential dwellings.

The Environmental Protection Authority's position is that where residential development is proposed closer than the recommended buffer distances and the poultry farm or piggery is operating to industry standards and/ or licence conditions, the onus should be on the developer of the residential land to show that impacts on future residents would be acceptable. If this can't be demonstrated then the development within the buffer zone should not proceed. If residential areas do encroach within the buffer area the poultry farm or piggery should be relocated.

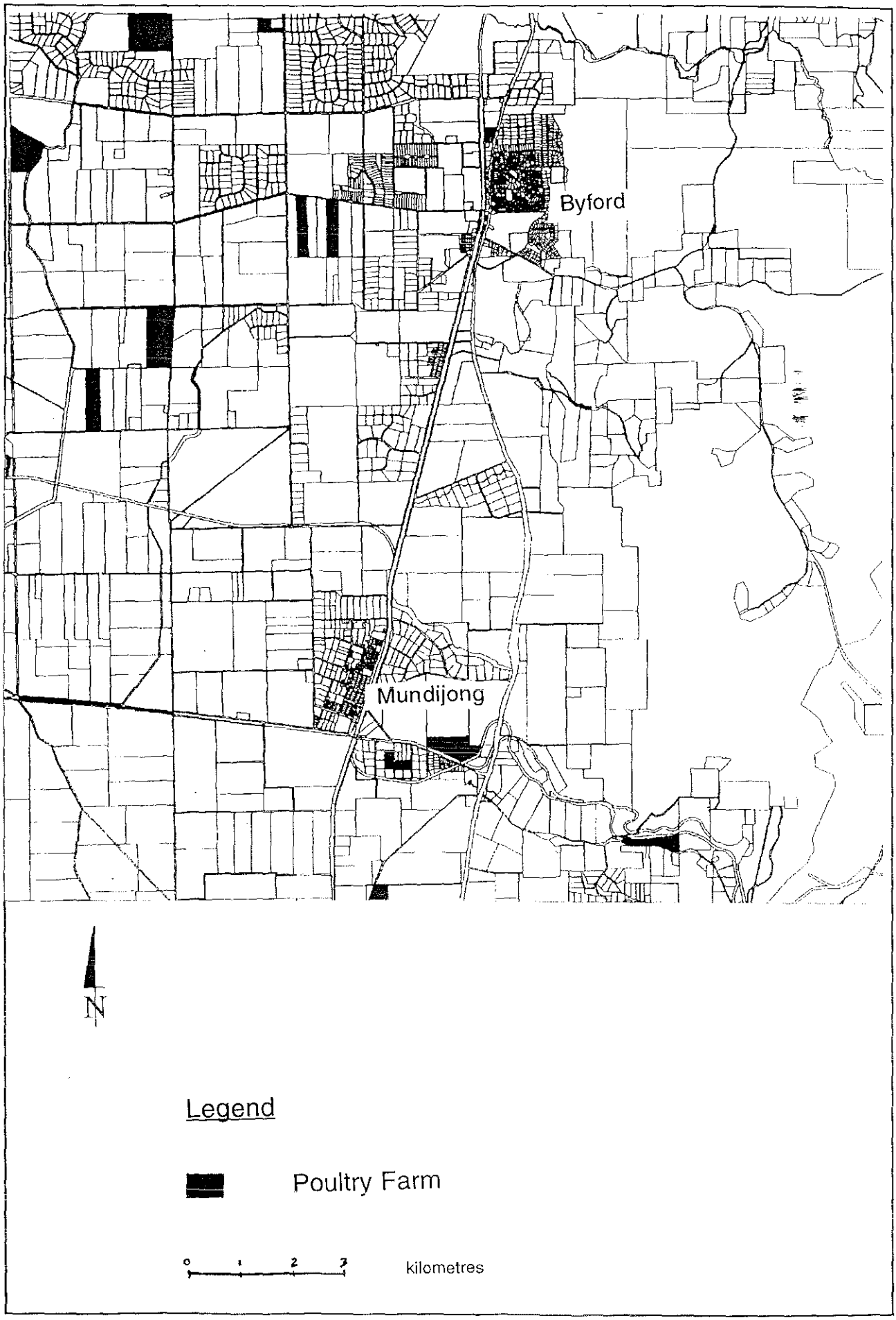


Figure 8. Location of Poultry Farms near Byford and Mundijong.

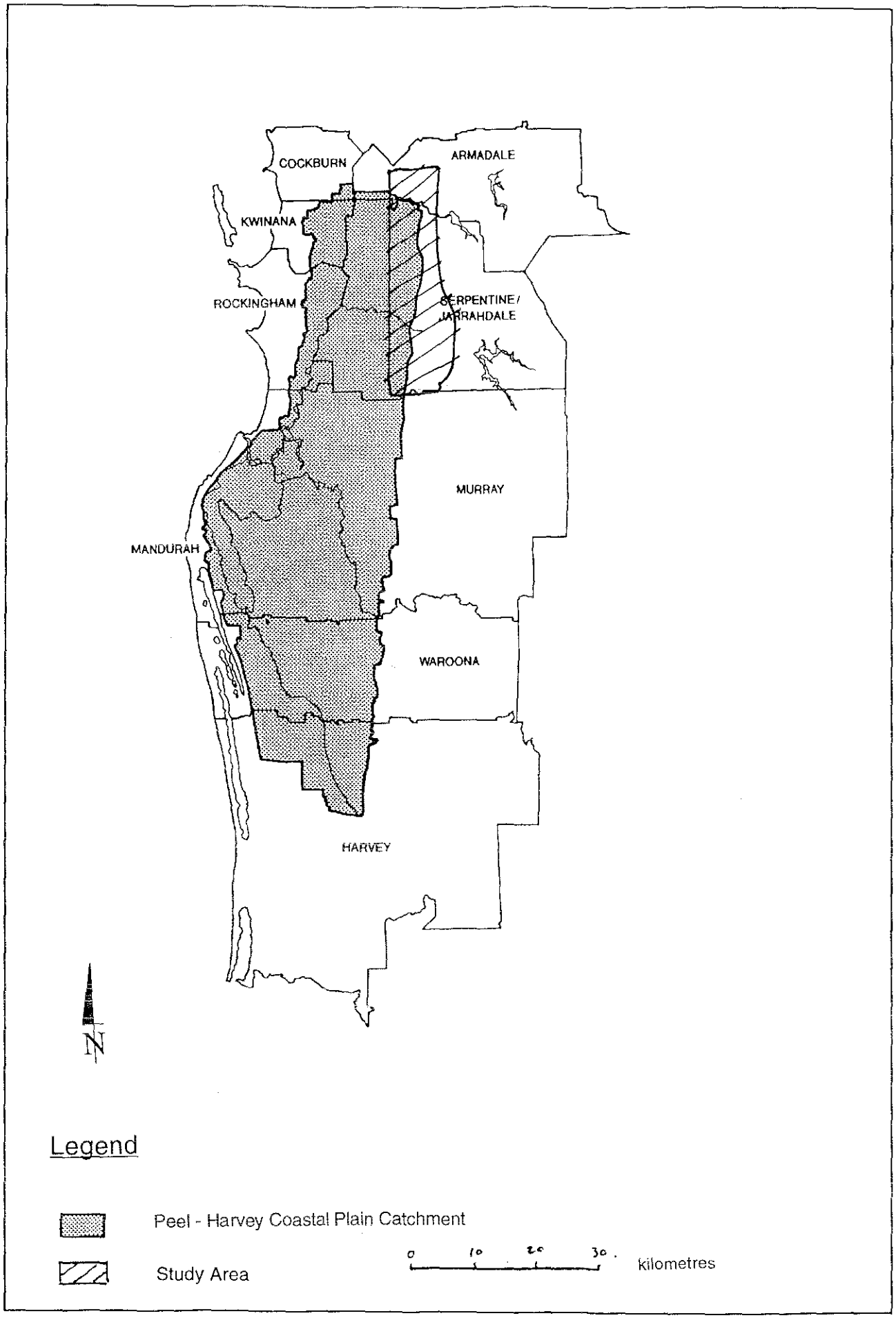


Figure 9. Peel - Harvey Coastal Plain Catchment

- increase high water using vegetation cover within the Peel - Harvey Coastal Plain catchment; and

- prevent landuses likely to result in excessive nutrient export into the drainage system.

General provisions of the policy:

- land shall not be rezoned for urban purposes unless certification is received from the Water Authority that arrangements have been made so that connection to an adequate sewerage service, or alternative system satisfactory to the Environmental Protection Authority and Health Department, will be available to all lots in the subdivision;

- proponents shall ensure that proposed changes to land zonings take account of land capability/suitability criteria with regard to the net effect that such changes are likely to have on the nutrient load discharging from the catchment into the Peel - Harvey Estuarine System;

- the retention and rehabilitation of existing remnant vegetation is to be encouraged. Remnant vegetation shall be retained along water courses, or the margins shall be replanted to higher water using vegetation to exert some control on sediment and nutrient movement; and

- subdivision proposals shall make provision for a drainage system which maximises the retention of drainage on site.

Planning proposal

The *Stormwater Management Strategy and Plans for New Urban Development at Byford and Mundijong* report was prepared to provide an improved method of stormwater management and flood protection for future urban development and reduce the export of nutrients to the Peel - Harvey Estuary from this development.

The *Green Towns Local Structure Plan (Hocking 1995), Stormwater Management Strategy and Plans for Byford Mundijong, Stormwater Management Plan for Byford and Mundijong* and *Draft Shire of Serpentine and Jarrahdale Mundijong Townsite Drainage Study* have been prepared for the Shire of Serpentine - Jarrahdale to assist in the implementing the Stormwater Management Strategy.

Drainage is an important engineering and environmental consideration in planning for proposed urban growth in Byford and Mundijong, due to the clay soils which result in high rates of run off and waterlogging.

The intention of the Strategy is to restrict the peak rate of stormwater flow and retain nutrient export to pre-urban rates. The Strategy also aims to maintain pre-urban water levels of valuable wetlands and creeks using water sensitive design techniques. The Water Sensitive Design Guidelines (Whelans, 1995) aim to enhance localised on site disposal at individual house and street level and provide temporary storage of stormwater at or near its origin with slow release to groundwater or downstream receiving bodies.

An important component of the *Stormwater Management Strategy* is the use of existing streams as multiple use stormwater drainage corridors (refer to Figure 5a & 5b). The corridors are identified in the *Structure Plan* where it is recommended that the land be reserved in a town planning scheme. The multiple use corridors are not reserved as Parks and Recreation or Public Purposes in the proposed *MRS Amendment.*

The *Stormwater Management Strategy* is aimed at designing a drainage network that will reduce the rate and quantity of stormwater runoff with the aim of reducing the nutrient levels. However, criteria has not been set to measure the quality (nutrient levels) of stormwater runoff and provisions to monitor nutrient levels have not been made.

5.1.3 EPA evaluation

The *Stormwater Management Strategy* and *Plans for New Urban Development at Byford and Mundijong* and the *Green Towns Local Structure Plan* accord with the Environmental Protection Authority's objective to reduce the export of nutrients into the Peel Harvey Inlet.

The Water Authority of Western Australia should develop a monitoring programme and criteria to measure nutrient levels in the stormwater runoff in accordance with the environmental quality objectives set out in the Environmental Protection (Peel Inlet - Harvey Estuary) Policy 1992 prior to the Local Authority's Town Planning Scheme being amended.

Should the *Stormwater Management Strategy* fail to adequately reduce nutrient levels, provisions should be made to implement the following contingency procedures:

- provision of additional detention basins within the multiple use corridors if the *Stormwater Management Strategy* does not reduce nutrient loads to an acceptable level;
- provision of regional detention basins to reduce nutrient levels in the event the multiple use corridors cannot be implemented; and
- defer further development if the monitoring of nutrient levels finds that the management strategy is ineffective.

Prior to the land identified as Urban and Urban Deferred in the Structure Plan and MRS Amendment being rezoned in the local authority's town planning scheme, the Western Australian Planning Commission and Environmental Protection Authority should agree to a process of implementing the multiple use corridors.

5.2 Transport

5.2.1 Objectives

Air quality

The Environmental Protection Authority's objective is to ensure that air quality in Perth does not exceed health and environmental standards.

Greenhouse gas emissions

The Greenhouse Co-ordination Council has proposed the following objectives for urban development:

- to stabilise total private passenger vehicle kilometres in the Perth Metropolitan Region by 2005 through urban planning, provision of public transport, cycleways and walkways.
- to implement programmes in urban planning and energy efficient building with the aim to stabilise residential and commercial energy use per capita and greenhouse gas emissions by the year 2005.

5.2.2 Evaluation framework

Perth Photochemical Smog Study

The Perth Photochemical Smog Study due for completion in late 1995 has confirmed that motor vehicle emissions of hydrocarbons and oxides of nitrogen are the dominant cause of Perth's photochemical smog.Photochemical smog (ozone) levels in the Perth airshed exceed World Health Organisation air quality criteria on about 10 days per year.

Policy framework

Revised Greenhouse Strategy for Western Australia 1994 (Greenhouse Coordination Council)

The pattern of urban and building design has a strong influence on energy use and greenhouse gas emissions. Emissions can be reduced by optimising landuse and transport related factors to reduce car travel, and by optimising dwelling siting and design to reduce heating and cooling related emissions.

The extent to which urban growth in metropolitan and regional areas is in energy efficient forms depends on the extent that concepts such as urban villages are facilitated and encouraged in planning strategies.

The Greenhouse Coordination Council recommends 'erring on the side of caution' or implementing 'no regrets' measures to reduce greenhouse emissions.

Planning proposal

Urban Villages. (Green Towns Local Structure Plan, Hocking 1995)

The Structure Plan proposes to accommodate 60,000 people over the next 25 years in Byford and Mundijong in a series of urban villages (or green towns) which will accommodate around 5,000 people each.

The villages will develop around a primary school, local shopping centre and open space and located adjacent to a bus route to foster a sense of community and reduce car dependence. Neighbourhoods will be clearly delineated by semi-rural development, green spaces and roads (Hocking 1995).

It is intended that these villages will be self sufficient to some extent and will reduce the need to travel long distances to schools, shops community facilities and open space.

Urban villages are more efficient in terms of energy, transport, land use, residential and housing design (Hocking 1995).

5.2.3 EPA evaluation

The South East Corridor Structure Plan is based on the urban village concept. As stated in the Revised Greenhouse Strategy this is considered to be an energy efficient form of urban growth and will help reduce the production of greenhouse gases.

6. Conclusions and recommendations

The Environmental Protection Authority concludes that the *Draft South East Corridor Structure Plan, Metropolitan Region Scheme Amendment No. 966/33;* and *Stormwater Management Strategy and Plans for New Urban Development at Byford and Mundijong* are environmentally acceptable subject to the recommendations listed below.

In reaching this conclusion, the Environmental Protection Authority identified the following main environmental objectives which the proposal should meet; that is to:

- avoid and minimise environmental damage to wetlands of local and regional significance;
- reserve land that has been identified in the System 6 Report as having conservation and recreation value;
- prevent nutrient enrichment and degradation of the groundwater and the surface water systems from on-site effluent disposal;
- protect remnant bushland communities identified in the System 6 review;
- minimise the potential impact of noise, dust and odour from existing poultry farms and piggeries on proposed adjoining landuses;
- ensure changes to land use within the catchment to the Peel Harvey Estuarine system are controlled so as to avoid and minimise environmental damage particularly in terms of nutrient export; and
- ensure suitable transport strategies have been adopted to ensure that air quality and greenhouse gas emissions in the South East Corridor meet health and environmental standards.

Recommendation 1

Wetlands with regional significance

The Environmental Protection Authority advises that:

- the South East Corridor Structure Plan report should refer to the need to protect those lakes east of Forrestdale Lake that are identified in the *Environmental Protection (Swan Coastal Plain Lakes) Policy* ;
- local structure plans should provide for the protection of the EPP lakes through the inclusion of the lakes and buffer areas in public open space;
- management plans should also be prepared and referred to the EPA for environmental impact assessment prior to the land being subdivided or developed;
- it supports the inclusion of M83 as a Parks and Recreation reserve in the Metropolitan Region Scheme Amendment; and
- proposals adjacent to or indirectly impacting EPP wetlands or land identified in the System 6 report should be referred to the Environmental Protection Authority for environmental impact assessment.

Recommendation 2

Wetlands with local significance

The Environmental Protection Authority advises that:

- the *Strategy for the Protection of Lakes and Wetlands of the Swan Coastal Plain (Bulletin 685);* and *A Guide to Wetland Management in the Perth and near Perth Swan Coastal Plain*

Area (Bulletin 686) provide adequate protection to the lakes not identified in the System 6 report and the Environmental Protection (Swan Coastal Plain) Policy; and

- proposals which significantly affect wetlands identified in Bulletin 686 as either Conservation and Recreation (Category O), Conservation (Category C) or High Conservation (Category H) should be considered environmentally unacceptable.

Prior to urban development occurring in areas likely to impact on a wetland the following work should be completed:

- the wetland and associated dryland buffer should be delineated;
- appropriate zoning or land use controls established for the wetland and buffer area;
- the wetland's management category, as described in Environmental Protection Authority Bulletin 686, should be determined;
- water level and water quality criteria set on a case by case basis; and
- a management plan should be developed consistent with the requirements above.

Any proposal which is inconsistent with Bulletins 685 or 686 or adversely affects category), C or H wetlands should be referred to the Environmental Protection Authority for formal assessment.

Recommendation 3

System 6 Areas (other than wetlands)

The Environmental Protection Authority advises that:

- the proposal to reserve M83 and M89 in the Metropolitan Region Scheme for Parks and Recreation purposes is supported;
- the identification of M80, M84, M85 and M87 in the Structure Plan as future Parks and Recreation reserves is supported;
- it is considered that the inclusion of M88 in the Private Land Conservation category of the Shire of Serpentine - Jarrahdale Local Rural Strategy will provide adequate protection; and
- proposals adjacent to or indirectly impacting land identified in the System 6 report should be referred to the Environmental Protection Authority for environmental impact assessment.
- any development proposals involving M88 should be referred to the Environmental Protection Authority for formal assessment.

Recommendation 4

Sewage

The Environmental Protection Authority advises that:

- any proposals for on-site waster water disposal including local treatment plants or the broad scale use of alternative treatment units (ATU's) must be referred to the Environmental Protection Authority for environmental impact assessment.

Recommendation 5

Threatened or Poorly Reserved Plant Communities Requiring Interim Protection

The Environmental Protection Authority advises that:

- the proposal to reserve Brickwood and Norman 3 in the Metropolitan Region Scheme for Parks and Recreation purposes is supported. The Western Australian Planning Commission (WAPC) should explore options to revise the boundaries of the Parks and Recreation reserve to be as close as possible to that shown on the maps showing the Threatened or Poorly Reserved Plant Communities Requiring Interim Protection;

- the Structure Plan should be modified to identify Punrack 1 and Page 30 as local open space. The significance of the Mundijong remnant bushland should be acknowledged in the Structure Plan and methods to explored by the WAPC to reserve these areas;

- road construction and batters must not impact on the Mundijong remnant bushland as shown on the maps showing the Threatened or Poorly Reserved Plant Communities Requiring Interim Protection. Construction plans should be referred to the Environmental Protection Authority for assessment prior to construction; and

- proposals affecting land identified in the System 6 review should be referred to the Environmental Protection Authority for environmental impact assessment.

Recommendation 6

Poultry Farms and Piggeries

The Environmental Protection Authority advises that:

- new residential lots should be separated at least 500m from the existing or proposed poultry sheds;

- where residential development is proposed closer than the recommended buffer distances and the industry is operating to industry standards and/ or licence conditions, the onus should be on the developer of the residential land to show that impacts on future residents would be acceptable, otherwise the development should be refused; and

- If residential areas encroach within the buffer area the poultry farm or piggery should be relocated.

Recommendation 7

Peel - Harvey Estuarine Catchment

The Environmental Protection Authority advises that:

- the *Stormwater Management Strategy and Plans for New Urban Development at Byford and Mundijong* and the *Green Towns Local Structure Plan* accord with the Environmental Protection Authority's objective to reduce the export of nutrients into the Peel - Harvey Inlet;

- The Water Authority of Western Australia should develop a monitoring programme and criteria to measure nutrient levels in the stormwater runoff in accordance with the environmental quality objectives set out in the Environmental Protection (Peel Inlet - Harvey Estuary) Policy 1992 prior to the Local Authority's Town Planning Scheme being amended;

- Should the Stormwater Management Strategy fail to adequately reduce nutrient levels, provisions should be made to implement the following contingency procedures:

    - provision of additional detention basins will be required within the multiple use corridors if the Stormwater Management Strategy does not reduce nutrient load to an acceptable level; and
    - provision of regional detention basins will be required to reduce nutrient levels in the event that multiple use corridors can not be implemented.

- Prior to the land identified as Urban and Urban Deferred in the Structure Plan and MRS Amendment being rezoned for urban purposes in the Shire of Serpentine - Jarrahdale Town Planning Scheme, the WAPC, Water Authority of WA, Shire of Serpentine - Jarrahdale and the Environmental Protection Authority should agree to a process of implementing the multiple use stormwater corridors.

- Defer further development if the monitoring of nutrient levels finds that the management strategy is ineffective.

Recommendation 8

Transport

The Environmental Protection Authority advises that:

- the urban village concept makes adequate provision for public transport, walking and cycling. Urban growth based on this concept will not exacerbate air quality or green house emissions to the same extent as typical growth patterns in the Perth Metropolitan area.

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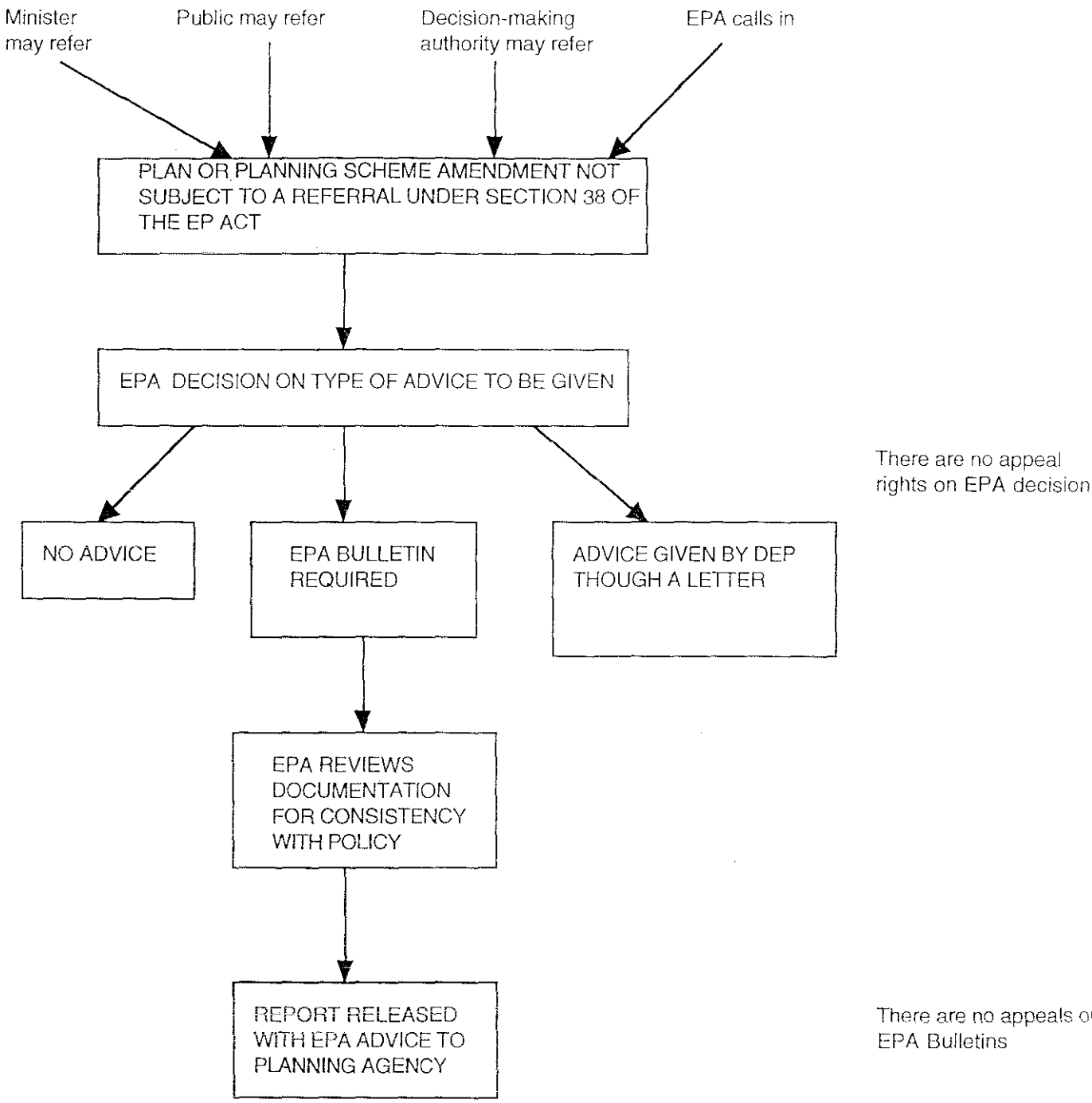
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Appendix 1

Strategic Environmental Assessment Process

Strategic environmental assessment process - assessment of plans, draft plans, statutory planning schemes and amendment to those schemes



•Protect land identified as having conservation and recreation value in the System 6 report	•There are no proposed land use changes within the boundaries of the System 6 area in either the Structure Plan or MRS Amendment. •The Structure Plan provides for the future reservation of four System 6 areas for Parks and Recreation purposes. These areas are M80, M84, M85, M87. •Two of the System 6 areas (M83 and M89) are included in the MRS amendment as Parks and Recreation reserves. •M88 has not been recommended for future reservation.	•M88 has not been recommended for future reservation.	•Land that has been identified in the System 6 report as having conservation and recreation value should be reserved.	•Seven System 6 areas located within the study area.	•The EPA supports the proposed reservation of M83 and M89. •The identification of M80, M84, M85, M86 and M87 as future reserves in the Structure Plan is supported. •The inclusion of M88 in the Private Land Conservation category of the Shire of Serpentine Jarrahdale Rural Strategy will provide adequate protection. •M88 proposals to be referred for EIA. •Proposals adjacent to or indirectly impacting land identified in the System 6 report should be referred to the EPA for EIA.
•Waste water disposal	•Byford and Mundijong are located a considerable distance from existing sewerage infrastructure. •A number of options to provide waste water disposal.	•Nutrients entering the surface drainage system could flow into the Peel - Harvey Estuary.	•Prevent nutrient enrichment and degradation of the groundwater and the surface water systems from on-site effluent disposal	•On-site waste water disposal should be appropriately located to prevent pollution and nutrient enrichment of groundwater and surface water.	•Proposals for on-site waste water disposal including local treatment plants or ATU's must be referred to the EPA for EIA.

Table 2 Indentification of Issues and Summary of EPA Recommendations

Topics	Proposal Characteristic	Identification of Issues	Objectives	Evaluation Framework	EPA Recommendations
•Environmental impacts to wetlands of regional significance within the south west corridor	•EPP wetlands east of Forrestdale Lake are within an area identified as Urban Deferred in the Structure Plan. There is potential for environmental from the urban development. •There are a number of System 6 wetlands within the study area. Forrestdale Lake (M95) is currently reserved for Parks and Recreation in the MRS It is proposed reserve M83 for Parks and Recreation as part of the MRS Amendment.	•The Structure Plan does not refer to the need to protect or manage EPP wetlands.	•Ensure that proposed land use changes do not cause environmental damage to wetlands of regional significance.	•The EPA is concerned with the filling, draining, mining and polluting of EPP Lakes, System 6 lakes, wetlands with rare vegetation communities and wetlands recognised by international agreements.	•The Structure Plan should refer to the need to protect the EPP lakes to the east of Forrestdale Lake. •Local structure plans should provide for the protection of the EPP lakes through the inclusion of the lakes and buffer areas in the public open space. •Where EPP lakes are affected, management plans should also be prepared and referred to the EPA for EIA prior to the land being subdivided or developed. •The EPA supports the proposed reservation of M83 as recommended in the System 6 report.
•Environmental impacts to wetlands of local significance within the south west corridor	•Lakes of local significance have not been identified in the Structure Plan or MRS Amendment. These wetlands can be adequately managed under the guidelines of Bulletin 685 and 686.	•Local wetlands should be managed in accordance with the requirements of Bulletin 685 and 686.	•Ensure that proposed land use changes do not cause environmental damage to wetlands of local significance.	•Local wetlands to be protected and managed in accordance with the principles outlined in Bulletins 685 and 686.	•Bulletins 685 and 686 provide adequate protection to those lakes not EPP lakes or identified in the System 6 report •Proposals affecting Category O, C and H lakes would likely be environmentally unacceptable. •Proposal inconsistent with Bulletins should be referred to the EPA for EIA.

•Protect remnant bushland communities identified in the System 6 review	•There are five areas of remnant bushland identified in the System 6 review located in the South East corridor. •It is proposed to reserve Brickwood and Norman 3 for Parks and Recreation in the MRS Amendment. •Mundijong Road is identifed as Controlled Access Highway in the MRS Amendment.	•Punrack 1 and Page 30 are not identified in the Structure Plan or MRS Amendment.	•Reserve remnant bushland communities that have been identified in the update of the System 6 report.	•Five areas of remnant bushland within the study area identified in the System 6 review.	•The reservation of Brickwood and Norman 3 in the MRS is supported. •The WAPC should expolre options to revise the boundaries of the Parks and Recreation reserve to be as close as possible to that shown on the Interim Protection Plan. •Punrack 1 and Page 30 should be identified as local open space in the Structure Plan. •Proposals affecting land identified in the System 6 review should be referred to the EPA for EIA. •Road construction and batters must not impact on the Mundijong remnant bushland. Construction plans to be referred to the EPA for EIA
•Impact of noise, dust and odour from existing poultry farms and piggeries on proposed adjoining landuses	•Four poultry farms and piggeries are located in the areas proposed to be zoned Urban or Urban Deferred in the MRS Amendment.	•Impact of existing poultry farms and piggeries on proposed residential areas.	•To minimise the impact of noise, dust and odour from existing poultry farms and piggeries on proposed adjoining landuses.	•Environmental Codes of Practice for Poultry Farms and Piggeries. •Environmental Management Guidelines for Animal Based Industries - Piggeries. •WAPC Poultry Farm Policy No. DC 3.5	•New residential lots should be separated at least 500m from existing poultry farms. •The onus is on the developer to demonstrate that existing poultry farms will not impact on proposed residential lots. •Poultry farms and piggeries should be relocated away from future or existing residential areas.

•Nutrient export into the Peel - Harvey Estuarine catchment	•The clay soils in the Byford and Mundijong area results in high rates rates of stormwater runoff.	•A drainage strategy will be necessary to control runoff and prevent the export of nutrient tto the the Peel-Harvey Estauary.	•Manage land use changes within the Peel - Harvey Estuarine catchment to avoid and minimise environmental damage in terms of nutrient export.	•Environmental Protection(Peel Harvey Estuary) Policy 1992 •Statement of Planning Policy No. 2 The Peel Harvey Coastal Plain Catchment.	• The Stormwater Strategy and Green Town Local Structure Plan accords with the EPA's objective to reduce the export of nutrients into the Peel Harvey Inlet •Criteria to measure nutrient levels in the stormwater runoff must be adopted by the Water Authority of Western Australia in accordance with the environmental quality objectives set out in the Peel - Harvey Estuary EPP prior to the Town Planning Scheme being amended. •Additional detention basins will be required within the multiple use corridors if the Stormwater Management Strategy does not reduce nutrient loads to an acceptable level. •Regional detention basins will be required to reduce nutrient levels in the event the multiple use corridors can no be implemented. •The decision making authorities must adopt an agreed method of implementing the stormwater management strategy prior to land being rezoned in the local authority's Town Planning Scheme for urban purposes.

•Air quality and greenhouse gas emissions	•The Structure Plan proposes to create urban villages which are intended to encourage pedestrian and bicycle use.		•Adopt suitable transport strategies to ensure that air quality and greenhouse gas emissions in the South East Corridor meet health and environmental standards	•Reduce traffic volume and distances travelled in private vehicles.	•The urban village concept will not exacerbate air quality and green house gas emissions to the same extent as typical urban growth patterns in the Metropolitan Region.

Appendix C

Local Water Management Strategy

wave international

DETERMINE • DESIGN • DELIVER





Mundijong Precinct G1
Local Water Management Strategy

Peet Limited

Rev B February 2016

engineering project management environment

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Project Brief

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EXECUTIVE SUMMARY

Wave International was commissioned by Peet Ltd to prepare this Local Water Management Strategy (LWMS) to support the Local Structure Plan for Precinct G1 of the Mundijong/Whitby District Structure Plan area. The LSP area is 199ha, and is located approximately 40km south of the Perth CBD and 3km north-west of the Mundijong Town Centre. The site is proposed to be developed for residential purposes, and is expected to yield approximately 2250 residential lots, with two primary schools and associated community infrastructure.

This LWMS has been developed to address and guide the management of groundwater and surface water resources at the site, and sets out the design objectives and criteria for the future development.

The site is defined by the following key characteristics:

- The site is zoned Urban under the Metropolitan Region Scheme and the Shire of Serpentine Jarrahdale's Town Planning Scheme No 2, and forms Precinct G1 of the Shire of Serpentine Jarrahdale's Mundijong/Whitby District Structure Plan.
- The site's natural topography falls from east to west, at an average grade of approximately 0.8%. The site's geotechnical conditions typically consist of sand of varying depth overlying clayey sands and/or ferricrete gravels. While the Department of Environment Regulation's acid sulphate soils risk mapping identifies the site as generally having 'moderate to low risk of ASS occurring within 3m of the natural surface', a geotechnical site investigation and subsequent lab testing found that there is a low likelihood of actual or potential ASS on the site.
- There are two conservation category wetlands on the site. The first is a sumpland in the site's south-eastern corner, and the second is the Manjedal Brook, which is a creek that runs from east to west across the site, and extends for a significant distance both upstream and downstream of the LSP area. These wetlands will be surrounded by buffer zones to protect the wetlands' values and integrate them into the surrounding development.
- There are six aboriginal heritage sites within the LSP area that are listed on the Department of Indigenous Affairs' Aboriginal Inquiry System. A detailed aboriginal heritage assessment has been undertaken be specialist consultants to support the LSP, and the water management measures outlined in this LWMS do not impact on any of the sites.
- Groundwater is relatively shallow across the site, ranging from near-surface to 2m deep, with groundwater perching on the underlying low-permeability clayey soils.
- Surface water runs from east to west across the site, with surface runoff being captured by farm drains that discharge to the Manjedal Brook. The Manjedal Brook conveys regional stormwater runoff from a large catchment to the east of the site, extending to the Darling Scarp. The Manjedal Brook extends downstream of the LSP area, discharging to the Oaklands Main Drain approximately 2.5km west of the LSP area.

The Mundijong Whitby District Structure Plan – District Water Management Strategy (GHD, 2010) sets out broad-scale stormwater management measures for the entire DSP area, which extends from South Western Highway to the future Tonkin Highway reserve. The DWMS includes the key design principles and objectives for water conservation, stormwater management & groundwater management that local structure plans within the DSP area need to address through the design of their developments.

This LWMS outlines the key design criteria that will apply to development within the LSP area, and includes preliminary details on stormwater, groundwater, and water conservation measures that will allow developments to achieve the required design criteria.

A preliminary stormwater drainage design has been undertaken, with the required bioretention and storage areas for 1yr, 5yr and 100yr ARI storm events in each catchment of the LSP area defined. Figure x.x shows the major stormwater drainage flow paths and the required drainage storage volumes for the critical storm events.

The LSP has identified the opportunity to develop multiple use wetland area (MUW 7834) for residential land use with associated community facilities. This area is adjacent to the CCW Sumpland 7835, in the south-eastern corner of the site. There are no drainage impediments to the implementation of this proposal, however potential environmental or aboriginal heritage constraints will dictate the final landuse of this area.

Recommendations

We make the following recommendations for the implementation of the LSP, with regards to water management:

- Drainage corridors be provided within areas of public open space throughout the structure plan area to achieve the minimum required drainage areas as outlined in Table 5-1and Figure 5.1 of this LWMS.
- The buffer around the Manjedal Brook be reduced to 30m (measured from the top of the brook's bank, on both the northern and southern sides of the brook), subject to confirmation that there are no environmental or aboriginal heritage impacts from the reduced buffer area. Section 5.3 of the LWMS discusses the reduction in buffer width for the Manjedal Brook.
- 5yr drainage swales for catchments located alongside the Manjedal Brook be located inside the buffer area. These areas are to be separated from the 1yr bioretention areas, which will be located in areas of public open space adjacent to, but outside of, the buffer area.
- Bioretention areas to be provided throughout the LSP area in road verges along inactive lot frontages where practicable. This will reduce the impact of bioretention areas on public open space, and increase the amount of usable POS through the LSP.
- Subsoil drainage network to be designed & installed in all subdivision roads to manage perched groundwater levels during winter months.
- The groundwater and surface water monitoring requirements outlined in Section 6 should be further refined in future urban water management plans, and adopted in future subdivision application areas within the LSP area.
- The future landuse of the area in the site's south-eastern corner (the potential development of multiple use wetland MUW 7834) is to be resolved through a Section 18 application under the Aboriginal Heritage Act (1972), which is being undertaken independently of this LWMS. The ultimate landuse of this area does not have a material impact on this LWMS, and the design can easily accommodate both residential and POS land uses.

1 INTRODUCTION

1.1 Background

Wave International was commissioned by Peet Ltd to prepare a Local Water Management Strategy for approximately 199 hectare landholding (the site) within the Mundijong/Whitby District Structure Plan area. This area is delineated as Precinct G1 in the DSP and is located approximately 40km south of the Perth CBD, and 3km north-west of the Mundijong Town Centre.

Precinct G1 is bounded by Bishop Road to the north, proposed Tonkin Highway to the west, Scott Road and Manjedal Brook to the south and Soldiers Road to the east. Refer to Figure 1.1 for site location in relation to surrounding areas.

The site is currently used for stock grazing and is almost entirely cleared. Two natural drainage flow paths currently traverse the site in east-west direction (further discussed in Section 2.4). The Precinct G1 area included the following land holdings:

Table 1-1 - Precinct G1 area

Owner	Lot no	Address	Area
Wellstrand Pty Ltd	2	No address provided	32ha
Wellstrand Pty Ltd	11	29 Taylor Road, Mundijong	35ha
Wellstrand Pty Ltd	10	52 Taylor Road, Mundijong	22ha
Peet Ltd	9000	9000 Taylor Road, Mundijong	61ha
Peet Ltd	405	405 Bishop Road, Mundijong	8ha
Peet Ltd	98	No address provided	10ha
Peet Ltd	98	No address provided	30ha
SJ Shire		Existing Road Reserves	2ha
Total			**199ha**

The development of the Precinct G1 area is expected to yield approximately 2250 residential lots, with two primary schools (with sporting ovals) and associated community infrastructure. The Subject Site contains seven properties with Peet Ltd and Wellstrand Pty Ltd as the primary land owners. There are several existing gazetted road reserves within the Precinct G1 area.

This Local Water Management Strategy will address water management issues over the proposed Precinct G1 Local Structure Plan (Precinct G1).

1.2 Planning context

The Subject Site is zoned "urban" in both the Metropolitan Region Scheme and the Shire of Serpentine-Jarrahdale Town Planning Scheme No 2 (TPS2).

The Mundijong/Whitby District Structure Plan (DSP) was adopted by the Shire of Serpentine Jarrahdale (SJ Shire) in August 2011 to govern the development of 1,420 ha of mostly rural and semi-rural land holdings for urban development. The DSP was divided into seven precincts (Precincts A-G).

An amendment to the DSP in April 2012 further delineated two of the precincts (E and G) into sub-precincts (E1, E2 and G1, G2). As discussed in Section 1.1, the site falls within precinct G1.

The Mundijong Whitby District Structure Plan District Water Management Strategy (DWMS) – GHD 2010, forms part of the DSP. The DWMS addresses broad-scale stormwater management measures over an 1800ha area which extends from the future Tonkin Highway reserve to South Western Highway. This document will be used as the basis of the this LWMS.

A Local Structure Plan has been prepared for the proposed development of Sub-Precinct G1 as shown on Figure 1.2. This LWMS is a key supporting document of the Precinct G1 LSP. Diagram 1-1 Extract from "Better Urban Water Management (2008)" – Integrating water planning with land planning process shows the planning stage this document relates to.

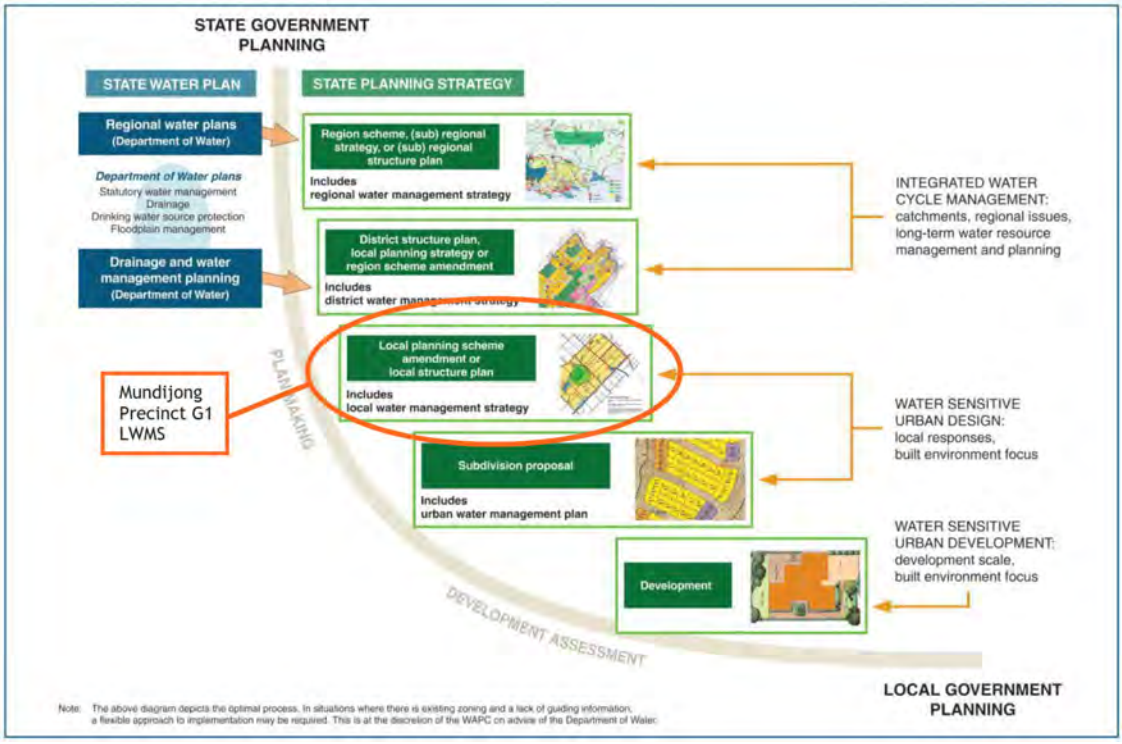


Diagram 1-1 Extract from "Better Urban Water Management (2008)" – Integrating water planning with land planning process

1.3 Design principles and objectives

The DWMS set out several design principles and objectives for water conservation, stormwater management and groundwater management within the DSP area. These design objectives and criteria are summarised in the table below:

Table 1-2 - DWMS design objectives

Category	Design objectives	Strategies	Design criteria
Protection of environmental assets	• Minimise changes to hydrology to prevent impacts on watercourses and wetlands • Manage and restore watercourses and wetlands • Assess and manage impacts on native flora and fauna • Assess and manage impacts on sites of indigenous significance	• Manage surface water to prevent increase in peak flows discharging to receiving environments. • Watercourses and wetlands must not dry out due to over abstraction of water resources or lowering of groundwater levels.	• Post-development critical 5yr peak flow and volume and 100yr ARI peak flow to be consistent with pre-development flows at the discharge point from all subdivisions, at discharge points from each structure plan and at discharge points from each subcatchment. • Floodways shown in DWMS Figure A11 are not to be developed or obstructed in any way.
Urban water use	• Ensure the efficient use of all water resources in the newly-developing urban form and aim to achieve highest value use for fit-for-purpose water.	Potable water: • Adopt drinking water targets. • Use only water efficient fixtures and fittings.	• Consumption target of 100 kL/person/year (40-60 kL/person/year of scheme water). • Meet 5-star Plus provisions for all new dwellings.
	• Maintain opportunities for future generations by using water more efficiently. This is best achieved	• Ensure that landscaping and irrigation use water efficiently.	• Promote the use of native plants. All parts of POS except turfed areas are to contain only native plants. Alternative non-local plants may be considered where passive solar exposure is required.

Category	Design objectives	Strategies	Design criteria
	by combining several approaches such as raising community awareness, regulation, market mechanisms to facilitate recognition of the true value of water and financial incentives/ assistance to facilitate change.	Fit-for-purpose water: • Ensure that non-potable water supply systems deliver a net benefit to the community. • Ensure that non-potable water supply systems are designed as part of an integrated water supply.	• The use of on-site rainwater tanks is to be promoted to achieve water consumption targets whilst also having the ability to fully or partially meet on-site retention requirements.
Stormwater management	• Protection of wetlands and waterways from the impacts of urban runoff. • Protection of infrastructure and assets from flooding and inundation.	• Minimise changes in hydrology to prevent impacts on receiving environments: • 1yr1hr ARI post-development discharge volume and peak flow rates shall be maintained relative to pre-development conditions at subcatchment outlets. Where there are identified impacts on significant ecosystems, maintain or restore desirable environmental flows and/or hydrological cycles as approved by the	• Retain 1yr 1hr ARI event at-source via soakage or storage devices. • Post-development critical 5yr peak flow and volume and 100yr ARI peak flow to be consistent with pre-development flows at the discharge point from all subdivisions, at discharge points from each structure plan and at discharge points from each subcatchment. • Flows from developed areas to be attenuated via flood detention storage areas incorporated into POS and located outside defined floodways. • Floodways shown in DWMS Figure A11 are not to be developed or obstructed in any way. • Development outside the floodway should ensure finished flood levels are a minimum of 0.5m above the 100yr ARI flood level in streamlines and basins, and 0.3m above the 100yr ARI flood level for other drainage paths (e.g. road reserves). • Existing cross-sectional areas of waterways to be maintained. Channel realignments and channel profile modifications may be

Category	Design objectives	Strategies	Design criteria
		DoW. • Implement BMPs that promote on-site retention of events up to 1yr 1hr ARI. • Manage surface water flows from major events to protect infrastructure an assets. • Uphold environmental values of downstream waterways within and surrounding the study area.	carried out provided that the pre development cross section area has been preserved. A permit is required to alter the beds and banks of waterways under the Rights in Water and Irrigation Act 1914. • POS and retention basins should operate as dry basins with minimum 0.3m separation between invert and Controlled Groundwater Level (CGL). • Defined major arterial roads to remain passable in the 100yr ARI storm event. • Minor roads to remain passable in the 5yr ARI event • Emergency evacuation areas to be at least 2m above 100yr ARI flood level. • Water quality treatment systems and WSUD structures to be designed in accordance with the Stormwater Management Manual and Australian Runoff Quality.

Surface water quality	• Uphold environmental values of downstream waterways within and surrounding the study area.		• Non-structural measures to reduce applied nutrient loads.
			• On-site retention of 1yr 1hr ARI event.
			• Use of bio-retention structures.
			• The following water quality targets are to be achieved as compared to a development that does not actively manage water quality:
			  • 80% reduction in TSS
			  • 60% reduction in TP
			  • 45% reduction in TN
			  • 70% reduction in gross pollutants.

Category	Design objectives	Strategies	Design criteria

			• If no water quality modelling is done, the following are to be achieved:
			  • Retain 1yr 1hr ARI event from connected impervious areas at-source.
			  • Maintain critical pre-development 1yr ARI peak flows and volumes.
			  • Size bio-retention systems to be 2% of connected impervious area.
			  • Soil amendment should include a 300mm deep layer of material to reduce nutrient export (PRI>10) across at least 10% of the site including all landscaped POS and drainage structures.
			• Swales and bio-retention/infiltration systems to have sufficient clearance from groundwater to ensure that they do not remain permanently wet.

Groundwater management	• Protect infrastructure and assets from flooding by high seasonal groundwater levels, perching and/or soil moisture. Protection of groundwater dependent ecosystems from the impacts of urban runoff. • Managing and minimising changes in groundwater level and groundwater quality following development /redevelopment.	• Manage groundwater levels to protect infrastructure and assets. • Maintain groundwater regimes for the protection of groundwater dependent ecosystems. • Manage the shallow aquifer to protect the value of groundwater resources.	• Where a perched water table exists or the predicted maximum groundwater level is within 1.2m of natural surface, clean fill and/or subsoil drainage is required to ensure adequate separation to finished levels. • Bio-retention system and drainage inverts to be at or above approved CGL, although existing inverts below this level may remain. • Subsoil drains to have free-draining outlets. • Finished lot levels to be at least 0.8m above the phreatic line (i.e. the mounding between parallel subsoil drains). • Clean fill imported on the site for WSUD elements is to incorporate a

Category	Design objectives	Strategies	Design criteria

			band of material that will reduce phosphorous export via soil leaching, whilst also meeting soil permeability and soil compaction criteria specified by the local government authority.
			• Where development is associated with any new or existing waterway or open drain that intersects the shallow water table, and that may discharge pollutants from the shallow groundwater to receiving environments, the following interim targets will be adopted (as compared to a site that does not actively manage water quality):
			  • 60% reduction in TP
			  • 45% reduction in TN.
			• Where development is associated with an ecosystem that is dependent of a particular hydrologic regime for survival, the water quality discharged to the groundwater must be in accordance with the requirements of the Department of Water.

2 PRE-DEVELOPMENT ENVIRONMENT

The subject area is 199 ha in area and is bounded by Bishop Road (north), the proposed Tonkin Highway (west), Soldiers Road (east). Manjedal Brook forms the southern boundary of the development up to its crossing under Taylor Road. West of Taylor Road the Subject Site extends further south to Scott Road.

The following sections include information on pre-development site conditions and summaries of the various studies and site investigations that have been completed to support the Precinct G1 LWMS and Precinct G1 LSP.

As noted in Section 1.1, the site is almost entirely cleared, except for a few scattered trees. Manjedal Brook is a significant watercourse identified in the DWMS to be retained.

Farm buildings are located on Lot 11 Taylor Road and a smaller farm establishment is located on Lot 10 Taylor Road. Figure 2.1 shows a recent aerial photo of the Precinct G1 site and surrounding area.

2.1 Topography

The natural surface levels of the Subject Site falls from east to west at an average grade of approximately 0.8%. The western half of the site has a gentler slope of 0.5%, which increases to a grade of 1% towards the eastern end. Existing ground levels range from 40mAHD along the eastern boundary to 25mAHD in the west. Existing surface contours are shown in Figure 2.1.

2.2 Geotechnical conditions

A geotechnical site investigation was carried out by Galt Geotechnics in 2011; the report "Report on Geotechnical Study Proposed Residential Development Lots 37, 98 and 9000 Bishop Road" is included in Appendix A.

The report summarised the combined findings of Galt Geotechnics site work and previous work undertaken by Parsons Brinckerhoff in 2006. It was found that soil conditions across the site can be described by two typical soil profiles:

- Sand – comprising of the following:
  - Sand (SP) – Medium to coarse grained, sub-rounded to sub-angular material with occasional 5mm to 15mm weakly to moderately cemented ferruginised modules. (between 0.5m and 2.5m, however average thickness 1.4m); overlaying
  - Ferricrete Gravels (GP/GC) – Located in 9 out of 18 test pits at depths below 1.0m. Fine to medium gravels in sand and clayey sand, becoming cemented in areas. Refusal encountered between 0.9m to 2.0m.
  - Clayey sand (SC) – Located in 2 out of 18 test-pits and present below sand layer. Localised layer/lenses of medium to course sub-rounded to sub-angular varying between 10-30% low to medium plasticity clay fines with occasional 5mm to 15mm weakly to moderately cemented ferruginised modules. (0.4m thick)
- Clayey sand – comprising of the following:
  - Sand (SP) – Medium to coarse grained, sub-rounded to sub-angular material between 0.0m and 1.3m. (average thickness 0.7m); overlaying
  - Clayey sand (SC)/Sandy Clay (CL) –Medium to course grained sub-rounded to sub-angular varying between 20-60% low to medium plasticity clay fines (localised high plasticity) with occasional weakly to moderately cemented ferruginised modules present between 1.2m to 2.6m.

- Ferricrete Gravels (GC) – Located in 3 out of 18 test pits. Moderately to well cemented ferricrete gravels in a matrix of medium sand/sandy clay material ranging from 1.2m to 2.5m. Refusal encountered on well cemented ferricrete in 1 test-pit.

Figure 2.2 shows the test-pit locations and contours of the underlying clayey sand levels, while Figure 2.3 shows the depth from natural surface to the underlying clays.

Galt Geotechnics Pty Ltd undertook four permeability tests across the Subject Site using the inverse auger hole method. The tests were conducted on clayey sand, sand and saturated sand at embedment depths ranging from 0.56m to 0.65m, which results in a varying permeability of 0.2 to 9.6m/day. Refer to Figure 2.2 for test pit locations and Table 2-1 for a more detailed permeability test results.

Table 2-1 Permeability Test Summary

Test Number	Description	Embedment (m)	Average Permeability k (m/day)*		
			Test 1	Test 2	Test 3
P1	Clayey Sand	0.56	0.4	0.4	0.2
P2	Sand	0.58	8.9	9.6	7.4
P3	Sand (Saturated)	0.58	4.5	4.6	3.8
P4	Sand (Saturated)	0.65	0.8	0.7	0.4

* Average permeability with head varying between 0.2m and 0.7m

This permeability test however relates only to the existing ground condition. The site will be extensively earthworked including the importation of sand fill. Therefore the post-development infiltration rate depends on the characteristics of the fill material more so than the in-situ material.

Galt Geotechnics was engaged to conduct geotechnical investigation only on the Precinct G1 area owned by Peet Ltd (Southern Portion). However it has been assumed that the same soil formation exists throughout the Precinct G1 area.

2.3 Acid sulfate soils

A review of the Department of Environment Regulation (previously the DEC) risk mapping for acid sulfate soils (ASS) via the WA Atlas (Shared Land Information Platform) showed that most of the site is classified as "Class 2 – Moderate to low risk of ASS occurring within 3m of natural surface". There are two small areas where the site is classified as "Class 1 – High to moderate risk of ASS occurring within 3m of natural soil surface.

Screening tests were undertaken by Galt Geotechnics in order to further improve knowledge of likely site ASS conditions and whether further investigation was required.

They further reported that there is a low likelihood of actual ASS or potential ASS at the site, based on 53 samples collected across the site (at varying depths) that were laboratory tested. Galt stated that they do not consider further ASS investigation is warranted. Refer to Appendix A.

2.4 Wetlands and Bush Forever sites

The majority of the site is classified as a Multiple Use Wetland (MUW) under the Department of Waters Perth Groundwater Atlas and the Department of Parks and Wildlife (DPaW), previously the DEC, Geomorphic Wetland mapping dataset.

The Manjedal Brook, a Conservation Category Wetland (CCW) – UFI 14945 & 15446 - traverses the site in an east-west direction. The Brook channels regional flow from the eastern escarpment to Folly River downstream. Manjedal Brook enters the site at Soldiers Road, draining west where Taylor Road crosses over the Brook and out of the site at the Tonkin Highway Reserve.

PGV Environmental undertook a study to determine the CCW and buffers for the Subject Site, which correspond with the CCW information provided by the DPaW mapping dataset. PGV Environmental workplans have been provided in Appendix B.

The classifications of the Geomorphic Wetlands for the site is as follows

1 Wetland Classification	Wetland Type	UFI Number	Location
Conservation Category	2 Paluspla in	3 14945, 15446	4 Manjedal Brook
5 Conservation Category	6 Sumpla nd	7 7835	CC Sumpland - on the south eastern corner of the site, north of the Manjedal Brook
8 Multiple Use	9 Sumpla nd	10 7834	On the south eastern corner of the site, to the west of the CC Sumpland
11 Multiple Use	12 Paluspla in	13 15447, 15448	On the south eastern corner of the site, between the Manjedal Brook and the CC Sumpland.
14 Multiple Use	15 Paluspla in	16 15785	17 The large areas of sandy clay soils on the site

According to information taken from the PGV Environmental Baseline Groundwater Monitoring Report, the Manjedal Brook has been mapped as a palusplain, however, it is actually a creek and not a palusplain. Descriptions of the above wetland types are:

- Sumplands: seasonally inundated basins;
- Palusplains: seasonally waterlogged flats; and
- Creeks: seasonally inundated channels.

Wetland mapping for the Precinct G1 area is included in Figure 2.4.

The DWMS echoed the recommendation by SKM (2007) in the Mundijong Floodplain Management Study for the DSP area, to protect the ecosystem of the Manjedal Conservation Category Wetland (UFI 7835 – Sumpland) by maintaining the existing groundwater levels within a 200m buffer of the CC Sumpland.

2.5 Aboriginal heritage sites

According to the Department of Ingenious Affairs (DIA) Aboriginal Inquiry System (DIA, 2013), there are six Aboriginal Heritage sites listed on their inquiry system that lie within the Subject Site.

Site ID	Status	Access Type	Restriction	Name	Type	Additional Info
32591	Lodged	Open	No Gender Restrictions	MJ-01	Artefacts / Scatter	Archeological Deposit
32614	Lodged	Open	No Gender Restrictions	MJ-05	Artefacts / Scatter	Archeological Deposit
32615	Lodged	Open	No Gender Restrictions	MJ-04	Artefacts / Scatter	Archeological Deposit
32616	Lodged	Open	No Gender Restrictions	MJ-03	Artefacts / Scatter	Archeological Deposit
32619	Lodged	Open	No Gender Restrictions	MJ-02	Artefacts / Scatter	Archeological Deposit
3648	Registered Site	Open	No Gender Restrictions	Soldiers Road, Mundijong	Artefacts / Scatter	Archeological Deposit

Figure 2.5 shows the existing Aboriginal Heritage sites registered with the DIA.

The DWMS recommends that prior to construction of individual developments, assessment should be undertaken by a qualified consultant to determine whether a more thorough Aboriginal heritage investigation of the area needs to be undertaken for any specific location to assess the significance of these sites or to identify unregistered sites.

A detailed aboriginal heritage assessment has been undertaken in the preparation of the LSP and no additional water management impacts were identified.

2.6 Groundwater

2.6.1 DWMS groundwater modelling

The maximum groundwater levels reported in the DWMS were based on a local scale model over a larger study area and were developed by CyMod System during 2007 based on DoW's Perth Regional Aquifer Modelling System (PRAMS). The DWMS noted that a systematic over estimation of water levels for the south western part of the DWMS study area around Mundijong was observed and that it is understood that a number of surface drains in this area were not modelled and resulted in simulated groundwater levels to be too high in that region. The DWMS also reported '*that the district scale predicted maximum groundwater level has not been defined at this time for the study area. Localised perching that is common within this catchment cannot be accurately represented by district scale modelling and must be considered when determining the local scale predicted maximum groundwater level, which is important for the protection of urban infrastructure*'.

Figure A.8 of the DWMS shows that GHD's estimated groundwater levels fall from 36-39mAHD at the eastern edge of Precinct G1 to 26mAHD at the western edge of Precinct G1. These modelled levels are, in areas, several metres above existing surface level, and are not considered to be an accurate representation of actual groundwater behaviour at this site.

The groundwater design criteria outlined in this Precinct G1 LWMS has been determined for Precinct G1 based on the site-specific groundwater monitoring data described below.

2.6.2 Pre-development groundwater levels

Groundwater flows from east to west across the region, generally following the topography. The Perth Groundwater Atlas (DoW – online) provides groundwater contours of the groundwater levels as measured in May 2003 (which is an indication of low groundwater levels). This information shows the groundwater levels at the site ranging from 30.0mAHD (approximately central to the Subject Site) to 23.5mAHD in the west. This information does not provide any groundwater contouring to the eastern side of the development area.

Information of five monitoring bores surrounding the proposed development was obtained from the DoW Water Information Reporting (WIR) website. The bores are drilled to depths between 19.0m to 32.0m. These bores have more than 20 years of records and provide information to determine the Annual Average Maximum Ground Water Level (AAMGL) surrounding the proposed development area. The recorded data provides groundwater contours of approximately 20.3mAHD (eastern side) to 17.5mAHD (south-west corner). These results relate to the underlying superficial aquifer.

Site-specific groundwater monitoring was carried out by Brown Geotechnical and Environmental and Emerson Stewart between September 2008 and August 2011 to gain an understanding of pre-development groundwater levels and water quality across the Precinct G1 area. The monitoring showed that groundwater levels were at their highest in September 2009 and based on these levels the groundwater is generally less than 0.2m below natural surface level. There are four areas that show an increase in groundwater separation from natural ground of over 2.0m however these areas are mounded areas.

The site is hydrologically distinct and isolated from the underlying superficial aquifer due to localised low permeability soils found on site. Therefore seasonal peak groundwater levels at the site are perched in areas. This surficial perching is referred to as the perched water levels in this Precinct G1 LWMS, to distinctively separate the perched system from the groundwater found within the deeper superficial aquifer.

Figure 2.6 shows the groundwater monitoring bore locations and the pre-development perched water level contours, and Figure 2.7 shows the depth from natural surface to pre-development perched winter water level.

Additional groundwater monitoring was undertaken by Aurora Environmental between July 2012 and July 2013 to improve the definition of ground water levels around the CC Sumpland (Refer to Appendix C)

Groundwater levels observed in the eleven groundwater monitoring bores are shown in Table 2-2 below.

Table 2-2 – Pre-development perched water levels

	MB07	MB08	MB09	MB10	MB11	MB12	MB13	MB14	MB15	MB16	MB17
Ground Level (mAHD)	32.300	36.260	31.180	35.510	31.170	27.400	28.100	27.490	26.020	28.490	25.640
Sep-08	31.382	35.664	30.897	34.738	30.841	25.709	27.694	26.599	25.582	27.801	24.867
Oct-08	31.272	35.784	31.197	34.668	30.541	25.609	27.564	26.479	25.452	27.571	24.737
Nov-08	31.152	35.684	31.117	34.508	30.531	25.439	27.484	26.389	25.352	27.491	24.697
Dec-08	31.062	35.674	31.037	34.438	30.491	25.329	27.374	26.289	25.272	27.381	24.637
Jan-09	30.762	35.284	30.727	34.308	30.411	25.049	26.994	26.009	24.882	27.001	24.397
Feb-09	30.422	35.034	30.507	34.138	30.321	24.889	26.734	25.839	24.632	26.721	24.227
Mar-09	30.262	34.884	30.357	34.048	30.311	24.739	26.584	25.689	24.472	26.571	24.107
Apr-09	30.062	34.764	30.197	33.918	30.311	24.619	26.424	25.549	24.322	26.411	23.957
May-09	30.042	34.814	30.227	33.988	30.561	24.459	26.444	25.489	24.372	26.451	23.997
Jun-09	29.882	34.884	30.007	34.038	30.631	24.469	26.504	25.519	24.572	26.551	24.297
Jul-09	30.772	35.774	31.217	34.788	30.941	25.309	27.484	26.419	25.602	27.801	25.217
Aug-09	31.762	35.944	31.627	35.228	31.151	25.829	28.144	27.059	26.132	28.491	25.557
Sep-09	32.042	35.984	31.657	35.138	31.091	26.329	28.234	27.089	26.132	28.461	25.507
Oct-09	31.822	35.914	31.487	34.928	30.681	26.019	27.924	26.769	25.802	27.931	25.007
Nov-09	31.446	35.866	31.17	34.565	30.456	25.531	27.579	26.473	25.344	27.397	24.644
Dec-09	31.251	35.597	30.96	34.443	30.363	25.349	27.306		25.145	27.247	24.539
Jan-10	30.914	35.233	30.686	34.286	30.296	25.074	26.926	26.003	24.892	26.923	24.354
Feb-10	30.622	34.979	30.474	34.168	30.287	24.855	26.705	25.808	24.547	26.654	24.185
Mar-10	30.448	34.879	30.397	34.149	30.421	24.669	26.597	25.699	24.488	26.555	24.227
Jun-10	30.661	35.21	30.706	34.402	30.826	24.731	26.851	25.824	24.937	26.908	24.628
Jul-10	31.198	35.846	31.166	34.728	31.05	25.309	27.399	26.318	25.521	27.525	25.217
Aug-10	31.204	35.821	31.079	34.665	30.796	25.378	27.467	26.369	25.564	27.762	25.055
Sep-10	31.112	35.652	30.873	34.491	30.486	25.304	27.323	26.198	25.332	27.478	24.826
Jun-11	30.23	34.913	30.551	34.111	30.966	24.739	25.638	25.702	24.856	26.741	24.619
Jul-11	31.108	35.466	31.156	34.715	30.996	25.47	27.567	26.535	25.733	28.181	25.281
Aug-11	31.752	35.97	31.595	35.191	31.17	26.151	28.132	27.067	26.105	28.475	25.537
Sep-11	31.736	35.915	31.498	35.002	30.858	26.041	27.939	26.825	25.882	28.095	25.154
Oct-11	31.535	35.754	31.27	34.808	30.757	25.929	27.717	26.816	25.807	27.985	25.007

Note: 31.170 Denotes highest recorded reading

25.638 Denotes lowest recorded reading

The levels observed varied from perched levels towards the end of winter to depths of 2.4m at the start of winter. The levels in the groundwater monitoring bores are shallower than predicted by the local scale modelling undertaken by CyMod during 2007 and supports the presence of a perched water table in areas which has no direct relationship to the regional groundwater levels in the underlying aquifers.

The water levels from the additional four groundwater monitoring bores, located in the CC sumpland area, monitored between July 2012 to July 2013 are shown in Table 2-3 below.

Table 2-3 – Pre-development perched water levels – 2 bores in CC sumpland area

	MB08	MB10	MW1	MW2
Ground Level (mAHD)	**36.260**	**35.510**	**39.500**	**37.250**
Jul-12	35.566	34.559	38.802	36.297
Aug-12	35.932	34.742	39.168	36.480
Sep-12	35.969	34.853	39.205	36.591
Oct-12	35.732	34.48	38.968	36.218
Nov-12	35.58	34.38	38.817	36.122
Jan-13	35.35	34.23	38.585	35.972
Jan-13	35.18	34.07	38.412	35.810
Feb-13	34.87	33.92	38.110	35.654
Mar-13	34.788	33.91	38.024	35.650
May-13	34.79	33.781	37.918	35.519
Jun-13	35.033	34.183	38.269	35.921
Jul-13	34.975	34.111	38.211	35.849

Note: 39.205 Denotes highest recorded reading

33.781 Denotes lowest recorded reading

The groundwater levels of MB08, MB10, MW1 and MW2 are consistent from September 2008 to July 2013. No perched water levels were recorded in the sumpland areas.

Due to the large difference in groundwater levels as set out by the Perth Groundwater Atlas (DoW – online) and the DoW Water Information Reporting (WIR), no comparison could be made with the site-specific pre-development groundwater monitoring data. Groundwater level September 2009 readings taken from the site-specific groundwater monitoring carried out by Brown Geotechnical and Environmental and Emerson Stewart are therefore determined to be the Control Ground Water Level (CGL).

A combination of fill and subsoil drainage will be required in the areas where groundwater is close to the natural surface – Section 4 contains details of how groundwater will be managed across the proposed development.

2.6.3 Pre-development groundwater quality

Groundwater quality at the site was monitored on a quarterly basis by Brown Geotechnical and Environmental and Emerson Stewart between September 2008 and October 2011 using 11 bores across the study site. Bore locations are shown in Figure 2.6. Samples were analysed for physical parameters and nutrients. A summary of average groundwater quality results is shown in Table 2-4 below.

Table 2-4 - Average pre-development water quality

Parameter	Units	No of Samples	Min Result	Max Result	Mean Result	Median of Results	Standard deviation
Dissolved Oxygen	mg/L	128	0.01	7.29	0.74	0.26	1.2
EC (field)	uS/cm	129	101	11930	1229	915	1195
pH (Field)	pH_Units	139	4.65	7.13	5.9	5.9	0.49
Temp	oC	129	16.26	23.9	20	19.8	1.7
Alkalinity (Hydroxide) as CaCO3	µg/L	59	ND	ND	0	0	0
Alkalinity (total) as CaCO3	mg/L	59	5	359	34	24	47
Ammonia as N	µg/L	72	20	2390	310	160	404
Bicarbonate	mg/L	59	5	359	34	24	47
Carbonate	mg/L	47	ND	ND	0.5	0.5	0
Kjeldahl Nitrogen Total	mg/L	72	0.1	29.8	3.5	2.05	5.1
Nitrate (as N)	mg/L	49	0.01	8.63	0.087	0.03	0.16
Nitrite (as N)	mg/L	49	0.01	0.02	0.0054	0.005	0.0022
Nitrogen (Total Oxidised)	mg/L	72	0.01	8.63	0.074	0.03	0.14
Nitrogen (Total)	mg/L	72	0.1	29.8	3.524	2.15	4.249
Reactive Phosphorus as P	mg/L	72	0.01	0.06	0.006	0.005	0.0062
TDS	mg/L	75	130	4855	785	585	729
Lead	mg/L	72	0.001	1.88	0.1	0.042	0.24
Aluminium	mg/L	59	0.05	734	41	17.8	107
Arsenic	mg/L	72	0.001	0.036	0.0048	0.003	0.0061
Cadmium	mg/L	72	0.0001	0.0014	0.00018	0.00005	0.00025
Chromium (III+VI)	mg/L	72	0.001	0.476	0.053	0.028	0.081
Copper	mg/L	72	0.001	0.239	0.032	0.014	0.045
Iron	mg/L	59	1.33	632	51	30.5	86
Manganese	mg/L	59	0.002	5.76	0.42	0.237	0.86
Mercury	mg/L	23	0.0001	0.0069	0.001	0.0002	0.0018
Nickel	mg/L	58	0.002	0.15	0.02	0.02	0.03
Phosphorus	mg/L	72	0.01	4.54	0.85	0.475	0.028
Zinc	mg/L	72	0.005	0.154	0.029	0.0185	0.032

The groundwater at the site is slightly acidic and ranges from pH 4.65 (MB14) to 6.90 (MB08) with the median value pH 5.9. The value is marginally lower than the guideline values of 6.5-8.5 target as set in the ANZECC & ARMCANZ (2000) Guidelines for Southwest Australian Aquatic Ecosystems.

The Nitrogen (Total) (TN) has a median value of 2.15mg/L which is higher than the 1.5mg/L target as set in the ANZECC & ARMCANZ (2000) Guidelines for Southwest Australian Aquatic Ecosystems. The minimum/maximum range indicates a significant difference in values across the site.

The median value for the Phosphorus is 0.475mg/L which exceed the ANZECC & ARMCANZ (2000) Guidelines for Southwest Australian Aquatic Ecosystems of 0.06mg/L. The maximum concentration for TP was 4.54mg/L.

The Phosphorus is the nutrient of concern; however this is not uncommon for agricultural land which has been subject to fertiliser/chemical spreading. The development of the site provides the opportunity to remove nutrients by the implementation of surface and groundwater management in the form of stormwater to be infiltrated on site, as far as practicable with the subsoil condition, thus improving the quality of the groundwater. Post development groundwater monitoring will ensure that there is no deterioration in the quality of the groundwater. This is further discussed in Section 6.

Results of the groundwater quality monitoring captured by Brown Geotechnical and Environmental and Emerson Stewart between September 2008 and October 2011 are contained in Appendix C

2.7 Surface water

The DWMS noted that low lying areas within the DSP are subject to water logging. Galt Geotechnical confirmed this in their report, noting that portions of the site were water logged during their field work in October 2011.

Five external catchments which discharge through the site were identified in the DWMS of which Manjedal Brook is the primary watercourse. Runoff from the five catchments within the Precinct G1 area merges into the Manjedal Brook which discharges on the western boundary near Leipold Road, as shown in Figure 2.8.

There are three existing stormwater reports that provide information relevant to the Subject Site. They are described below.

2.7.1 Summary of pre-development inflow rates and reports

Mundijong Floodplain Management Strategy (SKM, 2007)

The Mundijong Floodplain Management Strategy was commissioned by DoW with the intent to provide guidance on flood management for future development. Location and extents of flooding presented within the Floodplain Management Strategy (SKM, 2007) are indicative only. This report is superseded by the Mundijong Whitby DWMS (GHD, 2010).

The DWMS contains a summary of the SKM report findings and compares results of the SKM and subsequent DWMS models.

Mundijong Whitby District Structure Plan – District Water Management Strategy Rev 3(GHD, 2010)

The DWMS utilised a InfoWorks CS model within the DSP area to determine indicative subcatchment scale peak flows and levels at critical locations for both existing (Pre) and ultimate (Post) developments.

Pre- and post-development catchment runoff generated by the DWMS model was compared to the total catchment output from the Floodplain Management Strategy (SKM, 2007). The DWMS commented a close correlation between the GHD and SKM models with flows in the upper catchments, located east of the subject site, slightly less than the flood model produced by SKM.

The DWMS model identified the Manjedal Brook (M43) and Creek 1 – Tributary 6 (M40) as two inflows entering into Precinct G1. They are summarised in Table 2-5 and the inflow locations are shown on Figure 2.8.

Whitby, Local Water Management Strategy Rev 1f – Cardno 2011

The Whitby, Local Water Management Strategy Rev 1f (Cardno, 2011) was produced to support the Whitby Local Structure Plan (LSP), located directly east of subject site. Cardno utilised a 2D drainage model using XP Storm for the surface water drainage modelling to determine the flooded area in the pre-development environment, incorporating the inflow hydrographs from the modelling done by GHD for the DWMS (GHD, 2010).

The LWMS report clarified that the 2D modelling done for the Whitby LWMS (Cardno, 2011) is considered to be more accurate than the 1D modelling undertaken by GHD, given it used a digital terrain model created by LiDAR and is consistent with anecdotal evidence from residents within the region.

The Cardno model identified a less defined flow path that exists through the centre of the Whitby LWMS study area running east to west. They commented that while the upstream end is well defined, the western downstream end is poorly defined. This is referred to as 'Creek 1 Tributary 6' in the DWMS (GHD, 2010). The Cardno model included two separate streamline flows representing 'Creek 1 Tributary 6' and can be identified as Discharge Locations 2 and 3 in the Whitby LWMS (Cardno, 2011).

The pre-development discharging peak flows that were generated by the Cardno model is summarised in Table 2-5 and the inflow locations into Precinct G1 are shown on Figure 2.8.

Whitby Estate Precinct 2 – UWMP addendum

The Shire of Serpentine – Jarrahdale advised in 2015 that an addendum was adopted to the Whitby Estate LWMS (CArdno 2011) which increased the flows in the Manjedal Brook from the flows previously modelled in the LWMS. The Whitby Precinct 2 - UWMP addendum (Emerge 2015) found that the survey previously adopted in the LWMS model was incorrect and a greater portion of the flows passed eastwards through the Manjedal Brook, rather than bifurcate into the Kiernan Street drain. The increased flows of (11.02 m^3/s and 23.92 m^3/s (5 and 100year ARI respectively) was therefore adopted in the modelling for the Manjedal Brook through Precinct G1.

Additional external inflow from Taylor Road

The DWMS (GHD, 2010) has identified approximately 85ha of land located north of the subject site that has been marked as post development subcatchments but falls outside the Study Area. The location of this area can be seen in Figure 2.8.

This area of land may contribute to the Taylor Road runoff that has been included by the Whitby LWMS (Cardno, 2011). The additional external inflow rate was calculated by applying a flow rate per hectare of land area. The extrapolated 5yr and 100yr inflow rate for this area is 0.83m³/s and 1.45m³/s respectively.

The additional external inflow from Taylor Road is summarised in Table 2-5.

Adopted arterial inflows

Discussions were held with the Shire of Serpentine Jarrahdale to clarify the differences between the DWMS and Whitby LWMS modelling. The Shire advised that the Whitby modelling should be adopted due to the increased accuracy of the 2D drainage modelling that was undertaken and the finer catchment definition of the model, as compared to the DWMS. Where there were catchments that fell outside the LWMS model (Taylor Road catchment and Creek 2), the figures from the DWMS was used to ensure that all external inflows flows have been accounted for in the adopted Precinct G1 drainage modelling. The increased flows from the Precinct 2 UWMP was adopted for the Manjedal Brook modelling. A summary of the DWMS and Whitby LWMS inflows is shown in Table 2-5 below.

Table 2-5 - Summary of the Pre-Development inflow rates into Precinct G1

Name	DWMS (GHD, 2010)			Whitby LWMS (Cardno, 2011)			Adopted Arterial Flow Rates		
	Inflow Location	5yr ARI (m^3/s)	100yr ARI (m^3/s)	Inflow Location	5yr ARI (m^3/s)	100yr ARI (m^3/s)	Inflow Location	5yr ARI (m^3/s)	100yr ARI (m^3/s)
Manjedal Brook	M43	13.42	40.21	4	11.02	23.92	**4**	**11.02**	**23.92**
Creek 1 Tributary 6	M40	6.49	14.73	2 & 3	1.58	8.12	**2 & 3**	**1.58**	**8.12**
Taylor Road Runoff		No Info	No Info	1	3.85	6.70	**1**	**3.85**	**6.70**
Creek 2 near Lang Road	M42	3.26	7.74		No Info	No Info	**M42**	**3.26**	**7.74**
Taylor Road (Additional inflow)		No Info	No Info	Section 2.7.1	0.83	1.45	**Section 2.7.1**	**0.83**	**1.45**
TOTAL		23.17	62.68		17.28	40.19		**20.54**	**47.93**

2.7.2 Pre development surface water modelling

A pre-development stormwater model was developed using XP Storm to verify the pre-development flow rates to be used as the limit for post development runoff from Precinct G1 into any received waterway. .

The pre-development modelling for the site was performed using XP Storm and the purpose of this model was to help clarify the substantial difference between the modelling results of the DWMS (GHD, 2010) and Whitby LWMS (Cardno, 2011) as shown in Table 2-5.

For consistency, the pre-development model utilised infiltration parameters adopted in the Whitby LWMS, using the catchment boundaries as delineated in the DWMS (GHD, 2010). The total catchment area is 231.5ha, which is shown on Figure 2.8 as the 'LWMS boundary' area and the 'Additional Taylor Road Runoff Area'.

The model assumed 50% area to be sand (permeable) and 50% clay (impermeable) – similar to the LWMS. The external inflows into the model are as defined in Table 2-5 above.

All flows exclude inflows in Manjedal Brook and are development runoff only.

The result of the pre development surface water model and the DWMS (GHD, 2010) model is summarised in Table 2-6. When comparing the figures from Table 2-6, the pre-development surface water model site discharge per hectare of land area is slightly lower for the 5yr ARI with a more conservative allocation for the 100yr ARI. The pre-development surface water model produced a more conservative discharge rate.

Table 2-6 – Result of Pre-Development discharge per hectare of land area

	Area (ha)	DWMS (GHD, 2010)		Surface Water Model Results	
		5yr ARI L/s/ha	100yr ARI L/s/ha	5yr ARI L/s/ha	100yr ARI L/s/ha
Pre-development flow	231.5	11.02	18.19	9.45	20.11

The pre-development surface water modelling results will therefore be adopted as the allowable flow rates for the development of the LSP area. Basins within the POS areas will be sized to attenuate post-development flows to these pre-development results.

The pre-development model includes a total catchment area of 231.5ha as opposed to the subject site actual catchment area of 199.4ha. Using the area based flow rates from Table 2-7 the allowable flow rates for the 199.4ha site were calculated and are shown in Table 2.7.

Table 2-7 – Allowable flow rates from Precinct G1

	Area (ha)	5yr ARI (m^3/s)	5yr ARI L/s/ha	100yr ARI (m3/s)	100yr ARI L/s/ha
Peak allowable flow rate from Precinct G1	199.4	1.88	9.45	4.01	20.11

3 WATER CONSERVATION

The DWMS identified two key objectives for water use and conservation in the DSP area:

- Ensure the efficient use of all water resources in the newly-developing urban form and aim to achieve highest value use of fit-for-purpose water.
- Maintain opportunities for future generations by using water more efficiently.

This development will be designed to minimise potable water use, and to ensure fit-for-purpose water use. "Fit-for-purpose" refers to the use of water that is of a suitable quality for the intended use. The use of high-quality drinking water for garden irrigation, for example, is not a fit-for-purpose use and lower-quality water (e.g. rainwater, groundwater etc.) would be more suitable for this purpose.

The DWMS identified the following design criteria that should be considered for developments within the DSP area to achieve the water use objectives.

- Achieve a water consumption target of less than 100kL/person/year, of which only 40-60kL/person/year should be from potable water.
- Meet the State Government's '5-Star Plus' provisions for all new dwellings.
- Promote the use of native plants throughout the development. Non-turfed areas in POS to contain only native plants.
- Promote the use of on-site rainwater tanks to achieve water consumption targets.

Future urban water management plans (UWMPs) for the precinct will outline the specific water conservation measures that will be taken to ensure that the consumption targets are achieved.

3.1 Potable water supply

Potable water will be supplied from the Water Corporation's reticulated water supply.

The total water consumption target of 100kL/person/year is generally achieved through the use of waterwise fittings and appliances inside the house, along with planting water efficient gardens with minimal lawn areas and native, low-water-use plants. Future UWMPs will include a detailed water consumption estimate to show that the development can achieve the water consumption targets.

To achieve the potable water consumption target of 40-60kL/person/year, all water use outside the house (i.e. outdoor taps and irrigation) would need to be from non-potable sources like groundwater, rainwater or recycled water.

Appendix D contains an estimate of water consumption for the Precinct G1 area using Water Corporation Water Balance spreadsheet, based on the current estimate densities and approximate lot yield.

3.1.1 Water efficient appliances

Potable water use will be minimised throughout the Precinct G1 area by ensuring that new dwellings install water efficient appliances and fittings that comply with the State Government's 5 Star Plus program.

The requirements of the 5 Star Plus program have been incorporated into the Building Code of Australia to ensure that all new houses install water and energy efficient hot water systems, taps and toilets, and swimming pool covers.

In addition to these regulatory requirements, the developer will encourage lot purchasers to install water efficient appliances (e.g. washing machines) to further reduce potable water use.

3.2 Non-potable water supply

An important part of water sustainability is fit-for-purpose water use, or the use of alternative water sources for applications where drinking-quality water is not necessary (e.g. toilet flushing, garden watering).

The State Water Plan (Government of Western Australia, 2007) identified a potable water consumption target of 40-60 kL/person/year. This target can only by achieved if all outdoor water use is supplied by non-potable sources, and the widespread implementation of non-potable water schemes is most successful when installed with the construction of subdivision works. A non-potable water supply (third pipe) system would allow the use of alternative water sources throughout the development and would greatly reduce consumption of potable water.

The widespread implementation of non-potable water schemes is most successful when installed with the construction of subdivision works. A reticulated non-potable water supply (third pipe) system would allow the use of alternative water sources throughout the development and would greatly reduce consumption of potable water.

The Shire of Serpentine Jarrahdale is investigating potential alternative water sources that could be used for a third-pipe scheme throughout the greater Mundijong area. The developer will continue to liaise with the Shire as the development process continues, with a view to implementing a reticulated third-pipe system should an alternative water source be available at the time of development. The road reserves within the development are wide enough to accommodate a third pipe network within the verges, should an alternative water source be available at the time of subdivision.

3.2.1 POS irrigation

The site falls within the Serpentine Groundwater Area, and the Byford 3 Groundwater Subarea. According to the Department of Water database, there is available groundwater in the confined aquifers (Leederville or Cattamarra Coal Measures), as well as a considerable amount in the superficial aquifer. Landowners are in the process to apply for a groundwater allocation prior to the subdivision process to provide water for construction and POS irrigation purposes.

The groundwater licence application will be for approximately 80,000 kL/yr. The primary school site has not been included in the application and the DET will be responsible to secure a groundwater allocation for the primary school area. When a landowners groundwater licence is approved, exploratory drilling will be undertaken to determine the possible yield in the proposed bore locations.

4 GROUNDWATER MANAGEMENT

4.1 Groundwater levels and subsoil drainage

The design of the development will need to achieve sufficient separation between finished lot levels and post-development perched groundwater levels. This will be achieved via a combination of subsoil drainage and imported sand fill.

Existing groundwater levels are shallow, with some seasonal inundation occurring in low-lying areas of the site. During winter months, groundwater perches on the underlying clays, with the maximum measured water levels (in September 2009) within 0.2m of existing ground level. The calculation of typical winter perched water levels is included in Section 2.6.2.

The DWMS proposed controlled groundwater levels (CGLs) across the entire DSP area. However the DWMS noted that a systematic over-estimation of water levels for the south western part of the DWMS study area around Mundijong was observed and that it is understood that a number of surface drains in this area were not modelled and resulted in simulated groundwater levels to be too high in this region.

It is proposed that the following criteria should apply to setting a localised CGL for Precinct G1 which would set the minimum level for subsoil drainage or open drainage inverts:

- In areas near groundwater dependant ecosystems (eg CCWs), CGL should be equivalent to the pre-development perched winter water levels. The design of the subsoil drainage system will need to show that no drawdown of pre-development perched water levels will occur within wetlands or their buffers.
- In all other areas, the level of the underlying clay material will dictate the minimum subsoil drainage invert levels and grades. Some localised shaping of the clay may be undertaken, to ensure ponding of perched water in localised low points is avoided. Open drains and bio-retention areas should be designed to ensure that baseflow during winter months is contained within defined areas that will be planted with sedges and appropriate plant species. The open drains will be constructed as living streams that mimic pre-development flows and enable upstream bio-filtration and recharge of the groundwater table. Planting within the living stream areas is to consist of endemic species of which the native reed and sedge planting will enhance the uptake of nutrients and maximising the treatment of nutrients before entering into the hydrological system.
- Subsoil drainage invert levels at the outfall locations should be at least 0.65m above the invert of the closest open drain, to ensure sufficient separation of bio-retention areas below the drain outlet and above stream baseflow levels. Unless approved by the local authority, all subsoil drains should discharge to bio-retention treatment areas.

4.1.1 Subsoil drainage network

A combination of imported sand fill and subsoil drainage will be used to control the perching of infiltrated rainwater on the impermeable clay soils and ferricrete across the site and to ensure adequate separation between finished lot levels and perched water levels are achieved.

Minimum subsoil drainage levels will be dictated by several factors – the level of the clay and ferricrete material present across the site; the invert level of the open drainage swales at subsoil outfall locations and minimum pipe grades. A concept layout of subsoil drainage is shown in Figure 5.6.

The subsoil pipe systems located below the basins along the Manjedal Brook (UFI 15945 – Palusplain) will discharge into the Brook. The water filtrates through the bio-retention basin and into these subsoil pipe systems which discharge filtered/treated water into the Brook. The subsoil drainage invert levels will be calculated to preserve the pre-development hydraulic grade line along the Manjedal Brook to ensure the potential of development impacts to this area will be minimised.

The underlying clay and ferricrete material will be shaped towards the proposed open drains through POS corridors in localised areas, with the invert of the open drains to be no lower than the graded clay surface. Subsoil drains will be installed to alleviate the perching of infiltrated rainfall that occurs during winter months, with outfalls to be at least 0.65m above open drain inverts to ensure sufficient freeboard above winter baseflow levels. Subsoil drainage inverts must be above the clay surface in all locations to allow the drains to operate effectively.

The detailed design of the subsoil drainage network will need to ensure that subsoil drains at the eastern end of the site, near Soldiers Road, will be at or above typical pre-development perched water levels, to ensure that water levels in the CCW along Soldiers Road are not affected by the development.

The Manjedal CCW (UFI 7835 - Sumpland) has a 200m buffer and located in the south east of the LSP area is a significant weltand that is a water dependant ecosystem within Precinct G1. No surface water flow from the development will discharge to this wetland area and subsoil drainage should designed not to have any impact on groundwater levels within the buffer area.

4.2 Groundwater quality

Groundwater quality will primarily be managed through the landscaping design, with the design to include plants that required low fertiliser use to reduce the amount of nutrients leaching into the groundwater. A similar approach will be taken with the landscaping packages offered to residents, which will include information on minimising fertiliser use.

The perched groundwater that is intercepted by subsoil drains during winter months will be treated in bio-retention swales at the drainage outfalls, which will be located in POS areas and will be designed with appropriate soil media and plant species to retain and treat the discharge from subsoil drains.

5 SURFACE WATER MANAGEMENT

The DWMS identified the following key strategies for the management of stormwater in the DSP area:

- Minimise changes in hydrology to prevent impacts on receiving environments (by managing post-development runoff to pre-development flow rates, and promoting on-site retention of the 1yr 1hr ARI storm event).
- Manage surface water flows from major events to protect infrastructure and assets.
- Uphold environmental values of downstream waterways within and surrounding study area.

The surface water strategy for the site is to generally maintain the pre-development flow paths where practical, which follow the site's natural topography. Alterations to the existing flow paths may be made to best suit the developments layout and proposed stormwater drainage. Storage basins and swales will be integrated into the public open space to attenuate post-development runoff and ensure that runoff discharging from the site is within pre-development flow rates, to protect downstream landholdings from flooding.

5.1 Local drainage management

A proposed central open drainage system traverses the site from east to west, parallel with the Manjedal Brook. Three perpendicular north-south drains allow water to be discharged into the Manjedal Brook as shown on Figures 5.4 and 5.5. The interconnecting open drains will connect to the Manjedal Brook to discharge without disturbing the pre-development hydraulic grade line along the Manjedal Brook. These connections are proposed to be pipes conveying water into the Brook rather than continuing with the open drainage systems. DoW has advised that the 50m buffer along the Manjedal Brook may be used for attenuation basins for the 5yr and 100yr ARI events.

The Precinct G1 area is divided into sub-catchments based on preliminary stormwater design. Piped surface drainage networks are assumed to be installed throughout the site, discharging into bio-retention basins. Each sub-catchment has its own bio-retention basin and attenuation basin to manage post development flow up to 100yr ARI events.

Bio-retention basins will be designed to retain all 1yr 1hr inflow with a water depth no more than 0.3m deep. The bio-retention basins will be wet only during rainy seasons and remain dry for most part of the year. This is to avoid mosquito breeding and disease vectors. To achieve this, the basin invert will maintain a minimum of 0.5m separation from clay, CGL or creek base flow.

Main detention storage areas for 5yr and 100yr ARI events should be designed with their invert level 0.65m above the invert of the adjacent open drain. This will allow room for localised subsoil drainage beneath the main basins, to encourage infiltration and avoid extended waterlogging of the basin areas during periods of high groundwater.

The open drains that convey flow from upstream catchments – and from the basins within the site – to downstream waterways have been sized with a trapezoidal shape. The drains have a 3m wide base, with 1:6 side slopes, and the 100yr flood depth in these drainage swales is between 0.5m and 1.2m. The drainage swales will be constructed as living streams that mimic pre-development flows and enable upstream bio-filtration and recharge of the groundwater table. The drain sizing will be confirmed in the UWMP.

To minimise fill requirements, the proposed drains may drawdown the existing perched groundwater. The allowable drawdown is 0.3m with a maximum of 0.5m. Drawdown of perched groundwater is not allowed in the 200m buffer area around the Manjedal CCW, refer to Section 2.4.

Roof runoff from residential lost will be retained and infiltrated in soak-wells for storm events up to 1yr 1hr ARI (a soak-well 1200mm diameter x 1200mm deep or equivalent volume is required per 100m² or connected roof area).

Road runoff from events up to 1yr 1hr ARI will be directed into bio-retention swales which will be located in POS areas and road reserves (in medians or inactive lot frontages where practicable). Figure 5.7 shows indicative locations where bio-retention swales could be located within road reserves – however the final locations of the bio-retention swales cannot be finalised until detailed civil engineering design for the future subdivision is further progressed, and will be investigated further during UWMP's for this site.

The separation of the 1 year ARI bioretention areas from the 5 year and 100 year flood storage areas should be adopted as a preferred option in the subdivision drainage design to minimise the flushing of entrapped nutrients. These may be specific instances in the subdivision design, where due to size or invert level constraints, a combined bioretention swale and floor storage basin may be adopted. This cannot be determined at LSP stage and should be assessed during the UWMP/detail design stage, to the Shire's satisfaction (as part of subdivision condition). The LSP currently provides for a surplus of POS area which provides enough flexibility in POS and drainage design to not materially affect the LSP.

The Shire has noted its preference for the use of free-draining stormwater drainage outlets, as opposed to bubble-up pits. Free-draining stormwater drainage outlets will be used where site constraints dictate (in clay conditions or areas with high groundwater). Bubble-up pits may be used where the invert of the bubble-up pit is located in sandy soils and where subsoil drainage is provided below the invert of the bubble-up pit to allow the pit to empty (or where the invert of the bubble-up pit is above natural groundwater level). Future UWMP's for the site will specify where free-drainage outlets and/or bubble-up pits are to be installed.

Table 5-1 below shows the required storage areas for the 1yr 1hr ARI and critical 5yr and 100yr ARI storm events to attenuate post-development runoff to allowable (pre-development) levels. Parameters used in the stormwater modelling to size the storage areas are included in Appendix E. Figure 5.1 shows the required storage areas for the critical 100yr ARI storm event to attenuate post-development runoff to allowable levels.

Table 5-1 - Required storage volumes for critical storm events

Basin ref	1yr 1hr ARI bioretention area	5yr ARI flooded area	100yr ARI flooded area
1A	1,000 m²	6,600 m²	6,700 m²
1B	1,100 m²	1,900 m²	online
2	1,000 m²	2,700 m²	online
3	700 m²	2,000 m²	online
4	900 m²	2,600 m²	2,800 m²
5	600 m²	1,500 m²	online
6	2,300 m²	18,200 m²	19,000 m²
7	2,200 m²	8,600 m²	9,000 m²
8	1,000 m²	3,400 m²	3,700 m²
9	900 m²	1,400 m²	1,600 m²
10	500 m²	3,600 m²	online
11	400 m²	900 m²	online
12	700 m²	1,400 m²	1,400 m²
13	2,100 m²	9,600 m²	10,000 m²
14	1,500 m²	3,400 m²	3,800 m²
15	1,500 m²	6,900 m²	7,600m²
16	1,300 m²	5,400 m²	6,100m²
17	1,200 m²	2,400 m²	online
18	1,200 m²	2,900 m²	2,800 m²

The bioretention areas as shown above are total areas for each catchment. During future UWMP's for the development, the distribution of these areas between POS, verge and median bioretention swales will be determined.

5.2 Major flood management

Earthworks design through Precinct G1 will ensure that roads grade towards the POS areas, with finished floor levels required to achieve a minimum of 0.3m above 100yr flood levels in all parts of the catchment (0.5m above 100yr flood levels in basins and open drains).

The outlets from the flood storage basins, and culverts at road crossings, will be sized to ensure that post-development flows at the downstream (western) end of the site are within pre-development levels. Figure 5.1 shows the required storage areas for the critical 100yr ARI storm event to attenuate post-development runoff to allowable levels.

Figure 5.2 shows the expected 5yr and 100yr ARI flood width and depths in the open drains through the POS corridors.

5.3 Manjedal Brook buffer width

The Department of Water is the lead agency for the management of the Manjedal Brook CCW on behalf of the Department of Parks & Wildlife, as it is a watercourse rather than a discrete wetland. Discussions with the DoW to date regarding the design of the LSP have been based on a standard 50m wide buffer area from the top of the Manjedal Brook's bank be set aside on both the northern and southern sides of the brook.

The Shire of Serpentine Jarrahdale identified the option of reducing the buffer width of the Manjedal Brook during feedback on a draft of the LSP in early 2016. The brook's buffer has been almost entirely cleared of vegetation, with the only remaining vegetation being located directly adjacent to the brook's bank.

Wave investigated the hydraulic and drainage impacts associated with a reduced buffer. The assessment of the buffer was based on the following criteria:

- Ability to convey upstream inflows (23.9m^3/s for 100year ARI) without adversely impacting the upstream or downstream hydraulic grade line (HGL).
- Maintaining a 0.5m clearance to the finished flow level of all adjacent houses during the 100 year ARI flood event.
- Maintaining separation of the the 5year regional flow in the brook from the adjacent 5 year ARI subdivision drainage swales.
- Maximum flow velocities in the brook not increasing significantly from a reduction in buffer width.

Several scenarios were modelled in XP Storm to assess the impact of any proposed changes. The following was found:

- The incised brook channel can convey the regional 5 year ARI flows without overtopping the brook's banks along the majority of the its length through the LSP area. Where it does overtop it is to a very shallow depth (<100mm). The buffer width, therefore, does not play a role in the 5 year ARI event and 5 year flow in the brook can still be separated from the 5year subdivision drainage swales within the buffer. All 1 year ARI bioretention areas are located in POS outside the buffer and are not influenced.
- The incised brook channel is overtopped during the 100year ARI event, but only to a shallow depth (approximately 300-500mm) along the buffer. When the buffer was reduced to 30m the depth of inundation increased by less than 100 mm.
- The wide and shallow flow cross-section of the brook and buffer means that velocities in the buffer are low and are not very sensitive to the reduction in width. Small velocity increases were noted.
- The finished levels of lots adjacent to the brook are dictated by sub-soil drainage i.e. the level required for subsoil drainage is marginally higher than the level required to maintain a 0.5m freeboard to the 100 year ARI flood level. At 20m buffer width this is no longer the case and flood levels in the brook dictate finished lot levels. Therefore, a buffer width of less than 30m is not recommended as imported fill volumes will be increased unneccessarily.

Based on the above, reducing the width of the Manjedal Brook buffer to 30m, measured from the top of the brook's northern and southern banks (roughly 75m total width including width of the brook itself), will not adversely impact the LSP drainage management strategy. There may or may not be environmental or heritage considerations, but those are separate to the hydraulic investigation and should be considered separately.

5.4 Surface water quality

5.4.1 Strategy

Surface water quality will be managed via the bio-retention treatment swales within each POS area. Stormwater runoff will be directed into these areas, which will be constructed with amended soil and planted with appropriate plant species to maximise nutrient uptake from the stormwater runoff.

The provision of landscaping packages to lot purchasers will ensure that appropriate native species that require minimal fertiliser use are planted, and educational material will be provided to landowners about appropriate fertiliser use, to minimise the amount of fertiliser wash-off from gardens into the stormwater drainage network.

5.4.2 Bio-retention design

Bio-retention design should, wherever practicable, follow the requirements of the FAWB 2008 guidelines for Advancing the Design of Stormwater Biofiltration. The FAWB guidelines recommend using a 100-150mm thick sand transition layer over a 100-150mm thick gravel drainage layer (without a geotextile fabric between the layers). The function of the transition and drainage layers is to prevent fines from migrating from the overlying filter media into the subsoil drainage pipe which sits within the gravel drainage layer. Two alternative bio-retention designs are shown in Figure 5.3. These two designs allow for the inclusion or exclusion of the transition layer.

The FAWB guidelines make provision for the incorporation of 'submerged zones' into the bio-retention swales to promote denitrification and improve nitrate/nitrite removal, where appropriate. The following aspects must be considered if submerged zones are to be implemented:

- The bio-retention system must be fully lined to keep the submerged zone saturated and prevent exfiltration into the surrounding soils.
- The bio-retention system must receive rainfall on a regular basis to keep the submerged zone saturated, as extended periods without rain will allow the submerged zone to dry out through evapotranspiration.
- The guidelines note that bio-retention systems with a submerged zone will dry out (and release nitrogen back into the environment) after seven weeks of dry weather. Perth typically experiences long, dry periods over the summer months – with 80% of the average annual rainfall falling in the five months between May and September.

The FAWB guidelines caution against the creation of a lined system simply for the sake of creating a submerged zone. The guidelines note that, on average, 50% removal of nitrogen is possible simply through the selection of appropriate vegetation (the nitrogen reduction target for the Mundijong/Whitby DSP area is 45%). The FAWB guidelines also note that while the plants have a positive effect on phosphorous removal, the majority of phosphorous removal can be achieved through the selection of appropriate soil media.

The appropriate bio-retention design for future subdivision applications should consider the site specific constraints and develop responsive designs that meet the applicable nutrient reduction targets given in Section 1.3.

5.5 Wetlands and waterways

The Manjedal CCW is a significant wetland that is a water dependant ecosystem within Precinct G1. No stormwater flow from the development will discharge to this wetland area and subsoil drainage will not drain water from this wetland area.

The Manjedal Brook is a significant waterway that traverses the site from east to west. Stormwater flow from the development will discharge into the Manjedal Brook following a proposed central open drainage system and converts into pipes that'll be placed within the 50m buffer to minimise changes to the waterway. Subsoil drainage in the vicinity of the wetland area will be designed with invert levels at or above typical winter perched water levels to ensure that water levels in this waterway is not impacted by the development.

6 MONITORING AND IMPLEMENTATION

6.1 Monitoring program

The proposed monitoring program for the Precinct G1 area is outlined in Table 6-1 below, and indicative monitoring locations are shown in Figure 6.1. The monitoring locations are shown in areas of POS, and are subject to change as the planning process progresses and the subdivision layout evolves.

Table 6-1 – Monitoring program

Responsible agency	Monitoring program	Requirements	Duration and frequency
Developer	Pre-development groundwater monitoring	GW levels and nutrients (pH, EC, TN, FRP, TKN, ammonia, TP, heavy metals).	Minimum period of 18 months (including 2 winters), preferably 3 years. Monthly water levels, quarterly water quality.
	Post-development groundwater monitoring	GW levels and nutrients (ph, EC, TN, FRP, TKN, ammonia, TP, heavy metals).	Period of 2 years post-development (including at least 1 year following completion of 80% of the development. Monthly water levels, quarterly water quality.
	Post-development surface water monitoring	Flows, water levels and nutrients (pH, EC, TN, FRP, TKN, ammonia, TP, heavy metals)	Period of 2 years post-development (including at least 1 year following completion of 80% of the development.) – with monthly monitoring during times of flow. Levels and water quality as appropriate during winter periods.
SJ Shire – funding to be allocated	Post-development groundwater and surface water monitoring	Monitor local superficial groundwater levels, water quality and flows within development and wetlands, behavioural patterns with respect to non-structural measures for water quality management.	After developer-funding monitoring program is complete.

Responsible agency	Monitoring program	Requirements	Duration and frequency
DoW	Regional groundwater and surface water monitoring	Monitor regional surface water flows and quality, confined aquifer and regional groundwater levels and quality, groundwater abstraction, efficacy of BMPs, performance of new drainage systems.	Ongoing
DPAW/DER	Environmental asset monitoring	Evaluate health of significant environmental assets.	Ongoing

6.2 Trigger values and contingency actions

6.2.1 Groundwater quality targets

Groundwater quality targets for the Precinct G1 area have been determined (Table 6-2 below). Target values are set with regard to the baseline quality data and the potential to improve the groundwater quality at the site. Targets are the mean plus one standard deviation and are considered to be met if the mean of all the post development bores is within the target range.

Table 6-2 - Post-development groundwater quality targets

Analyte	Groundwater quality target
pH	> 6.39
Electrical conductivity	< 2,424 µS/cm
Dissolved oxygen	< 1.94 mg/L
Phosphorous	< 0.878 mg/L
Reactive Phosphorous	< 0.0122 mg/L
Total Nitrogen	< 7.773 mg/L

6.2.2 Contingency actions

If post-development monitoring finds that water quality-related objectives are not being met, the developer and Shire would undertake the following procedures:

- Ensure that the development has fully complied with development conditions relating to water quality management (i.e. installation and operation of BMPs). If such BMPs have not been designed and installed as approved, then the developer would do so or council would be entitled to take regulatory action for a breach of development conditions.

- Investigate opportunities to apply additional non-structural BMPs to the study area (e.g. educational programs, street sweeping, nutrient management plans, alteration of maintenance regimes, soil amendment, local rainwater tank rebate scheme etc). Funding for such additional measures would typically be covered by the local government authority.

These contingency actions will depend on the specific BMPs that are implemented in the development, and will be confirmed as part of future UWMPs within the Precinct G1 area.

6.3 Implementation

Table 12 of the DWMS includes an extensive list of actions and responsibilities for the implementation of the measures outlined in the DWMS. These actions and responsibilities cover the protection of environmental assets, surface water management, groundwater management, monitoring and implementation and water conservation.

6.4 Matters to be addressed in future UWMPs

Future urban water management plans for developments in the Precinct G1 area will include more detailed information on the design of the following infrastructure:

- Stormwater swale, retention/detention basin sizes, depths and configurations, including details of bio-retention areas.
- Subsoil drainage layouts and invert levels.
- Minimum earthworks levels to achieve drainage design objectives.
- Proposed cross-sections for open drains through the site.
- Confirmation that the final stormwater drainage design achieves the objectives of the LWMS – particularly that post-development flow rates remain within pre-development levels.
- Details of the specific water-conservation measures that will be applied at the site (including any proposed non-potable water supply).
- POS landscaping concept plan, and confirmation that a water source for POS irrigation has been secured.

7 REFERENCES

Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ and ANZECC) 2000, National Water Quality Management Strategy Australian Guidelines for Urban Stormwater Management

Western Australian Planning Commission 2008, Better Urban Water Management

Department of Water 2008, Stormwater Management Manual for Western Australia

Shire of Serpentine Jarrahdale 2011, Mundijong/Whitby District Structure Plan

GHD 2010, Mundijong Whitby District Structure Plan – District Water Management Strategy

Cardno 2011, Whitby, Various Lots – Local Water Management Strategy

Galt Geotechnics 2011, Geotechnical Study – Proposed Residential Development Lot 37, 98 and 9000 Bishop Road, Mundijong

Engineers Australia 2001, Australian Rainfall and Runoff, A Guide to Flood Estimation

APPENDIX A - Geotechnical bore logs

Galt GEOTECHNICS

Report on

GEOTECHNICAL STUDY
PROPOSED RESIDENTIAL DEVELOPMENT
LOTS 37, 98 AND 9000 BISHOP ROAD
MUNDIJONG

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Site Photographs

APPENDIX B
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APPENDIX H
Understanding Your Geotechnical Engineering Report

1. INTRODUCTION

This report presents the outcomes of Galt Geotechnics Pty Ltd's (Galt's) geotechnical study for the proposed residential development on Lots 37, 98 and 9000 Bishop Road, Mundijong ("the site"). The location of the site relative to the surrounding area is shown on Figure 1, Location Plan. The investigation was authorised by Mr Onn Chan of Wave Engineering Solutions Pty Ltd (WES) in a Client Authorisation form dated 23 September 2011.

2. SITE DESCRIPTION AND PROPOSED DEVELOPMENT

We understand that the site is irregular in shape and covers a total plan area of approximately 145.6 ha. The site comprises a series of open paddocks and is surrounded by farmland. The Manjedal Brook flows through the middle of the site from east to west. Photographs of the site are included in Appendix A.

Published contour plans show surface levels vary between RL 25 m AHD on the west side of the site and RL 38 m AHD on the east side of the site.

We understand that the site is to be subdivided into 744 residential lots, a primary school, associated access roads and various areas of public open space, mainly along Manjedal Brook. We assume that the proposed structures comprise steel/timber framed, masonry/steel clad construction with shallow footings and concrete slabs on ground. Our recommendations do not apply to large or heavily loaded structures, or residential structures above two stories high.

3. PREVIOUS STUDY

Parsons Brinckerhoff (PB) carried out a preliminary geotechnical investigation in August 2006 (PB project number 2140323A). Their investigation included the excavation of 22 backhoe test pits to a maximum depth of 2.5 m.

In a draft report provided to us by WES, PB advise that:

- the site to be underlain by sand with localised layers of ferricrete and clay. PB classified the site as a Class P in terms of AS2870 due to the presence of surface water;
- the classification could be improved to between A and M following the implementation of suitable drainage; and
- Class M areas could be improved to Class S by placing at least 0.5 m of clean sand over the clay.

The PB information has been incorporated in this report. The PB test pit reports are included in Appendix C for reference. The locations of the PB test pits are shown on Figure 2 and 3.

4. OBJECTIVES

The objectives of the study were to:

- assess subsurface soil and groundwater conditions across the site;
- provide a site classification(s) in accordance with AS 2870-2011 "Residential Slabs and Footings";
- provide recommendations and geotechnical design parameters for earth retaining structures;
- assess excavation conditions including appropriate batter angles;
- assess the suitability of the site for on-site disposal of stormwater by infiltration;
- recommend appropriate site preparation procedures including compaction criteria for buildings and pavements and re-use of the existing site soils as fill;
- provide a subgrade California bearing ratio (CBR) value for pavement thickness design (by others); and

- provide a preliminary assessment of the likely presence and impact of acid sulfate soils (ASS) at the site and advice on further studies, if necessary.

5. FIELDWORK

The fieldwork for the investigation was undertaken between 3 October and 7 October 2011 and comprised:

- excavation of backhoe test pits at 25 locations extending to 2.5 m, shallow refusal or hole collapse;
- dynamic cone penetrometer (DCP) tests adjacent to selected test pits;
- infiltration tests using the 'inverse auger hole' technique at 4 locations, at a depth of between 0.5 m and 1.0 m below existing ground; and
- collection of 53 samples for Acid Sulfate Soil (ASS) screening tests, taken at 0.5 m intervals at selected locations.

General

The test locations are shown on Figure 2, Site Plan. Test locations were positioned using a handheld GPS which is accurate to about 5 m in the horizontal plane.

The tests were positioned by a geotechnical engineer from Galt, who observed the test pitting, logged the materials encountered in the holes, undertook field permeability and penetrometer testing and collected representative samples for laboratory testing.

Test Pits

Test Pits were excavated using a Komatsu WB 97R tractor mounted backhoe fitted with a 600 mm toothed bucket supplied and operated by Erskine Earthmoving. Details of the test pits are presented in Table 1, Summary of Test Pits. Test Pit Reports along with the method of soil description, cementation and explanatory notes used on the reports are provided in Appendix B, Test Pit Reports.

Table 1: Summary of Test Pits

Test Name	Test Depth (m)	Depth of Water Inflow (m)	ASS screening tests	Reason for Termination	Stratigraphy
TP01	1.0	1.0	Yes	Refusal (Ferricrete)	Sand
TP02	2.5	1.5-2.0	Yes	Target Depth	Sand over Clayey Sand with Ferricrete Gravels
TP03	2.5	0.5	No	Target Depth	Sand over Clayey Sand
TP04	0.9	0.9	No	Refusal (Ferricrete)	Sand over Ferricrete Gravel
TP05	1.5	GNE	Yes	Refusal (Ferricrete)	Sand
TP06	2.0	GNE	No	Refusal (Ferricrete)	Sand
TP07	2.5	1.0	Yes	Target Depth	Sand
TP08	2.5	GNE	No	Hole Collapse	Sand

Test Name	Test Depth (m)	Depth of Water Inflow (m)	ASS screening tests	Reason for Termination	Stratigraphy
TP09	2.5	1.0	Yes	Target Depth	Sand over Clayey Sand
TP10	2.5	1.1	Yes	Target Depth	Sand over Clayey Sand
TP11	2.0	0.5	No	Hole Collapse	Sand
TP12	2.0	1.5	Yes	Hole Collapse	Sand
TP13	2.0	0.5	No	Hole Collapse	Sand
TP14	2.2	1.5	No	Refusal (Ferricrete)	Sand over Clayey Sand
TP15	1.0	1.0	No	Refusal (Ferricrete)	Sand
TP16	2.0	1.5	No	Refusal (Ferricrete)	Sand over Clayey Sand/Sandy Clay
TP17	2.0	2.0	Yes	Hole Collapse	Sand
TP18	2.6	0.7	No	Target Depth	Sand over Sandy Gravel over Clayey Sand
TP19	2.0	0.6	No	Hole Collapse	Sand
TP20	1.6	1.0	Yes	Refusal (Ferricrete)	Sand over boundary of Sand and Clayey Sand
TP21	1.0	0.8	No	Refusal (Ferricrete)	Sand
TP22	1.4	GNE	No	Refusal (Ferricrete)	Sand over Ferricrete Gravels
TP23	2.0	1.9	Yes	Hole Collapse	Sand
TP24	2.0	1.0	Yes	Refusal (Ferricrete)	Silty Sand over Sand over boundary of Sand and Clayey Sand
TP25	2.3	0.5	Yes	Hole Collapse	Sand

Notes: GNE – Groundwater not encountered

Dynamic Cone Penetrometer (DCP) Test Results

DCP testing was performed adjacent each to test pit location. The tests were carried out in accordance with AS1289.6.3.2. The results of the testing are presented in Appendix D, DCP Test Results.

Permeability Testing

Permeability Tests were undertaken at 4 locations across the site using the inverse auger hole method described by Cocks[1]. The results of the permeability testing are presented in Appendix E, Permeability Test Results and summarised in Table 2, Summary of Permeability Test Results.

Table 2: Summary of Permeability Test Results

Test Number	Description	Embedment (m)	Average Permeability k (m/day)		
			Test 1	Test 2	Test 3
P1	Clayey Sand	0.56	0.4	0.4	0.2
P2	Sand	0.58	8.9	9.6	7.4
P3	Sand (saturated)	0.58	4.5	4.6	3.8
P4	Sand (saturated)	0.65	0.8	0.7	0.4

Note: The average permeabilities are over the duration of the test with head varying between about 0.2 m and 0.7 m.

6. LABORATORY TESTING

Geotechnical

Laboratory testing on soil samples were undertaken by Mining and Civil Geotest in their NATA accredited laboratory.

Laboratory testing comprised determination of:

- particle size distribution on 10 samples;
- Atterberg Limits and linear shrinkage on 6 samples;
- dry density moisture content relationship using Modified compactive effort on 2 samples;
- soaked California Bearing Ratio tests on 2 samples; and
- shrink-swell index tests on 2 samples.

Laboratory test results along with the test methods followed are presented in Appendix F, Laboratory Test Results and summarised in Table 3, Summary of Laboratory Test Results.

[1] Cocks, G (2007), "Disposal of Stormwater Runoff by Soakage in Perth Western Australia", Journal and News of the Australian Geomechanics Society, Volume 42 No. 3, pp 101-114

Table 3: Summary of Laboratory Test Results

Sample	% Gravel	% Sand	% Fines	LL (%)	PI (%)	LS (%)	I_{ss} (%)	MMDD (t/m3)	OMC (%)	CBR @ 95%
TP02 @ 1.5-2.0 m	18	49	33	63	46	10.5	2.1			
TP06 @ 0.5-1.0 m	0	86	14	21	6	1.0		2.04	9.4	60
TP08 @ 1.0-1.5 m	0	83	7							
TP09 @ 0.0-0.5 m	2	71	27							
TP14 @ 0.25-0.7 m	3	65	32	29	16	5.5				
TP14 @ 1.0-1.5 m	7	56	37	32	19	6.5	1.2			
TP16 @ 0.5-1.0 m	0	38	62	46	29	9.5				
TP17 @ 0.5-1.0 m	0	98	2					1.683	16.1	17
TP21 @ 0.2-0.7 m	3	91	6							
TP24 @ 0.8-1.2 m	0	55	45	40	25	9				

LL: Liquid Limit PI: Plasticity Index LS: Linear Shrinkage
MC: Moisture Content MMDD: Maximum Dry Density (using modified compaction energy)
OMC: Optimum Moisture Content I_{ss}: Shrink-Swell Index

Environmental

Soil samples were collected at 0.5 m intervals to 2.5 m depth (where achievable) in a number of selected test pits and kept on ice until delivery to the laboratory. The samples were sent to ALS Laboratories, a NATA accredited facility, for ASS field screening tests, namely:

- pH_F [2]; and
- pH_{fOX} [3].

The results of the screening tests are included in Appendix G, Acid Sulfate Soils Screening Test Results.

7. SITE CONDITIONS

7.1 Geology

The Serpentine sheet of the 1:50,000 scale Environmental Geology series map indicates that the area is predominantly underlain by *SANDY CLAY – white, grey to brown, fine to coarse, sub-angular to rounded, clay of moderate plasticity; gravel and silt layers near scarp, of alluvial origin.*

There also localised areas of *SAND – overlying sandy clay of the Guildford Formation, of eolian origin.*

The investigation showed that the near-surface soils are typically sand rather than sandy clay. There are also layers of well cemented ferricrete at depths between 0.9 m and 2.5 m in a number of the test pits.

[2] pH_F: field pH as determined on a sample of soil mixed with distilled water
[3] pH_{FOX}: oxidized field pH as determined on a sample of soil mixed with an oxidizing agent (in this case, hydrogen peroxide)

7.2 Subsurface Conditions

The general site stratigraphy can be described by two typical soil profiles. The soil zones are shown on Figure 3.

SAND (Test Pits TP01,TP04-08, TP11-13, TP15, TP17-19, TP21-25)

Zones of sand are present throughout the site as shown on Figure 3. The soil strata are descried below.

SAND (SP): medium to coarse grained, sub rounded to sub angular, varying between dark grey at top (organic topsoil layer), becoming white, pale brown, yellow brown, pale grey mottled yellow brown, trace silt/clay fines with occasional 5mm to 15mm diameter, weakly to moderately cemented ferruginised nodules, wet, generally very loose to loose, between 0.5 m and 2.5 m thick (average thickness: 1.4 m); overlying

Ferricrete GRAVELS (GP / GC): noted in nine of the eighteen test pits in this soil zone at depths below 1.0 m. Comprises medium and fine gravels in a matrix of sand and clayey sand, becoming well cemented in places (backhoe refusal on hardpan ferricrete occurred in eight test pits at depths between 0.9 m and 2.0 m).

Localised Clayey SAND (SC) layers / lenses: medium to coarse grained, sub rounded to sub angular, generally pale mottled yellow brown occasionally olive green, varying between 10% and 30% low to medium plasticity clay fines, occasional 5mm to 15mm weakly to moderately cemented ferruginised nodules, moist to wet, loose to medium-dense, present below sand layer, localised thin layers (0.4 m thick), only present in two of the eighteen test pits.

Groundwater: the groundwater depth in this area ranged between 0.5 m and 2.0 m (average: 1.1 m).

CLAYEY SAND (Test Pits TP02-03, TP09-10, TP14, TP16, TP20)

The remainder of the site is underlain by a relatively thin layer of sand overlying clayey sand. This soil zone is shown on Figure 3 and comprises the following strata.

SAND (SP): medium to coarse grained, sub rounded to sub angular, dark grey topsoil to 0.1 m, moist to wet, generally loose, between 0.0 m and 1.3 m thick (average thickness: 0.7m); overlying

Clayey SAND (SC)/Sandy CLAY (CL-CI): medium to coarse grained, sub rounded to sub angular, generally pale grey mottled yellow brown, occasionally olive green, varying between 20% and 60% low to medium plasticity clay fines (localised high plasticity), occasional weakly to moderately cemented ferruginised nodules, moist to wet, very loose to medium-dense, present to depths between 1.2 m and deeper than 2.6 m.

Ferricrete GRAVEL (GC): noted in three test pits, fine to coarse, moderately to well cemented ferricrete gravel in a matrix (20% – 60%) of medium plasticity Clayey SAND/Sandy CLAY, pale grey mottled yellow brown, moist to wet, medium dense, present below depths ranging from 1.2 m to 2.5 m. Backhoe refusal occurred on well cemented (hardpan) ferricrete in one test pit.

Groundwater: the groundwater depth in this area ranged between 0.4 m and 2.5 m (average: 1.1 m).

7.3 Groundwater

The online Perth Groundwater Atlas published by the Department of Water shows that the groundwater level (May 2003 – end of summer) varies from about RL 23.5 m AHD at the west side of the site to RL 30 m AHD towards the eastern boundary. This is within 2 m of the current ground surface. We note that records of the historical maximum groundwater levels do not extend to the site location.

Water inflow occurred in the majority of the test pits excavated across the site. This typically occurred in the sandier horizons which varied between depths of 0.1 m to 2.5 m. In many cases, the groundwater appeared to be perched at shallow depth on the less permeable clayey horizon. This perched watertable is likely to drop during the dry summer months.

At the time of fieldwork, a number of water filled depressions were noted across the site. The ground conditions were also noticeably "boggy" and untraffickable in areas of saturated topsoil (i.e. the top 0.1 m).

8. DISCUSSION

8.1 Site Classification

The site classification is based on AS 2870-2011 "Residential Slabs and Footings" which defines the following site classes:

Table 4: Summary of Site Classification (AS2780-2011)

Class	Description	Characteristic Surface Movement (y_s)
A	Moist sand and rock site with little or no ground movement from moisture change	Not defined (typically <5 mm)
S	Slightly reactive clay sites with only slight ground movement from moisture changes	0-20 mm

On the basis of the above, we consider that the entire site is suitable for development subject to appropriate site preparation measures (see Section 8.2) being undertaken and the lots being raised to avoid flooding / saturated surface conditions.

Based on our assessment we have divided the site into site classes A and S, the extents of which are shown on Figure 3. The boundaries of the different site classifications shown on the figure are approximate and are our best estimation based on the subsurface conditions encountered and the laboratory test results.

- Site Class A: "Sand" zone
- Site Class S: "Clayey Sand" zone

The site classification of the Class 'S' lots can be changed to a Class 'A' site classification by ensuring that there is a minimum thickness of 1.8 m of inert granular material above the clayey soils. This thickness includes any depth of *in situ* sand and/or gravels present. Any fill required to achieve this minimum thickness must be in accordance with Section 8.4 and comprise compacted inert soil (*in situ* or imported fill) above the expansive clayey sand layers. This would typically involve importing about 0.5 m – 1.0 m of fill.

Note: Where it is proposed to improve the site classification of an individual lot, a geotechnical engineer must assess the conditions on that particular lot and confirm the thickness of sand and/or gravel cover required.

8.2 Site Preparation

The site preparation measures outlined below are aimed at improvement of the site in preparation for construction of buildings including on-ground slabs and shallow footings, retaining walls and pavement subgrades.

The following site preparation measures must be followed:

- strip vegetation from the site including grubbing out of tree roots and removal of rubbish;

- strip and stockpile topsoil from the site for potential re-use in non-structural applications;
- cut to the desired finished level;
- compact the exposed soil to achieve the level of compaction specified in Section 8.3 to at least 0.9 m depth below areas where structures and pavements are proposed – any areas of very loose to loose soil, etc, must be removed and replaced with approved fill as outlined in Section 8.4; and
- where fill is required to build up levels (or to achieve an improved site classification as discussed in Section 8.1), use approved fill (refer to Section 8.4), placed and compacted in layers of no greater than 0.3 m loose thickness.

After compaction, verify that the required level of compaction has been achieved by testing to a minimum depth of 0.9 m below foundations:

- on each lift of fill at the rate of 1 test per 500 m^3;
- at 15 m centres along retaining wall footings; and
- at 15 m centres on pavement subgrades (on the road centreline).

8.3 Compaction

Granular fill must be compacted using suitable compaction equipment to achieve a dry density ratio (DDR) of at least 95 % maximum dry density (MDD) as determined in accordance with AS 1289 5.2.1. If sand is used as fill and a Perth sand penetrometer (PSP) is used for compaction control, we recommend a minimum blow count of 8 blows per 0.3 m penetration. If difficulty arises in achieving the specified PSP blow count, then a calibration must be established between PSP blow count and the *in situ* density. This will allow confirmation of the blow count required to achieve a DDR of at least 95 % MDD.

Over-excavation and replacement of loose materials may be required where the minimum density ratio cannot be achieved.

Fill must be placed in horizontal layers of not greater than 0.3 m loose thickness. Each layer must be compacted by suitable compaction equipment, and carefully controlled to ensure even compaction over the full area and depth of each layer.

We note that compaction within 1 m of the groundwater table is likely to be difficult. Difficulties may be encountered where shallow perched water tables develop on the ferricrete or clayey layers during and shortly after the rainy season. Dewatering may be required in places (e.g. using spears, sumps and / or cut-off trenches).

8.4 Approved Fill

Imported granular fill must comply with the material requirements as stated in AS 3798-2007, "Guidelines on Earthworks for Commercial and Residential Developments". Sand fill must comprise clean sand that is free of organic matter and have a fines content of less than 5%.

Generally, the *in situ* sand present on the site will be suitable for re-use as inert structural fill. Any organic-rich sand or sand containing significant proportions of fines (material less than 0.075 mm in size) must not be used within 1 m of the finished level of fill pads.

Where doubt exists about the excavation or use of any materials on site, a geotechnical engineer must be engaged to inspect and approve the use of potential fill materials.

8.5 Excavations

We do not expect that any difficulty will be encountered in the gravel and sand areas with excavations undertaken using conventional earthmoving equipment (e.g. 10-tonne and larger excavators, push-pulls, etc) to depths of about 2.0 m.

Localised shallow hardpan ferricrete / coffee rock (depth 1.0 m or less) was encountered in five test pits although other areas of shallow hardpan may be present. Excavations below this depth will probably require the use of a larger excavator (say 25 tonne fitted with a rock bucket or hydraulic breaker).

Test pits generally collapsed due to the loose nature of the sand and clayey sand and the high groundwater table.

8.6 Retaining Structures

Retaining structures may be designed in accordance with AS 4678-2002 "Earth-Retaining Structures". For the design of retaining structures, the following parameters are considered appropriate for retaining wall design using compacted *in situ* sand, *in situ* medium dense sand and compacted sand backfill:

- angle of internal friction, $\phi = 36°$;
- coefficient of active earth pressure $K_a = 0.26$;
- coefficient of passive earth pressure $K_p = 3.85$;
- at rest coefficient of earth pressure $K_0 = 0.41$; and
- bulk density: 18 kN/m^3.

Compaction plant can augment the lateral earth pressure acting on retaining walls. Hand operated compaction equipment is recommended within 2 m of any retaining walls to minimise compaction pressures.

It is important to note that some ground movement is to be expected behind any soil retaining system, including gravity retaining walls.

8.7 Pavement Design

Where pavement subgrades are constructed according to the site preparation requirements outlined in Section 8.2, the thickness of pavements built upon them may be calculated using a subgrade California bearing ratio (CBR) of 12% where the sub-grade is expected to remain dry and the subgrade comprises at least 0.5 m of compacted sand.

Where clayey soils occur within 0.5 m of the pavement layers, a sub-grade CBR of 3% should be assumed as the clayey gravel and gravelly clay soils at the site are susceptible to significant softening if they become saturated. Accordingly, all pavements must be designed to shed water away from the subgrade.

The use of a seal (as opposed to, or in conjunction with, asphaltic concrete) will assist in this. Subsoil drainage may be required where water ingress is expected around pavement subgrades.

8.8 Stormwater Disposal

While the permeability of the near-surface soils is relatively high (k = 0.2 m/day to 7.4 m/day), we do not recommend the use of soakwells due to the presence of the high perched water table and the less permeable clayey horizons.

However, soakwells may generally be used where sand pads are placed such that the final surface is at least 1.2 m above the average groundwater table.

8.9 Acid Sulfate Soils

The online Nation Acid Sulfate Soils Mapping published by the CSIRO indicates that the site is in an area of "low probability" of ASS within the upper 3 m of the soil profile.

The results of the screening tests provide further indication that there is a low likelihood of ASS at the site, given that:

- all samples have $pH_F > 4$ (i.e. there are no currently strongly acidic soils at the site, or actual acid sulfate soils (AASS));
- no strong reactions were observed when mixing an oxidising agent with the soil samples with the exception of an extreme reaction at TP20 between 0.5 m and 1.0 m depth; and
- $pH_{FOX} > 3$ applies to all samples (i.e. there are no samples that became strongly acidic when oxidised, indicating that the soils at the site are also not potential acid sulfate soils (PASS).

In addition to the above, the vegetation on the site appears to be in a good condition which suggests that there is no actual ASS.

We therefore do not consider that further ASS investigation is warranted.

9. CLOSURE

We would like to draw your attention to Appendix H of this report, "Understanding your Geotechnical Engineering Report". The information provided within is intended to inform you as to what your realistic expectations of this report should be. Guidance is also provided on how to minimise risks associated with groundworks for this project. This information is provided not to reduce the level of responsibility accepted by Galt, but to ensure that all parties who rely on this report are aware of the responsibilities each assumes in so doing.

Yours Faithfully,

GALT GEOTECHNICS PTY LTD

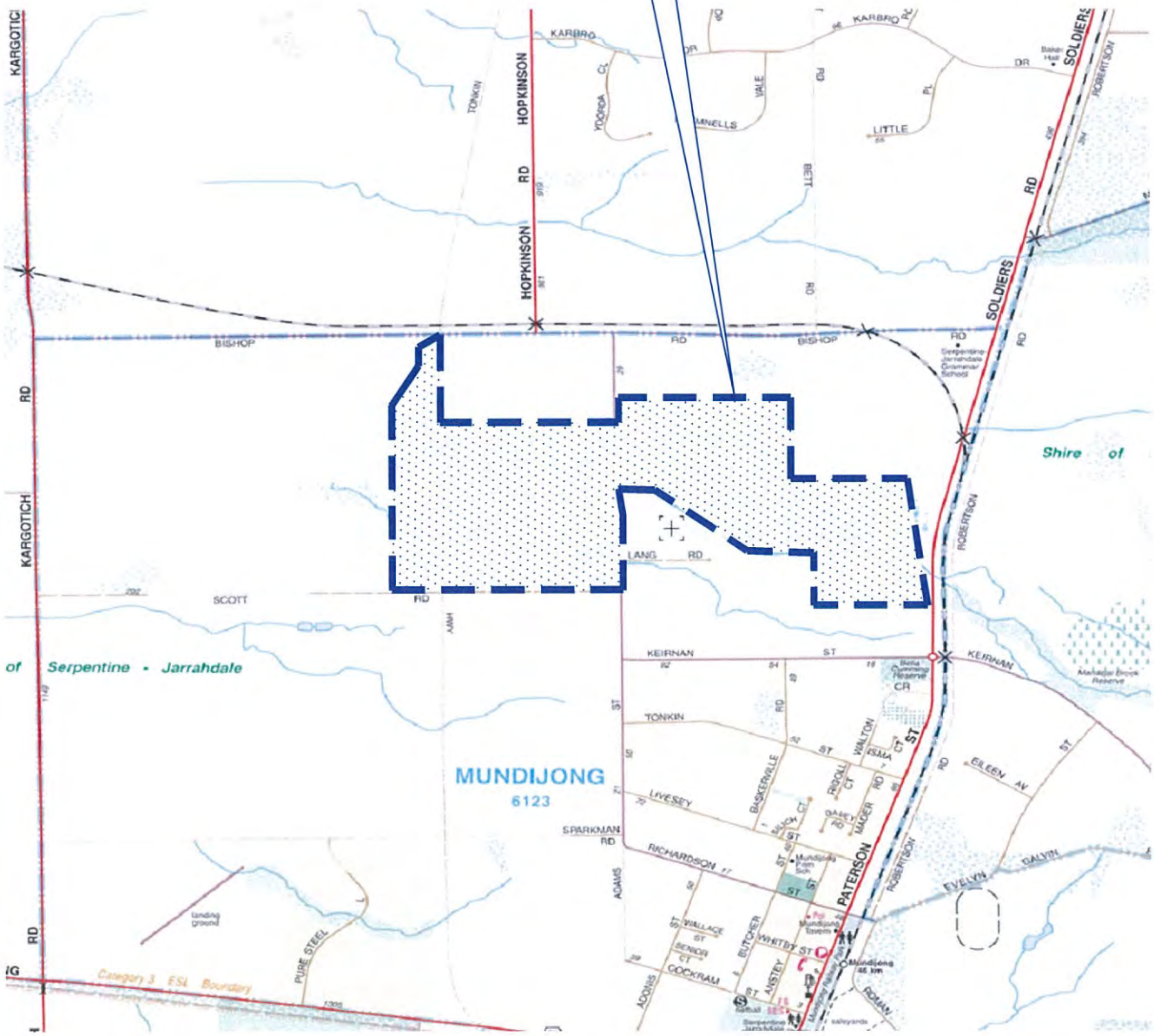
Rick Piovesan CPEng

Geotechnical Engineer

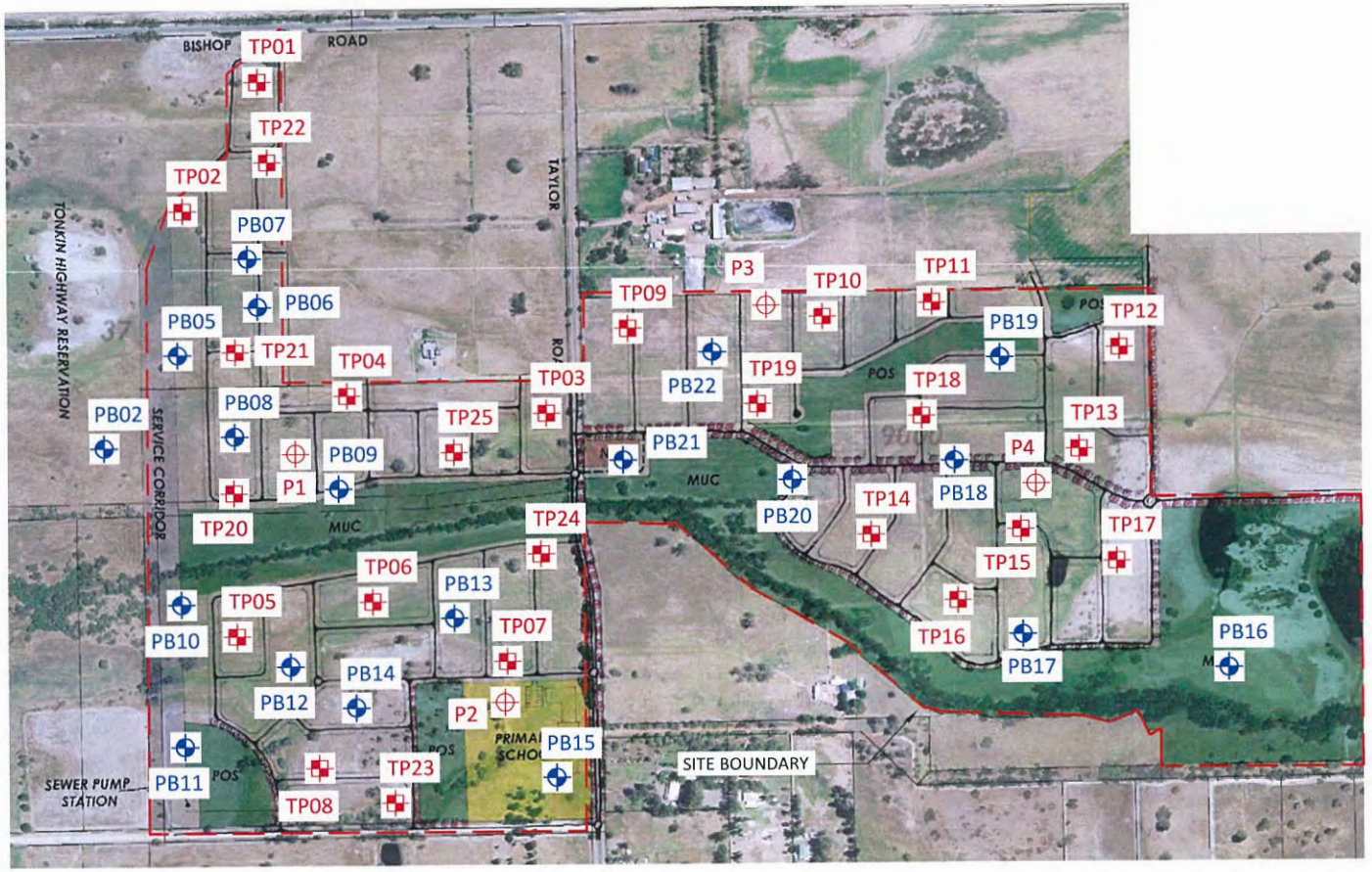
Harry Chambers

Graduate Engineer

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Galt GEOTECHNICS	SCALE NTS	CLIENT Wave Engineering Pty Ltd	
	DRAWN DAR DATE Oct '11	PROJECT RESIDENTIAL DEVELOPMENT BISHOP ROAD, MUNDIJONG	
	CHECKED ORW DATE Oct '11		
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		Job No J1101128	FIGURE 1 A4



LEGEND

TP01 - TEST PIT LOCATION

P2 - PERMEABILITY TEST LOCATION

PB1 - PARSONS BRINKERHOFF TEST PIT LOCATION (2006)

SITE BOUNDARY

NOTE - TEST LOCATIONS ARE APPROXIMATE ONLY

REV.	DESCRIPTION	DATE	CHK
0	ISSUED FOR REVIEW	11/10/2011	ORW

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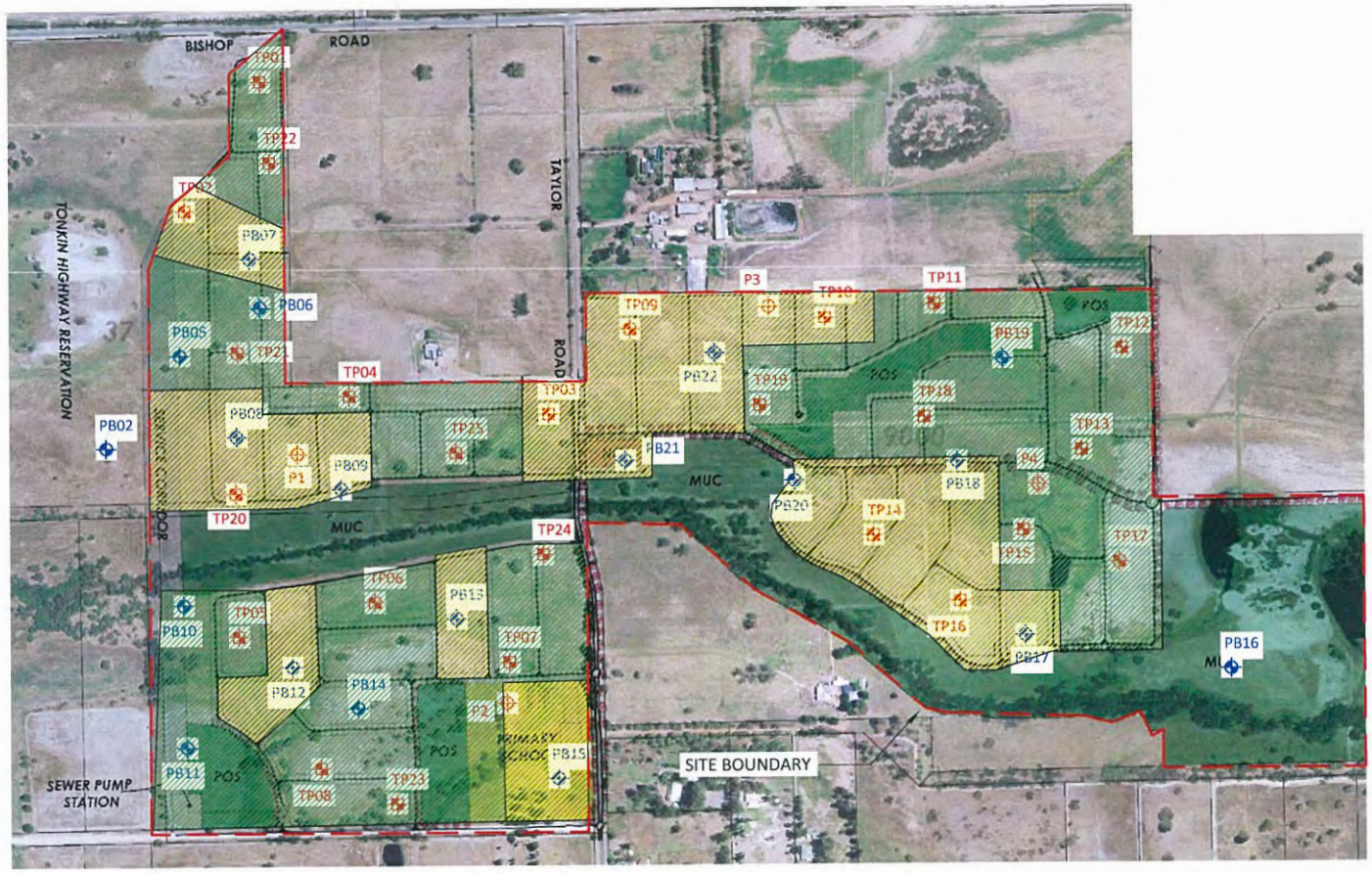
Galt GEOTECHNICS
Galt Geotechnics Pty Ltd
ABN 73 292 586 155
Tel: +61 (0)8 6272 0200
2/54 Flynn St
Wembley, WA, 6014

CLIENT: Wave Engineering Solutions Pty Ltd

PROJECT: Residential Development
Lots 37, 98 & 9000 Bishop Road, Mundijong

TITLE: SITE PLAN

JOB No: J1101128 | FIGURE 2 | A3 | REV: 0



LEGEND

TP01 - TEST PIT LOCATION

P2 - PERMEABILITY TEST LOCATION

PB1 - PARSONS BRINKERHOFF TEST PIT LOCATION (2006)

— — - SITE BOUNDARY

SOIL ZONE AND SITE CLASSIFICATION

DEEP SAND - CLASS A

CLAYEY SAND - CLASS S

NOTE - TEST LOCATIONS ARE APPROXIMATE ONLY

REV.	DESCRIPTION	DATE	CHK
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PROJECT: Residential Development
Lots 37, 98 & 9000 Bishop Road, Mundijong

TITLE: SOIL ZONES

JOB NO: J1101128 | FIGURE 3 | A3 | REV: 0

APPENDIX A

Site Photographs

www.galtgeo.com.au
2/39 Flynn St, WEMBLEY WA 6014

ABN: 73 292 586 155



Photograph 1: General site condition



Photograph 2: Surface water encountered



Photograph 3: Water filled depression



Photograph 4: Test Pit TP08 (Sand)



Photograph 5: Test Pit TP02 (Clay)

APPENDIX B

Test Pit Reports

www.galtgeo.com.au
2/39 Flynn St, WEMBLEY WA 6014

ABN: 73 292 586 155

EXPLANATORY NOTES TO BE READ WITH BOREHOLE AND TEST PIT REPORTS

Galt GEOTECHNICS

METHOD OF DRILLING OR EXCAVATION

AC	Air Core	E	Excavator	PQ3	PQ3 Core Barrel
AD/T	Auger Drilling with TC-Bit	EH	Excavator with Hammer	PT	Push Tube
AD/V	Auger Drilling with V-Bit	HA	Hand Auger	R	Ripper
AT	Air Track	HMLC	HMLC Core Barrel	RR	Rock Roller
B	Bulldozer Blade	HQ3	HQ3 Core Barrel	SON	Sonic Rig
BH	Backhoe Bucket	N	Natural Exposure	SPT	Driven SPT
CT	Cable Tool	NMLC	NMLC Core Barrel	WB	Washbore
DT	Diatube	PP	Push Probe	X	Existing Excavation

SUPPORT

T	Timbering

PENETRATION EFFORT (RELATIVE TO THE EQUIPMENT USED)

VE	Very Easy	E	Easy	F	Firm
H	Hard	VH	Very Hard		

WATER

►	Water Inflow	▼	Water Level
◄	Water Loss (complete)		
◁	Water Loss (partial)		

SAMPLING AND TESTING

B	Bulk Disturbed Sample	P	Piston Sample
BLK	Block Sample	PBT	Plate Bearing Test
C	Core Sample	U	Undisturbed Push-in Sample
CBR	CBR Mould Sample		U50: 50 mm diameter
D	Small Disturbed Sample	SPT	Standard Penetration Test
ES	Environmental Soil Sample		Example: 3, 4, 5 N=9
EW	Environmental Water Sample		3,4,5: Blows per 150 mm
G	Gas Sample		N=9: Blows per 300 mm after
HP	Hand Penetrometer		150 mm seating interval
LB	Large Bulk Disturbed Sample	VS	Vane Shear; P = Peak
M	Mazier Type Sample		R = Remoulded (kPa)
MC	Moisture Content Sample	W	Water Sample

ROCK CORE RECOVERY

TCR = Total Core Recovery (%) $= \frac{CRL}{TCL} \times 100$

SCR = Solid Core Recovery (%) $= \frac{CCR}{TCL} \times 100$

RQD = Rock Quality Designation (%) $= \frac{ALC > 100}{TCL} \times 100$

TCL	Length of Core Run
CRL	Recovered Length of Core
CCR	Total Length of Cylindrical Pieces of Core Recovered
ALC>100	Total Length of Axial Lengths of Core Greater than 100 mm Long

METHOD OF SOIL DESCRIPTION
BOREHOLE AND TEST PIT REPORTS

Galt GEOTECHNICS

GRAPHIC LOG & UNIFIED SOIL CLASSIFICATION SYSTEM (USCS) SYMBOLS

Graphic	USCS	Soil Name
		FILL (various types)
		BOULDERS and/or COBBLES
	GP	GRAVEL (poorly graded)
	GW	GRAVEL (well graded)
	GC	Clayey GRAVEL
	SP	SAND (poorly graded
	SW	SAND (well graded)
	SC	Clayey SAND

Graphic	USCS	Soil Name
	ML	SILT (low liquid limit)
	MH	SILT (high liquid limit)
	CL	CLAY (low plasticity)
	CI	CLAY (medium plasticity)
	CH	CLAY (high plasticity)
	OL	Organic SILT (low liquid limit)
	OH	Organic SILT (high liquid limit)
	Pt	PEAT

RESISTANCE TO EXCAVATION

Symbol	Term	Description
VE	Very easy	All resistances are relative to the selected method of excavation
E	Easy	
F	Firm	
H	Hard	
VH	Very hard	

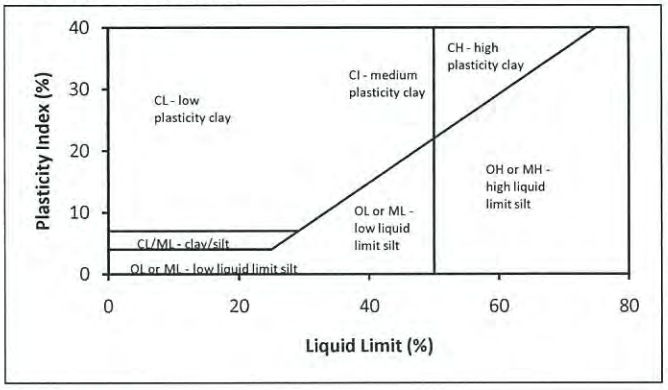
SOIL CLASSIFICATION AND INFERRED STRATIGRAPHY

Soil descriptions are based on AS1726-1993, Appendix A. Material properties are assessed in the field by visual/tactile methods in combination with field testing techniques (where used).

PARTICLE SIZE

Soil Name		Particle Size (mm)
BOULDERS		>200
COBBLES		63 to 200
GRAVEL	Coarse	20 to 63
	Medium	6 to 20
	Fine	2 to 6
SAND	Coarse	0.6 to 2.0
	Medium	0.2 to 0.6
	Fine	0.075 to 0.2
FINES	SILT	0.002 to 0.075
	CLAY	<0.002

PLASTICITY PROPERTIES



MOISTURE CONDITION

AS1726-1993

Symbol	Term	Description
D	Dry	Sands and gravels are free flowing. Clays and silts may be brittle or friable and powdery.
M	Moist	Soils are darker than in the dry condition and may feel cool. Sands and gravels tend to cohere.
W	Wet	Soils exude free water. Sands and gravels tend to cohere.

CONSISTENCY AND DENSITY

AS1726-1993 and HB160-2006

Symbol	Term	Undrained Shear Strength (kPa)	SPT "N"	DCP blows per 100 mm
VS	Very Soft	0 to 12	0 to 2	<1
S	Soft	12 to 25	2 to 4	<1
F	Firm	25 to 50	4 to 8	1 to 2
St	Stiff	50 to 100	8 to 15	3 to 4
VSt	Very Stiff	100 to 200	15 to 30	5 to 10
H	Hard	>200	>30	>10

Symbol	Term	Density Index (%)	SPT "N"	DCP blows per 100 mm	PSP Blows per 300 mm
VL	Very Loose	<15	0 to 4	<1	0 to 2
L	Loose	15 to 35	4 to 10	1 to 2	2 to 6
MD	Medium Dense	35 to 65	10 to 30	2 to 3	6 to 8
D	Dense	65 to 85	30 to 50	4 to 8	8 to 15
VD	Very Dense	>85	>50	>8	>15

Note: PSP correlations only valid to 450 mm depth

Consistency and density may also be inferred from excavation performance and material behaviour.

REPORT OF TEST PIT — TP01

PROJECT DETAILS	SPATIAL DETAILS	DRILLING DETAILS
Job Number: J1101128	Position: See Plan	Logged: HWC — Logged Date: 05/10/2011
Client: Wave Engineering Pty Ltd	Easting (m): 403177	Checked: RP — Checked Date: 30/10/2011
Project: Residential Development	Northing (m): 6429250	TP Width (m): 0.6 — TP Length (m):
Location: Lots 37, 98, 9000 Bishop Road Mundijong	Datum: MGA94	Machine: Komatsu WB 97R — Bucket: Toothed
	Surface RL (m):	Contractor: Erskine EM — Operator: James

DEPTH (m)	EXCAVATION RESISTANCE	GROUNDWATER	SAMPLES & FIELD TESTS	GRAPHIC LOG	USCS CLASSIFICATION	MATERIAL DESCRIPTION (Soil type, plasticity or particle characteristics, colour, secondary and minor components)	MOISTURE CONDITION	CONSISTENCY/ DENSITY	ADDITIONAL OBSERVATIONS	DEPTH (m)
0.0	VE	▶	ASS Sampling at 0.5 m intervals		SP	SAND (Topsoil): Medium to coarse grained, sub-rounded to sub-angular, dark grey, trace silt fines, abundant rootlets	W	L-MD	Hole collapse.	0.0
0.2						As above, grey, no fines, no rootlets				0.2
0.4						As above, pale brown				0.4
0.6										0.6
0.8						As above, dark brown, with very weakly cemented ferruginised nodules, trace silt fines				0.8
1.0	H					As above, pale brown, no nodules, no fines, fine to coarse grained ferricrete gravel				1.0
1.2										1.2
1.4										1.4
1.6										1.6
1.8										1.8
2.0										2.0
2.2										2.2
2.4										2.4
2.6										2.6

End of test pit at 1.0 m.
Refusal on Ferricrete.
Water inflow at 1.0 m.

See Explanatory Notes and Method of Soil Description sheets for detials of abbreviations and basis of descriptions

GALT GEOTECHNICS PTY LTD

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REPORT OF TEST PIT **TP02**

PROJECT DETAILS	SPATIAL DETAILS	DRILLING DETAILS
Job Number: J1101128	Position: See Plan	Logged: HWC — Logged Date: 05/10/2011
Client: Wave Engineering Pty Ltd	Easting (m): 403067	Checked: RP — Checked Date: 30/10/2011
Project: Residential Development	Northing (m): 6429028	TP Width (m): 2 — TP Length (m):
Location: Lots 37, 98, 9000 Bishop Road Mundijong	Datum: MGA94	Machine: Komatsu WB 97R — Bucket: Toothed
	Surface RL (m):	Contractor: Erskine EM — Operator: James

DEPTH (m)	EXCAVATION RESISTANCE	GROUNDWATER	SAMPLES & FIELD TESTS	GRAPHIC LOG	USCS CLASSIFICATION	MATERIAL DESCRIPTION (Soil type, plasticity or particle characteristics, colour, secondary and minor components)	MOISTURE CONDITION	CONSISTENCY/ DENSITY	ADDITIONAL OBSERVATIONS	DEPTH (m)
0.0	VE				SP	SAND: Medium to coarse grained, sub-rounded to sub-angular, dark grey, trace silt fines, abundant rootlets	M-W	L	Topsoil to 0.1 m.	0.0
0.2						As above, pale brown, trace clay fines, trace ferruginised nodules				0.2
0.4						As above, grey, some low plasticity clay fines				0.4
0.6						As above, pale brown, trace clay fines, trace ferruginised nodules				0.6
0.8									Hole collapse.	0.8
1.0					GP	GRAVEL: Fine to coarse grained ferricrete in a matrix of ~20% Clayey SAND, medium to coarse grained, grey-white and yellow-brown, 20-30% medium to high plasticity fines				1.0
1.2			ASS Sampling at 0.5 m intervals							1.2
1.4	E	▶			SC	Clayey SAND: Medium to coarse grained, sub-rounded to sub-angular, grey-white and yellow-brown with occasional olive grey mottling (with higher clay content), 20-40% med and high plasticity clay fines, ~10% ferruginised nodules ~10 mm		L-MD	Occasional bands of white sand.	1.4
1.6										1.6
1.8										1.8
2.0										2.0
2.2										2.2
2.4										2.4
2.6			In Situ Sample							2.6

End of test pit at 2.5 m.
Target depth.
Water inflow at 1.5 to 2.0 m.

See Explanatory Notes and Method of Soil Description sheets for detials of abbreviations and basis of descriptions

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REPORT OF TEST PIT **TP03**

PROJECT DETAILS	SPATIAL DETAILS	DRILLING DETAILS
Job Number: J1101128	Position: See Plan	Logged: HWC — Logged Date: 05/10/2011
Client: Wave Engineering Pty Ltd	Easting (m): 403610	Checked: RP — Checked Date: 30/10/2011
Project: Residential Development	Northing (m): 6428743	TP Width (m): 2 — TP Length (m):
Location: Lots 37, 98, 9000 Bishop Road Mundijong	Datum: MGA94	Machine: Komatsu WB 97R — Bucket: Toothed
	Surface RL (m):	Contractor: Erskine EM — Operator: James

DEPTH (m)	EXCAVATION RESISTANCE	GROUNDWATER	SAMPLES & FIELD TESTS	GRAPHIC LOG	USCS CLASSIFICATION	MATERIAL DESCRIPTION (Soil type, plasticity or particle characteristics, colour, secondary and minor components)	MOISTURE CONDITION	CONSISTENCY/ DENSITY	ADDITIONAL OBSERVATIONS	DEPTH (m)
0.0	VE	▶			SP	SAND (Topsoil): Medium to coarse grained, sub-rounded to sub-angular, dark grey, trace silt fines, abundant rootlets	M-W	VL-L		0.0
0.2						As above, yellow-brown, trace clay fines, no rootlets				0.2
0.4										0.4
0.6										0.6
0.8										0.8
1.0										1.0
1.2					SC	Clayey SAND: Medium to coarse grained, sub-rounded to sub-angular, pale grey mottled yellow-brown, ~15% low to medium plasticity clay fines, ferruginised nodules 5-15 mm				1.2
1.4										1.4
1.6										1.6
1.8										1.8
2.0										2.0
2.2										2.2
2.4	H									2.4
2.6						End of test pit at 2.5 m. Target depth. Water inflow at 0.5 m.				2.6

See Explanatory Notes and Method of Soil Description sheets for detials of abbreviations and basis of descriptions

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REPORT OF TEST PIT **TP04**

PROJECT DETAILS	SPATIAL DETAILS	DRILLING DETAILS
Job Number: J1101128	Position: See Plan	Logged: HWC — Logged Date: 05/10/2011
Client: Wave Engineering Pty Ltd	Easting (m): 403309	Checked: RP — Checked Date: 30/10/2011
Project: Residential Development	Northing (m): 6428764	TP Width (m): 0.6 — TP Length (m):
Location: Lots 37, 98, 9000 Bishop Road Mundijong	Datum: MGA94	Machine: Komatsu WB 97R — Bucket: Toothed
	Surface RL (m):	Contractor: Erskine EM — Operator: James

DEPTH (m)	EXCAVATION RESISTANCE	GROUNDWATER	SAMPLES & FIELD TESTS	GRAPHIC LOG	USCS CLASSIFICATION	MATERIAL DESCRIPTION (Soil type, plasticity or particle characteristics, colour, secondary and minor components)	MOISTURE CONDITION	CONSISTENCY/ DENSITY	ADDITIONAL OBSERVATIONS	DEPTH (m)
0.0	VE				SP	SAND (Topsoil): Medium to coarse grained, sub-rounded to sub-angular, dark grey, trace silt fines, abundant rootlets	W	L		0.0
0.2						As above, yellow-brown, trace clay fines, no rootlets				0.2
0.4										0.4
0.6										0.6
0.8	H	▶				As above, becoming ferruginised				0.8
1.0										1.0
1.2										1.2
1.4										1.4
1.6										1.6
1.8										1.8
2.0										2.0
2.2										2.2
2.4										2.4
2.6										2.6

End of test pit at 0.9 m.
Refusal on Ferricrete.
Water inflow at 0.9 m.

See Explanatory Notes and Method of Soil Description sheets for detials of abbreviations and basis of descriptions

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REPORT OF TEST PIT **TP05**

PROJECT DETAILS	SPATIAL DETAILS	DRILLING DETAILS
Job Number: J1101128	Position: See Plan	Logged: HWC — Logged Date: 05/10/2011
Client: Wave Engineering Pty Ltd	Easting (m): 403139	Checked: RP — Checked Date: 30/10/2011
Project: Residential Development	Northing (m): 6428417	TP Width (m): 2 — TP Length (m):
Location: Lots 37, 98, 9000 Bishop Road Mundijong	Datum: MGA94	Machine: Komatsu WB 97R — Bucket: Toothed
	Surface RL (m):	Contractor: Erskine EM — Operator: James

DEPTH (m)	EXCAVATION RESISTANCE	GROUNDWATER	SAMPLES & FIELD TESTS	GRAPHIC LOG	USCS CLASSIFICATION	MATERIAL DESCRIPTION (Soil type, plasticity or particle characteristics, colour, secondary and minor components)	MOISTURE CONDITION	CONSISTENCY/ DENSITY	ADDITIONAL OBSERVATIONS	DEPTH (m)
0.0	VE		ASS Sampling at 0.5 m intervals		SP	SAND (Topsoil): Medium to coarse grained, sub-rounded to sub-angular, dark grey, trace silt fines, abundant rootlets	W	VL-L	Hole collapse.	0.0
0.2						As above, pale brown and white, no silt, no rootlets				0.2
0.4										0.4
0.6						As above, grey-white mottled yellow-brown, becoming ferruginised				0.6
0.8										0.8
1.0										1.0
1.2										1.2
1.4	H									1.4
1.6										1.6
1.8										1.8
2.0										2.0
2.2										2.2
2.4										2.4
2.6										2.6
						End of test pit at 1.5 m. Refusal on Ferricrete. Groundwater not encountered.				

See Explanatory Notes and Method of Soil Description sheets for detials of abbreviations and basis of descriptions

GALT GEOTECHNICS PTY LTD

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REPORT OF TEST PIT TP06

PROJECT DETAILS

Job Number: J1101128
Client: Wave Engineering Pty Ltd
Project: Residential Development
Location: Lots 37, 98, 9000 Bishop Road Mundijong

SPATIAL DETAILS

Position: See Plan
Easting (m): 403330
Northing (m): 6428450
Datum: MGA94
Surface RL (m):

DRILLING DETAILS

Logged: HWC Logged Date: 05/10/2011
Checked: RP Checked Date: 30/10/2011
TP Width (m): 2 TP Length (m):
Machine: Komatsu WB 97R Bucket: Toothed
Contractor: Erskine EM Operator: James

DEPTH (m)	EXCAVATION RESISTANCE	GROUNDWATER	SAMPLES & FIELD TESTS	GRAPHIC LOG	USCS CLASSIFICATION	MATERIAL DESCRIPTION Soil type, plasticity or particle characteristics, colour, secondary and minor components	MOISTURE CONDITION	CONSISTENCY/ DENSITY	ADDITIONAL OBSERVATIONS	DEPTH (m)
0.0	VE				SP	SAND: Medium to coarse grained, sub-rounded to sub-angular, dark grey, trace silt fines, abundant rootlets	W	VL-L		0.0
0.2						As above, pale brown, no fines, no rootlets				0.2
0.4										0.4
0.6			Bulk Sample SA06-1							0.6
0.8										0.8
1.0						As above, grey-white mottled yellow-brown, variable clay content (10-20% low plasticity fines), becoming ferruginised with depth			Estimated depth due to hole collapse	1.0
1.2										1.2
1.4										1.4
1.6	M									1.6
1.8	H									1.8
2.0										2.0
2.2										2.2
2.4										2.4
2.6										2.6

End of test pit at 2.0 m.
Refusal on Ferricrete.
Groundwater not encountered.

See Explanatory Notes and Method of Soil Description sheets for detials of abbreviations and basis of descriptions

GALT GEOTECHNICS PTY LTD

Galt GEOTECHNICS

REPORT OF TEST PIT — TP07

PROJECT DETAILS	SPATIAL DETAILS	DRILLING DETAILS
Job Number: J1101128	Position: See Plan	Logged: HWC — Logged Date: 05/10/2011
Client: Wave Engineering Pty Ltd	Easting (m): 403538	Checked: RP — Checked Date: 30/10/2011
Project: Residential Development	Northing (m): 6428366	TP Width (m): 2 — TP Length (m):
Location: Lots 37, 98, 9000 Bishop Road Mundijong	Datum: MGA94	Machine: Komatsu WB 97R — Bucket: Toothed
	Surface RL (m):	Contractor: Erskine EM — Operator: James

DEPTH (m)	EXCAVATION RESISTANCE	GROUNDWATER	SAMPLES & FIELD TESTS	GRAPHIC LOG	USCS CLASSIFICATION	MATERIAL DESCRIPTION (Soil type, plasticity or particle characteristics, colour, secondary and minor components)	MOISTURE CONDITION	CONSISTENCY/ DENSITY	ADDITIONAL OBSERVATIONS	DEPTH (m)
0.0						SAND (Topsoil): Medium to coarse grained, sub-rounded to sub-angular, dark grey, trace silt fines, abundant rootlets				0.0
0.2						As above, pale brown mottled yellow-brown, no silt, no rootlets				0.2
0.4										0.4
0.6										0.6
0.8										0.8
1.0		▶							Hole collapse.	1.0
1.2	VE		ASS Sampling at 0.5 m intervals		SP		W	VL-L		1.2
1.4						As above, grey-white mottled yellow-brown, trace clay fines				1.4
1.6										1.6
1.8						As above, increasing to 5-10% clay fines, with some iron cementing				1.8
2.0										2.0
2.2										2.2
2.4	H					FERRICRETE				2.4
2.6						End of test pit at 2.5 m. Target depth. Water inflow at 1.0 m.				2.6

See Explanatory Notes and Method of Soil Description sheets for detials of abbreviations and basis of descriptions

GALT GEOTECHNICS PTY LTD

Galt GEOTECHNICS

REPORT OF TEST PIT — TP08

PROJECT DETAILS	SPATIAL DETAILS	DRILLING DETAILS
Job Number: J1101128	Position: See Plan	Logged: HWC — Logged Date: 05/10/2011
Client: Wave Engineering Pty Ltd	Easting (m): 403256	Checked: RP — Checked Date: 30/10/2011
Project: Residential Development	Northing (m): 6428213	TP Width (m): 2 — TP Length (m):
Location: Lots 37, 98, 9000 Bishop Road Mundijong	Datum: MGA94	Machine: Komatsu WB 97R — Bucket: Toothed
	Surface RL (m):	Contractor: Erskine EM — Operator: James

DEPTH (m)	EXCAVATION RESISTANCE	GROUNDWATER	SAMPLES & FIELD TESTS	GRAPHIC LOG	USCS CLASSIFICATION	MATERIAL DESCRIPTION (Soil type, plasticity or particle characteristics, colour, secondary and minor components)	MOISTURE CONDITION	CONSISTENCY/ DENSITY	ADDITIONAL OBSERVATIONS	DEPTH (m)
0.0	VE		Disturbed Sample SA08-1		SP	SAND (Topsoil): Medium to coarse grained, sub-rounded to sub-angular, dark grey, 20-30% silt fines, abundant rootlets	W	VL-L	Hole collapse.	0.0
0.2						As above, white, no fines, no rootlets				0.2
0.4										0.4
0.6						Pale brown, becoming grey-white and yellow-brown, trace silt fines				0.6
0.8										0.8
1.0										1.0
1.2										1.2
1.4										1.4
1.6										1.6
1.8										1.8
2.0										2.0
2.2										2.2
2.4										2.4
2.6						End of test pit at 2.5 m. Target depth. Groundwater not encountered (due to hole collapse).				2.6

See Explanatory Notes and Method of Soil Description sheets for detials of abbreviations and basis of descriptions

GALT GEOTECHNICS PTY LTD

Galt GEOTECHNICS

REPORT OF TEST PIT **TP09**

PROJECT DETAILS	SPATIAL DETAILS	DRILLING DETAILS
Job Number: J1101128	Position: See Plan	Logged: HWC — Logged Date: 05/10/2011
Client: Wave Engineering Pty Ltd	Easting (m): 403731	Checked: RP — Checked Date: 30/10/2011
Project: Residential Development	Northing (m): 6428853	TP Width (m): 2 — TP Length (m):
Location: Lots 37, 98, 9000 Bishop Road Mundijong	Datum: MGA94	Machine: Komatsu WB 97R — Bucket: Toothed
	Surface RL (m):	Contractor: Erskine EM — Operator: James

DEPTH (m)	EXCAVATION RESISTANCE	GROUNDWATER	SAMPLES & FIELD TESTS	GRAPHIC LOG	USCS CLASSIFICATION	MATERIAL DESCRIPTION (Soil type, plasticity or particle characteristics, colour, secondary and minor components)	MOISTURE CONDITION	CONSISTENCY/ DENSITY	ADDITIONAL OBSERVATIONS	DEPTH (m)
0.0	VE	▶	ASS Sampling at 0.5 m intervals		SM	Silty SAND (Topsoil): Medium to coarse grained, sub-rounded to sub-angular, dark grey, trace silt fines, abundant rootlets	W	VL-L		0.0
0.2					SP	As above, brown, with some low plasticity clay fines, trace ferruginised nodules, no rootlets				0.2
0.4										0.4
0.6										0.6
0.8									Hole collapse.	0.8
1.0						As above, pale brown, no fines, no cementation				1.0
1.2										1.2
1.4					SC	Clayey SAND: Medium to coarse grained, sub-rounded to sub-angular, grey-white mottled yellow-brown, 10-20 low to medium plasticity clay fines, becoming ferruginised from ~1.8 m	M-W			1.4
1.6										1.6
1.8										1.8
2.0										2.0
2.2										2.2
2.4										2.4
2.6						End of test pit at 2.5 m. Target depth. Water inflow at 1.0 m.				2.6

See Explanatory Notes and Method of Soil Description sheets for detials of abbreviations and basis of descriptions

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REPORT OF TEST PIT — TP10

PROJECT DETAILS	SPATIAL DETAILS	DRILLING DETAILS
Job Number: J1101128	Position: See Plan	Logged: HWC — Logged Date: 05/10/2011
Client: Wave Engineering Pty Ltd	Easting (m): 404020	Checked: RP — Checked Date: 30/10/2011
Project: Residential Development	Northing (m): 6428843	TP Width (m): 2 — TP Length (m):
Location: Lots 37, 98, 9000 Bishop Road Mundijong	Datum: MGA94	Machine: Komatsu WB 97R — Bucket: Toothed
	Surface RL (m):	Contractor: Erskine EM — Operator: James

DEPTH (m)	EXCAVATION RESISTANCE	GROUNDWATER	SAMPLES & FIELD TESTS	GRAPHIC LOG	USCS CLASSIFICATION	MATERIAL DESCRIPTION (Soil type, plasticity or particle characteristics, colour, secondary and minor components)	MOISTURE CONDITION	CONSISTENCY/ DENSITY	ADDITIONAL OBSERVATIONS	DEPTH (m)
0.0	VE	▶	ASS Sampling at 0.5 m intervals		SP	SAND (Topsoil): Medium to coarse grained, sub-rounded to sub-angular, dark grey, trace silt fines, abundant rootlets	W	VL-L	Hole collapse.	0.0
0.2						As above, white, no fines, no rootlets				0.2
0.4										0.4
0.6						As above, brown				0.6
0.8										0.8
1.0										1.0
1.2					SC	Clayey SAND: Medium to coarse grained, sub-rounded to sub-angular, olive grey mottled yellow-brown, with ferruginised nodules	M	L		1.2
1.4										1.4
1.6										1.6
1.8						As above, no iron cementing, no yellow-brown mottling	m	MD		1.8
2.0										2.0
2.2										2.2
2.4										2.4
2.6						End of test pit at 2.5 m. Target depth. Water inflow at 1.1 m.				2.6

See Explanatory Notes and Method of Soil Description sheets for detials of abbreviations and basis of descriptions

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REPORT OF TEST PIT — TP11

PROJECT DETAILS	SPATIAL DETAILS	DRILLING DETAILS
Job Number: J1101128	Position: See Plan	Logged: HWC — Logged Date: 05/10/2011
Client: Wave Engineering Pty Ltd	Easting (m): 404194	Checked: RP — Checked Date: 30/10/2011
Project: Residential Development	Northing (m): 6428912	TP Width (m): 2 — TP Length (m):
Location: Lots 37, 98, 9000 Bishop Road Mundijong	Datum: MGA94	Machine: Komatsu WB 97R — Bucket: Toothed
	Surface RL (m):	Contractor: Erskine EM — Operator: James

DEPTH (m)	EXCAVATION RESISTANCE	GROUNDWATER	SAMPLES & FIELD TESTS	GRAPHIC LOG	USCS CLASSIFICATION	MATERIAL DESCRIPTION (Soil type, plasticity or particle characteristics, colour, secondary and minor components)	MOISTURE CONDITION	CONSISTENCY/ DENSITY	ADDITIONAL OBSERVATIONS	DEPTH (m)
0.0	VE	▶			SP	SAND (Topsoil): Medium to coarse grained, sub-rounded to sub-angular, dark grey/black, some silt fines, abundant rootlets	W	VL-L	Pungent odour from topsoil	0.0
0.2						As above, white, no fines, no rootlets				0.2
0.4										0.4
0.6										0.6
0.8										0.8
1.0						As above, pale brown, some ferruginised nodules 5-15 mm				1.0
1.2										1.2
1.4									Estimated depth due to hole collapse	1.4
1.6						As above, olive grey mottled yellow-brown, 5-15% low to medium plasticity fines, becoming ferruginised				1.6
1.8										1.8
2.0										2.0
2.2										2.2
2.4										2.4
2.6										2.6

End of test pit at 2.0 m.
Stopped due to hole collapse.
Water inflow at 0.5 m.

See Explanatory Notes and Method of Soil Description sheets for detials of abbreviations and basis of descriptions

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REPORT OF TEST PIT — TP12

PROJECT DETAILS	SPATIAL DETAILS	DRILLING DETAILS
Job Number: J1101128	Position: See Plan	Logged: HWC — Logged Date: 05/10/2011
Client: Wave Engineering Pty Ltd	Easting (m): 404461	Checked: RP — Checked Date: 30/10/2011
Project: Residential Development	Northing (m): 6428814	TP Width (m): 2 — TP Length (m):
Location: Lots 37, 98, 9000 Bishop Road Mundijong	Datum: MGA94	Machine: Komatsu WB 97R — Bucket: Toothed
	Surface RL (m):	Contractor: Erskine EM — Operator: James

DEPTH (m)	EXCAVATION RESISTANCE	GROUNDWATER	SAMPLES & FIELD TESTS	GRAPHIC LOG	USCS CLASSIFICATION	MATERIAL DESCRIPTION (Soil type, plasticity or particle characteristics, colour, secondary and minor components)	MOISTURE CONDITION	CONSISTENCY/ DENSITY	ADDITIONAL OBSERVATIONS	DEPTH (m)
0.0	VE	▶	ASS Sampling at 0.5 m intervals		SP	SAND (Topsoil): Medium to coarse grained, sub-rounded to sub-angular, dark grey, trace silt fines, abundant rootlets	W	VL-L		0.0
0.2						As above, white, no fines, no rootlets				0.2
0.4										0.4
0.6										0.6
0.8						As above, yellow-brown becoming pale brown at unknown depth				0.8
1.0										1.0
1.2										1.2
1.4										1.4
1.6										1.6
1.8										1.8
2.0										2.0
2.2										2.2
2.4										2.4
2.6										2.6

End of test pit at 2.0 m.
Stopped due to hole collapse.
Water inflow at 1.5 m.

See Explanatory Notes and Method of Soil Description sheets for detials of abbreviations and basis of descriptions

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REPORT OF TEST PIT — TP13

PROJECT DETAILS	SPATIAL DETAILS	DRILLING DETAILS
Job Number: J1101128	Position: See Plan	Logged: HWC — Logged Date: 05/10/2011
Client: Wave Engineering Pty Ltd	Easting (m): 404391	Checked: RP — Checked Date: 30/10/2011
Project: Residential Development	Northing (m): 6428681	TP Width (m): 2 — TP Length (m):
Location: Lots 37, 98, 9000 Bishop Road Mundijong	Datum: MGA94	Machine: Komatsu WB 97R — Bucket: Toothed
	Surface RL (m):	Contractor: Erskine EM — Operator: James

DEPTH (m)	EXCAVATION RESISTANCE	GROUNDWATER	SAMPLES & FIELD TESTS	GRAPHIC LOG	USCS CLASSIFICATION	MATERIAL DESCRIPTION (Soil type, plasticity or particle characteristics, colour, secondary and minor components)	MOISTURE CONDITION	CONSISTENCY/ DENSITY	ADDITIONAL OBSERVATIONS	DEPTH (m)
0.0	VE	▶			SP	SAND (Topsoil): Medium to coarse grained, sub-rounded to sub-angular, dark grey, trace silt fines, abundant rootlets	W	L	Pungent odour	0.0
0.2						As above, grey, no rootlets				0.2
0.4						As above, white, no fines				0.4
0.6									Hole collapse.	0.6
0.8										0.8
1.0										1.0
1.2										1.2
1.4										1.4
1.6	E-M					As above, brown, becoming ferruginised, cementation becoming stronger with depth				1.6
1.8										1.8
2.0										2.0
2.2										2.2
2.4										2.4
2.6										2.6

End of test pit at 2.0 m.
Stopped due to hole collapse.
Water inflow at 0.5 m.

See Explanatory Notes and Method of Soil Description sheets for detials of abbreviations and basis of descriptions

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REPORT OF TEST PIT — TP14

PROJECT DETAILS	SPATIAL DETAILS	DRILLING DETAILS
Job Number: J1101128	Position: See Plan	Logged: HWC — Logged Date: 05/10/2011
Client: Wave Engineering Pty Ltd	Easting (m): 404096	Checked: RP — Checked Date: 30/10/2011
Project: Residential Development	Northing (m): 6428552	TP Width (m): 0.6 — TP Length (m):
Location: Lots 37, 98, 9000 Bishop Road Mundijong	Datum: MGA94	Machine: Komatsu WB 97R — Bucket: Toothed
	Surface RL (m):	Contractor: Erskine EM — Operator: James

DEPTH (m)	EXCAVATION RESISTANCE	GROUNDWATER	SAMPLES & FIELD TESTS	GRAPHIC LOG	USCS CLASSIFICATION	MATERIAL DESCRIPTION (Soil type, plasticity or particle characteristics, colour, secondary and minor components)	MOISTURE CONDITION	CONSISTENCY/ DENSITY	ADDITIONAL OBSERVATIONS	DEPTH (m)
0.0	VE				SP	SAND (Topsoil): Medium to coarse grained, sub-rounded to sub-angular, dark grey, some silt fines, trace rootlets	M	L-MD		0.0
0.2										0.2
0.4			Disturbed Sample SA14-1		SC	Clayey SAND: Medium to coarse grained, sub-rounded to sub-angular, pale brown, 10-15% low plasticity clay fines	W			0.4
0.6										0.6
0.8						As above, olive grey mottled dark brown, 15-30% medium plasticity fines, with infrequent intervals in clay content				0.8
1.0			Disturbed Sample SA14-2							1.0
1.2										1.2
1.4		▶								1.4
1.6			In Situ Sample SA14-3		SP	SAND: Medium to coarse grained, sub-rounded to sub-angular, grey-white and yellow-brown with some localised sections olive grey, with low to medium plasticity fines 10-15%				1.6
1.8										1.8
2.0										2.0
2.2										2.2
2.4										2.4
2.6										2.6

End of test pit at 2.2 m.
Refusal on Ferricrete.
Water inflow at 1.5 m.

See Explanatory Notes and Method of Soil Description sheets for detials of abbreviations and basis of descriptions

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REPORT OF TEST PIT — TP15

PROJECT DETAILS	SPATIAL DETAILS	DRILLING DETAILS
Job Number: J1101128	Position: See Plan	Logged: HWC — Logged Date: 05/10/2011
Client: Wave Engineering Pty Ltd	Easting (m): 404296	Checked: RP — Checked Date: 30/10/2011
Project: Residential Development	Northing (m): 6428564	TP Width (m): 0.6 — TP Length (m):
Location: Lots 37, 98, 9000 Bishop Road Mundijong	Datum: MGA94	Machine: Komatsu WB 97R — Bucket: Toothed
	Surface RL (m):	Contractor: Erskine EM — Operator: James

DEPTH (m)	EXCAVATION RESISTANCE	GROUNDWATER	SAMPLES & FIELD TESTS	GRAPHIC LOG	USCS CLASSIFICATION	MATERIAL DESCRIPTION (Soil type, plasticity or particle characteristics, colour, secondary and minor components)	MOISTURE CONDITION	CONSISTENCY/ DENSITY	ADDITIONAL OBSERVATIONS	DEPTH (m)
0.0	VE	▶			SP	SAND (Topsoil): Medium to coarse grained, sub-rounded to sub-angular, dark grey, trace silt fines, abundant rootlets	W	L-MD		0.0
0.2						As above, brown, with trace 5-15 mm ferruginised nodules				0.2
0.4										0.4
0.6										0.6
0.8										0.8
1.0	H					As above, becoming well cemented				1.0
1.2										1.2
1.4										1.4
1.6										1.6
1.8										1.8
2.0										2.0
2.2										2.2
2.4										2.4
2.6										2.6

End of test pit at 1.0 m.
Refusal on Ferricrete.
Water inflow at 1.0 m.

See Explanatory Notes and Method of Soil Description sheets for detials of abbreviations and basis of descriptions

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REPORT OF TEST PIT — TP16

PROJECT DETAILS

Job Number: J1101128
Client: Wave Engineering Pty Ltd
Project: Residential Development
Location: Lots 37, 98, 9000 Bishop Road Mundijong

SPATIAL DETAILS

Position: See Plan
Easting (m): 404217
Northing (m): 6428462
Datum: MGA94
Surface RL (m):

DRILLING DETAILS

Logged: HWC — Logged Date: 05/10/2011
Checked: RP — Checked Date: 30/10/2011
TP Width (m): 0.6 — TP Length (m):
Machine: Komatsu WB 97R — Bucket: Toothed
Contractor: Erskine EM — Operator: James

DEPTH (m)	EXCAVATION RESISTANCE	GROUNDWATER	SAMPLES & FIELD TESTS	GRAPHIC LOG	USCS CLASSIFICATION	MATERIAL DESCRIPTION (Soil type, plasticity or particle characteristics, colour, secondary and minor components)	MOISTURE CONDITION	CONSISTENCY/ DENSITY	ADDITIONAL OBSERVATIONS	DEPTH (m)
0.0	VE	▶	Disturbed Sample SA16-1		SP	SAND (Topsoil): Medium to coarse grained, sub-rounded to sub-angular, dark grey, trace silt fines, abundant rootlets	W	L		0.0
0.2						As above, brown, ~10% low plasticity clay fines				0.2
0.4					SC	Clayey SAND: Medium to coarse grained, sub-rounded to sub-angular, pale brown, ~20% low plasticity clay fines				0.4
0.6					CI	Sandy CLAY: Medium plasticity fines, olive grey, 20-30% sand		St		0.6
0.8										0.8
1.0										1.0
1.2										1.2
1.4					SP/SC	SAND/Clayey SAND: Medium to coarse grained, sub-rounded to sub-angular, olive grey mottled yellow-brown, 5-15% low to medium plasticity clay fines		MD		1.4
1.6										1.6
1.8										1.8
2.0						End of test pit at 2.0 m. Refusal on Ferricrete. Water inflow at 1.5 m.				2.0
2.2										2.2
2.4										2.4
2.6										2.6

See Explanatory Notes and Method of Soil Description sheets for detials of abbreviations and basis of descriptions

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REPORT OF TEST PIT — TP17

PROJECT DETAILS	SPATIAL DETAILS	DRILLING DETAILS
Job Number: J1101128	Position: See Plan	Logged: HWC — Logged Date: 05/10/2011
Client: Wave Engineering Pty Ltd	Easting (m): 404433	Checked: RP — Checked Date: 30/10/2011
Project: Residential Development	Northing (m): 6428515	TP Width (m): 2 — TP Length (m):
Location: Lots 37, 98, 9000 Bishop Road Mundijong	Datum: MGA94	Machine: Komatsu WB 97R — Bucket: Toothed
	Surface RL (m):	Contractor: Erskine EM — Operator: James

DEPTH (m)	EXCAVATION RESISTANCE	GROUNDWATER	SAMPLES & FIELD TESTS	GRAPHIC LOG	USCS CLASSIFICATION	MATERIAL DESCRIPTION (Soil type, plasticity or particle characteristics, colour, secondary and minor components)	MOISTURE CONDITION	CONSISTENCY/ DENSITY	ADDITIONAL OBSERVATIONS	DEPTH (m)
0.0	VE	▶	ASS Sampling at 0.5 m intervals		SP	SAND (Topsoil): Medium to coarse grained, sub-rounded to sub-angular, grey, trace silt fines, abundant rootlets	W	L		0.0
0.2						As above, white, no fines, no rootlets		L-MD		0.2
0.4										0.4
0.6										0.6
0.8										0.8
1.0										1.0
1.2										1.2
1.4										1.4
1.6										1.6
1.8										1.8
2.0			Bulk Sample SA17-1							2.0
2.2										2.2
2.4										2.4
2.6										2.6

End of test pit at 2.0 m.
Stopped due to hole collapse.
Water inflow at 2.0 m.

See Explanatory Notes and Method of Soil Description sheets for detials of abbreviations and basis of descriptions

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REPORT OF TEST PIT — TP18

PROJECT DETAILS	SPATIAL DETAILS	DRILLING DETAILS
Job Number: J1101128	Position: See Plan	Logged: HWC — Logged Date: 05/10/2011
Client: Wave Engineering Pty Ltd	Easting (m): 404087	Checked: RP — Checked Date: 30/10/2011
Project: Residential Development	Northing (m): 6428713	TP Width (m): 0.6 — TP Length (m):
Location: Lots 37, 98, 9000 Bishop Road Mundijong	Datum: MGA94	Machine: Komatsu WB 97R — Bucket: Toothed
	Surface RL (m):	Contractor: Erskine EM — Operator: James

DEPTH (m)	EXCAVATION RESISTANCE	GROUNDWATER	SAMPLES & FIELD TESTS	GRAPHIC LOG	USCS CLASSIFICATION	MATERIAL DESCRIPTION (Soil type, plasticity or particle characteristics, colour, secondary and minor components)	MOISTURE CONDITION	CONSISTENCY/ DENSITY	ADDITIONAL OBSERVATIONS	DEPTH (m)
0.0	VE	▶				SAND (Topsoil): Medium to coarse grained, sub-rounded to sub-angular, dark grey, trace silt fines, abundant rootlets	W	L-MD		0.0
0.2						As above, brown, some silt fines, no rootlets				0.2
0.4										0.4
0.6										0.6
0.8					SP	As above, pale brown, no fines				0.8
1.0										1.0
1.2										1.2
1.4										1.4
1.6	E				GP	Sandy GRAVEL: Ferricrete gravel in a matrix (20-30%) of Clayey SAND, ~20% low to medium plasticity fines, olive grey mottled yellow-brown				1.6
1.8										1.8
2.0										2.0
2.2					SC	Clayey SAND: Medium to coarse grained, sub-rounded to sub-angular, pale olive grey, ~15% medium plasticity fines				2.2
2.4										2.4
2.6						End of test pit at 2.6 m. Target depth. Water inflow at 0.7 m.				2.6

See Explanatory Notes and Method of Soil Description sheets for detials of abbreviations and basis of descriptions

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REPORT OF TEST PIT — TP19

PROJECT DETAILS

Job Number: J1101128
Client: Wave Engineering Pty Ltd
Project: Residential Development
Location: Lots 37, 98, 9000 Bishop Road Mundijong

SPATIAL DETAILS

Position: See Plan
Easting (m): 403911
Northing (m): 6428745
Datum: MGA94
Surface RL (m):

DRILLING DETAILS

Logged: HWC — Logged Date: 05/10/2011
Checked: RP — Checked Date: 30/10/2011
TP Width (m): 2 — TP Length (m):
Machine: Komatsu WB 97R — Bucket: Toothed
Contractor: Erskine EM — Operator: James

DEPTH (m)	EXCAVATION RESISTANCE	GROUNDWATER	SAMPLES & FIELD TESTS	GRAPHIC LOG	USCS CLASSIFICATION	MATERIAL DESCRIPTION (Soil type, plasticity or particle characteristics, colour, secondary and minor components)	MOISTURE CONDITION	CONSISTENCY/ DENSITY	ADDITIONAL OBSERVATIONS	DEPTH (m)
0.0	VE	▶			SP	SAND (Topsoil): Medium to coarse grained, sub-rounded to sub-angular, dark grey, trace silt fines, abundant rootlets	W	L-MD		0.0
0.2						As above, pale brown, no fines, no rootlets				0.2
0.4										0.4
0.6						As above, brown, some low to medium plasticity clay fines			Hole collapse.	0.6
0.8										0.8
1.0						As above, pale brown, with lower fines content in places				1.0
1.2										1.2
1.4										1.4
1.6										1.6
1.8						As above, pale olive grey mottled yellow-brown, trace clay fines				1.8
2.0										2.0
2.2										2.2
2.4										2.4
2.6										2.6

End of test pit at 2.0 m.
Stopped due to excavator problems.
Water inflow at 0.6 m.

See Explanatory Notes and Method of Soil Description sheets for detials of abbreviations and basis of descriptions

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REPORT OF TEST PIT — TP20

PROJECT DETAILS	SPATIAL DETAILS	DRILLING DETAILS
Job Number: J1101128	Position: See Plan	Logged: HWC — Logged Date: 05/10/2011
Client: Wave Engineering Pty Ltd	Easting (m): 403131	Checked: RP — Checked Date: 30/10/2011
Project: Residential Development	Northing (m): 6428625	TP Width (m): 2 — TP Length (m):
Location: Lots 37, 98, 9000 Bishop Road Mundijong	Datum: MGA94	Machine: Komatsu WB 97R — Bucket: Toothed
	Surface RL (m):	Contractor: Erskine EM — Operator: James

DEPTH (m)	EXCAVATION RESISTANCE	GROUNDWATER	SAMPLES & FIELD TESTS	GRAPHIC LOG	USCS CLASSIFICATION	MATERIAL DESCRIPTION (Soil type, plasticity or particle characteristics, colour, secondary and minor components)	MOISTURE CONDITION	CONSISTENCY/ DENSITY	ADDITIONAL OBSERVATIONS	DEPTH (m)
0.0	VE	▶	ASS Sampling at 0.5 m intervals		SM	Silty SAND (Topsoil): Medium to coarse grained, sub-rounded to sub-angular, dark grey, ~20% silt fines, abundant rootlets	W	L		0.0
0.2					SC/SP	Clayey SAND: Medium to coarse grained, sub-rounded to sub-angular, brown, ~20% low to medium plasticity fines		L-MD		0.2
0.4									Hole collapse.	0.4
0.6										0.6
0.8										0.8
1.0										1.0
1.2					SP	SAND: Medium to coarse grained, sub-rounded to sub-angular, yellow-brown and grey-white, some clay fines				1.2
1.4										1.4
1.6						FERRICRETE				1.6
1.8										1.8
2.0										2.0
2.2										2.2
2.4										2.4
2.6										2.6

End of test pit at 1.6 m.
Refusal on Ferricrete.
Water inflow at 1.0 m.

See Explanatory Notes and Method of Soil Description sheets for detials of abbreviations and basis of descriptions

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REPORT OF TEST PIT — TP21

PROJECT DETAILS	SPATIAL DETAILS	DRILLING DETAILS
Job Number: J1101128	Position: See Plan	Logged: HWC — Logged Date: 05/10/2011
Client: Wave Engineering Pty Ltd	Easting (m): 403135	Checked: RP — Checked Date: 30/10/2011
Project: Residential Development	Northing (m): 6428828	TP Width (m): 2 — TP Length (m):
Location: Lots 37, 98, 9000 Bishop Road Mundijong	Datum: MGA94	Machine: Komatsu WB 97R — Bucket: Toothed
	Surface RL (m):	Contractor: Erskine EM — Operator: James

DEPTH (m)	EXCAVATION RESISTANCE	GROUNDWATER	SAMPLES & FIELD TESTS	GRAPHIC LOG	USCS CLASSIFICATION	MATERIAL DESCRIPTION (Soil type, plasticity or particle characteristics, colour, secondary and minor components)	MOISTURE CONDITION	CONSISTENCY/ DENSITY	ADDITIONAL OBSERVATIONS	DEPTH (m)
0.0	VE	▶	Disturbed Sample SA21-1		SP	SAND (Topsoil): Medium to coarse grained, sub-rounded to sub-angular, dark grey, trace silt fines, abundant rootlets	W	L	Hole collapse.	0.0
0.2						As above, yellow-brown, no rootlets, trace low plasticity clay fines				0.2
0.4										0.4
0.6										0.6
0.8						As above, grey-white				0.8
1.0										1.0
1.2										1.2
1.4										1.4
1.6										1.6
1.8										1.8
2.0										2.0
2.2										2.2
2.4										2.4
2.6										2.6

End of test pit at 1.0 m.
Refusal on Ferricrete.
Water inflow at 0.8 m.

See Explanatory Notes and Method of Soil Description sheets for detials of abbreviations and basis of descriptions

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REPORT OF TEST PIT — TP22

PROJECT DETAILS	SPATIAL DETAILS	DRILLING DETAILS
Job Number: J1101128	Position: See Plan	Logged: HWC — Logged Date: 05/10/2011
Client: Wave Engineering Pty Ltd	Easting (m): 403182	Checked: RP — Checked Date: 30/10/2011
Project: Residential Development	Northing (m): 6424117	TP Width (m): 0.6 — TP Length (m):
Location: Lots 37, 98, 9000 Bishop Road Mundijong	Datum: MGA94	Machine: Komatsu WB 97R — Bucket: Toothed
	Surface RL (m):	Contractor: Erskine EM — Operator: James

DEPTH (m)	EXCAVATION RESISTANCE	GROUNDWATER	SAMPLES & FIELD TESTS	GRAPHIC LOG	USCS CLASSIFICATION	MATERIAL DESCRIPTION (Soil type, plasticity or particle characteristics, colour, secondary and minor components)	MOISTURE CONDITION	CONSISTENCY/ DENSITY	ADDITIONAL OBSERVATIONS	DEPTH (m)
0.0	VE				SP	SAND (Topsoil): Medium to coarse grained, sub-rounded to sub-angular, dark grey, trace silt fines, abundant rootlets	W	L-MD		0.0
0.2						As above, white, no fines, no rootlets				0.2
0.4										0.4
0.6						As above, pale brown				0.6
0.8										0.8
1.0										1.0
1.2										1.2
1.4					GP	GRAVEL: Ferricrete gravel with 10% Clayey SAND, grey, 20% low to medium plasticity fines				1.4
1.6										1.6
1.8										1.8
2.0										2.0
2.2										2.2
2.4										2.4
2.6										2.6

End of test pit at 1.4 m.
Refusal on Ferricrete.
Groundwater not encountered.

See Explanatory Notes and Method of Soil Description sheets for detials of abbreviations and basis of descriptions

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REPORT OF TEST PIT **TP23**

PROJECT DETAILS	SPATIAL DETAILS	DRILLING DETAILS
Job Number: J1101128	Position: See Plan	Logged: HWC — Logged Date: 05/10/2011
Client: Wave Engineering Pty Ltd	Easting (m): 403375	Checked: RP — Checked Date: 30/10/2011
Project: Residential Development	Northing (m): 6428151	TP Width (m): 2 — TP Length (m):
Location: Lots 37, 98, 9000 Bishop Road Mundijong	Datum: MGA94	Machine: Komatsu WB 97R — Bucket: Toothed
	Surface RL (m):	Contractor: Erskine EM — Operator: James

DEPTH (m)	EXCAVATION RESISTANCE	GROUNDWATER	SAMPLES & FIELD TESTS	GRAPHIC LOG	USCS CLASSIFICATION	MATERIAL DESCRIPTION (Soil type, plasticity or particle characteristics, colour, secondary and minor components)	MOISTURE CONDITION	CONSISTENCY/ DENSITY	ADDITIONAL OBSERVATIONS	DEPTH (m)
0.0	VE	▶	ASS Sampling at 0.5 m intervals		SP	SAND (Topsoil): Medium to coarse grained, sub-rounded to sub-angular, dark grey, trace silt fines, abundant rootlets			Some 5 mm roots	0.0
0.2						As above, brown, no rootlets				0.2
0.4						As above, becoming variably grey-white mottled yellow-brown and pale brown with trace low plasticity clay fines				0.4
0.6										0.6
0.8										0.8
1.0										1.0
1.2										1.2
1.4										1.4
1.6										1.6
1.8										1.8
2.0										2.0
2.2										2.2
2.4										2.4
2.6										2.6

End of test pit at 2.0 m.
Stopped due to hole collapse.
Water inflow at 1.9 m.

See Explanatory Notes and Method of Soil Description sheets for detials of abbreviations and basis of descriptions

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REPORT OF TEST PIT — TP24

PROJECT DETAILS	SPATIAL DETAILS	DRILLING DETAILS
Job Number: J1101128	Position: See Plan	Logged: HWC — Logged Date: 05/10/2011
Client: Wave Engineering Pty Ltd	Easting (m): 403593	Checked: RP — Checked Date: 30/10/2011
Project: Residential Development	Northing (m): 6428662	TP Width (m): 0.6 — TP Length (m):
Location: Lots 37, 98, 9000 Bishop Road Mundijong	Datum: MGA94	Machine: Komatsu WB 97R — Bucket: Toothed
	Surface RL (m):	Contractor: Erskine EM — Operator: James

DEPTH (m)	EXCAVATION RESISTANCE	GROUNDWATER	SAMPLES & FIELD TESTS	GRAPHIC LOG	USCS CLASSIFICATION	MATERIAL DESCRIPTION (Soil type, plasticity or particle characteristics, colour, secondary and minor components)	MOISTURE CONDITION	CONSISTENCY/ DENSITY	ADDITIONAL OBSERVATIONS	DEPTH (m)
0.0	VE	▶	ASS Sampling at 0.5 m intervals		SM	Silty SAND: Medium to coarse grained, sub-rounded to sub-angular, dark grey, ~20% silt fines, abundant rootlets	M-W	L-MD		0.0
0.2					SP	SAND: Medium to coarse grained, pale brown, variable clay content (up to 15% low plasticity fines)				0.2
0.4										0.4
0.6									Hole collapse.	0.6
0.8										0.8
1.0			Disturbed Sample SA24-1		SC	Clayey SAND: Medium to coarse grained, pale olive grey mottled yellow brown, 40-50% low to medium plasticity fines				1.0
1.2										1.2
1.4					SC/SP	SAND: Medium to coarse grained, sub-rounded to sub-angular, grey-white mottled yellow-brown, 10% low plasticity fines				1.4
1.6										1.6
1.8										1.8
2.0										2.0
2.2										2.2
2.4										2.4
2.6						End of test pit at 2.0 m. Refusal on Ferricrete. Water inflow at 1.0 m.				2.6

See Explanatory Notes and Method of Soil Description sheets for detials of abbreviations and basis of descriptions

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REPORT OF TEST PIT **TP25**

PROJECT DETAILS	SPATIAL DETAILS	DRILLING DETAILS
Job Number: J1101128	Position: See Plan	Logged: HWC — Logged Date: 05/10/2011
Client: Wave Engineering Pty Ltd	Easting (m): 403470	Checked: RP — Checked Date: 30/10/2011
Project: Residential Development	Northing (m): 6428662	TP Width (m): 2 — TP Length (m):
Location: Lots 37, 98, 9000 Bishop Road Mundijong	Datum: MGA94	Machine: Komatsu WB 97R — Bucket: Toothed
	Surface RL (m):	Contractor: Erskine EM — Operator: James

DEPTH (m)	EXCAVATION RESISTANCE	GROUNDWATER	SAMPLES & FIELD TESTS	GRAPHIC LOG	USCS CLASSIFICATION	MATERIAL DESCRIPTION (Soil type, plasticity or particle characteristics, colour, secondary and minor components)	MOISTURE CONDITION	CONSISTENCY/ DENSITY	ADDITIONAL OBSERVATIONS	DEPTH (m)
0.0	VE	▶	ASS Sampling at 0.5 m intervals		SP	SAND: Medium to coarse grained, sub-rounded to sub-angular, dark grey, abundant rootlets	W	VL-L		0.0
0.2						As above, yellow-brown, no rootlets, trace low plasticity clay fines				0.2
0.4						Becoming olive grey mottled yellow-brown, with some ferruginous nodules				0.4
0.6										0.6
0.8										0.8
1.0										1.0
1.2										1.2
1.4										1.4
1.6										1.6
1.8										1.8
2.0										2.0
2.2										2.2
2.4										2.4
2.6										2.6

End of test pit at 2.30 m.
Stopped due to hole collapse.
Water inflow at 0.5 m.

See Explanatory Notes and Method of Soil Description sheets for detials of abbreviations and basis of descriptions

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APPENDIX C

PB Test Pit Reports

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2/39 Flynn St, WEMBLEY WA 6014

ABN: 73 292 586 155

TEST PIT ENGINEERING LOG

TEST PIT NO.

TP01

SHEET 1 OF 1

Client:	Peet Limited	Date Commenced:	14/08/06
Project:	Lot 37 Bishop Rd, Lots 98, 182, 522 Taylor Road & Lot 212 Soldiers Rd	Date Completed:	14/08/06
Test Pit Location:	Mundijong	Recorded By:	FK
Project Number:	2140323A	Log Checked By:	JJ

Excavation Method: Backhoe

Surface RL:

Co-ords: E 402772 N 6428674

Test Pit Information				Field Material Description						
1	2	3	4	5	6	7	8	9	10	11
WATER	RL(m) mAHD / DEPTH(m)	FIELD TEST	SAMPLE	GRAPHIC LOG	USC SYMBOL	SOIL/ROCK MATERIAL FIELD DESCRIPTION	MOISTURE	RELATIVE DENSITY /CONSISTENCY (VS S F ST VST H; FB VL L MD D VD)	HAND PENETROMETER (kPa)	STRUCTURE AND ADDITIONAL OBSERVATIONS
▼			ASS			TOPSOIL, Clayey SAND, fine to medium grained, dark brown, with fines of low plasticity and estimated to have greater than 2% organic fines content by mass	W			
						Ferricrete, cemented laterite gravel				Refusal on ferricrete
	1					END OF TEST PIT AT 0.15 m				
	2									
	3									

This test pit log should be read in conjunction with Parsons Brinckerhoff's accompanying standard notes.

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TEST PIT ENGINEERING LOG

TEST PIT NO.

TP02

SHEET 1 OF 1

Client:	Peet Limited	Date Commenced:	14/08/06
Project:	Lot 37 Bishop Rd, Lots 98, 182, 522 Taylor Road & Lot 212 Soldiers Rd	Date Completed:	14/08/06
Test Pit Location:	Mundijong	Recorded By:	FK
Project Number:	2140323A	Log Checked By:	JJ
Excavation Method:	Backhoe	Surface RL:	
		Co-ords:	E 402943 N 6428671

Test Pit Information				Field Material Description						
1	2	3	4	5	6	7	8	9	10	11
WATER	RL(m) mAHD / DEPTH(m)	FIELD TEST	SAMPLE	GRAPHIC LOG	USC SYMBOL	SOIL/ROCK MATERIAL FIELD DESCRIPTION	MOISTURE	RELATIVE DENSITY /CONSISTENCY (VS FB, S VL, F L, MD ST, D VST, VD H)	HAND PENETROMETER (kPa)	STRUCTURE AND ADDITIONAL OBSERVATIONS
	0.10		ASS		SM	TOPSOIL, Silty SAND, fine to medium grained, dark brown, estimated to have greater than 2% organic fines content by mass	M			
			ASS			Silty SAND, fine to medium grained, light brown, non plastic fines				
						Ferricrete, cemented laterite gravel				Refusal on ferricrete
	1					END OF TEST PIT AT 0.90 m				
	2									
	3									

This test pit log should be read in conjunction with Parsons Brinckerhoff's accompanying standard notes.

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TEST PIT ENGINEERING LOG

TEST PIT NO.

TP04

SHEET 1 OF 1

Client:	Peet Limited	Date Commenced:	14/08/06
Project:	Lot 37 Bishop Rd, Lots 98, 182, 522 Taylor Road & Lot 212 Soldiers Rd	Date Completed:	14/08/06
Test Pit Location:	Mundijong	Recorded By:	FK
Project Number:	2140323A	Log Checked By:	JJ

Excavation Method: Backhoe

Surface RL:

Co-ords: E 402698 N 6428998

Test Pit Information						Field Material Description				
1	2	3	4	5	6	7	8	9	10	11
WATER	RL(m) mAHD / DEPTH(m)	FIELD TEST	SAMPLE	GRAPHIC LOG	USC SYMBOL	SOIL/ROCK MATERIAL FIELD DESCRIPTION	MOISTURE	RELATIVE DENSITY /CONSISTENCY (VS S, F, FB VL, L, MD ST, VST D, VD H)	HAND PENETROMETER (kPa)	STRUCTURE AND ADDITIONAL OBSERVATIONS
	0.10		ASS		SP	TOPSOIL, SAND, fine to medium grained, dark brown, estimated to have greater than 2% organic fines content by mass	M			
						SAND, fine to medium grained, white to light grey with patches of orange iron staining				
			ASS							
	1		ASS				W			
▼						Ferricrete boulders throughout				
						Ferricrete, cemented laterite gravel				Refusal on ferricrete
						END OF TEST PIT AT 1.50 m				
	2									
	3									

This test pit log should be read in conjunction with Parsons Brinckerhoff's accompanying standard notes.

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TEST PIT ENGINEERING LOG

TEST PIT NO.

TP05

SHEET 1 OF 1

Client:	Peet Limited	Date Commenced:	14/08/06
Project:	Lot 37 Bishop Rd, Lots 98, 182, 522 Taylor Road & Lot 212 Soldiers Rd	Date Completed:	14/08/06
Test Pit Location:	Mundijong	Recorded By:	FK
Project Number:	2140323A	Log Checked By:	JJ

Excavation Method: Backhoe

Surface RL:

Co-ords: E 403046 N 6428829

Test Pit Information				Field Material Description						
1	2	3	4	5	6	7	8	9	10	11
WATER	RL(m) mAHD / DEPTH(m)	FIELD TEST	SAMPLE	GRAPHIC LOG	USC SYMBOL	SOIL/ROCK MATERIAL FIELD DESCRIPTION	MOISTURE	RELATIVE DENSITY /CONSISTENCY (VS S F ST VST H / FB VL L MD D VD)	HAND PENETROMETER (kPa)	STRUCTURE AND ADDITIONAL OBSERVATIONS
	0.10		ASS		SP	TOPSOIL, SAND, fine to medium grained, dark brown, estimated to have greater than 2% organic fines content by mass SAND, fine to medium grained, brown	M			
▼			ASS			Ferricrete, cemented laterite gravel END OF TEST PIT AT 0.50 m				Refusal on ferricrete

1

2

3

This test pit log should be read in conjunction with Parsons Brinckerhoff's accompanying standard notes.

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TEST PIT ENGINEERING LOG

TEST PIT NO.

TP06

SHEET 1 OF 1

Client:	Peet Limited	Date Commenced:	14/08/06
Project:	Lot 37 Bishop Rd, Lots 98, 182, 522 Taylor Road & Lot 212 Soldiers Rd	Date Completed:	14/08/06
Test Pit Location:	Mundijong	Recorded By:	FK
Project Number:	2140323A	Log Checked By:	JJ
Excavation Method:	Backhoe	Surface RL:	
		Co-ords:	E 403173 N 6428896

Test Pit Information				Field Material Description						
1	2	3	4	5	6	7	8	9	10	11
WATER	RL(m) mAHD / DEPTH(m)	FIELD TEST	SAMPLE	GRAPHIC LOG	USC SYMBOL	SOIL/ROCK MATERIAL FIELD DESCRIPTION	MOISTURE	RELATIVE DENSITY /CONSISTENCY (VS FB, S VL, F L, ST MD, VST D, H VD)	HAND PENETROMETER (kPa)	STRUCTURE AND ADDITIONAL OBSERVATIONS
	0.15		ASS			TOPSOIL, SAND, fine to medium grained, dark brown, estimated to have greater than 2% organic fines content by mass	M			
					SP	SAND, fine to medium grained, light grey				
			ASS							
	1									
▼	2					Orange iron staining				
						Ferricrete, cemented laterite gravel				Refusal on ferricrete
						END OF TEST PIT AT 2.00 m				
	3									

This test pit log should be read in conjunction with Parsons Brinckerhoff's accompanying standard notes.

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TEST PIT ENGINEERING LOG

TEST PIT NO.

TP07

SHEET 1 OF 1

Client:	Peet Limited	Date Commenced:	14/08/06
Project:	Lot 37 Bishop Rd, Lots 98, 182, 522 Taylor Road & Lot 212 Soldiers Rd	Date Completed:	14/08/06
Test Pit Location:	Mundijong	Recorded By:	FK
Project Number:	2140323A	Log Checked By:	JJ

Excavation Method: Backhoe

Surface RL:

Co-ords: E 403156 N 6428985

Test Pit Information				Field Material Description						
1	2	3	4	5	6	7	8	9	10	11
WATER	RL(m) mAHD / DEPTH(m)	FIELD TEST	SAMPLE	GRAPHIC LOG	USC SYMBOL	SOIL/ROCK MATERIAL FIELD DESCRIPTION	MOISTURE	RELATIVE DENSITY /CONSISTENCY (VS FB, S VL, F L, ST MD, VST D, H VD)	HAND PENETROMETER (kPa)	STRUCTURE AND ADDITIONAL OBSERVATIONS
	0.10		ASS			TOPSOIL, SAND, fine to medium grained, dark brown, estimated to have greater than 2% organic fines content by mass	M			
					SP	SAND, fine to medium grained, light brown with minor fine to medium sized gravel throughout				
			ASS							
	0.63				SC	Clayey SAND, fine to medium grained, light grey mottled orange/brown with fines of low plasticity				
▼			D							
	1		ASS			Ferricrete, cemented laterite gravel				Refusal on ferricrete
						END OF TEST PIT AT 1.00 m				
	2									
	3									

This test pit log should be read in conjunction with Parsons Brinckerhoff's accompanying standard notes.

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TEST PIT ENGINEERING LOG

TEST PIT NO.

TP08

SHEET 1 OF 1

Client:	Peet Limited	Date Commenced:	14/08/06
Project:	Lot 37 Bishop Rd, Lots 98, 182, 522 Taylor Road & Lot 212 Soldiers Rd	Date Completed:	14/08/06
Test Pit Location:	Mundijong	Recorded By:	FK
Project Number:	2140323A	Log Checked By:	JJ

Excavation Method: Backhoe

Surface RL:

Co-ords: E 403146 N 6428705

Test Pit Information						Field Material Description				
1	2	3	4	5	6	7	8	9	10	11
WATER	RL(m) mAHD / DEPTH(m)	FIELD TEST	SAMPLE	GRAPHIC LOG	USC SYMBOL	SOIL/ROCK MATERIAL FIELD DESCRIPTION	MOISTURE	RELATIVE DENSITY /CONSISTENCY (VS, S, F, FB, VL, L, MD, ST, VST, D, VD, H)	HAND PENETROMETER (kPa)	STRUCTURE AND ADDITIONAL OBSERVATIONS
	0.10		D		SC	TOPSOIL, SAND, fine to medium grained, dark brown, estimated to have greater than 2% organic fines content by mass Clayey SAND, fine to medium grained, brown, with fines of low plasticity	M			
	1									
	1.20		D		SC	Clayey SAND, finw to medium grained, light grey mottled orange, with fines of low plasticity				
▼						Ferricrete, cemented laterite gravel END OF TEST PIT AT 1.80 m				Refusal on ferricrete
	2									
	3									

This test pit log should be read in conjunction with Parsons Brinckerhoff's accompanying standard notes.

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TEST PIT ENGINEERING LOG

TEST PIT NO.

TP09

SHEET 1 OF 1

Client:	Peet Limited	Date Commenced:	14/08/06
Project:	Lot 37 Bishop Rd, Lots 98, 182, 522 Taylor Road & Lot 212 Soldiers Rd	Date Completed:	14/08/06
Test Pit Location:	Mundijong	Recorded By:	FK
Project Number:	2140323A	Log Checked By:	JJ

Excavation Method: Backhoe

Surface RL:

Co-ords: E 403286 N 6428633

Test Pit Information				Field Material Description						
1	2	3	4	5	6	7	8	9	10	11
WATER	RL(m) mAHD / DEPTH(m)	FIELD TEST	SAMPLE	GRAPHIC LOG	USC SYMBOL	SOIL/ROCK MATERIAL FIELD DESCRIPTION	MOISTURE	RELATIVE DENSITY /CONSISTENCY (VS, S/F, ST, VST, H; FB, VL, L, MD, D, VD)	HAND PENETROMETER (kPa)	STRUCTURE AND ADDITIONAL OBSERVATIONS
	0.10					TOPSOIL, SAND, fine to medium grained, dark brown, estimated to have greater than 2% organic fines content by mass	M			
					SP	SAND, fine to medium grained, brown/orange				
	0.50				SC	Clayey SAND, fine to medium grained, dark grey mottled orange, with fines of medium plasticity. Minor fine sized gravel throughout.				
			D							
			U75							
	1									
▼						Ferricrete, cemented laterite gravel				Refusal on ferricrete
						END OF TEST PIT AT 1.80 m				
	2									
	3									

This test pit log should be read in conjunction with Parsons Brinckerhoff's accompanying standard notes.

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TEST PIT ENGINEERING LOG

TEST PIT NO.

TP10

SHEET 1 OF 1

Client:	**Peet Limited**	Date Commenced:	**14/08/06**
Project:	**Lot 37 Bishop Rd, Lots 98, 182, 522 Taylor Road & Lot 212 Soldiers Rd**	Date Completed:	**14/08/06**
Test Pit Location:	**Mundijong**	Recorded By:	**FK**
Project Number:	**2140323A**	Log Checked By:	**JJ**

Excavation Method: **Backhoe**

Surface RL:

Co-ords: **E 403061 N 6428482**

Test Pit Information				Field Material Description						
1	2	3	4	5	6	7	8	9	10	11
WATER	RL(m) mAHD / DEPTH(m)	FIELD TEST	SAMPLE	GRAPHIC LOG	USC SYMBOL	SOIL/ROCK MATERIAL FIELD DESCRIPTION	MOISTURE	RELATIVE DENSITY / CONSISTENCY (VS S F ST VST H; FB VL L MD D VD)	HAND PENETROMETER (kPa)	STRUCTURE AND ADDITIONAL OBSERVATIONS
	0.10				SP	TOPSOIL, SAND, fine to medium grained, dark brown, estimated to have greater than 2% organic fines content by mass SAND, fine to medium grained, brown	M			
						Ferricrete, cemented laterite gravel. Some of the ferricrete has weathered to clayey sand, fine to medium grained, grey mottled orange with fines of low plasticity. END OF TEST PIT AT 0.50 m				Refusal on ferricrete

1

2

3

This test pit log should be read in conjunction with Parsons Brinckerhoff's accompanying standard notes.

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TEST PIT ENGINEERING LOG

TEST PIT NO.

TP11

SHEET 1 OF 1

Client:	Peet Limited	Date Commenced:	14/08/06
Project:	Lot 37 Bishop Rd, Lots 98, 182, 522 Taylor Road & Lot 212 Soldiers Rd	Date Completed:	14/08/06
Test Pit Location:	Mundijong	Recorded By:	FK
Project Number:	2140323A	Log Checked By:	JJ

Excavation Method: Backhoe

Surface RL:

Co-ords: E 403075 N 6428232

Test Pit Information				Field Material Description						
1	2	3	4	5	6	7	8	9	10	11
WATER	RL(m) mAHD / DEPTH(m)	FIELD TEST	SAMPLE	GRAPHIC LOG	USC SYMBOL	SOIL/ROCK MATERIAL FIELD DESCRIPTION	MOISTURE	RELATIVE DENSITY /CONSISTENCY (VS, S, F, FB, VL, L, MD, ST, VST, D, VD, H)	HAND PENETROMETER (kPa)	STRUCTURE AND ADDITIONAL OBSERVATIONS
	0.10				SP	TOPSOIL, SAND, fine to medium grained, dark brown, estimated to have greater than 2% organic fines content by mass SAND, fine to medium grained, light brown/yellow, with minor non plastic fines throughout	M			
	1									
	2					Becoming grey with minor fines of low plasticity				
						END OF TEST PIT AT 2.50 m				
	3									

This test pit log should be read in conjunction with Parsons Brinckerhoff's accompanying standard notes.

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TEST PIT ENGINEERING LOG

TEST PIT NO.

TP12

SHEET 1 OF 1

Client:	Peet Limited	Date Commenced:	14/08/06
Project:	Lot 37 Bishop Rd, Lots 98, 182, 522 Taylor Road & Lot 212 Soldiers Rd	Date Completed:	14/08/06
Test Pit Location:	Mundijong	Recorded By:	FK
Project Number:	2140323A	Log Checked By:	JJ

Excavation Method: Backhoe

Surface RL:

Co-ords: E 403224 N 6428350

Test Pit Information				Field Material Description						
1	2	3	4	5	6	7	8	9	10	11
WATER	RL(m) mAHD / DEPTH(m)	FIELD TEST	SAMPLE	GRAPHIC LOG	USC SYMBOL	SOIL/ROCK MATERIAL FIELD DESCRIPTION	MOISTURE	RELATIVE DENSITY /CONSISTENCY (VS, S/L, F/B, VL, L, MD, ST, VST, D, VD, H)	HAND PENETROMETER (kPa)	STRUCTURE AND ADDITIONAL OBSERVATIONS
	0.10		ASS		SP	TOPSOIL, SAND, fine to medium grained, dark brown, estimated to have greater than 2% organic fines content by mass	M			
						SAND, fine to medium grained, light brown with minor non plastic fines throughout				
	0.50		ASS		SC	Clayey SAND, fine to medium grained, grey mottled orange/red, with fines of medium plasticity				
			D							
▽	1		ASS				W			
	2					Ferricrete, cemented laterite gravel				Refusal on ferricrete
						END OF TEST PIT AT 2.00 m				
	3									

This test pit log should be read in conjunction with Parsons Brinckerhoff's accompanying standard notes.

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TEST PIT ENGINEERING LOG

TEST PIT NO.

TP13

SHEET 1 OF 1

Client:	Peet Limited	Date Commenced:	14/08/06
Project:	Lot 37 Bishop Rd, Lots 98, 182, 522 Taylor Road & Lot 212 Soldiers Rd	Date Completed:	14/08/06
Test Pit Location:	Mundijong	Recorded By:	FK
Project Number:	2140323A	Log Checked By:	JJ
Excavation Method:	Backhoe	Surface RL:	
		Co-ords:	E 403464 N 6428443

Test Pit Information				Field Material Description						
1	2	3	4	5	6	7	8	9	10	11
WATER	RL(m) mAHD / DEPTH(m)	FIELD TEST	SAMPLE	GRAPHIC LOG	USC SYMBOL	SOIL/ROCK MATERIAL FIELD DESCRIPTION	MOISTURE	RELATIVE DENSITY / CONSISTENCY (VS S F ST VST H / FR VL L MD D VD)	HAND PENETROMETER (kPa)	STRUCTURE AND ADDITIONAL OBSERVATIONS
	0.10		ASS		SC	TOPSOIL, SAND, fine to medium grained, dark brown, estimated to have greater than 2% organic fines content by mass	M			
	0.20				SC	SAND with some clay, fine to medium grained, dark grey				
			ASS			Clayey SAND, fine to medium grained, brown mottled grey, with fines of medium plasticity				
			D							
			ASS							
	1		D			Small pockets of green sandy clay				
						Pockets of sand, fine to medium grained, white stained brown				
						Ferricrete, cemented laterite gravel				Refusal on ferricrete
						END OF TEST PIT AT 1.50 m				
	2									
	3									

This test pit log should be read in conjunction with Parsons Brinckerhoff's accompanying standard notes.

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TEST PIT ENGINEERING LOG

TEST PIT NO.

TP14

SHEET 1 OF 1

Client:	Peet Limited	Date Commenced:	14/08/06
Project:	Lot 37 Bishop Rd, Lots 98, 182, 522 Taylor Road & Lot 212 Soldiers Rd	Date Completed:	14/08/06
Test Pit Location:	Mundijong	Recorded By:	FK
Project Number:	2140323A	Log Checked By:	JJ

Excavation Method: Backhoe

Surface RL:

Co-ords: E 403312 N 6428293

Test Pit Information				Field Material Description						
1	2	3	4	5	6	7	8	9	10	11
WATER	RL(m) mAHD / DEPTH(m)	FIELD TEST	SAMPLE	GRAPHIC LOG	USC SYMBOL	SOIL/ROCK MATERIAL FIELD DESCRIPTION	MOISTURE	RELATIVE DENSITY /CONSISTENCY (VS FB, S VL, F L, MD ST, D VST, VD H)	HAND PENETROMETER (kPa)	STRUCTURE AND ADDITIONAL OBSERVATIONS
	0.10				SP	TOPSOIL, SAND, fine to medium grained, dark brown, estimated to have greater than 2% organic fines content by mass SAND, fine to medium grained, light brown/yellow, with minor non plastic fines throughout	M			
	1									
	2									
						END OF TEST PIT AT 2.20 m				
	3									

This test pit log should be read in conjunction with Parsons Brinckerhoff's accompanying standard notes.

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TEST PIT ENGINEERING LOG

TEST PIT NO.

TP15

SHEET 1 OF 1

Client:	**Peet Limited**	Date Commenced:	**15/08/06**
Project:	**Lot 37 Bishop Rd, Lots 98, 182, 522 Taylor Road & Lot 212 Soldiers Rd**	Date Completed:	**15/08/06**
Test Pit Location:	**Mundijong**	Recorded By:	**FK**
Project Number:	**2140323A**	Log Checked By:	**JJ**

Excavation Method: Backhoe

Surface RL:

Co-ords: E 403619 N 6428213

Test Pit Information				Field Material Description						
1	2	3	4	5	6	7	8	9	10	11
WATER	RL(m) mAHD / DEPTH(m)	FIELD TEST	SAMPLE	GRAPHIC LOG	USC SYMBOL	SOIL/ROCK MATERIAL FIELD DESCRIPTION	MOISTURE	RELATIVE DENSITY / CONSISTENCY (VS FB, SF VL, F L, ST MD, VST D, H VD)	HAND PENETROMETER (kPa)	STRUCTURE AND ADDITIONAL OBSERVATIONS
	0		ASS			TOPSOIL, SAND, fine to medium grained, dark brown, estimated to have greater than 2% organic fines content by mass	M			
	0.20				SP	SAND, fine to medium grained, light brown, minor fines of low plasticity				
			ASS							
	0.70				SC	Clayey SAND, fine to medium grained, grey mottled orange, with fines of medium plasticity. Minor fine to medium sized gravel throughout				
	1		ASS							
			D				W			
	2					END OF TEST PIT AT 2.00 m				
	3									

This test pit log should be read in conjunction with Parsons Brinckerhoff's accompanying standard notes.

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TEST PIT ENGINEERING LOG

TEST PIT NO.

TP16

SHEET 1 OF 1

Client:	Peet Limited	Date Commenced:	15/08/06
Project:	Lot 37 Bishop Rd, Lots 98, 182, 522 Taylor Road & Lot 212 Soldiers Rd	Date Completed:	15/08/06
Test Pit Location:	Mundijong	Recorded By:	FK
Project Number:	2140323A	Log Checked By:	JJ

Excavation Method: **Excavator**

Surface RL:

Co-ords: **E 404616 N 6428370**

Test Pit Information						Field Material Description				
1	2	3	4	5	6	7	8	9	10	11
WATER	RL(m) mAHD / DEPTH(m)	FIELD TEST	SAMPLE	GRAPHIC LOG	USC SYMBOL	SOIL/ROCK MATERIAL FIELD DESCRIPTION	MOISTURE	RELATIVE DENSITY /CONSISTENCY (VS S F ST VST H / FB VL L MD D VD)	HAND PENETROMETER (kPa)	STRUCTURE AND ADDITIONAL OBSERVATIONS
	0.10		ASS		SP	TOPSOIL, SAND, fine to medium grained, dark brown, estimated to have greater than 2% organic fines content by mass	M			
			ASS			SAND, fine to medium grained, orange/brown				
	1		ASS							
▼			ASS			Becoming weakly cemented and dark brown				
	2		ASS			END OF TEST PIT AT 2.00 m				
	3									

This test pit log should be read in conjunction with Parsons Brinckerhoff's accompanying standard notes.

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TEST PIT ENGINEERING LOG

TEST PIT NO.

TP17

SHEET 1 OF 1

Client:	Peet Limited	Date Commenced:	15/08/06
Project:	Lot 37 Bishop Rd, Lots 98, 182, 522 Taylor Road & Lot 212 Soldiers Rd	Date Completed:	15/08/06
Test Pit Location:	Mundijong	Recorded By:	FK
Project Number:	2140323A	Log Checked By:	JJ
Excavation Method:	Excavator	Surface RL:	
		Co-ords:	E 404321 N 6428398

Test Pit Information				Field Material Description						
1	2	3	4	5	6	7	8	9	10	11
WATER	RL(m) mAHD / DEPTH(m)	FIELD TEST	SAMPLE	GRAPHIC LOG	USC SYMBOL	SOIL/ROCK MATERIAL FIELD DESCRIPTION	MOISTURE	RELATIVE DENSITY /CONSISTENCY (VS FB, S VL, F L, MD, ST, VST D, H VD)	HAND PENETROMETER (kPa)	STRUCTURE AND ADDITIONAL OBSERVATIONS
	0.10		ASS		SM	TOPSOIL, Silty SAND, fine to medium grained, dark grey, with non plastic fines and estimated to have greater than 2% organic fines content by mass	W			
			ASS			Silty SAND, fine to medium grained, grey stained orange, with non plastic fines				
						END OF TEST PIT AT 0.80 m				Test pit collapsing
	1									
	2									
	3									

This test pit log should be read in conjunction with Parsons Brinckerhoff's accompanying standard notes.

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TEST PIT ENGINEERING LOG

TEST PIT NO.

TP18

SHEET 1 OF 1

Client:	Peet Limited	Date Commenced:	15/08/06
Project:	Lot 37 Bishop Rd, Lots 98, 182, 522 Taylor Road & Lot 212 Soldiers Rd	Date Completed:	15/08/06
Test Pit Location:	Mundijong	Recorded By:	FK
Project Number:	2140323A	Log Checked By:	JJ

Excavation Method: Excavator

Surface RL:

Co-ords: E 404208 N 6428661

Test Pit Information				Field Material Description						
1	2	3	4	5	6	7	8	9	10	11
WATER	RL(m) mAHD / DEPTH(m)	FIELD TEST	SAMPLE	GRAPHIC LOG	USC SYMBOL	SOIL/ROCK MATERIAL FIELD DESCRIPTION	MOISTURE	RELATIVE DENSITY / CONSISTENCY (VS FB, S F, VL L, ST MD, VST D, H VD)	HAND PENETROMETER (kPa)	STRUCTURE AND ADDITIONAL OBSERVATIONS
	0.10		ASS		SP	TOPSOIL, SAND, fine to medium grained, dark brown, estimated to have greater than 2% organic fines content by mass SAND, fine to medium grained, grey/orange with minor non plastic fines throughout	W			
			ASS							
▼	0.70		ASS		GM	Silty Sandy GRAVEL, fine to medium sized, orange/brown. Sand is fine to medium grained with non plastic fines throughout END OF TEST PIT AT 0.80 m				Test pit collapsing
	1									
	2									
	3									

This test pit log should be read in conjunction with Parsons Brinckerhoff's accompanying standard notes.

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TEST PIT ENGINEERING LOG

TEST PIT NO.

TP19

SHEET 1 OF 1

Client:	Peet Limited	Date Commenced:	15/08/06
Project:	Lot 37 Bishop Rd, Lots 98, 182, 522 Taylor Road & Lot 212 Soldiers Rd	Date Completed:	15/08/06
Test Pit Location:	Mundijong	Recorded By:	FK
Project Number:	2140323A	Log Checked By:	JJ

Excavation Method: Excavator

Surface RL:

Co-ords: E 404282 N 6428822

Test Pit Information				Field Material Description						
1	2	3	4	5	6	7	8	9	10	11
WATER	RL(m) mAHD / DEPTH(m)	FIELD TEST	SAMPLE	GRAPHIC LOG	USC SYMBOL	SOIL/ROCK MATERIAL FIELD DESCRIPTION	MOISTURE	RELATIVE DENSITY /CONSISTENCY (VS FB, S VL, F L, ST MD, VST D, H VD)	HAND PENETROMETER (kPa)	STRUCTURE AND ADDITIONAL OBSERVATIONS
	0.10		ASS		SP	TOPSOIL, SAND, fine to medium grained, dark brown, estimated to have greater than 2% organic fines content by mass	W			
						SAND, fine to medium grained, light grey to white				
			ASS							
▼						Becoming weakly cemented and dark brown with medium sized gravel throughout				
			ASS			END OF TEST PIT AT 0.80 m				Test pit collapsing
	1									
	2									
	3									

This test pit log should be read in conjunction with Parsons Brinckerhoff's accompanying standard notes.

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TEST PIT ENGINEERING LOG

TEST PIT NO.

TP20

SHEET 1 OF 1

Client:	**Peet Limited**	Date Commenced:	**15/08/06**
Project:	**Lot 37 Bishop Rd, Lots 98, 182, 522 Taylor Road & Lot 212 Soldiers Rd**	Date Completed:	**15/08/06**
Test Pit Location:	**Mundijong**	Recorded By:	**FK**
Project Number:	**2140323A**	Log Checked By:	**JJ**

Excavation Method: **Excavator**

Surface RL:

Co-ords: **E 403973 N 6428634**

Test Pit Information						Field Material Description				
1	2	3	4	5	6	7	8	9	10	11
WATER	RL(m) mAHD / DEPTH(m)	FIELD TEST	SAMPLE	GRAPHIC LOG	USC SYMBOL	SOIL/ROCK MATERIAL FIELD DESCRIPTION	MOISTURE	RELATIVE DENSITY /CONSISTENCY (VS S F L MD D VD / VL S St VSt H)	HAND PENETROMETER (kPa)	STRUCTURE AND ADDITIONAL OBSERVATIONS
	0.10		ASS		SM	TOPSOIL, SAND, fine to medium grained, dark brown, estimated to have greater than 2% organic fines content by mass	M			
			ASS D			Silty SAND, fine to medium grained, orange/brown, with non plastic fines. Minor fine to medium sized gravel throughout Gravel up to 50mm in size				
	0.90				SC	Clayey SAND, fine to medium grained, grey mottled orange, with fines of medium plasticity.				
	1		ASS D							
			ASS							
						END OF TEST PIT AT 1.80 m				
	2									
	3									

This test pit log should be read in conjunction with Parsons Brinckerhoff's accompanying standard notes.

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TEST PIT ENGINEERING LOG

TEST PIT NO.

TP21

SHEET 1 OF 1

Client:	Peet Limited	Date Commenced:	15/08/06
Project:	Lot 37 Bishop Rd, Lots 98, 182, 522 Taylor Road & Lot 212 Soldiers Rd	Date Completed:	15/08/06
Test Pit Location:	Mundijong	Recorded By:	FK
Project Number:	2140323A	Log Checked By:	JJ

Excavation Method: **Excavator**

Surface RL:

Co-ords: **E 403718 N 6428675**

Test Pit Information						Field Material Description				
1	2	3	4	5	6	7	8	9	10	11
WATER	RL(m) mAHD / DEPTH(m)	FIELD TEST	SAMPLE	GRAPHIC LOG	USC SYMBOL	SOIL/ROCK MATERIAL FIELD DESCRIPTION	MOISTURE	RELATIVE DENSITY /CONSISTENCY (VS, S, F, FB, VL, L, MD, ST, D, VST, VD, H)	HAND PENETROMETER (kPa)	STRUCTURE AND ADDITIONAL OBSERVATIONS
	0.10		ASS		SM	TOPSOIL, SAND, fine to medium grained, dark brown, estimated to have greater than 2% organic fines content by mass Silty SAND, fine to medium grained, orange/brown, with non plastic fines.	M			
			ASS D							
	0.60				SP	SAND with some minor clay, fine to medium grained, light brown, fines of low plasticity				
	1		ASS							
	1.20				SC	Clayey SAND, fine to medium grained, grey mottled orange with some small pockets of green, with fines of medium plasticity.				
			D ASS							
	2		ASS			END OF TEST PIT AT 2.00 m				
	3									

This test pit log should be read in conjunction with Parsons Brinckerhoff's accompanying standard notes.

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TEST PIT ENGINEERING LOG

TEST PIT NO.

TP22

SHEET 1 OF 1

Client:	Peet Limited	Date Commenced:	15/08/06
Project:	Lot 37 Bishop Rd, Lots 98, 182, 522 Taylor Road & Lot 212 Soldiers Rd	Date Completed:	15/08/06
Test Pit Location:	Mundijong	Recorded By:	FK
Project Number:	2140323A	Log Checked By:	JJ
Excavation Method:	Excavator	Surface RL:	
		Co-ords:	E 403854 N 6428817

Test Pit Information				Field Material Description						
1	2	3	4	5	6	7	8	9	10	11
WATER	RL(m) mAHD / DEPTH(m)	FIELD TEST	SAMPLE	GRAPHIC LOG	USC SYMBOL	SOIL/ROCK MATERIAL FIELD DESCRIPTION	MOISTURE	RELATIVE DENSITY /CONSISTENCY (VS FB, SF VL, F L, ST MD, VST D, H VD)	HAND PENETROMETER (kPa)	STRUCTURE AND ADDITIONAL OBSERVATIONS
	0.10		ASS		SP	TOPSOIL, SAND, fine to medium grained, dark brown, estimated to have greater than 2% organic fines content by mass SAND, fine to medium grained, light grey	M			
			ASS							
	0.80				SC	Clayey SAND, fine to medium grained, grey stained orange with some small pockets of green, with fines of medium plasticity.	W			
	1		D							
			ASS							
			D							
	2		ASS			END OF TEST PIT AT 2.00 m				
	3									

This test pit log should be read in conjunction with Parsons Brinckerhoff's accompanying standard notes.

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APPENDIX D

DCP Test Results

www.galtgeo.com.au
2/39 Flynn St, WEMBLEY WA 6014

ABN: 73 292 586 155

DYNAMIC CONE PENETROMETER RESULTS
AS1289.6.3.2

Depth (m)	Test Number / Number of Blows Per 100 mm of penetration									
	TP01	TP02	TP03	TP04	TP05	TP06	TP07	TP08	TP09	TP10
0 – 0.1	1	1	1	1	1	1	1	1	1	1
0.1 – 0.2	1	2	1	2	1	1	1	1	2	2
0.2 – 0.3	2	2	1	3	2	1	1	1	1	2
0.3 – 0.4	2	2	1	2	1	2	1	2	2	2
0.4 – 0.5	2	1	1	1	2	2	2	1	1	1
0.5 – 0.6	2	2	1	1	1	2	2	2	1	2
0.6 – 0.7	3	2	1	2	2	2	2	1	1	1
0.7 – 0.8	4	3	1	1	1	2	2	1	2	1
0.8 – 0.9	2	3	1	1	3	2	1	1	2	1
0.9 – 1.0	3	3	1	2	2	2	1	1	2	4
1.0 – 1.1								0		

Depth (m)	Test Number / Number of Blows Per 100 mm of penetration									
	TP11	TP12	TP13	TP14	TP15	TP16	TP17	TP18	TP19	TP20
0 – 0.1	1	1	1	1	1	1	1	1	1	1
0.1 – 0.2	1	1	2	1	2	1	0	2	2	1
0.2 – 0.3	2	1	2	2	2	1	0	1	2	1
0.3 – 0.4	2	2	2	1	2	1	1	1	3	1
0.4 – 0.5	1	1	2	1	2	2	1	1	2	2
0.5 – 0.6	1	1	2	1	2	2	2	1	3	3
0.6 – 0.7	1	1	2	1	2	2	3	1	3	3
0.7 – 0.8	1	2	2	3	3	4	3	2	3	4
0.8 – 0.9	0	1	2	2	10R	5	2	2	2	4
0.9 – 1.0	1	0	2	2			3	2	2	2
1.0 – 1.1				2						

Depth (m)	Test Number / Number of Blows Per 100 mm of penetration									
	TP21	TP22	TP23	TP24	TP25					
0 – 0.1	1	1	1	1	1					
0.1 – 0.2	1	1	2	1	2					
0.2 – 0.3	1	2	2	1	2					
0.3 – 0.4	2	3	2	0	2					
0.4 – 0.5	2	3	2	1	2					
0.5 – 0.6	2	2	1	2	1					
0.6 – 0.7	1	1	2	3	2					
0.7 – 0.8	1	2	2	2	2					
0.8 – 0.9	2	2	2	3	2					
0.9 – 1.0	1		2	2	1					
1.0 – 1.1										

Note: R - Refusal

APPENDIX E

Permeability Test Results

www.galtgeo.com.au
2/39 Flynn St, WEMBLEY WA 6014

ABN: 73 292 586 155

Permeability Calculation - Inverse Auger Hole Method

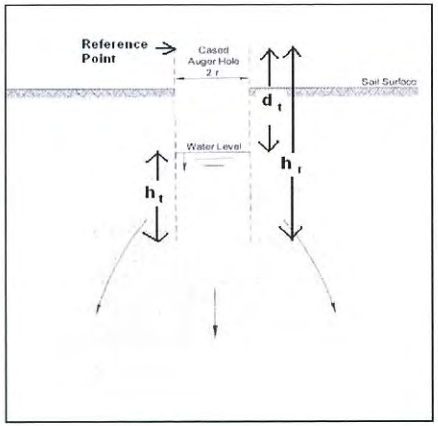
Galt Geotechnics

Job No:	J1101128
Client:	Wave Engineering
Site:	SI
Location:	Bishop Rd, Mundijong
Calc by:	HWC 10-Oct-11
BH Name:	P1
Test Depth:	0.56 m

Spreadsheet author:	ORW	17-Oct-09

$$K = 1.15r\frac{\log_{10}(h_0 + \frac{1}{2}r) - \log_{10}(h_t + \frac{1}{2}r)}{t - t_0}$$

REFERENCE: Cocks, G. *Disposal of Stormwater Runoff by Soakage in Perth Western Australia*, Journal and News of the Australian Geomechanics Society, Volume 42 No 3 September 2007, pp101-114



Spreadsheet Legend

	Required input
	Calculated field
	Comment field
	Field not used
	Fixed field

Parameter	Description	Value	Units
K	Permeability		m/s
r	radius of test hole	0.05	m
t	time since start of measurement		s
h_r	reference point height above base	0.955	m
d_t	depth from reference point to water at time t		m
h_t	Water column height at time t		m
h_0	h_t at t=0		m

Test 1

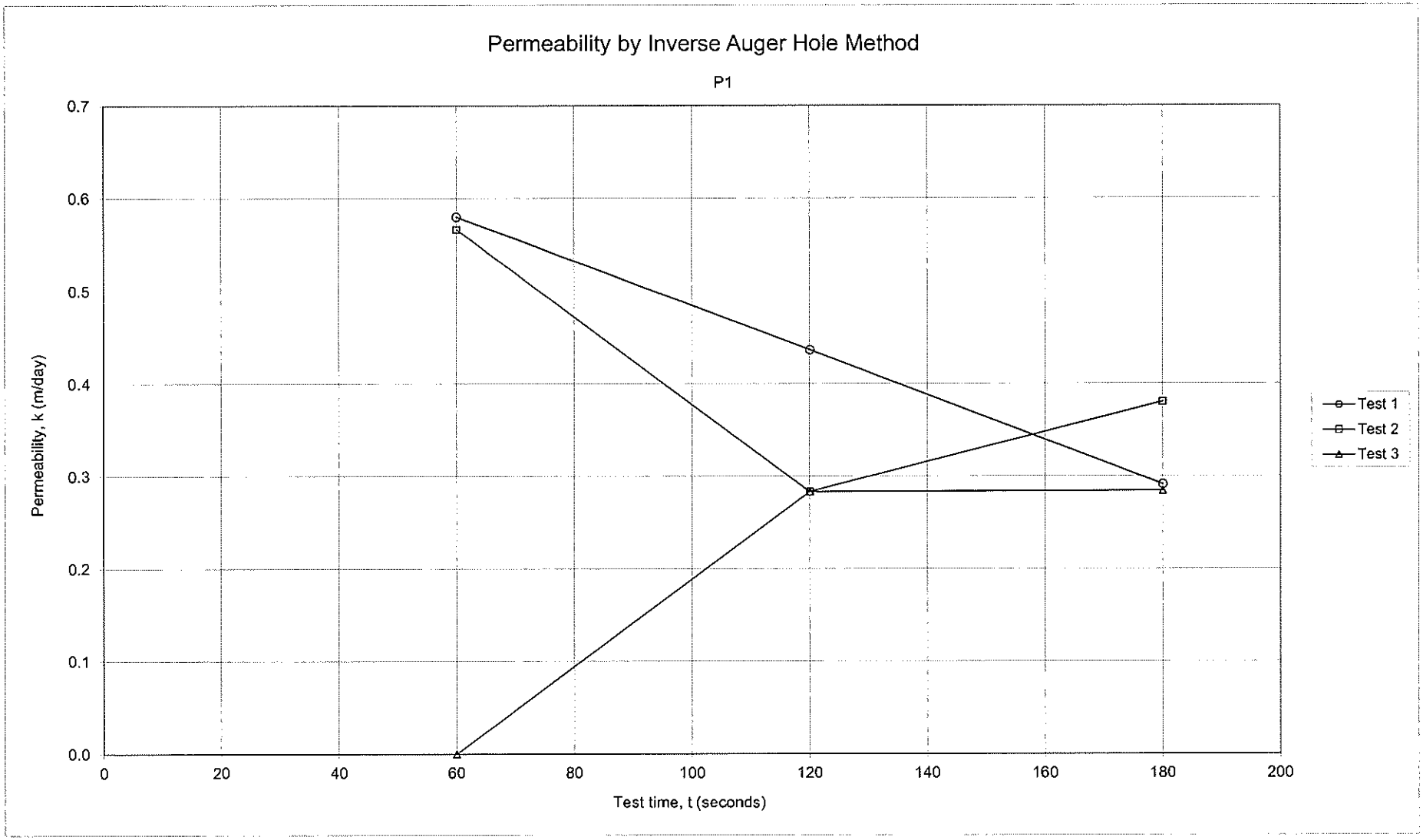
t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
0	0.355	0.6		
60	0.365	0.59	6.7E-06	0.6
120	0.37	0.585	5.1E-06	0.4
180	0.37	0.585	3.4E-06	0.3
		AVERAGE	5.0E-06	0.4

Test 2

t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
0	0.34	0.615		
60	0.35	0.605	6.6E-06	0.6
120	0.35	0.605	3.3E-06	0.3
180	0.36	0.595	4.4E-06	0.4
		AVERAGE	4.7E-06	0.4

Test 3

t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
0	0.34	0.615		
60	0.34	0.615	0.0E+00	0.0
120	0.35	0.605	3.3E-06	0.3
180	0.355	0.6	3.3E-06	0.3
		AVERAGE	2.2E-06	0.2


Permeability by Inverse Auger Hole Method
P1
Permeability, k (m/day)
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0
20
40
60
80
100
120
140
160
180
200
Test time, t (seconds)
Test 1
Test 2
Test 3

Permeability Calculation - Inverse Auger Hole Method

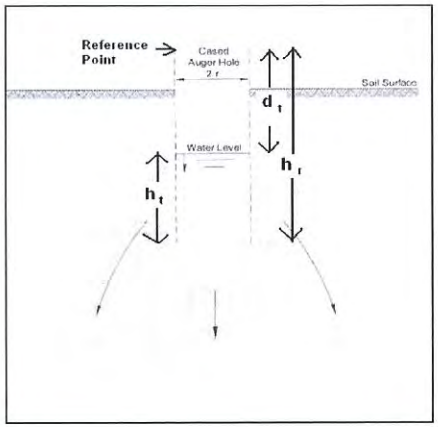
Galt Geotechnics

Job No:	J1101128
Client:	Wave Engineering
Site:	SI
Location:	Bishop Rd, Mundijong
Calc by:	HWC 10-Oct-11
BH Name:	P2
Test Depth:	0.58 m

Spreadsheet author:	ORW	17-Oct-09

$$K = 1.15r\frac{\log_{10}(h_0 + \frac{1}{2}r) - \log_{10}(h_t + \frac{1}{2}r)}{t - t_0}$$

REFERENCE: Cocks, G. *Disposal of Stormwater Runoff by Soakage in Perth Western Australia*, Journal and News of the Australian Geomechanics Society, Volume 42 No 3 September 2007, pp101-114



Spreadsheet Legend

	Required input
	Calculated field
	Comment field
	Field not used
	Fixed field

Parameter	Description	Value	Units
K	Permeability		m/s
r	radius of test hole	0.05	m
t	time since start of measurement		s
h_r	reference point height above base	0.955	m
d_t	depth from reference point to water at time t		m
h_t	Water column height at time t		m
h_0	h_t at t=0		m

Test 1

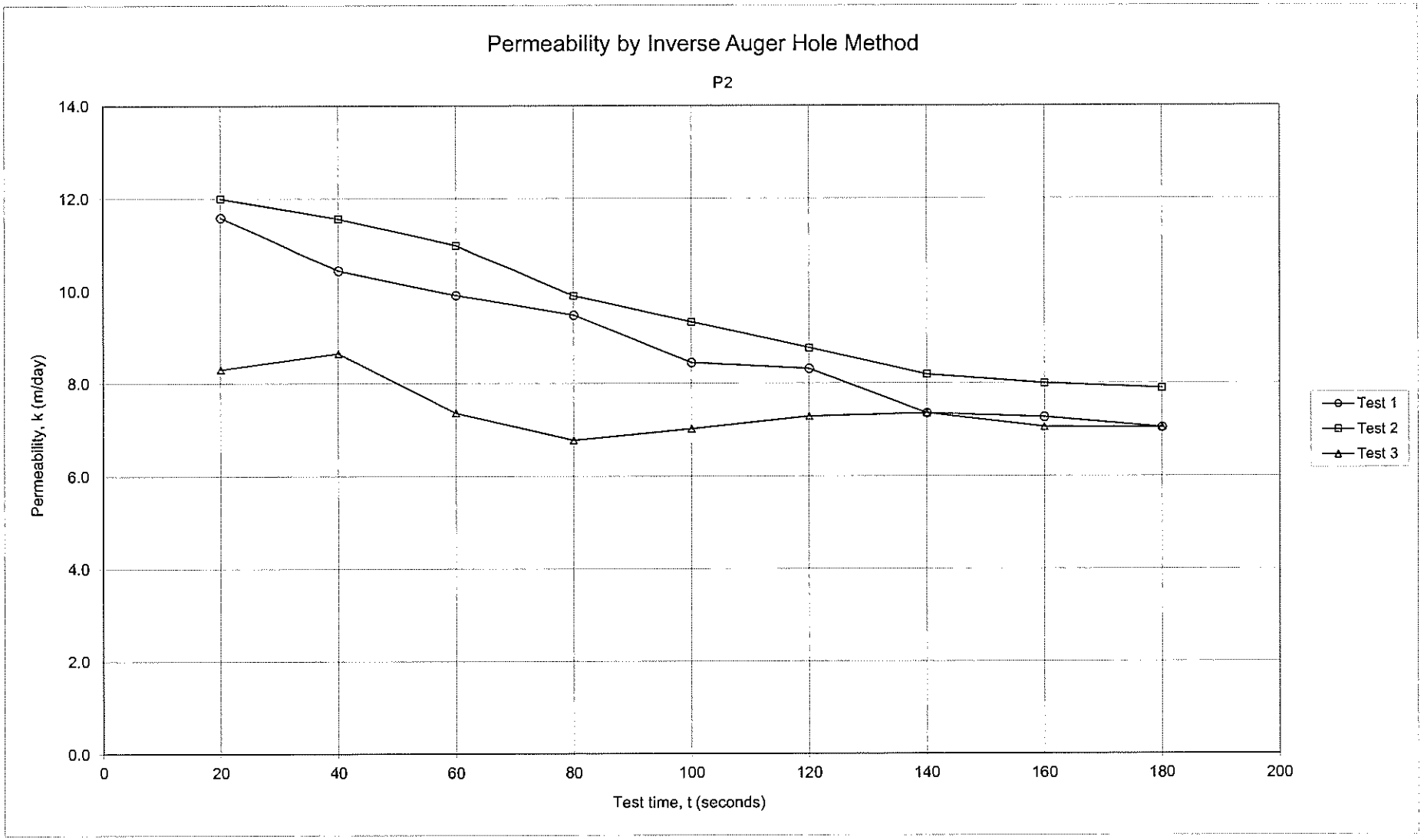
t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
0	0.44	0.515		
20	0.495	0.46	1.3E-04	11.6
40	0.535	0.42	1.2E-04	10.4
60	0.57	0.385	1.1E-04	9.9
80	0.6	0.355	1.1E-04	9.5
100	0.615	0.34	9.8E-05	8.5
120	0.64	0.315	9.6E-05	8.3
140	0.645	0.31	8.5E-05	7.4
160	0.665	0.29	8.4E-05	7.3
180	0.68	0.275	8.2E-05	7.0
		AVERAGE	1.0E-04	8.9

Test 2

t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
0	0.41	0.545		
20	0.47	0.485	1.4E-04	12.0
40	0.52	0.435	1.3E-04	11.6
60	0.56	0.395	1.3E-04	11.0
80	0.585	0.37	1.1E-04	9.9
100	0.61	0.345	1.1E-04	9.3
120	0.63	0.325	1.0E-04	8.8
140	0.645	0.31	9.5E-05	8.2
160	0.665	0.29	9.3E-05	8.0
180	0.685	0.27	9.1E-05	7.9
		AVERAGE	1.1E-04	9.6

Test 3

t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
0	0.44	0.515		
20	0.48	0.475	9.6E-05	8.3
40	0.52	0.435	1.0E-04	8.6
60	0.54	0.415	8.5E-05	7.4
80	0.56	0.395	7.8E-05	6.8
100	0.59	0.365	8.1E-05	7.0
120	0.62	0.335	8.4E-05	7.3
140	0.645	0.31	8.5E-05	7.4
160	0.66	0.295	8.2E-05	7.1
180	0.68	0.275	8.2E-05	7.0
		AVERAGE	8.6E-05	7.4


Permeability by Inverse Auger Hole Method
P2
Permeability, k (m/day)
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
0
20
40
60
80
100
120
140
160
180
200
Test time, t (seconds)
Test 1
Test 2
Test 3

Permeability Calculation - Inverse Auger Hole Method

Galt Geotechnics

Spreadsheet author:	ORW	17-Oct-09

Job No:	J1101128
Client:	Wave Engineering
Site:	SI
Location:	Bishop Rd, Mundijong
Calc by:	HWC 10-Oct-11
BH Name:	P3
Test Depth:	0.58 m

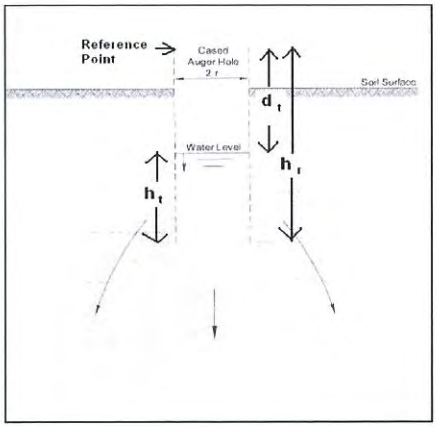
$$K = 1.15r\frac{\log_{10}(h_0 + \frac{1}{2}r) - \log_{10}(h_t + \frac{1}{2}r)}{t - t_0}$$

REFERENCE: Cocks, G. *Disposal of Stormwater Runoff by Soakage in Perth Western Australia*, Journal and News of the Australian Geomechanics Society, Volume 42 No 3 September 2007, pp101-114

Spreadsheet Legend

	Required input
	Calculated field
	Comment field
	Field not used
	Fixed field

Parameter	Description	Value	Units
K	Permeability		m/s
r	radius of test hole	0.05	m
t	time since start of measurement		s
h_r	reference point height above base	0.955	m
d_t	depth from reference point to water at time t		m
h_t	Water column height at time t		m
h_0	h_t at t=0		m



Test 1

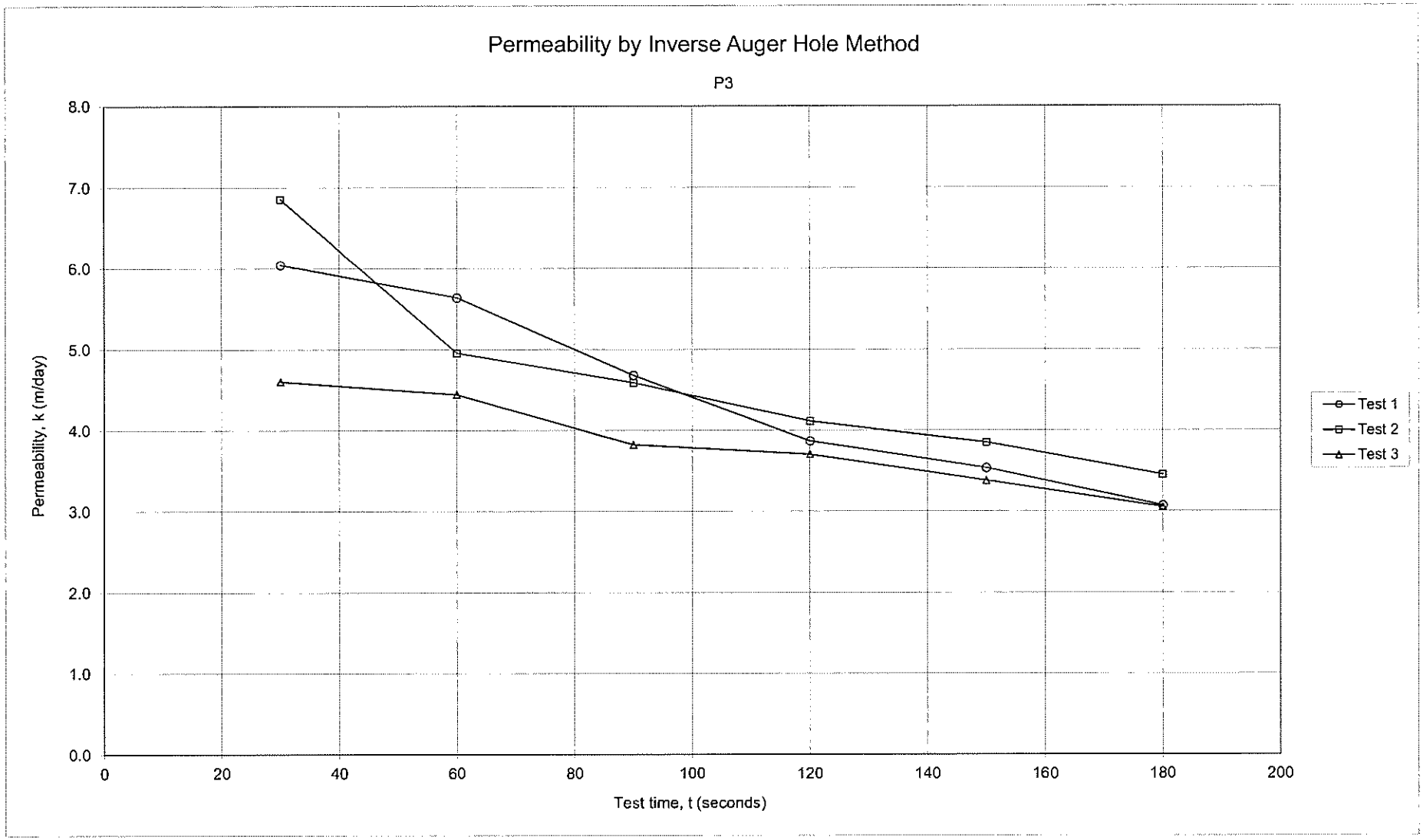
t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
0	0.36	0.595		
30	0.41	0.545	7.0E-05	6.0
60	0.45	0.505	6.5E-05	5.6
90	0.47	0.485	5.4E-05	4.7
120	0.48	0.475	4.5E-05	3.9
150	0.495	0.46	4.1E-05	3.5
180	0.5	0.455	3.6E-05	3.1
		AVERAGE	5.2E-05	4.5

Test 2

t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
0	0.32	0.635		
30	0.38	0.575	7.9E-05	6.9
60	0.405	0.55	5.7E-05	5.0
90	0.435	0.52	5.3E-05	4.6
120	0.455	0.5	4.8E-05	4.1
150	0.475	0.48	4.5E-05	3.9
180	0.485	0.47	4.0E-05	3.4
		AVERAGE	5.4E-05	4.6

Test 3

t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
0	0.335	0.62		
30	0.375	0.58	5.3E-05	4.6
60	0.41	0.545	5.1E-05	4.4
90	0.43	0.525	4.4E-05	3.8
120	0.455	0.5	4.3E-05	3.7
150	0.47	0.485	3.9E-05	3.4
180	0.48	0.475	3.5E-05	3.1
		AVERAGE	4.4E-05	3.8


Permeability by Inverse Auger Hole Method
P3
Permeability, k (m/day)
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
0
20
40
60
80
100
120
140
160
180
200
Test time, t (seconds)
Test 1
Test 2
Test 3

Permeability Calculation - Inverse Auger Hole Method

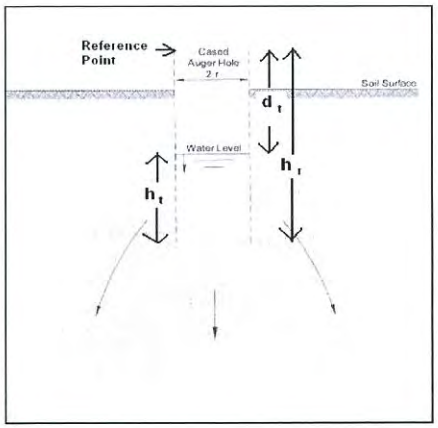
Galt Geotechnics

Job No:	J1101128
Client:	Wave Engineering
Site:	SI
Location:	Bishop Rd, Mundijong
Calc by:	HWC 10-Oct-11
BH Name:	P4
Test Depth:	0.65 m

Spreadsheet author:	ORW	17-Oct-09

$$K = 1.15r\frac{\log_{10}(h_0 + \frac{1}{2}r) - \log_{10}(h_t + \frac{1}{2}r)}{t - t_0}$$

REFERENCE: Cocks, G. *Disposal of Stormwater Runoff by Soakage in Perth Western Australia*, Journal and News of the Australian Geomechanics Society, Volume 42 No 3 September 2007, pp101-114



Spreadsheet Legend

	Required input
	Calculated field
	Comment field
	Field not used
	Fixed field

Parameter	Description	Value	Units
K	Permeability		m/s
r	radius of test hole	0.05	m
t	time since start of measurement		s
h_r	reference point height above base	0.955	m
d_t	depth from reference point to water at time t		m
h_t	Water column height at time t		m
h_0	h_t at t=0		m

Test 1

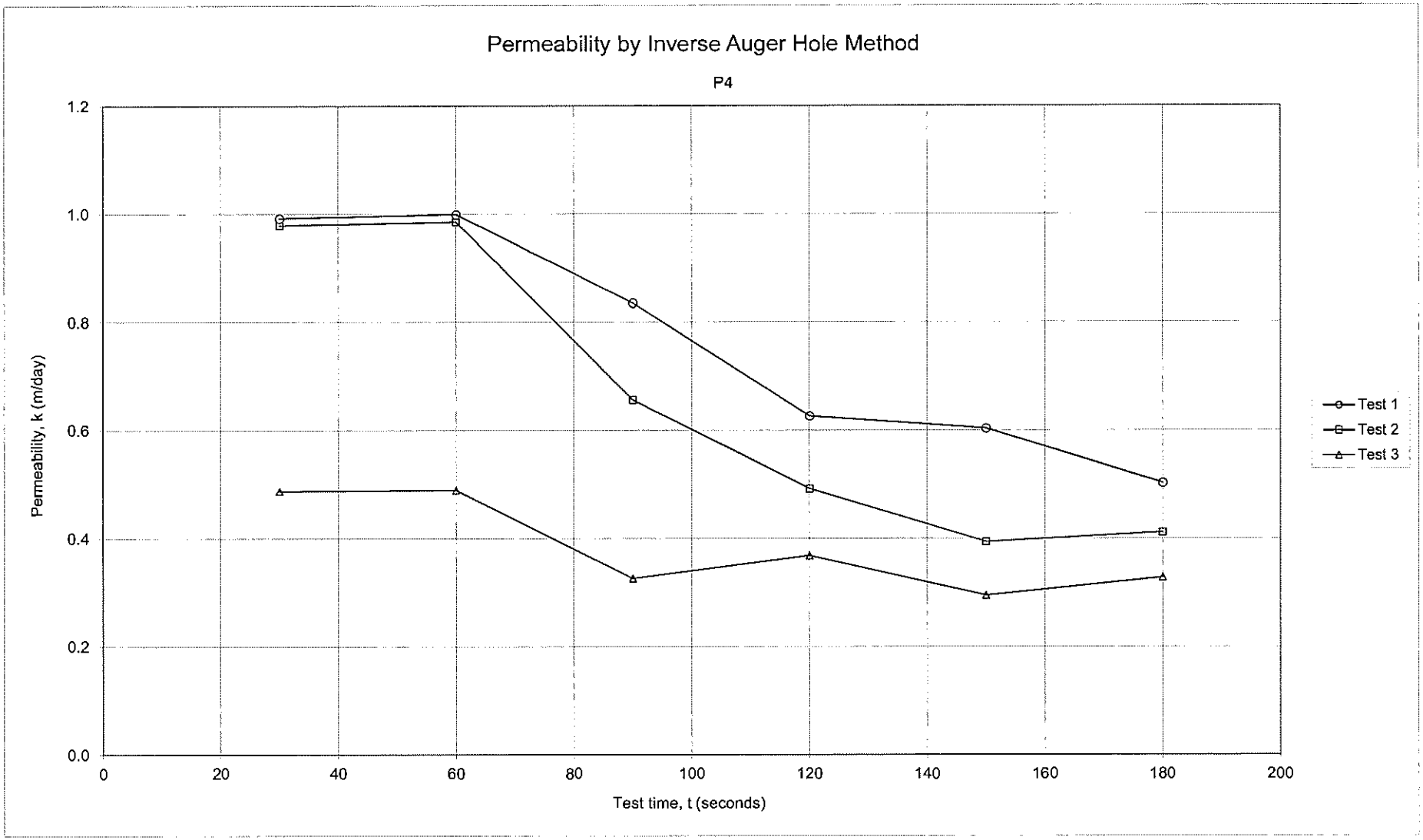
t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
0	0.25	0.705		
30	0.26	0.695	1.1E-05	1.0
60	0.27	0.685	1.2E-05	1.0
90	0.275	0.68	9.7E-06	0.8
120	0.275	0.68	7.3E-06	0.6
150	0.28	0.675	7.0E-06	0.6
180	0.28	0.675	5.8E-06	0.5
		AVERAGE	8.8E-06	0.8

Test 2

t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
0	0.24	0.715		
30	0.25	0.705	1.1E-05	1.0
60	0.26	0.695	1.1E-05	1.0
90	0.26	0.695	7.6E-06	0.7
120	0.26	0.695	5.7E-06	0.5
150	0.26	0.695	4.6E-06	0.4
180	0.265	0.69	4.8E-06	0.4
		AVERAGE	7.6E-06	0.7

Test 3

t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
0	0.24	0.715		
30	0.245	0.71	5.6E-06	0.5
60	0.25	0.705	5.7E-06	0.5
90	0.25	0.705	3.8E-06	0.3
120	0.255	0.7	4.3E-06	0.4
150	0.255	0.7	3.4E-06	0.3
180	0.26	0.695	3.8E-06	0.3
		AVERAGE	4.4E-06	0.4


Permeability by Inverse Auger Hole Method
P4
Permeability, k (m/day)
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0
20
40
60
80
100
120
140
160
180
200
Test time, t (seconds)
Test 1
Test 2
Test 3

APPENDIX F

Laboratory Tests Results

www.galtgeo.com.au
2/39 Flynn St, WEMBLEY WA 6014

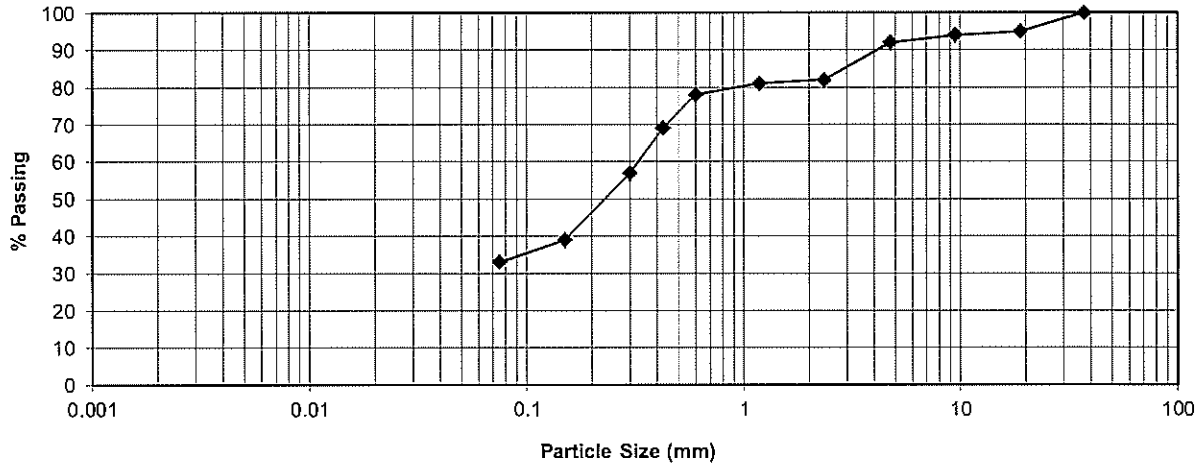
ABN: 73 292 586 155

Particle Size Distribution & Plasticity Index tests

Mining &
Civil
Geotest Pty Ltd
unit1/1 Pusey Road, Jandakot, WA 6164
Ph (08) 9414 8022 Fax (08) 9414 8011
Email: kevin@mcgeotest.com.au

Job No:	60083
Report No:	60083-P11/3406
Sample No:	P11/3406
Issue Date:	26 October 2011

Client:	Galt Geotechnics	Sample location:	TP 02
Project:	Wave Engineering Pty Ltd	Depth:	1.5 - 2.0
Location:	Residential Development, Bishop Road		



SIEVE ANALYSIS AS 1289.3.6.1

Sieve Size (mm)	% Passing
75.0	
37.5	100
19.0	95
9.5	94
4.75	92
2.36	82
1.18	81
0.600	78
0.425	69
0.300	57
0.150	39
0.075	33

Plasticity index tests		
AS 1289		
Liquid limit 3.1.1	63	%
Plastic limit 3.2.1	17	%
Plasticity index 3.3.1	46	%
Linear shrinkage 3.4.1	10.5	%
Linear shrinkage		
Cracked	☐	
Curled	☑	

Client Address: 2/54 Flynn Street, Wembley WA

Sampling Procedure: Tested as received

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Approved signature

Kevin M Jones

AS PSDPI May 2009

Mining & Civil Geotest Pty Ltd

Ph (08) 9414 8022 Fax (08) 9414 8011
Email kevin@mcgeotest.com.au
Unit 1/1 Pusey Road, JANDAKOT WA 6164

Determination of the Shrinkage Index of a Soil
Shrink Swell Index
AS 1289.7.1.1

		Job No:	60083
		Report No:	60083-P11/3406
		Date of issue:	26 October 2011
Client:	GALT Geotechnics	Date tested:	17 October 2011
Project:	Wave Engineering Pty Ltd	Tested by:	M van Herk
Location:	Residential Development, Bishop Road	Checked:	K M Jones
Test Pit:	02, 1.5 - 2.0m	Sample No:	P11/3406

Sample details

Sample description : Brown Orange Gravelly Clayey Sand

Sample Type : 63 mm Ø tube sample

Swell Specimen		Shrinkage Specimen	
Dry Density - Initial (t/m^3)	1.35	Moisture Content Initial (%)	42.3
Moisture Content - Initial (%)	43.6	Length/Diameter Ratio	1.8
Moisture Content - Final (%)	43.7	Extent of Crumbling	Nil
Overburden Pressure (kPa)	25	Extent of Cracking	Minor
Significant Inert Inclusions (%)	10		

Shrink-Swell Index

I_{ss} = **2.1** % Vertical strain per pF change in Total suction

Client address: 2/54 Flynn St, Wembley WA

Tested as received

Approved Signature

Kevin M Jones

Particle Size Distribution & Plasticity Index tests

Mining & Civil

Geotest Pty Ltd

unit1/1 Pusey Road, Jandakot, WA 6164

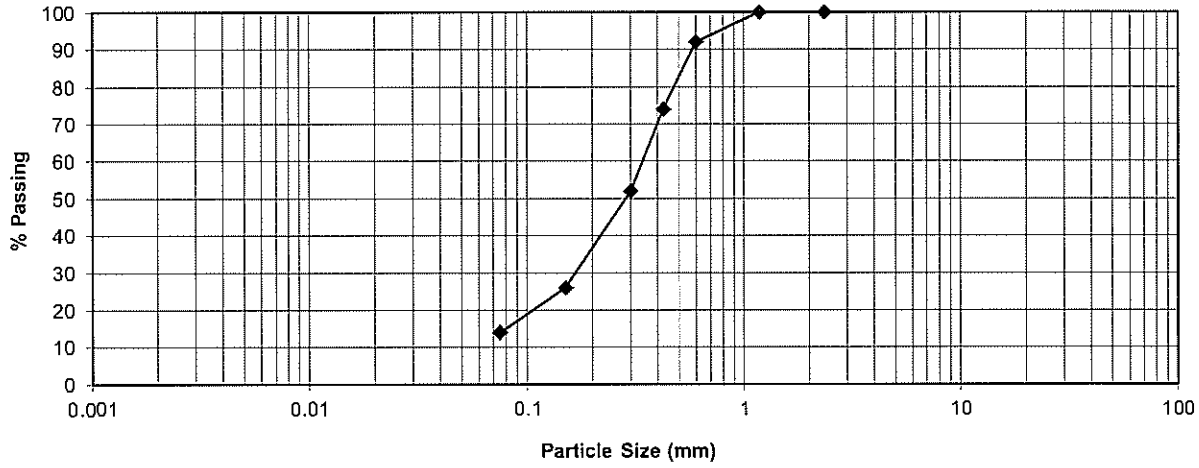
Ph (08) 9414 8022 Fax (08) 9414 8011

Email: kevin@mcgeotest.com.au

Job No:	60083
Report No:	60083-P11/3407
Sample No:	P11/3407
Issue Date:	26 October 2011

Client: Galt Geotechnics
Project: Wave Engineering Pty Ltd
Location: Residential Development, Bishop Road

Sample location: TP 06
Depth: 0.5 - 1.0



SIEVE ANALYSIS AS 1289.3.6.I

Sieve Size (mm)	% Passing
75.0	
37.5	
19.0	
9.5	
4.75	
2.36	100
1.18	100
0.600	92
0.425	74
0.300	52
0.150	26
0.075	14

Plasticity index tests		
AS 1289		
Liquid limit 3.1.1	21	%
Plastic limit 3.2.1	15	%
Plasticity index 3.3.1	6	%
Linear shrinkage 3.4.I	1.0	%
Linear shrinkage		
Cracked	☐	
Curled	☐	

Client Address: 2/54 Flynn Street, Wembley WA

Sampling Procedure: Tested as received

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Kevin M Jones

AS PSDPI May 2009

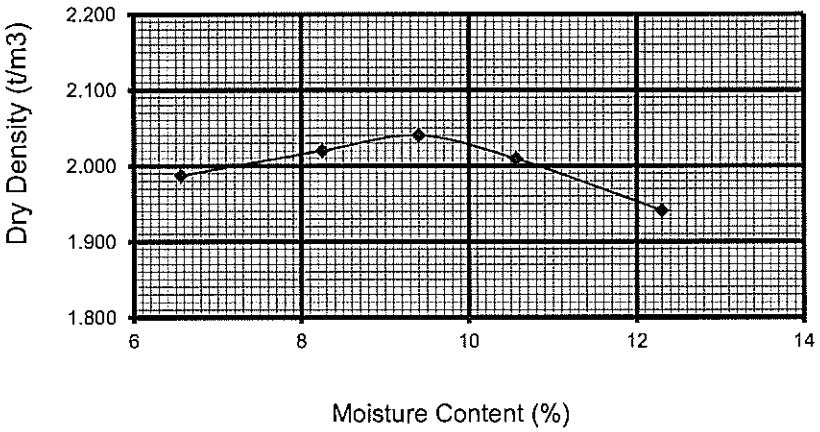
Mining &
Civil
Geotest Pty Ltd
Unit 1/1 Pusey Road, JANDAKOT WA 6164
Ph (08) 9414 8022
Fax (08)9414 8011
Email kevin@mcgeotest.com.au

Maximum Dry Density (AS 1289.5.2.1) & California Bearing Ratio (AS 1289.6.1.1) Test Report

Certificate No:	60083-P11/3407	**Sample No.:**	P11/3407
Client:	GALT Geotechnics	**Project:**	Wave Engineering Pty Ltd
Location:	Residential Development, Bishop Road	**Date of issue:**	26 October 2011
	TP 06, 0.5 - 1.0m	**Job No:**	60083

Maximum Dry Density t/m^3:	2.040	**Conditions at Test**	
Optimum Moisture Content %:	9.4	Soaking Period (Days)	4
Desired Conditions: %MDD / %OM	95/100	Surcharge (kg)	4.5
Compactive Effort		Entire Moisture Content %	11.3
Mass of hammer kg	4.9	Entire Moisture Ratio %	120.6
Number of layers	5	Top 30mm Moisture Content %	11.7
Number of blows/layer	22	Top 30mm Moisture Ratio %	124.3
Conditions after Compaction		Swell %	0.0
Dry Density t/m^3	1.920	C.B.R. at 2.5 mm Penetration %	60
Moisture Content %	9.7	**Conditions after Soaking**	
Density Ratio %	94.1	Dry Density t/m^3	1.920
Moisture Ratio %	103.4	Moisture Content %	12.3
Soaked / Unsoaked	Soaked	Dry Density Ratio %	94.1
		Moisture Ratio %	130.9

Comments: Tested as received



Client address: 2/54 Flynn St, Wembley WA

ASMDD-CBR June 2009

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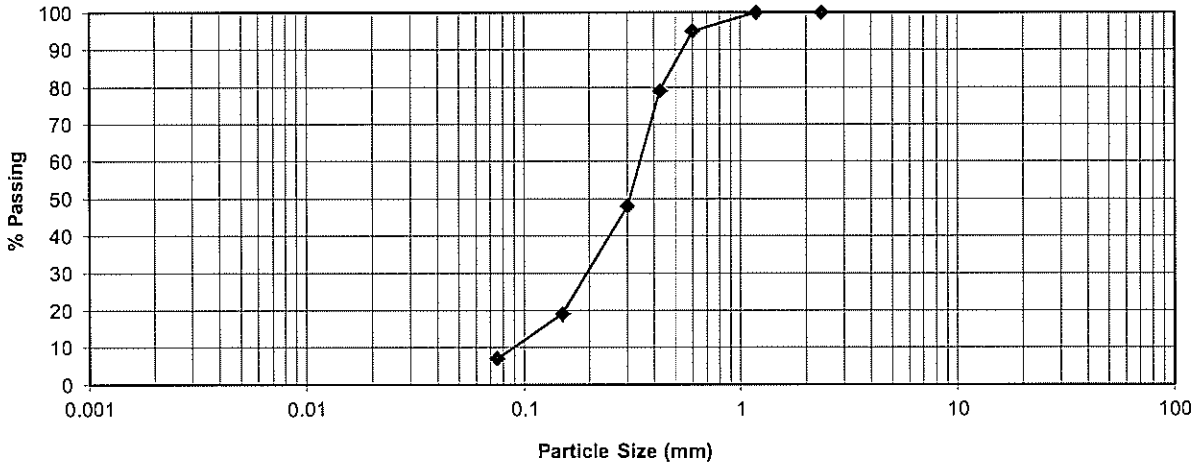
Particle Size Distribution & Plasticity Index tests

Mining &
Civil
Geotest Pty Ltd
unit1/1 Pusey Road, Jandakot, WA 6164
Ph (08) 9414 8022 Fax (08) 9414 8011
Email: kevin@mcgeotest.com.au

Job No:	60083
Report No:	60083-P11/3408
Sample No:	P11/3408
Issue Date:	26 October 2011

Client: Galt Geotechnics
Project: Wave Engineering Pty Ltd
Location: Residential Development, Bishop Road

Sample location: TP 08
Depth: 1.0 - 1.5



SIEVE ANALYSIS AS 1289.3.6.1

Sieve Size (mm)	% Passing
75.0	
37.5	
19.0	
9.5	
4.75	
2.36	100
1.18	100
0.600	95
0.425	79
0.300	48
0.150	19
0.075	7

Plasticity index tests
AS 1289

Liquid limit 3.1.1	na	%
Plastic limit 3.2.1		%
Plasticity index 3.3.1		%
Linear shrinkage 3.4.1		%
Linear shrinkage		
Cracked	☐	
Curled	☐	

Client Address: 2/54 Flynn Street, Wembley WA

Sampling Procedure: Tested as received

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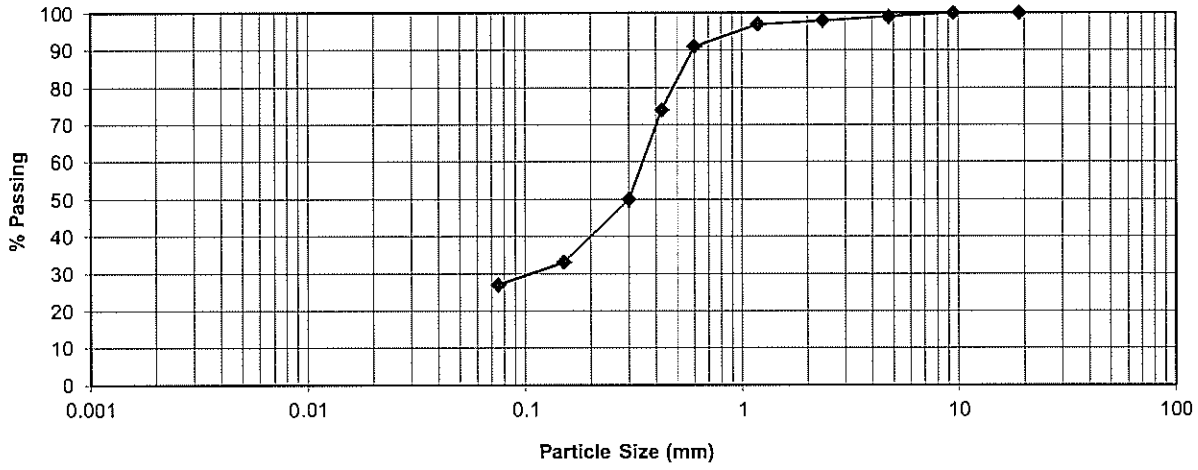
Kevin M Jones

Particle Size Distribution & Plasticity Index tests

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Civil
Geotest Pty Ltd
unit1/1 Pusey Road, Jandakot, WA 6164
Ph (08) 9414 8022 Fax (08) 9414 8011
Email: kevin@mcgeotest.com.au

Job No:	60083
Report No:	60083-P11/3409
Sample No:	P11/3409
Issue Date:	26 October 2011

Client:	Galt Geotechnics	Sample location:	TP 09
Project:	Wave Engineering Pty Ltd	Depth:	0.0 - 0.5
Location:	Residential Development, Bishop Road		



SIEVE ANALYSIS AS 1289.3.6.1

Sieve Size (mm)	% Passing
75.0	
37.5	
19.0	100
9.5	100
4.75	99
2.36	98
1.18	97
0.600	91
0.425	74
0.300	50
0.150	33
0.075	27

Plasticity index tests		
AS 1289		
Liquid limit 3.1.1	na	%
Plastic limit 3.2.1		%
Plasticity index 3.3.1		%
Linear shrinkage 3.4.1		%
Linear shrinkage		
Cracked	☐	
Curled	☐	

Client Address: 2/54 Flynn Street, Wembley WA

Sampling Procedure: Tested as received

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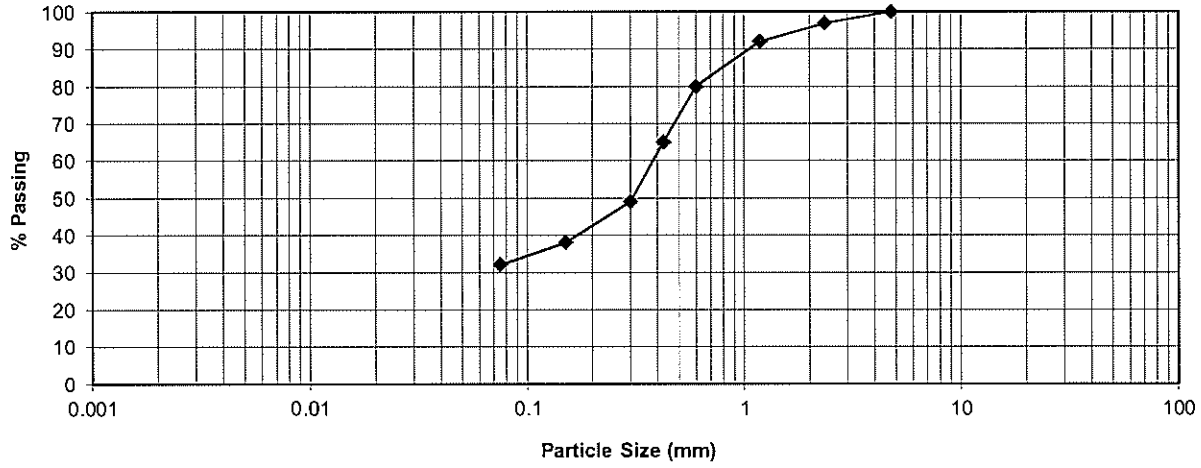
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Particle Size Distribution & Plasticity Index tests

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unit1/1 Pusey Road, Jandakot, WA 6164
Ph (08) 9414 8022 Fax (08) 9414 8011
Email: kevin@mcgeotest.com.au

Job No:	60083
Report No:	60083-P11/3410
Sample No:	P11/3410
Issue Date:	26 October 2011

Client:	Galt Geotechnics	Sample location:	TP 14
Project:	Wave Engineering Pty Ltd	Depth:	0.25 - 0.7
Location:	Residential Development, Bishop Road		



SIEVE ANALYSIS AS 1289.3.6.1

Sieve Size (mm)	% Passing
75.0	
37.5	
19.0	
9.5	
4.75	100
2.36	97
1.18	92
0.600	80
0.425	65
0.300	49
0.150	38
0.075	32

Plasticity index tests
AS 1289

Liquid limit 3.1.1	29	%
Plastic limit 3.2.1	13	%
Plasticity indcx 3.3.1	16	%
Linear shrinkage 3.4.1	5.5	%
Linear shrinkage		
Cracked	☐	
Curled	☑	

Client Address: 2/54 Flynn Street, Wembley WA

Sampling Procedure: Tested as received

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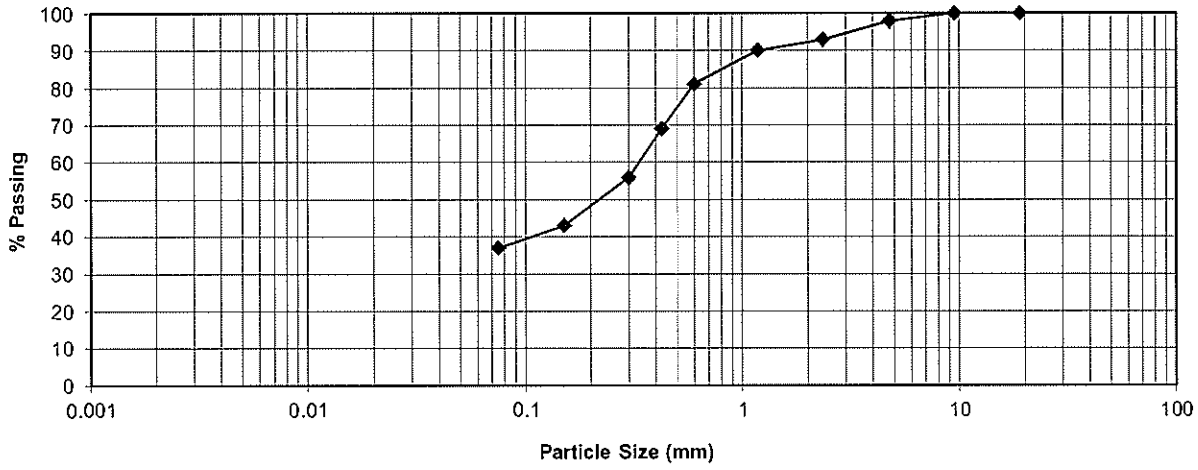
AS PSDPI May 2009

Particle Size Distribution & Plasticity Index tests

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Geotest Pty Ltd
unit1/1 Pusey Road, Jandakot, WA 6164
Ph (08) 9414 8022 Fax (08) 9414 8011
Email: kevin@mcgeotest.com.au

Job No:	60083
Report No:	60083-P11/3411
Sample No:	P11/3411
Issue Date:	26 October 2011

Client:	Galt Geotechnics	Sample location:	TP 14
Project:	Wave Engineering Pty Ltd	Depth:	1.0 - 1.5
Location:	Residential Development, Bishop Road		



SIEVE ANALYSIS AS 1289.3.6.1

Sieve Size (mm)	% Passing
75.0	
37.5	
19.0	100
9.5	100
4.75	98
2.36	93
1.18	90
0.600	81
0.425	69
0.300	56
0.150	43
0.075	37

Plasticity index tests		
AS 1289		
Liquid limit 3.1.1	32	%
Plastic limit 3.2.1	13	%
Plasticity index 3.3.1	19	%
Linear shrinkage 3.4.1	6.5	%
Linear shrinkage		
Cracked	☐	
Curled	☑	

Client Address: 2/54 Flynn Street, Wembley WA

Sampling Procedure: Tested as received

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Mining & Civil Geotest Pty Ltd

Ph (08) 9414 8022 Fax (08) 9414 8011
Email kevin@mcgeotest.com.au
Unit 1/1 Pusey Road, JANDAKOT WA 6164

Determination of the Shrinkage Index of a Soil
Shrink Swell Index
AS 1289.7.1.1

		Job No:	60083
		Report No:	60083-P11/3411
		Date of issue:	26 October 2011
Client:	GALT Geotechnics	Date tested:	17 October 2011
Project:	Wave Engineering Pty Ltd	Tested by:	M van Herk
Location:	Residential Development, Bishop Road	Checked:	K M Jones
Test Pit:	14, 1.0 - 1.5m	Sample No:	P11/3411

Sample details

Sample description : Brown Clayey Sand

Sample Type : 63 mm Ø tube sample

Swell Specimen		**Shrinkage Specimen**	
Dry Density - Initial (t/m^3)	1.82	Moisture Content Initial (%)	16.3
Moisture Content - Initial (%)	16.6	Length/Diameter Ratio	1.6
Moisture Content - Final (%)	19.6	Extent of Crumbling	Nil
Overburden Pressure (kPa)	25	Extent of Cracking	Nil
Significant Inert Inclusions (%)	2		

Shrink-Swell Index

I_{ss} = **1.2** % Vertical strain per pF change in Total suction

Client address: 2/54 Flynn St, Wembley WA

Tested as received

Approved Signature

Kevin M Jones

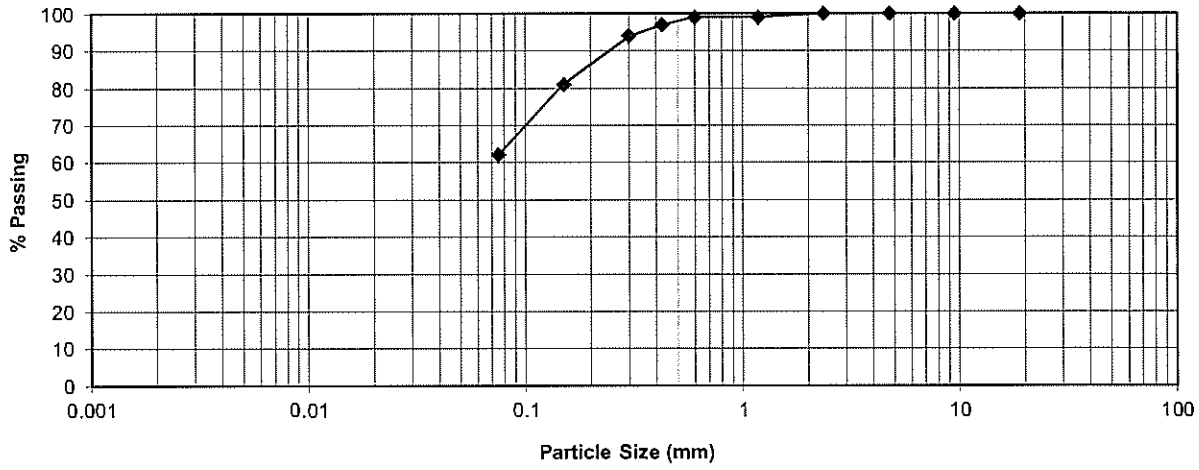
Particle Size Distribution & Plasticity Index tests

Mining & Civil
Geotest Pty Ltd
unit1/1 Pusey Road, Jandakot, WA 6164
Ph (08) 9414 8022 Fax (08) 9414 8011
Email: kevin@mcgeotest.com.au

Job No:	60083
Report No:	60083-P11/3412
Sample No:	P11/3412
Issue Date:	26 October 2011

Client: Galt Geotechnics
Project: Wave Engineering Pty Ltd
Location: Residential Development, Bishop Road

Sample location: TP 16
Depth: 0.5 - 1.0



SIEVE ANALYSIS AS 1289.3.6.1

Sieve Size (mm)	% Passing
75.0	
37.5	
19.0	100
9.5	100
4.75	100
2.36	100
1.18	99
0.600	99
0.425	97
0.300	94
0.150	81
0.075	62

Plasticity index tests
AS 1289

Liquid limit 3.1.1	46	%
Plastic limit 3.2.1	17	%
Plasticity index 3.3.1	29	%
Linear shrinkage 3.4.1	9.5	%
Linear shrinkage		
Cracked	☐	
Curled	☑	

Client Address: 2/54 Flynn Street, Wembley WA

Sampling Procedure: Tested as received

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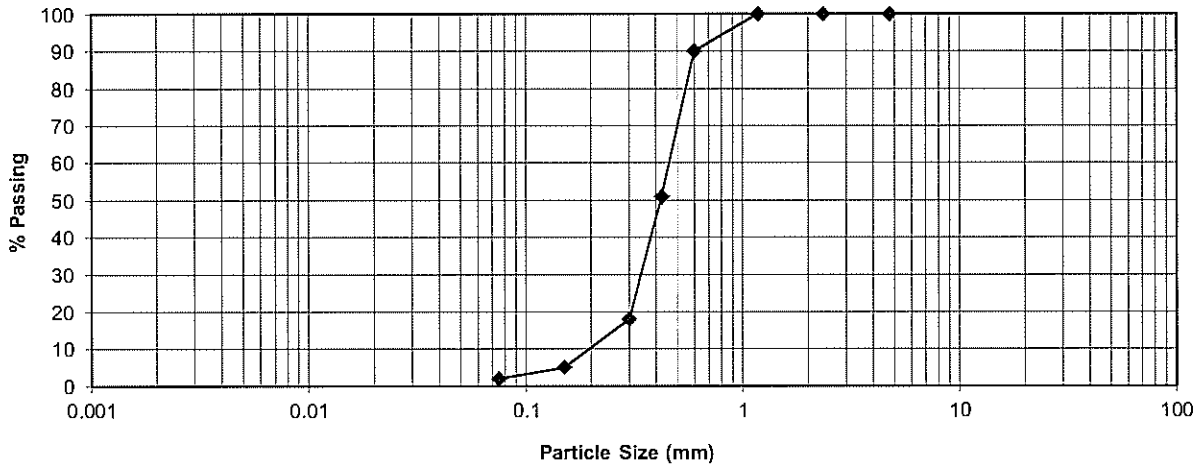
Kevin M Jones

Particle Size Distribution & Plasticity Index tests

Mining & Civil
Geotest Pty Ltd
unit1/1 Pusey Road, Jandakot, WA 6164
Ph (08) 9414 8022 Fax (08) 9414 8011
Email: kevin@mcgeotest.com.au

Job No:	60083
Report No:	60083-P11/3413
Sample No:	P11/3413
Issue Date:	26 October 2011

Client:	Galt Geotechnics	Sample location:	TP 17
Project:	Wave Engineering Pty Ltd	Depth:	0.5 - 1.0
Location:	Residential Development, Bishop Road		



SIEVE ANALYSIS AS 1289.3.6.1

Sieve Size (mm)	% Passing
75.0	
37.5	
19.0	
9.5	
4.75	100
2.36	100
1.18	100
0.600	90
0.425	51
0.300	18
0.150	5
0.075	2

Plasticity index tests
AS 1289

Liquid limit 3.1.1	na	%
Plastic limit 3.2.1		%
Plasticity index 3.3.1		%
Linear shrinkage 3.4.1		%
Linear shrinkage		
Cracked	☐	
Curled	☐	

Client Address: 2/54 Flynn Street, Wembley WA

Sampling Procedure: Tested as received

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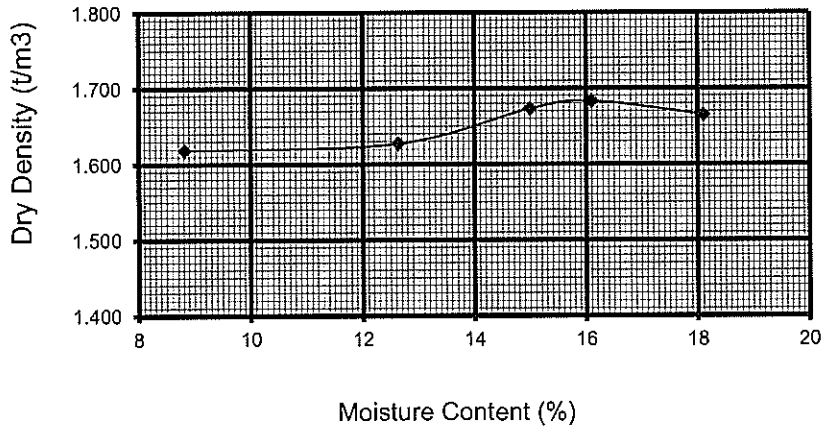
Mining &
Civil
Geotest Pty Ltd
Unit 1/1 Pusey Road, JANDAKOT WA 6164
Ph (08) 9414 8022
Fax (08)9414 8011
Email kevin@mcgeotest.com.au

Maximum Dry Density (AS 1289.5.2.1) & California Bearing Ratio (AS 1289.6.1.1) Test Report

Certificate No:	60083-P11/3413	**Sample No.:**	P11/3413
Client:	GALT Geotechnics	**Project:**	Wave Engineering Pty Ltd
Location:	Residential Development, Bishop Road	**Date of issue:**	26 October 2011
	TP 17, 0.5 - 1.0m	**Job No:**	60083

Maximum Dry Density t/m^3:	1.683	**Conditions at Test**	
Optimum Moisture Content %:	16.1	Soaking Period (Days)	4
Desired Conditions: %MDD / %OM	95/100	Surcharge (kg)	4.5
Compactive Effort		Entire Moisture Content %	18.1
Mass of hammer kg	4.9	Entire Moisture Ratio %	112.3
Number of layers	5	Top 30mm Moisture Content %	16.6
Number of blows/layer	16	Top 30mm Moisture Ratio %	103.7
Conditions after Compaction		Swell %	0.0
Dry Density t/m^3	1.599	C.B.R. at 5.0 mm Penetration %	17
Moisture Content %	15.9	**Conditions after Soaking**	
Density Ratio %	95.0	Dry Density t/m^3	1.599
Moisture Ratio %	98.8	Moisture Content %	18.4
Soaked / Unsoaked	Soaked	Dry Density Ratio %	95.0
		Moisture Ratio %	114.5

Comments: Tested as received



Client address: 2/54 Flynn St, Wembley WA

ASMDD-CBR June 2009

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Particle Size Distribution & Plasticity Index tests

Mining & Civil

Geotest Pty Ltd

unit1/1 Pusey Road, Jandakot, WA 6164

Ph (08) 9414 8022 Fax (08) 9414 8011

Email: kevin@mcgeotest.com.au

Job No:	60083
Report No:	60083-P11/3414
Sample No:	P11/3414
Issue Date:	26 October 2011

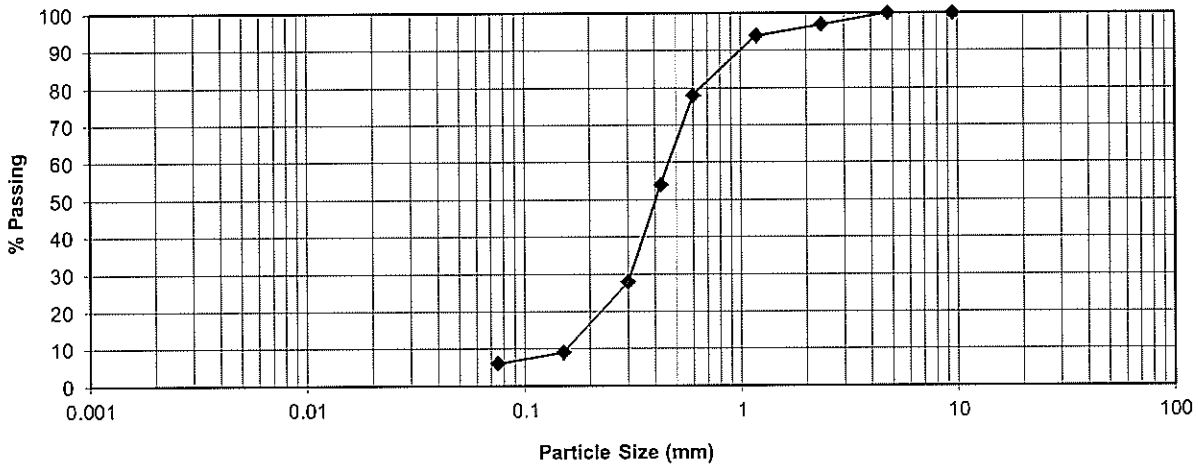
Client: Galt Geotechnics

Project: Wave Engineering Pty Ltd

Location: Residential Development, Bishop Road

Sample location: TP 21

Depth: 0.2 - 0.7



SIEVE ANALYSIS AS 1289.3.6.1

Sieve Size (mm)	% Passing
75.0	
37.5	
19.0	
9.5	100
4.75	100
2.36	97
1.18	94
0.600	78
0.425	54
0.300	28
0.150	9
0.075	6

Plasticity index tests

AS 1289

Liquid limit 3.1.1	na	%
Plastic limit 3.2.1		%
Plasticity index 3.3.1		%
Linear shrinkage 3.4.1		%
Linear shrinkage		
Cracked	☐	
Curled	☐	

Client Address: 2/54 Flynn Street, Wembley WA

Sampling Procedure: Tested as received

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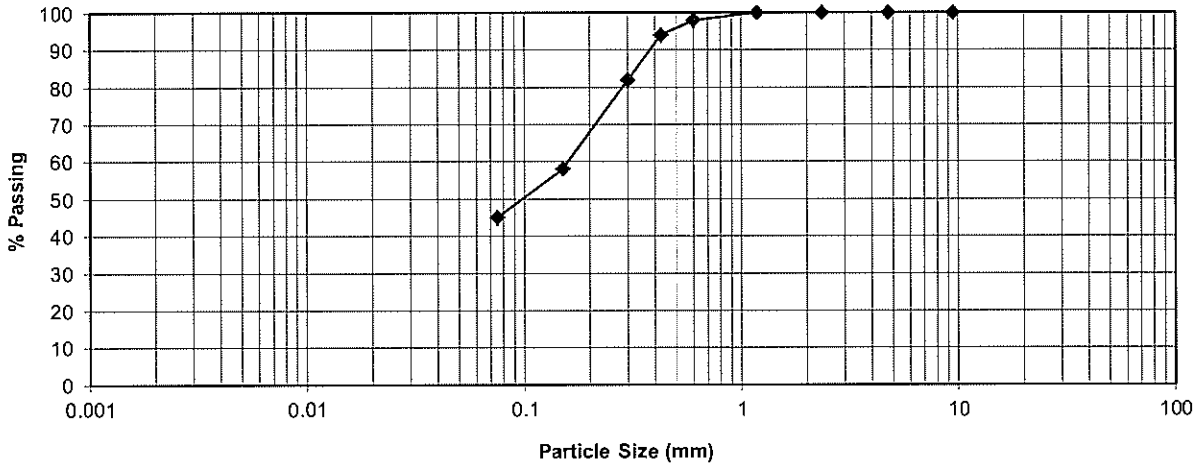
AS PSDPI May 2009

Particle Size Distribution & Plasticity Index tests

Mining & Civil
Geotest Pty Ltd
unit1/1 Pusey Road, Jandakot, WA 6164
Ph (08) 9414 8022 Fax (08) 9414 8011
Email: kevin@mcgeotest.com.au

Job No:	60083
Report No:	60083-P11/3415
Sample No:	P11/3415
Issue Date:	26 October 2011

Client:	Galt Geotechnics	Sample location:	TP 24
Project:	Wave Engineering Pty Ltd	Depth:	0.8 - 1.2
Location:	Residential Development, Bishop Road		



SIEVE ANALYSIS AS 1289.3.6.1

Sieve Size (mm)	% Passing
75.0	
37.5	
19.0	
9.5	100
4.75	100
2.36	100
1.18	100
0.600	98
0.425	94
0.300	82
0.150	58
0.075	45

Plasticity index tests		
AS 1289		
Liquid limit 3.1.1	40	%
Plastic limit 3.2.1	15	%
Plasticity index 3.3.1	25	%
Linear shrinkage 3.4.1	9.0	%
Linear shrinkage		
Cracked	☐	
Curled	☑	

Client Address: 2/54 Flynn Street, Wembley WA

Sampling Procedure: Tested as received

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AS PSDPI May 2009

APPENDIX G

Acid Sulfate Soil Screening Test Results

www.galtgeo.com.au
2/39 Flynn St, WEMBLEY WA 6014

ABN: 73 292 586 155

SUMMARY OF ACID SULFATE SOILS FIELD SCREENING TESTS

Job: Lots 37, 98 and 9000 Bishop Road, Mundijong
Job No: J1101128
By: HWC
Lab: ALS Laboratory Group

Date: 11/10/2011
Lab Batch No: EP1106948

Sample	Test Pit	Depth (m)	Material	pH_f	pH_{fox}	pH_f-pH_{fox}	Reaction	Prelim. Risk Rating
001	TP01	0.00-0.50		4.1	3.7	0.4	Slight	Low
002		0.50-1.00		4.9	4.7	0.2	Slight	Low
003	TP02	0.00-0.50		7.8	6.0	1.8	Slight	Low
004		0.50-1.00		7.8	5.9	1.9	Slight	Low
005		1.00-1.50		7.7	5.9	1.8	Slight	Low
006		1.50-2.00		7.8	5.9	1.9	Slight	Low
007		2.00-2.50		7.3	5.8	1.5	Slight	Low
008	TP05	0.00-0.50		6.5	5.6	0.9	Slight	Low
009		0.50-1.00		4.5	3.6	0.9	Slight	Low
010		1.00-1.50		4.7	4.5	0.2	Slight	Low
011	TP07	0.00-0.50		6.6	5.5	1.1	Slight	Low
012		0.50-1.00		6.8	5.5	1.3	Slight	Low
013		1.00-1.50		5.6	5.1	0.5	Slight	Low
014		1.50-2.00		5.2	4.4	0.8	Slight	Low
015		2.00-2.50		5.9	4.7	1.2	Slight	Low
016	TP09	0.00-0.50		4.4	3.5	0.9	Slight	Low
017		0.50-1.00		5.4	4.6	0.8	Slight	Low
018		1.00-1.50		6.3	5.2	1.1	Slight	Low
019		1.50-2.00		6.1	5.0	1.1	Slight	Low
020		2.00-2.50		6.1	4.9	1.2	Slight	Low
021	TP10	0.00-0.50		6.4	5.4	1.0	Slight	Low
022		0.50-1.00		6.8	5.6	1.2	Slight	Low
023		1.00-1.50		4.9	3.4	1.5	Slight	Low
024		1.50-2.00		5.2	3.2	2.0	Moderate	Low
025		2.00-2.50		5.3	4.1	1.2	Slight	Low
026	TP12	0.00-0.50		6.1	5.0	1.1	Slight	Low
027		0.50-1.00		7.0	5.4	1.6	Slight	Low
028		1.00-1.50		7.0	5.1	1.9	Slight	Low
029		1.50-2.00		6.8	5.1	1.7	Slight	Low
030	TP13	0.00-0.50		5.9	4.0	1.9	Slight	Low
031		0.50-1.00		6.0	4.4	1.6	Slight	Low
032		1.00-1.50		5.8	3.4	2.4	Moderate	Low
033		1.50-2.00		6.3	3.6	2.7	Moderate	Low
034	TP17	0.00-0.50		5.2	4.9	0.3	Slight	Low
035		0.50-1.00		5.6	4.6	1.0	Slight	Low
036		1.00-1.50		5.4	5.3	0.1	Slight	Low
037		1.50-2.00		5.3	5.4	-0.1	Slight	Low
038	TP20	0.00-0.50		6.2	4.6	1.6	Slight	Low
039		0.50-1.00		6.2	5.0	1.2	Extreme	Low
040		1.00-1.50		6.4	5.3	1.1	Slight	Low
041	TP23	0.00-0.50		5.1	4.5	0.6	Moderate	Low
042		0.50-1.00		6.0	5.6	0.4	Slight	Low
043		1.00-1.50		5.0	4.9	0.1	Slight	Low
044		1.50-2.00		5.9	5.6	0.3	Slight	Low
045	TP24	0.00-0.50		5.6	5.3	0.3	Slight	Low
046		0.50-1.00		6.2	5.8	0.4	Slight	Low
047		1.00-1.50		5.8	5.4	0.4	Slight	Low
048		1.50-2.00		6.1	5.6	0.5	Slight	Low
049	TP25	0.00-0.50		5.4	5.0	0.4	Slight	Low
050		0.50-1.00		6.6	5.6	1.0	Slight	Low
051		1.00-1.50		6.6	5.8	0.8	Slight	Low
052		1.50-2.00		6.3	5.4	0.9	Slight	Low
053		2.00-2.50		6.2	5.6	0.6	Slight	Low

Indicators	$pH_F \leq 4$	$pH_{FOX} < 3$	pH_F-$pH_{FOX} > 3$

ALS Laboratory Group
ANALYTICAL CHEMISTRY & TESTING SERVICES

Environmental Division

CERTIFICATE OF ANALYSIS

Work Order	: **EP1106948**	Page	: 1 of 13
Client	: **GALT GEOTECHNICS**	Laboratory	: Environmental Division Perth
Contact	: HARRY CHAMBERS	Contact	: Scott James
Address	: UNIT 2 54 FLYNN STREET WEMBLEY 6014	Address	: 10 Hod Way Malaga WA Australia 6090
E-mail	: harry.chambers@galtgeo.com.au	E-mail	: perth.enviro.services@alsglobal.com
Telephone	: 08 6272 0200	Telephone	: +61-8-9209 7655
Facsimile	: 08 9285 8444	Facsimile	: +61-8-9209 7600
Project	: J1101128 Residential Development- Bishop Road	QC Level	: NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Order number	: ----		
C-O-C number	: ----	Date Samples Received	: 10-OCT-2011
Sampler	: HWC	Issue Date	: 11-OCT-2011
Site	: ----		
		No. of samples received	: 53
Quote number	: ----	No. of samples analysed	: 53

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. All pages of this report have been checked and approved for release.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

NATA Accredited Laboratory 825

This document is issued in accordance with NATA accreditation requirements.

Accredited for compliance with ISO/IEC 17025.

Signatories

This document has been electronically signed by the authorized signatories indicated below. Electronic signing has been carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Leanne Cooper	Acid Sulfate Soils Supervisor	Perth ASS

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insuffient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting

- **ASS: EA037 (Rapid Field and F(ox) screening): pH F(ox) Reaction Rate: 1 - Slight; 2 - Moderate; 3 - Vigorous; 4 - Very Vigorous**

Analytical Results

Sub-Matrix: SOIL	Client sample ID	TP01 0.0-0.5	TP01 0.5-1.0	TP02 0.0-0.5	TP02 0.5-1.0	TP02 1.0-1.5
	Client sampling date / time	05-OCT-2011 15:00	05-OCT-2011 15:00	05-OCT-2011 15:00	05-OCT-2011 15:00	05-OCT-2011 15:00
Compound / CAS Number / LOR / Unit		EP1106948-001	EP1106948-002	EP1106948-003	EP1106948-004	EP1106948-005
EA037: Ass Field Screening Analysis						
pH (F)	---- 0.1 pH Unit	4.1	4.9	7.8	7.8	7.7
pH (Fox)	---- 0.1 pH Unit	3.7	4.7	6.0	5.9	5.9
Reaction Rate	---- 1 -	Slight	Slight	Slight	Slight	Slight

Analytical Results

Sub-Matrix: SOIL	Client sample ID	TP02 1.5-2.0	TP02 2.0-2.5	TP05 0.0-0.5	TP05 0.5-1.0	TP05 1.0-1.5
	Client sampling date / time	05-OCT-2011 15:00	05-OCT-2011 15:00	05-OCT-2011 15:00	05-OCT-2011 15:00	05-OCT-2011 15:00
Compound / CAS Number / LOR / Unit		EP1106948-006	EP1106948-007	EP1106948-008	EP1106948-009	EP1106948-010
EA037: Ass Field Screening Analysis						
pH (F) ---- 0.1 pH Unit		7.8	7.3	6.5	4.5	4.7
pH (Fox) ---- 0.1 pH Unit		5.9	5.8	5.6	3.6	4.5
Reaction Rate ---- 1 -		Slight	Slight	Slight	Slight	Slight

Analytical Results

Sub-Matrix: SOIL	Client sample ID	TP07 0.0-0.5	TP07 0.5-1.0	TP07 1.0-1.5	TP07 1.5-2.0	TP07 2.0-2.5
	Client sampling date / time	05-OCT-2011 15:00	05-OCT-2011 15:00	05-OCT-2011 15:00	05-OCT-2011 15:00	05-OCT-2011 15:00
Compound / CAS Number	LOR / Unit	EP1106948-011	EP1106948-012	EP1106948-013	EP1106948-014	EP1106948-015
EA037: Ass Field Screening Analysis						
pH (F) ----	0.1 pH Unit	6.6	6.8	5.6	5.2	5.9
pH (Fox) ----	0.1 pH Unit	5.5	5.5	5.1	4.4	4.7
Reaction Rate ----	1 -	Slight	Slight	Slight	Slight	Slight

Analytical Results

Sub-Matrix: SOIL			Client sample ID	TP09 0.0-0.5	TP09 0.5-1.0	TP09 1.0-1.5	TP09 1.5-2.0	TP09 2.0-2.5
			Client sampling date / time	06-OCT-2011 15:00	06-OCT-2011 15:00	06-OCT-2011 15:00	06-OCT-2011 15:00	06-OCT-2011 15:00
Compound	CAS Number	LOR	Unit	EP1106948-016	EP1106948-017	EP1106948-018	EP1106948-019	EP1106948-020
EA037: Ass Field Screening Analysis								
pH (F)	----	0.1	pH Unit	4.4	5.4	6.3	6.1	6.1
pH (Fox)	----	0.1	pH Unit	3.5	4.6	5.2	5.0	4.9
Reaction Rate	----	1	-	Slight	Slight	Slight	Slight	Slight

Analytical Results

Sub-Matrix: SOIL	Client sample ID	TP10 0.0-0.5	TP10 0.5-1.0	TP10 1.0-1.5	TP10 1.5-2.0	TP10 2.0-2.5
	Client sampling date / time	06-OCT-2011 15:00	06-OCT-2011 15:00	06-OCT-2011 15:00	06-OCT-2011 15:00	06-OCT-2011 15:00
Compound / CAS Number	LOR / Unit	EP1106948-021	EP1106948-022	EP1106948-023	EP1106948-024	EP1106948-025
EA037: Ass Field Screening Analysis						
pH (F) ----	0.1 pH Unit	6.4	6.8	4.9	5.2	5.3
pH (Fox) ----	0.1 pH Unit	5.4	5.6	3.4	3.2	4.1
Reaction Rate ----	1 -	Slight	Slight	Slight	Moderate	Slight

Analytical Results

Sub-Matrix: SOIL	Client sample ID	TP12 0.0-0.5	TP12 0.5-1.0	TP12 1.0-1.5	TP12 1.5-2.0	TP13 0.0-0.5
	Client sampling date / time	06-OCT-2011 15:00	06-OCT-2011 15:00	06-OCT-2011 15:00	06-OCT-2011 15:00	06-OCT-2011 15:00
Compound / CAS Number / LOR / Unit		EP1106948-026	EP1106948-027	EP1106948-028	EP1106948-029	EP1106948-030
EA037: Ass Field Screening Analysis						
pH (F) ---- 0.1 pH Unit		6.1	7.0	7.0	6.8	5.9
pH (Fox) ---- 0.1 pH Unit		5.0	5.4	5.1	5.1	4.0
Reaction Rate ---- 1 -		Slight	Slight	Slight	Slight	Slight

Analytical Results

Sub-Matrix: SOIL	Client sample ID	TP13 0.5-1.0	TP13 1.0-1.5	TP13 1.5-2.0	TP17 0.0-0.5	TP17 0.5-1.0
	Client sampling date / time	06-OCT-2011 15:00	06-OCT-2011 15:00	06-OCT-2011 15:00	06-OCT-2011 15:00	06-OCT-2011 15:00
Compound / CAS Number / LOR / Unit		EP1106948-031	EP1106948-032	EP1106948-033	EP1106948-034	EP1106948-035
EA037: Ass Field Screening Analysis						
pH (F) ---- 0.1 pH Unit		6.0	5.8	6.3	5.2	5.6
pH (Fox) ---- 0.1 pH Unit		4.4	3.4	3.6	4.9	4.6
Reaction Rate ---- 1 -		Slight	Moderate	Moderate	Slight	Slight

Analytical Results

Sub-Matrix: SOIL	Client sample ID	TP17 1.0-1.5	TP17 1.5-2.0	TP20 0.0-0.5	TP20 0.5-1.0	TP20 1.0-1.5
	Client sampling date / time	06-OCT-2011 15:00	06-OCT-2011 15:00	05-OCT-2011 15:00	05-OCT-2011 15:00	05-OCT-2011 15:00
Compound	CAS Number / LOR / Unit	EP1106948-036	EP1106948-037	EP1106948-038	EP1106948-039	EP1106948-040
EA037: Ass Field Screening Analysis						
pH (F)	---- / 0.1 / pH Unit	5.4	5.3	6.2	6.2	6.4
pH (Fox)	---- / 0.1 / pH Unit	5.3	5.4	4.6	5.0	5.3
Reaction Rate	---- / 1 / -	Slight	Slight	Slight	Extreme	Slight

Analytical Results

Sub-Matrix: **SOIL**

Compound	CAS Number	LOR	Unit	Client sample ID	TP23 0.0-0.5	TP23 0.5-1.0	TP23 1.0-1.5	TP23 1.5-2.0	TP24 0.0-0.5
				Client sampling date / time	05-OCT-2011 15:00	05-OCT-2011 15:00	05-OCT-2011 15:00	05-OCT-2011 15:00	05-OCT-2011 15:00
					EP1106948-041	EP1106948-042	EP1106948-043	EP1106948-044	EP1106948-045
EA037: Ass Field Screening Analysis									
pH (F)	----	0.1	pH Unit		5.1	6.0	5.0	5.9	5.6
pH (Fox)	----	0.1	pH Unit		4.5	5.6	4.9	5.6	5.3
Reaction Rate	----	1	-		Moderate	Slight	Slight	Slight	Slight

Analytical Results

Sub-Matrix: **SOIL**

Compound	CAS Number	LOR	Unit	Client sample ID	TP24 0.5-1.0	TP24 1.0-1.5	TP24 1.5-2.0	TP25 0.0-0.5	TP25 0.5-1.0
				Client sampling date / time	05-OCT-2011 15:00	05-OCT-2011 15:00	05-OCT-2011 15:00	05-OCT-2011 15:00	05-OCT-2011 15:00
					EP1106948-046	EP1106948-047	EP1106948-048	EP1106948-049	EP1106948-050
EA037: Ass Field Screening Analysis									
pH (F)	----	0.1	pH Unit		6.2	5.8	6.1	5.4	6.6
pH (Fox)	----	0.1	pH Unit		5.8	5.4	5.6	5.0	5.6
Reaction Rate	----	1	-		Slight	Slight	Slight	Slight	Slight

Analytical Results

Sub-Matrix: **SOIL**

Compound	CAS Number	LOR	Unit	Client sample ID	TP25 1.0-1.5	TP25 1.5-2.0	TP25 2.0-2.5	----	----
				Client sampling date / time	05-OCT-2011 15:00	05-OCT-2011 15:00	05-OCT-2011 15:00	----	----
					EP1106948-051	EP1106948-052	EP1106948-053	----	----
EA037: Ass Field Screening Analysis									
pH (F)	----	0.1	pH Unit		**6.6**	**6.3**	**6.2**	----	----
pH (Fox)	----	0.1	pH Unit		**5.8**	**5.4**	**5.6**	----	----
Reaction Rate	----	1	-		**Slight**	**Slight**	**Slight**	----	----

APPENDIX H

Understanding Your Geotechnical Engineering Report

www.galtgeo.com.au
2/39 Flynn St, WEMBLEY WA 6014

ABN: 73 292 586 155

UNDERSTANDING YOUR GEOTECHNICAL ENGINEERING REPORT

GALT FORM PMP11 Rev1

1. EXPECTATIONS OF A GEOTECHNICAL ENGINEERING REPORT

This document has been prepared to clarify what is and is not provided in your geotechnical report. It is intended to inform you of what your realistic expectations of this report should be and how to manage your risks associated with geotechnical conditions.

Geotechnical engineering is a less exact science than other engineering disciplines. We include this information to help you understand where our responsibilities as geotechnical engineers begin and end, to help the client recognise his responsibilities and risks. You should read and understand this information. Please contact us if you do not understand the report or this explanation. We have extensive experience in a wide variety of geotechnical problems and we can help you to manage your risk.

2. THIS REPORT RELATES TO PROJECT-SPECIFIC CONDITIONS

This report was developed for a unique set of project-specific conditions to meet the needs of the nominated client. It took into account the following :

- The project objectives as we understood them and as described in this report;
- the specific site mentioned in this report; and
- the current and proposed development at the site.

It should not be used for any purpose other than that indicated in the report. You should not rely on this geotechnical report if any of the following conditions apply:

- the report was not written for you;
- the report was not written for the site specific to your development;
- the report was not written for your project (including a development at the correct site but other than that listed in the report); or
- the report was written before significant changes occurred at the site (such as a development or a change in ground conditions).

You should always inform us of changes in the proposed project (including minor changes) and request an assessment of their impact.

Where we are not informed of developments relevant to your geotechnical engineering report, we cannot be held responsible or liable for problems that may arise as a consequence.

Where design is to be carried out by others using information provided by us, we recommend that we be involved in the design process by being engaged for consultation with other members of the design team and by being able to review work produced by other members of the design team which relies on geotechnical information provided in our report.

3. GEOTECHNICAL ENGINEERING LOGS

Our reports often include logs of intrusive and non-intrusive geotechnical investigation techniques. These logs are based on our interpretation of field data and laboratory results. The logs should only be read in conjunction with the report they were issued with and should not be re-drawn for inclusion in other documents not prepared by us.

4. THIRD PARTY RELIANCE

We have prepared this report for use by the client. This report must be regarded as confidential to the client and the client's professional advisors. We do not accept any responsibility for contents of this document from any party other than the nominated client. We take no responsibility for any damages suffered by a third party as a consequence of any decisions or actions they may make based on this report. Any reliance or decisions made by a third party based on this report are the responsibility of the third party and not of us.

5. CHANGE IN SUBSURFACE CONDITIONS

The geotechnical recommendations in this report are based on the ground conditions that existed at the time when the study was undertaken. Changes in ground conditions can occur in numerous ways including as a result of anthropogenic events (such as construction on or adjacent to the site) or natural events (such as floods, groundwater fluctuations or earthquakes). We should be consulted prior to use of this report so that we can comment on its reliability. It is important to note that where ground conditions have changed, additional sampling, testing or analysis may be required to fully assess the changed conditions.

6. SUBSURFACE CONDITIONS DURING CONSTRUCTION

Practical constraints mean that we cannot know every minute detail about the subsurface conditions at a particular site. We use engineering judgement to form an opinion about the subsurface conditions at the site. Some variation to our evaluated conditions is likely and significant variation is possible. Accordingly, our report should not be considered as final as it is developed from engineering judgement and opinion.

The most effective means of dealing with unanticipated ground conditions is to engage us for construction support. We can only finalise our recommendations by observing actual subsurface conditions encountered during construction. We cannot accept liability for a report's recommendations if we cannot observe construction.

7. ENVIRONMENTAL ISSUES

Unless specifically mentioned otherwise in our report, environmental considerations are not included. The investigation techniques used by us in developing our report differ from those for an environmental investigation. Our report was not prepared with environmental considerations in mind and it is the client's responsibility to satisfy himself that environmental considerations have been taken into account for the site. If you require guidance on how to proceed on evaluating environmental risk at the site, we can provide further information and contacts.

APPENDIX B - Environmental workplans and data

N

0 10 20 30 40 50m

SCALE 1 : 1 500 at A3 (MGA)

Legend

- Site Boundary
- Cadastral Boundary
- Topographic Contour
- Manjedal Brook - Top of Bank
- 50m Buffer from Top of Bank
- Conservation Category Wetland
- 50m Wetland Buffer
- 7835 Wetland UFI

404 600mE
404 700mE
404 800mE
404 900mE
405 000mE
6 428 400mN
6 428 300mN
6 428 200mN
40
7835
15446
Manjedal Brook
ROAD
SOLDIERS

BASE SOURCE: Taylor Burrell Barnett.
WETLANDS SOURCE: DEC, March 2011.
AERIAL PHOTOGRAPH SOURCE: Taylor Burrell Barnett.
MANJEDAL BROOK SURVEY SOURCE: Whelans, Plan 11395-006, 04-11-11.

pgv ENVIRONMENTAL

Peet Limited
MUNDIJONG

Drawn: B. Heath	Date: 8 Nov 2011
Job: 10054	Revision: A

AERIAL PHOTOGRAPH WITH CONSERVATION CATEGORY WETLAND AND BUFFERS

Workplan 1

10054-wkpln01.dgn

PINPOINT CARTOGRAPHICS (08) 9562 7136

404 000mE
404 100mE
404 200mE
404 300mE
6 428 500mN
6 428 400mN
6 428 300mN
101
LANG
ROAD
Manjedal
Brook
15446
35

N

0 10 20 30 40 50m

SCALE 1 : 1 250 at A3 (MGA)

Legend

- Site Boundary
- Cadastral Boundary
- Topographic Contour
- Manjedal Brook - Top of Bank
- 50m Buffer from Top of Bank
- Conservation Category Wetland
- 50m Wetland Buffer
- **7835** Wetland UFI

BASE SOURCE: Taylor Burrell Barnett.
WETLANDS SOURCE: DEC, March 2011.
AERIAL PHOTOGRAPH SOURCE: Taylor Burrell Barnett.
MANJEDAL BROOK SURVEY SOURCE: Whelans, Plan 11395-006, 04-11-11.

pgv ENVIRONMENTAL

Peet Limited
MUNDIJONG

Drawn: B. Heath	Date: 8 Nov 2011
Job: 10054	Revision: A

AERIAL PHOTOGRAPH WITH CONSERVATION CATEGORY WETLAND AND BUFFERS

Workplan 2

10054-wkpln02.dgn

PINPOINT CARTOGRAPHICS (08) 9562 7136

6 428 700mN
6 428 600mN
6 428 500mN
6 428 400mN
403 500mE
403 600mE
403 700mE
403 800mE
403 900mE
Manjedal
14945
TAYLOR
ROAD
Brook
15446
30

N

0 10 20 30 40 50m

SCALE 1 : 1 250 at A3 (MGA)

Legend

- Site Boundary
- Cadastral Boundary
- Topographic Contour
- Manjedal Brook - Top of Bank
- 50m Buffer from Top of Bank
- Conservation Category Wetland
- 50m Wetland Buffer
- 7835 Wetland UFI

BASE SOURCE: Taylor Burrell Barnett.
WETLANDS SOURCE: DEC, March 2011.
AERIAL PHOTOGRAPH SOURCE: Taylor Burrell Barnett.
MANJEDAL BROOK SURVEY SOURCE: Whelans, Plan 11395-006, 04-11-11.

10054-wkpln03.dgn

PINPOINT CARTOGRAPHICS (08) 9562 7136

pgv ENVIRONMENTAL

Peet Limited
MUNDIJONG

Drawn: B. Heath	Date: 8 Nov 2011
Job: 10054	Revision: A

AERIAL PHOTOGRAPH WITH CONSERVATION CATEGORY WETLAND AND BUFFERS

Workplan 3

N

0 10 20 30 40 50m

SCALE 1 : 1 250 at A3 (MGA)

Legend

- Site Boundary
- Cadastral Boundary
- Topographic Contour
- Manjedal Brook - Top of Bank
- 50m Buffer from Top of Bank
- Conservation Category Wetland
- 50m Wetland Buffer
- 7835 Wetland UFI

403 100mE
403 200mE
403 300mE
403 400mE
98
30
Brook
14945
Manjedal
6 428 500mN
6 428 400mN
30

BASE SOURCE: Taylor Burrell Barnett.
WETLANDS SOURCE: DEC, March 2011.
AERIAL PHOTOGRAPH SOURCE: Taylor Burrell Barnett.
MANJEDAL BROOK SURVEY SOURCE: Whelans, Plan 11395-006, 04-11-11.

pgv ENVIRONMENTAL

Peet Limited
MUNDIJONG

Drawn: B. Heath	Date: 8 Nov 2011
Job: 10054	Revision: A

AERIAL PHOTOGRAPH WITH CONSERVATION CATEGORY WETLAND AND BUFFERS

Workplan 4

10054-wkpln04.dgn

PINPOINT CARTOGRAPHICS (08) 9562 7136

N

0 50 100 150 200m

SCALE 1 : 6 000 at A3 (MGA)

Legend

- Site Boundary
- Cadastral Boundary
- Topographic Contour
- Manjedal Brook - Top of Bank
- 50m Buffer from Top of Bank
- Conservation Category Wetland
- 50m Wetland Buffer

BISHOP ROAD

ROAD

TAYLOR ROAD

LANG ROAD

SOLDIERS ROAD

Manjedal Brook

11

2

40

35

9000

98

30

98

101

6 428 500mN

6 428 000mN

403 000mE

403 500mE

404 000mE

404 500mE

405 000mE

BASE SOURCE: Taylor Burrell Barnett.
WETLANDS SOURCE: DEC, March 2011.
AERIAL PHOTOGRAPH SOURCE: Taylor Burrell Barnett.
MANJEDAL BROOK SURVEY SOURCE: Whelans, Plan 11395-006, 04-11-11.

10054-wkpln06.dgn

PINPOINT CARTOGRAPHICS (08) 9562 7136

pgv ENVIRONMENTAL

Peet Limited
MUNDIJONG

Drawn: B. Heath | Date: 8 Nov 2011

Job: 10054 | Revision: A

AERIAL PHOTOGRAPH WORKPLAN

Workplan 6

APPENDIX C - Pre-development groundwater monitoring data

TABLE 1
12 MONTH GROUNDWATER LEVEL MONITORING
July 2012 - June 2013
TAYLOR ROAD LAKE, MUNDIJONG
LOT 2 AND 9000 TAYLOR ROAD, MUNDIJONG

Sample ID	Date	Casing Stickup: Measured / **Surveyed** (m)	Depth to Water (mBTOC)	Depth to Base (mBTOC)	Top of Casing Survey Height (mAHD)	Ground Level Survey Height (mAHD)	Water Level (mAHD)
MW1	30-Jul-12	1.225	4.300	6.280	Not Provided		
	28-Aug-12		3.860	6.287			
	28-Sep-12		3.380	6.280			
	31-Oct-12		3.960	6.289			
	27-Nov-12		4.025	6.290			
	02-Jan-13		4.141	6.290			
	31-Jan-13		4.283	6.293			
	28-Feb-13		4.437	6.280			
	28-Mar-13		4.507	6.290			
	02-May-13		4.616	6.290			
	04-Jun-13		4.432	6.290			
	05-Jul-13		4.54*	6.336*			
MW2	30-Jul-12	0.970	2.225	5.863	Not Provided		
	28-Aug-12		2.034	5.865			
	28-Sep-12		1.898	5.860			
	31-Oct-12		2.144	5.868			
	27-Nov-12		2.226	5.870			
	02-Jan-13		2.405	5.868			
	31-Jan-13		2.650	5.845			
	28-Feb-13		2.920	5.815			
	28-Mar-13		3.026	5.819			
	02-May-13		3.195	5.845			
	04-Jun-13		2.860	5.830			
	05-Jul-13		2.832	5.807			
MB08	30-Jul-12	**0.520**	1.218	5.505	36.784	36.264	35.566
	28-Aug-12		0.852	5.511			35.932
	28-Sep-12		0.815	5.508			35.969
	31-Oct-12		1.052	5.516			35.732
	27-Nov-12		1.203	5.515			35.580
	02-Jan-13		1.435	5.521			35.350
	31-Jan-13		1.608	5.520			35.180
	28-Feb-13		1.910	5.510			34.870
	28-Mar-13		1.996	5.515			34.788
	02-May-13		2.102	5.519			34.790
	04-Jun-13		1.751	5.515			35.033
	05-Jul-13		1.809	5.513			34.975
MB10	30-Jul-12	**0.486**	1.439	5.487	35.998	35.512	34.559
	28-Aug-12		1.256	5.497			34.742
	28-Sep-12		1.145	5.490			34.853
	31-Oct-12		1.518	5.499			34.480
	27-Nov-12		1.614	5.499			34.380
	02-Jan-13		1.764	5.499			34.230
	31-Jan-13		1.926	5.505			34.070
	28-Feb-13		2.082	5.488			33.920
	28-Mar-13		2.086	5.500			33.910
	02-May-13		2.217	5.502			33.781
	04-Jun-13		1.815	5.499			34.183
	05-Jul-13		1.887	5.495			34.111

mBTOC = Metres Below Top Of Casing
mAHD = Metres Australian Height Datum

*Please note: MB01 was found slightly damaged on the final monitoring round (5 July 2013)

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BOREHOLE NUMBER MB 07

CLIENT Emerson Stewart **PROJECT NAME** Lot 37 Bishop Road

PROJECT NUMBER J08050 **PROJECT LOCATION** Mundijong

DATE STARTED 10/9/08 **COMPLETED** 10/9/08 **R.L. SURFACE** --- **DATUM** ---

DRILLING CONTRACTOR Ecoprobe **SLOPE** 0° **BEARING** ---

EQUIPMENT Geoprobe Rig **HOLE LOCATION** 404191.51E 6428381.37N

HOLE SIZE 100mm **LOGGED BY** DE **CHECKED BY** KB

NOTES

Method	Water	Well Details	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
				0.0			TOPSOIL: Medium, dark brown sand, moist		No odour, 3 attempts to bore in this area, 2 refusals due to gravelly concreted clayey sand at 1.5m
						SP	SAND: Medium, brown/yellow, moist		
				0.5					
				1.0					
				1.5					
				2.0					
				2.5		SC	CLAYEY SAND: Fine to medium, cemented, brown with gravel, wet		
				3.0					
				3.5			grey below 3.5m		
				4.0					
				4.5					
				5.0					

Borehole MB 07 terminated at 5m

BOREHOLE / TEST PIT MONITORING BORES.GPJ GINT AUSTRALIA.GDT 17/6/09

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BOREHOLE NUMBER MB 08

CLIENT Emerson Stewart **PROJECT NAME** Lot 37 Bishop Road

PROJECT NUMBER J08050 **PROJECT LOCATION** Mundijong

DATE STARTED 10/9/08 **COMPLETED** 10/9/08 **R.L. SURFACE** _____ **DATUM** _____

DRILLING CONTRACTOR Ecoprobe **SLOPE** 0° **BEARING** ---

EQUIPMENT Geoprobe Rig **HOLE LOCATION** 404610.40E 6428441.1N

HOLE SIZE 100mm **LOGGED BY** DE **CHECKED BY** KB

NOTES _____

Method	Water	Well Details	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
				0.5		SP	SAND: Coarse, grey, wet		Some odour
				1.0					
				1.5			medium below 1.4m		
				2.0					
				2.5		SC	CLAYEY SAND: Fine to medium, red/brown, moist		exposed laterite in adjacent swale (to the east) at similar depth, consistent with cemented layer.
							brown below 2.6m		
				3.0			Yellow/brown below 3.0m		
				3.5					
				4.0			grey below 4.0m		
				4.5					
				5.0					

Borehole MB 08 terminated at 5m

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BOREHOLE NUMBER MB 09

CLIENT Emerson Stewart **PROJECT NAME** Lot 37 Bishop Road

PROJECT NUMBER J08050 **PROJECT LOCATION** Mundijong

DATE STARTED 11/9/08 **COMPLETED** 11/9/08 **R.L. SURFACE** _____ **DATUM** _____

DRILLING CONTRACTOR Ecoprobe **SLOPE** 0° **BEARING** ---

EQUIPMENT Geoprobe Rig **HOLE LOCATION** 404182.44E 6428742.31N

HOLE SIZE 100mm **LOGGED BY** DE **CHECKED BY** KB

NOTES _____

Method	Water	Well Details	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
				0			TOPSOIL: Medium, brown sand, moist		no odour
						SP	SAND: Medium, grey/brown, moist		
				0.5					
				1.0					
				1.5			yellow/grey below 1.5m		
				2.0		SC	CLAYEY SAND: Fine to medium, red/brown, moist		Broken auger on first attempt, re drill 5 m north East.
				2.5					
				3.0					
				3.5			grey below 3.5m		
				4.0					
				4.5					
				5.0					

Borehole MB 09 terminated at 5m

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BOREHOLE NUMBER MB 10

CLIENT Emerson Stewart **PROJECT NAME** Lot 37 Bishop Road

PROJECT NUMBER J08050 **PROJECT LOCATION** Mundijong

DATE STARTED 11/9/08 **COMPLETED** 11/9/08 **R.L. SURFACE** _____ **DATUM** _____

DRILLING CONTRACTOR Ecoprobe **SLOPE** 0° **BEARING** ---

EQUIPMENT Geoprobe Rig **HOLE LOCATION** 404490.98E 6428911.35N

HOLE SIZE 100mm **LOGGED BY** DE **CHECKED BY** KB

NOTES _____

Method	Water	Well Details	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
				0.0		SP	TOPSOIL: Medium, dark brown sand, moist		no odour
						SP	SAND: Medium, grey, moist		
				0.5					
				1.0					
				1.5		SC	CLAYEY SAND: Fine to medium, grey, moist		
				2.0					
				2.5					
				3.0					
				3.5					
				4.0					
				4.5					
				5.0					

Borehole MB 10 terminated at 5m

BOREHOLE / TEST PIT MONITORING BORES.GPJ GINT AUSTRALIA.GDT 17/6/09

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BOREHOLE NUMBER MB 11

CLIENT Emerson Stewart **PROJECT NAME** Lot 37 Bishop Road

PROJECT NUMBER J08050 **PROJECT LOCATION** Mundijong

DATE STARTED 11/9/08 **COMPLETED** 11/9/08 **R.L. SURFACE** _____ **DATUM** _____

DRILLING CONTRACTOR Ecoprobe **SLOPE** 0° **BEARING** ---

EQUIPMENT Geoprobe Rig **HOLE LOCATION** 404142.31E 6428913.47N

HOLE SIZE 100mm **LOGGED BY** DE **CHECKED BY** KB

NOTES _____

Method	Water	Well Details	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
				0.0		SP	TOPSOIL: Medium, brown/grey sand, moist		no odour
						SP	SAND: Medium, grey, moist		
				0.5					
				1.0		SC	CLAYEY SAND: Medium, yellow/grey, wet		
				1.5					
				2.0			grey below 2.0m		
				2.5					
				3.0					
				3.5					
				4.0					
				4.5					
				5.0					

Borehole MB 11 terminated at 5m

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BOREHOLE NUMBER MB 12

CLIENT Emerson Stewart **PROJECT NAME** Lot 37 Bishop Road

PROJECT NUMBER J08050 **PROJECT LOCATION** Mundijong

DATE STARTED 10/9/08 **COMPLETED** 10/9/08 **R.L. SURFACE** _____ **DATUM** _____

DRILLING CONTRACTOR Ecoprobe **SLOPE** 0° **BEARING** ---

EQUIPMENT Geoprobe Rig **HOLE LOCATION** 403068.11E 6428163.26N

HOLE SIZE 100mm **LOGGED BY** DE **CHECKED BY** KB

NOTES _____

Method	Water	Well Details	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
				0.0		SP	TOPSOIL: Medium, grey sand, moist		no odour
						SP	SAND: Medium, grey/yellow, moist		
				0.5					
				1.0					
				1.5			yellow below 1.5m		
				2.0					
				2.5		SC	CLAYEY SAND: Medium, yellow, wet		
				3.0			grey below 3.0m		
				3.5					
				4.0					
				4.5					
				5.0					

Borehole MB 12 terminated at 5m

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BOREHOLE NUMBER MB 13

CLIENT Emerson Stewart **PROJECT NAME** Lot 37 Bishop Road

PROJECT NUMBER J08050 **PROJECT LOCATION** Mundijong

DATE STARTED 8/9/08 **COMPLETED** 8/9/08 **R.L. SURFACE** _____ **DATUM** _____

DRILLING CONTRACTOR Ecoprobe **SLOPE** 0° **BEARING** ---

EQUIPMENT Geoprobe Rig **HOLE LOCATION** 403608.05E 6428331.27N

HOLE SIZE 100mm **LOGGED BY** DE **CHECKED BY** KB

NOTES _____

Method	Water	Well Details	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
				0.0		SP	TOPSOIL: Medium, brown, moist		no odour
						SC	CLAYEY SAND: Medium, grey/brown, moist		
				0.5					
				1.0			wet below 1.0m		
				1.5					
				2.0			grey below 2.2m		
				2.5					
				3.0					
				3.5					
				4.0					
				4.5					
				5.0					

Borehole MB 13 terminated at 5m

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BOREHOLE NUMBER MB 14

CLIENT Emerson Stewart **PROJECT NAME** Lot 37 Bishop Road

PROJECT NUMBER J08050 **PROJECT LOCATION** Mundijong

DATE STARTED 10/9/08 **COMPLETED** 10/9/08 **R.L. SURFACE** _____ **DATUM** _____

DRILLING CONTRACTOR Ecoprobe **SLOPE** 0° **BEARING** ---

EQUIPMENT Geoprobe Rig **HOLE LOCATION** 403355.10E 6428419.60N

HOLE SIZE 100mm **LOGGED BY** DE **CHECKED BY** KB

NOTES _____

Method	Water	Well Details	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
				0		SP	TOPSOIL: Medium, brown, moist		no odour
						SP	SAND: Medium, grey, moist		
				0.5					
				1.0			grey/brown below 1.0m		
				1.5					
				2.0					
						SC	CLAYEY SAND: Medium, grey, moist		
				2.5					
				3.0					
				3.5					
				4.0					
				4.5					
				5.0					

Borehole MB 14 terminated at 5m

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Brown Geotechnical and Environmental
Suite 4, 47 Monash Avenue
Como, WA 6152
Telephone: 9358 2615
Fax: 9367 7409

BOREHOLE NUMBER MB 15

CLIENT Emerson Stewart **PROJECT NAME** Lot 37 Bishop Road

PROJECT NUMBER J08050 **PROJECT LOCATION** Mundijong

DATE STARTED 11/9/08 **COMPLETED** 11/9/08 **R.L. SURFACE** _____ **DATUM** _____

DRILLING CONTRACTOR Ecoprobe **SLOPE** 0° **BEARING** ---

EQUIPMENT Geoprobe Rig **HOLE LOCATION** 403219.30E 6428599.65N

HOLE SIZE 100mm **LOGGED BY** DE **CHECKED BY** KB

NOTES _____

Method	Water	Well Details	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
				0.0		SP	TOPSOIL: Medium, yellow/brown sand, moist		no odour
						SP	SAND: Medium, yellow/brown, moist		
				0.5					
				1.0					
						SC	CLAYEY SAND: Medium, brown, moist		
				1.5					
				2.0					
				2.5					Laterite (exposed in nearby creek) hole re- drilled twice.
				3.0					
				3.5			grey and saturated below 3.5m		
				4.0					
				4.5					
				5.0					

Borehole MB 15 terminated at 5m

BOREHOLE / TEST PIT MONITORING BORES.GPJ GINT AUSTRALIA.GDT 17/6/09

BGE
Brown Geotechnical and Environmental
Suite 4, 47 Monash Avenue
Como, WA 6152
Telephone: 9358 2615
Fax: 9367 7409

BOREHOLE NUMBER MB 16

CLIENT Emerson Stewart **PROJECT NAME** Lot 37 Bishop Road

PROJECT NUMBER J08050 **PROJECT LOCATION** Mundijong

DATE STARTED 10/9/08 **COMPLETED** 10/9/08 **R.L. SURFACE** _____ **DATUM** _____

DRILLING CONTRACTOR Ecoprobe **SLOPE** 0° **BEARING** ---

EQUIPMENT Geoprobe Rig **HOLE LOCATION** 403712.62E 6428671.07N

HOLE SIZE 100mm **LOGGED BY** DE **CHECKED BY** KB

NOTES _____

Method	Water	Well Details	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
				0.0		SP	TOPSOIL: Medium, yellow brown/ sand, moist		no odour
						SP	SAND: Medium, yellow/brown, moist		
				0.5					
				1.0		SC	CLAYEY SAND: Medium, yellow/brown, moist		
				1.5					
				2.0					
				2.5			brown below 2.6m		
				3.0			yellow/brown below 3.2m		
				3.5					
				4.0			grey below 4.0m		
				4.5					
				5.0					

Borehole MB 16 terminated at 5m

BOREHOLE / TEST PIT MONITORING BORES.GPJ GINT AUSTRALIA.GDT 17/6/09

BGE
Brown Geotechnical and Environmental
Suite 4, 47 Monash Avenue
Como, WA 6152
Telephone: 9358 2615
Fax: 9367 7409

BOREHOLE NUMBER MB 17

CLIENT Emerson Stewart **PROJECT NAME** Lot 37 Bishop Road

PROJECT NUMBER J08050 **PROJECT LOCATION** Mundijong

DATE STARTED 11/9/08 **COMPLETED** 11/9/08 **R.L. SURFACE** _____ **DATUM** _____

DRILLING CONTRACTOR Ecoprobe **SLOPE** 0° **BEARING** ---

EQUIPMENT Geoprobe Rig **HOLE LOCATION** 403153.56E 6429022.50N

HOLE SIZE 100mm **LOGGED BY** DE **CHECKED BY** KB

NOTES _____

Method	Water	Well Details	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
				0		SP	TOPSOIL: Medium, brown/grey sand, moist		no odour
						SP	SAND: Medium, grey, moist		
				0.5					
				1.0					
									Rocky layey - laterite. Hole redirlled 4 times
				1.5			brown below 1.6m		
				2.0					
						SC	CLAYEY SAND: Medium, brown, moist		
				2.5					
				3.0					
				3.5			grey below 3.5m		
				4.0					
				4.5					
				5.0					

Borehole MB 17 terminated at 5m

BOREHOLE / TEST PIT MONITORING BORES.GPJ GINT AUSTRALIA.GDT 17/6/09

BGE
Brown Geotechnical and Environmental
Suite 4, 47 Monash Avenue
Como, WA 6152
Telephone: 9358 2615
Fax: 9367 7409

BOREHOLE NUMBER MB 18

CLIENT Emerson Stewart **PROJECT NAME** Lot 37 Bishop Road

PROJECT NUMBER J08050 **PROJECT LOCATION** Mundijong

DATE STARTED 11/9/08 **COMPLETED** 11/9/08 **R.L. SURFACE** _____ **DATUM** _____

DRILLING CONTRACTOR Ecoprobe **SLOPE** 0° **BEARING** ---

EQUIPMENT Geoprobe Rig **HOLE LOCATION** 402862.00E 6428797.58N

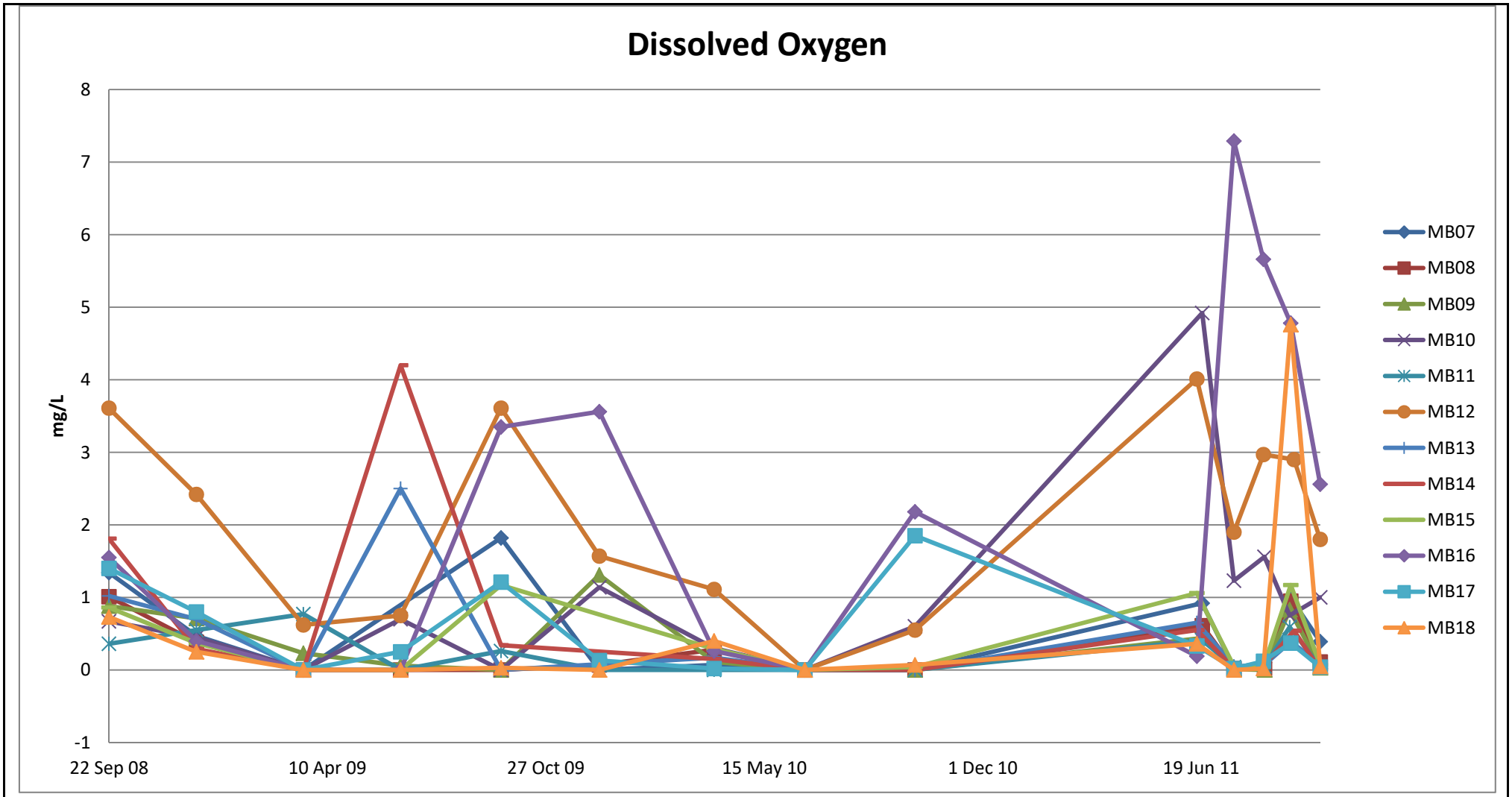
HOLE SIZE 100mm **LOGGED BY** DE **CHECKED BY** KB

NOTES _____

Method	Water	Well Details	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Samples Tests Remarks	Additional Observations
				0		SP	TOPSOIL: Medium, brown/grey sand, moist		no odour
						SP	SAND: Medium, brown, moist		
				0.5					
				1.0		SC	CLAYEY SAND: Medium, brown, moist		
				1.5					
				2.0					
				2.5			yellow/brown below 2.5m		
				3.0					
				3.5			grey below 3.5m		
				4.0					
				4.5					
				5.0					

Borehole MB 18 terminated at 5m

BOREHOLE / TEST PIT MONITORING BORES.GPJ GINT AUSTRALIA.GDT 17/6/09

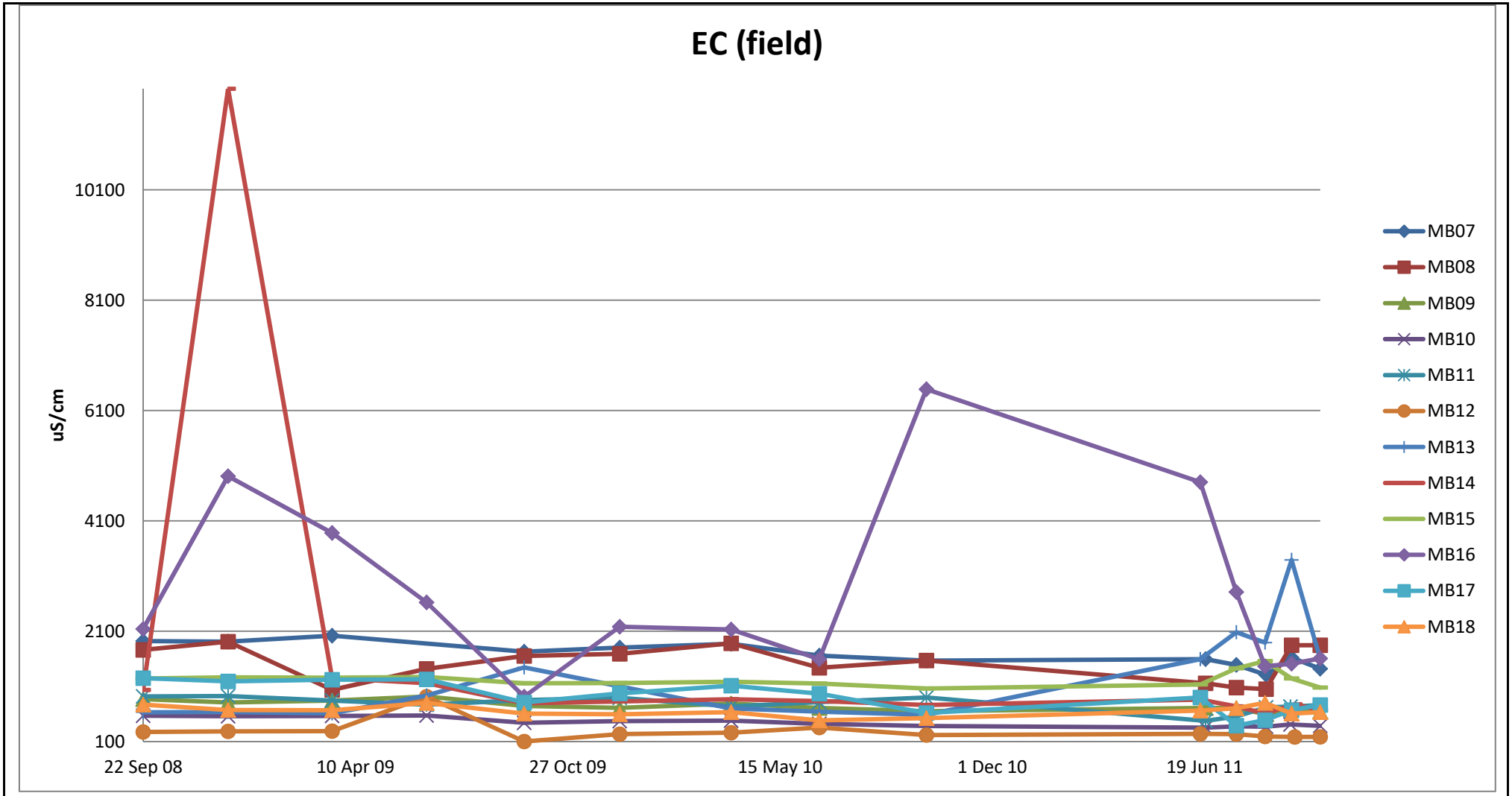


Figure

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Scale: nts	**Chk'd:**
Original:	**Rev:**
File Reference:	

[Project_Name], Where(WellCode In('MB07' , 'MB08' , 'MB09' , 'MB10' , 'MB11' , 'MB12' , 'MB13' , 'MB14' , 'MB15' , 'MB16' , 'MB17' , 'MB1

ESDAT

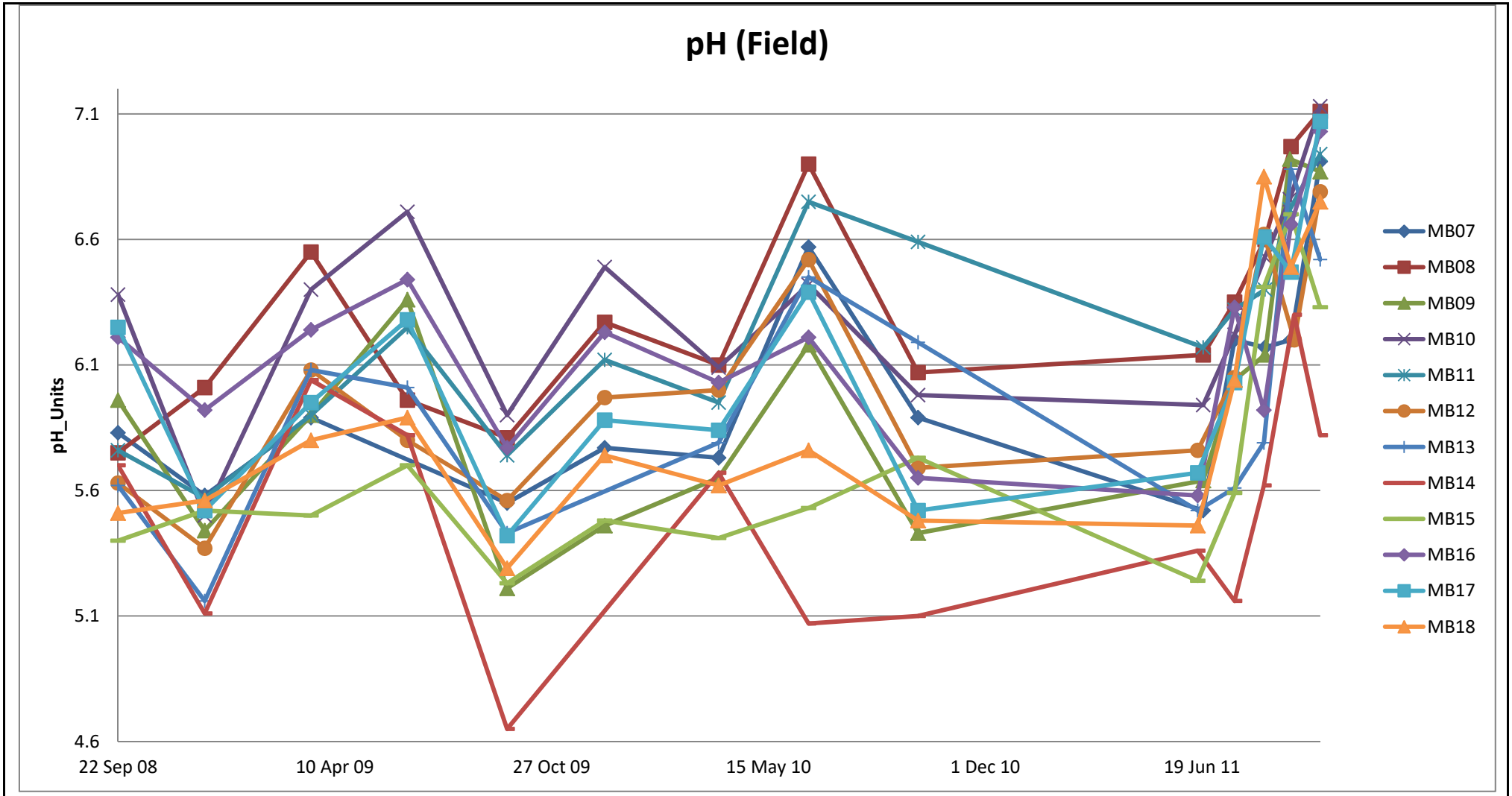


Figure

[Project_Name], Where(WellCode In('MB07' , 'MB08' , 'MB09' , 'MB10' , 'MB11' , 'MB12' , 'MB13' , 'MB14' , 'MB15' , 'MB16' , 'MB17' , 'MB1

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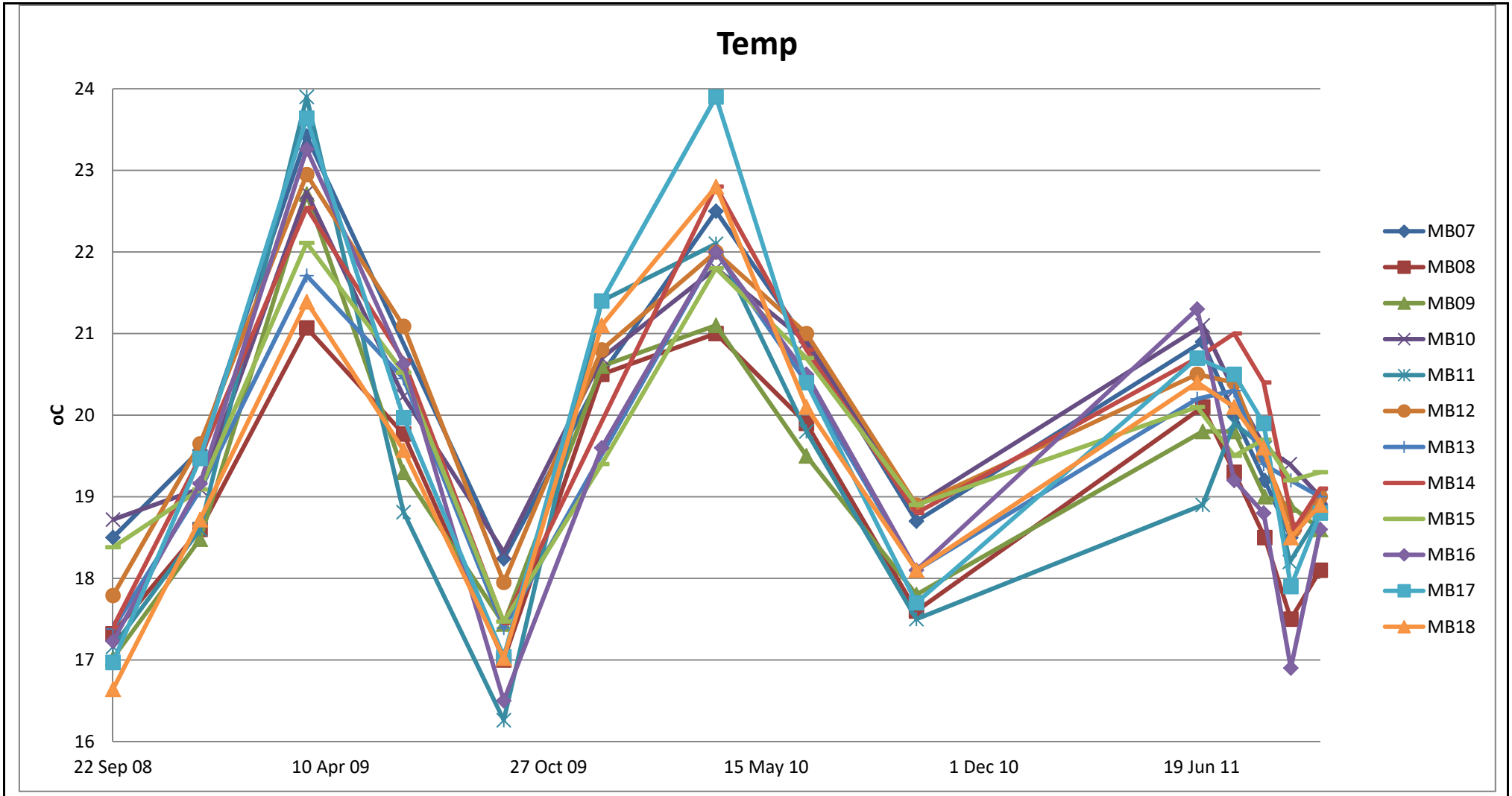


Figure

[Project_Name], Where(WellCode In('MB07' , 'MB08' , 'MB09' , 'MB10' , 'MB11' , 'MB12' , 'MB13' , 'MB14' , 'MB15' , 'MB16' , 'MB17' , 'MB1

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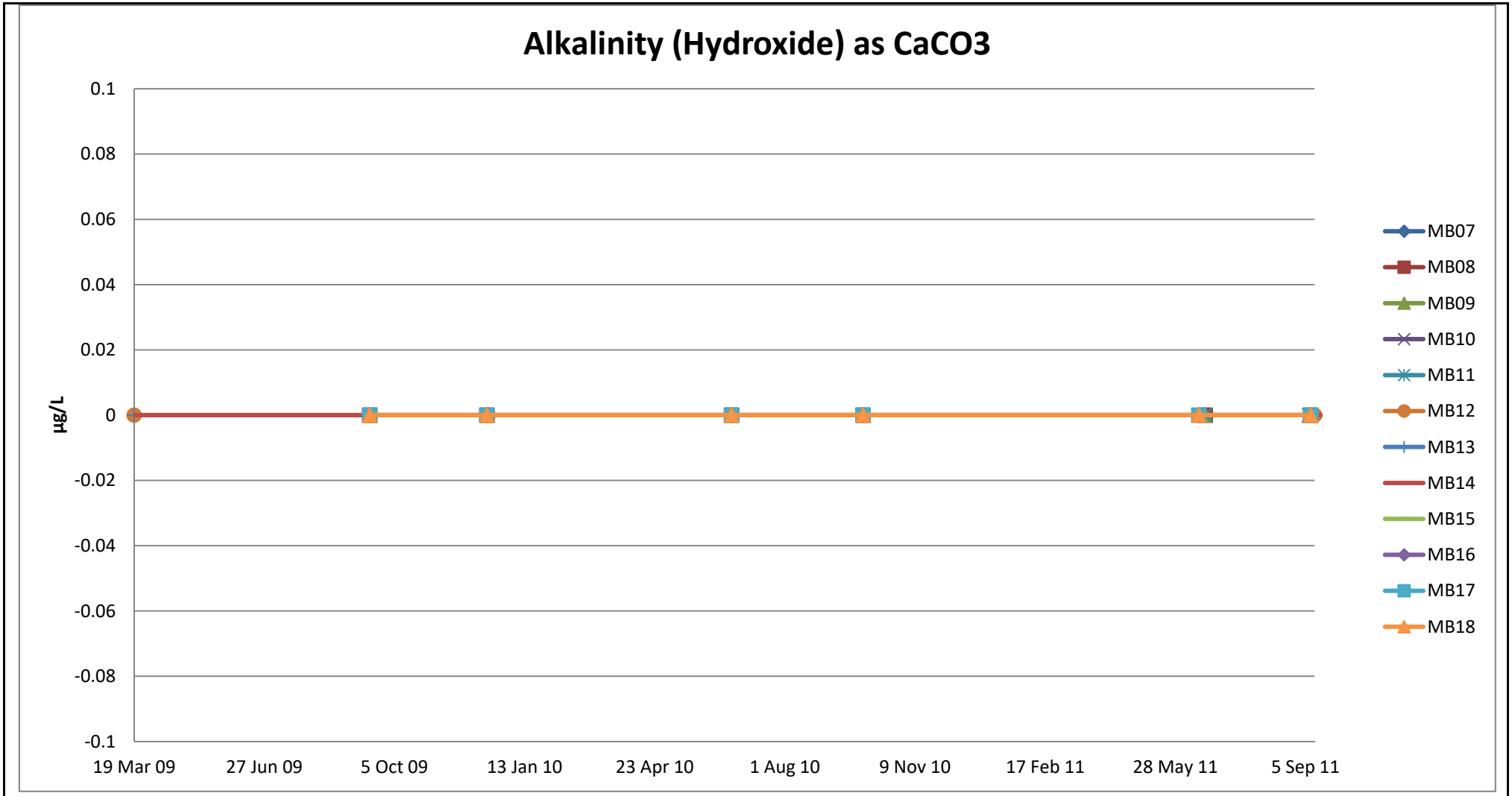


Figure

[Project_Name], Where(WellCode In('MB07' , 'MB08' , 'MB09' , 'MB10' , 'MB11' , 'MB12' , 'MB13' , 'MB14' , 'MB15' , 'MB16' , 'MB17' , 'MB1

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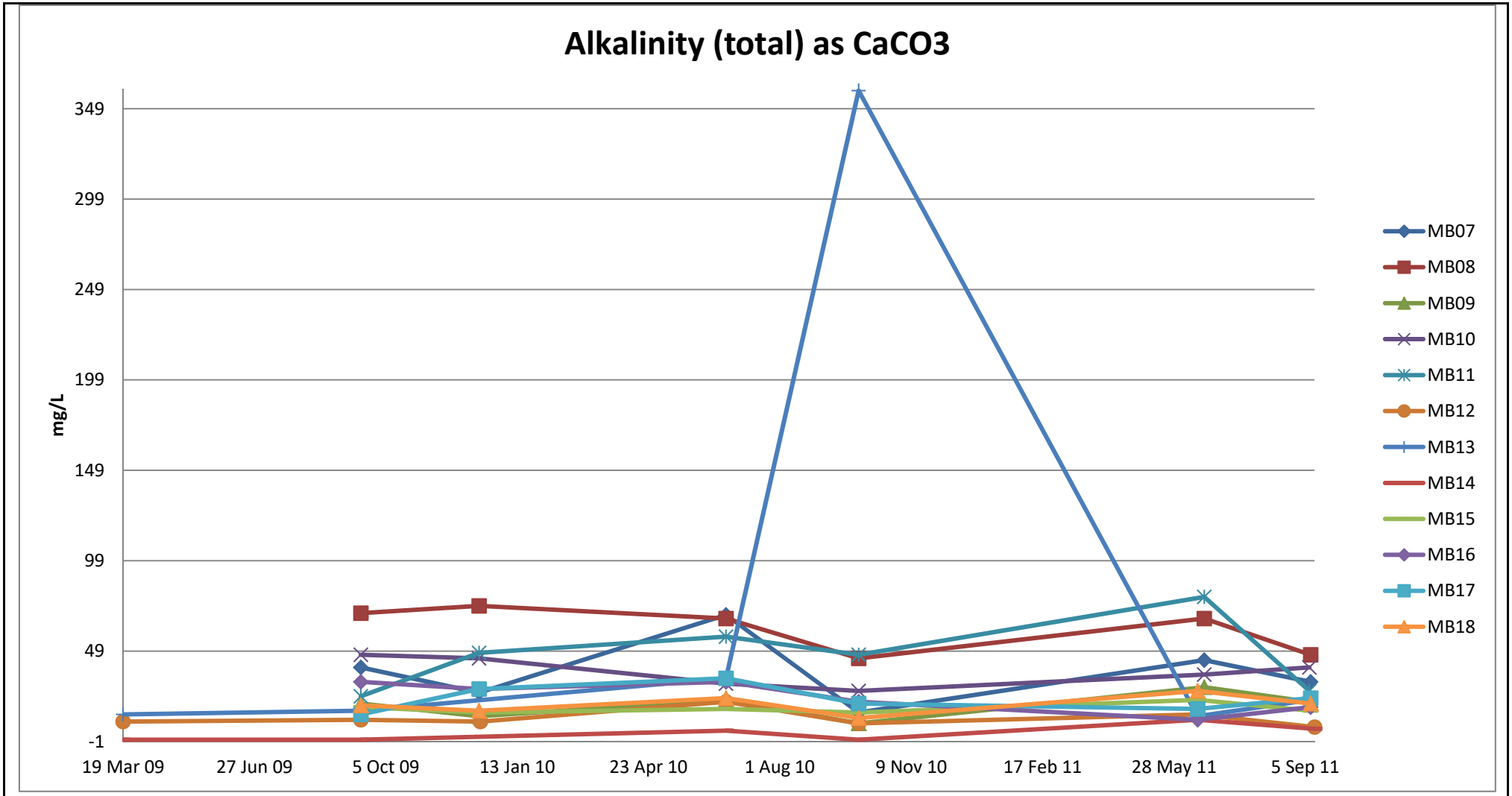


Figure

[Project_Name], Where(WellCode In('MB07' , 'MB08' , 'MB09' , 'MB10' , 'MB11' , 'MB12' , 'MB13' , 'MB14' , 'MB15' , 'MB16' , 'MB17' , 'MB1

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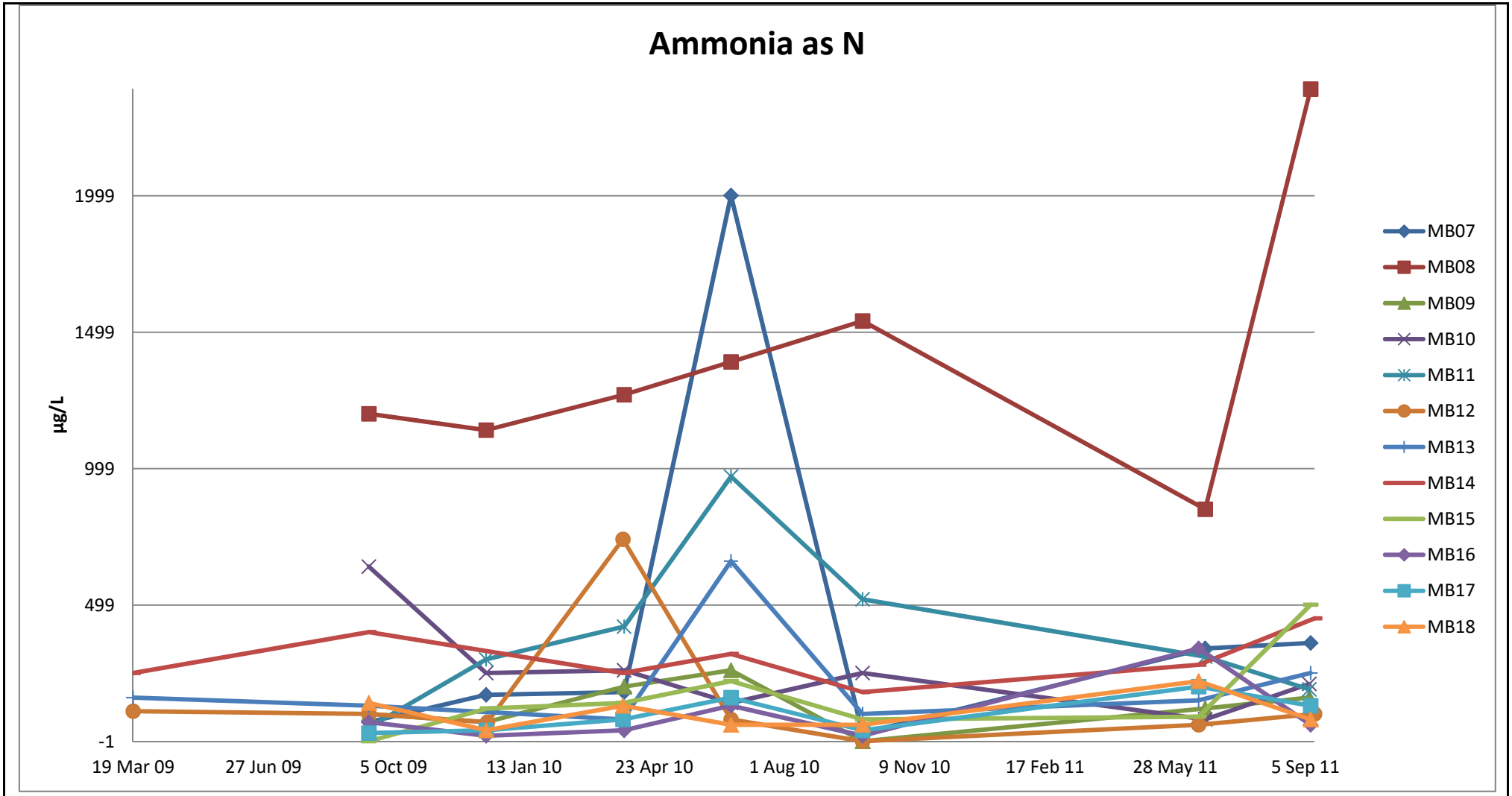


Figure

[Project_Name], Where(WellCode In('MB07' , 'MB08' , 'MB09' , 'MB10' , 'MB11' , 'MB12' , 'MB13' , 'MB14' , 'MB15' , 'MB16' , 'MB17' , 'MB1

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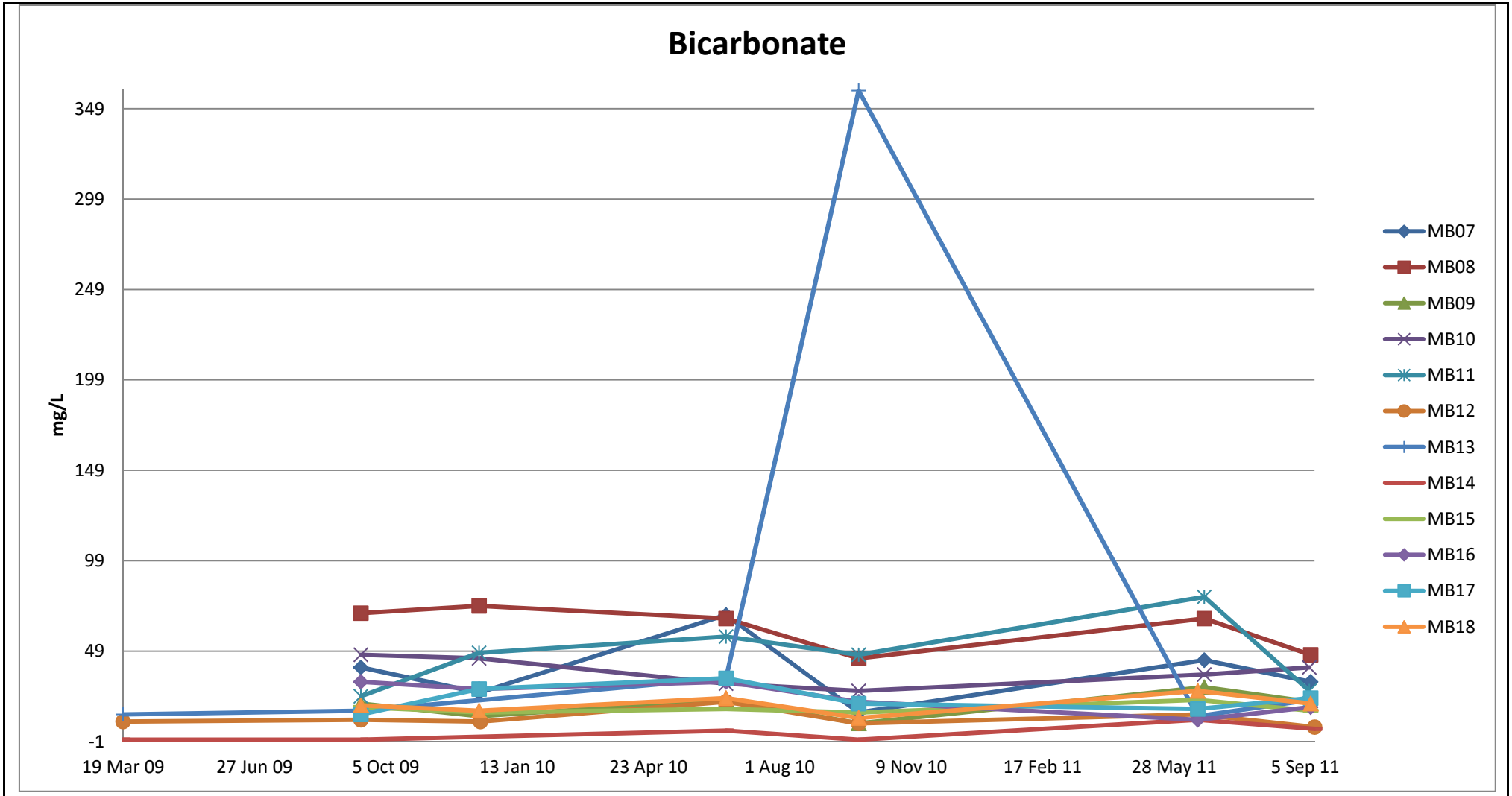


Figure

[Project_Name], Where(WellCode In('MB07' , 'MB08' , 'MB09' , 'MB10' , 'MB11' , 'MB12' , 'MB13' , 'MB14' , 'MB15' , 'MB16' , 'MB17' , 'MB1

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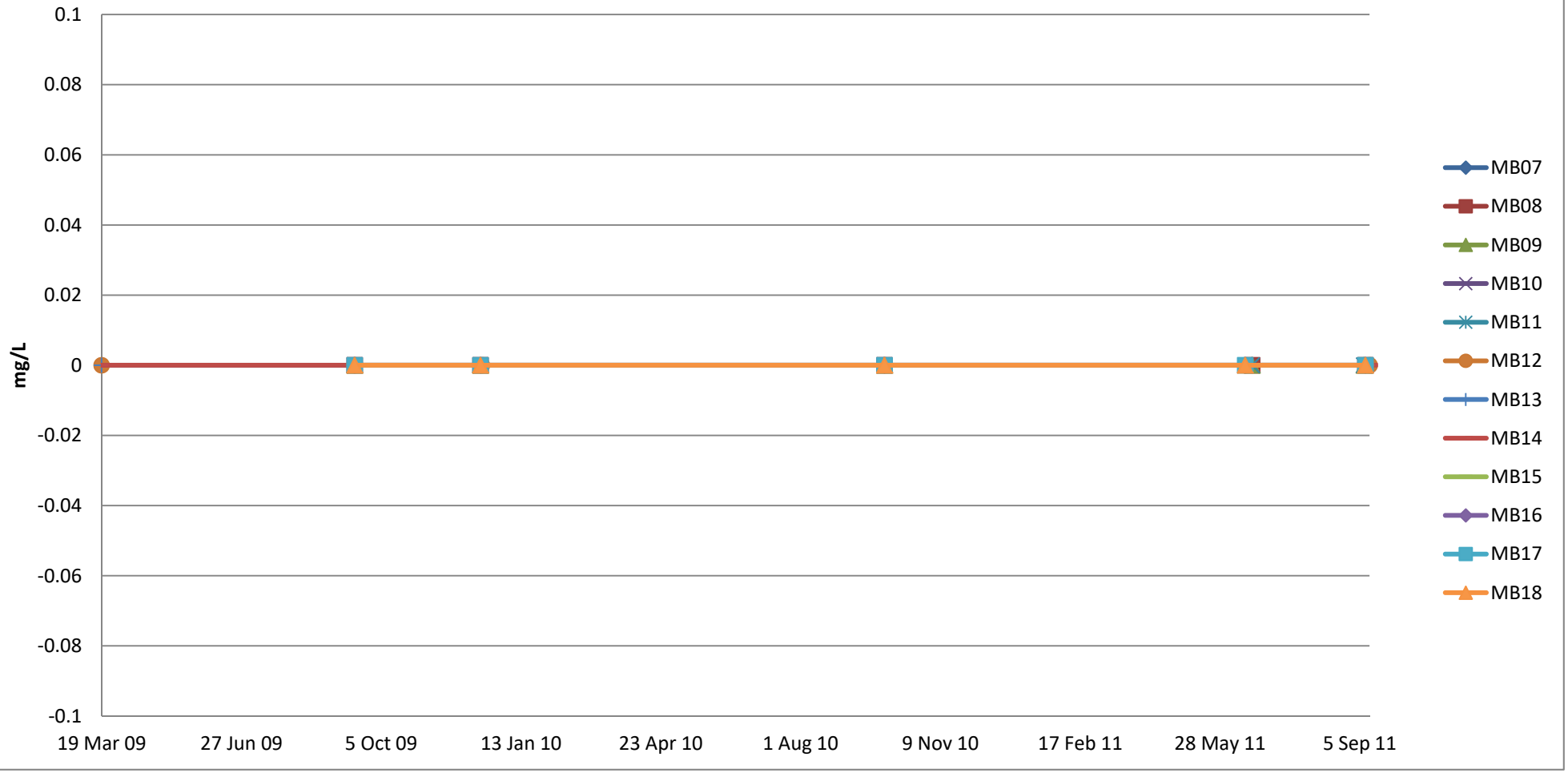
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Carbonate

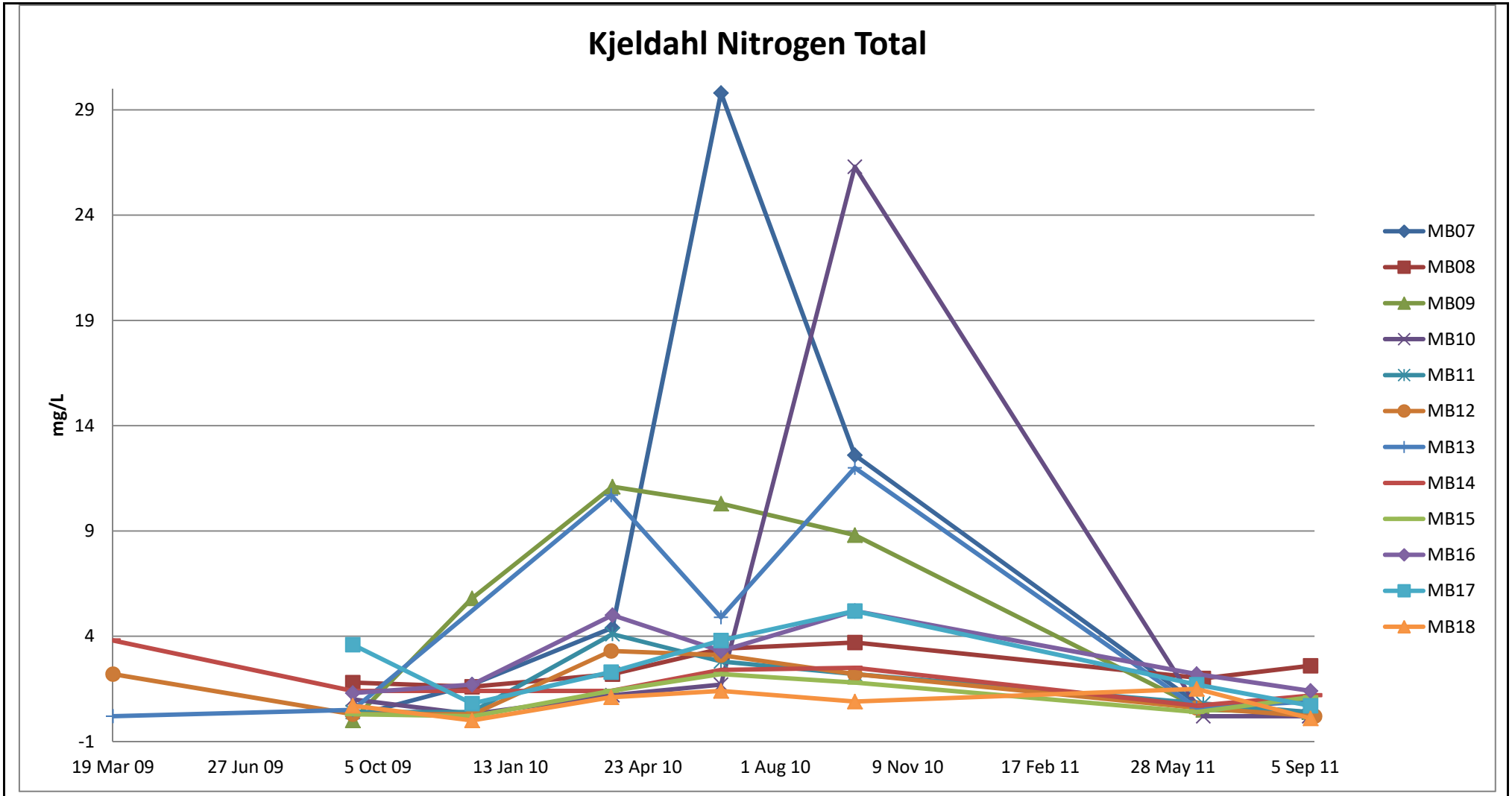


Figure

[Project_Name], Where(WellCode In('MB07' , 'MB08' , 'MB09' , 'MB10' , 'MB11' , 'MB12' , 'MB13' , 'MB14' , 'MB15' , 'MB16' , 'MB17' , 'MB1

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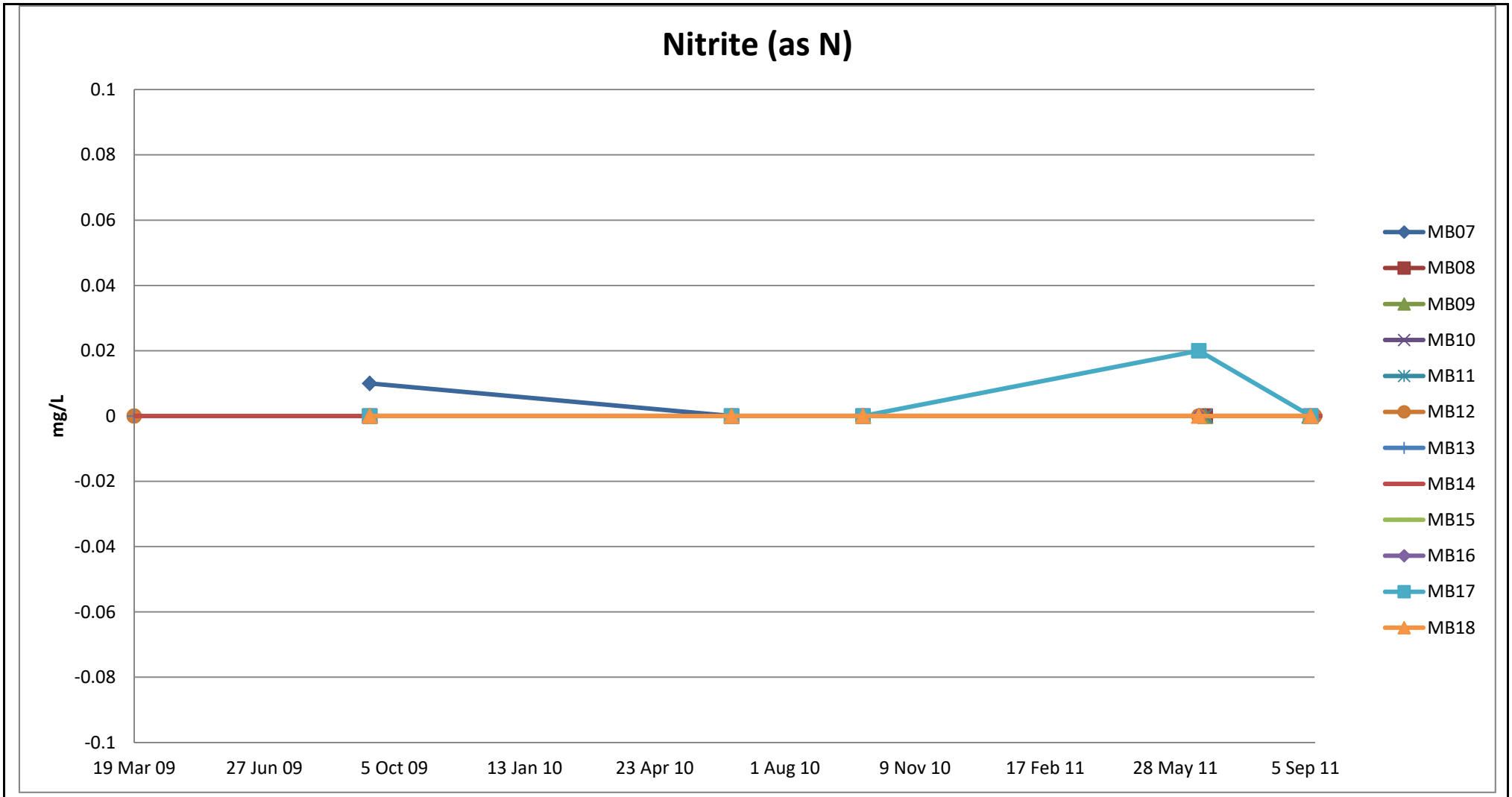


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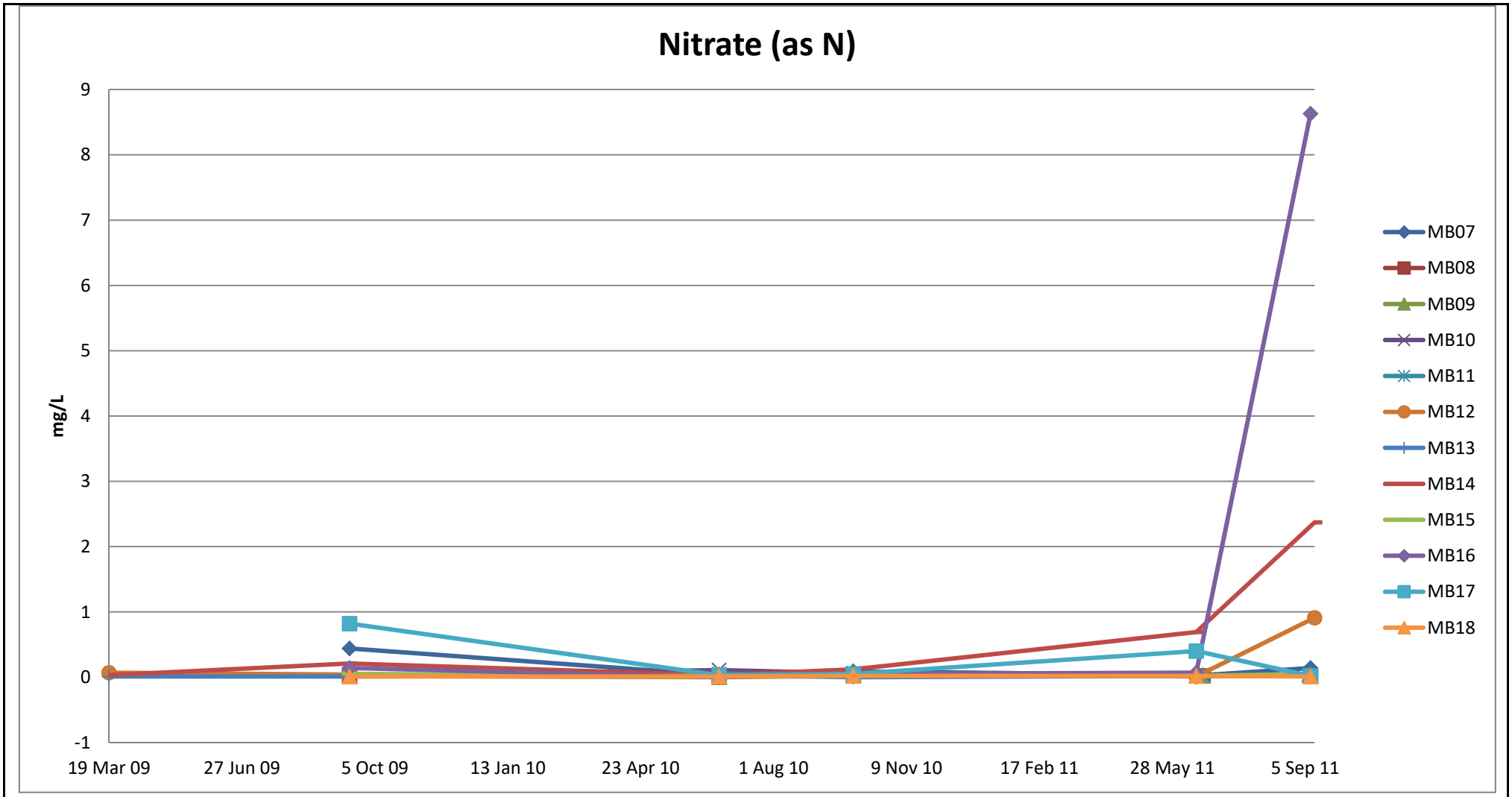


Figure

[Project_Name], Where(WellCode In('MB07' , 'MB08' , 'MB09' , 'MB10' , 'MB11' , 'MB12' , 'MB13' , 'MB14' , 'MB15' , 'MB16' , 'MB17' , 'MB1

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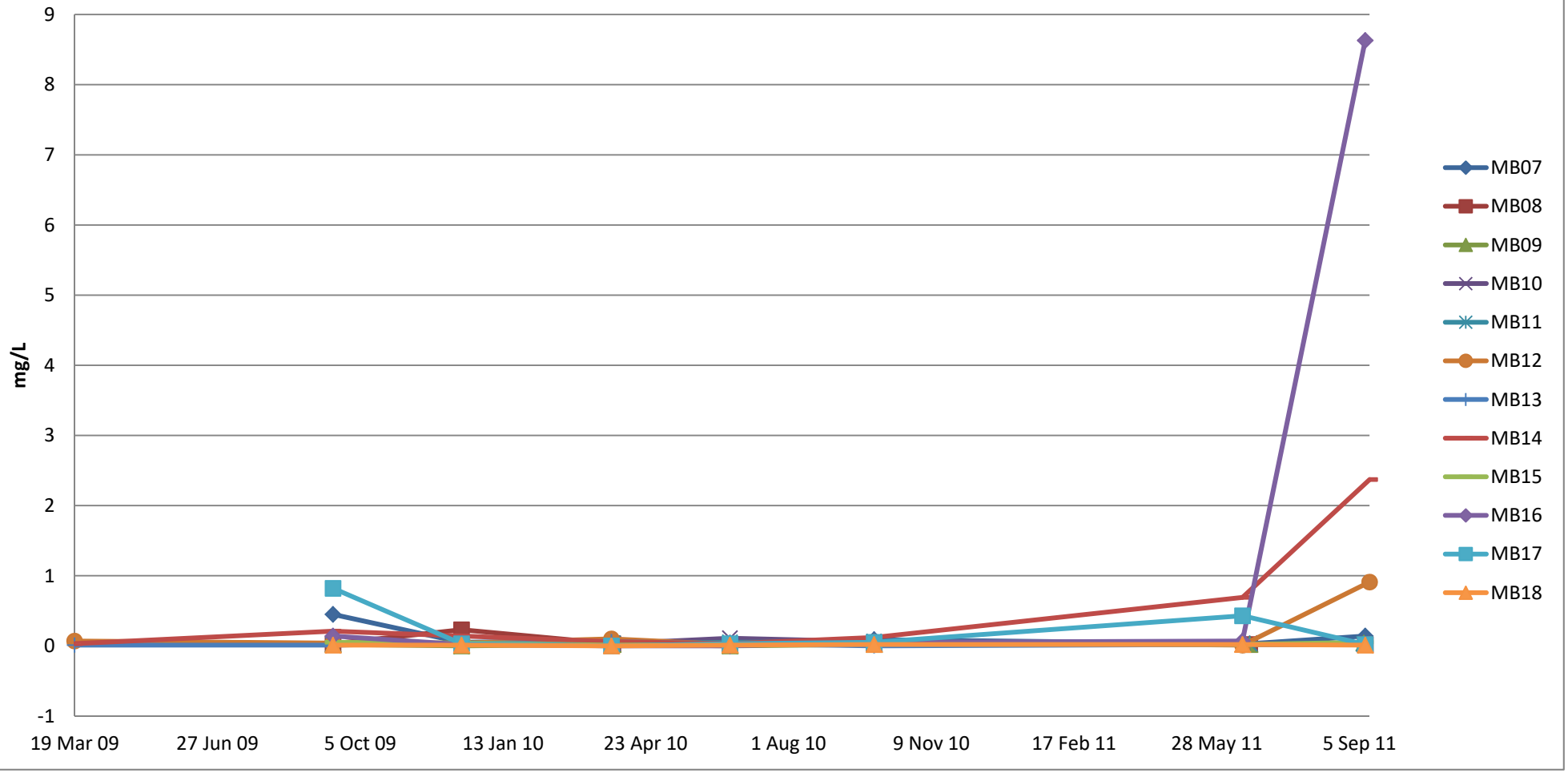
Figure

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Nitrogen (Total Oxidised)

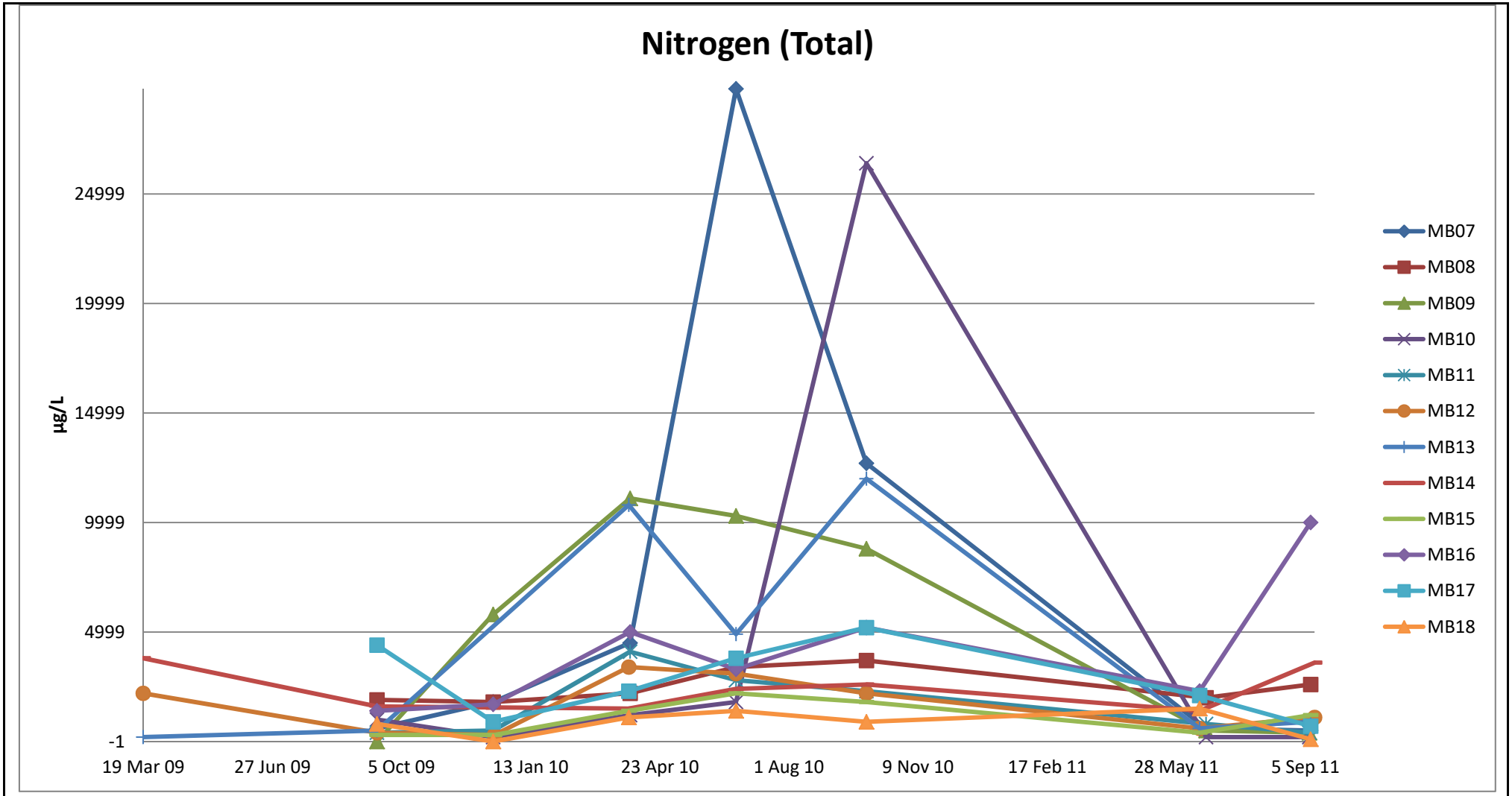


Figure

[Project_Name], Where(WellCode In('MB07' , 'MB08' , 'MB09' , 'MB10' , 'MB11' , 'MB12' , 'MB13' , 'MB14' , 'MB15' , 'MB16' , 'MB17' , 'MB1

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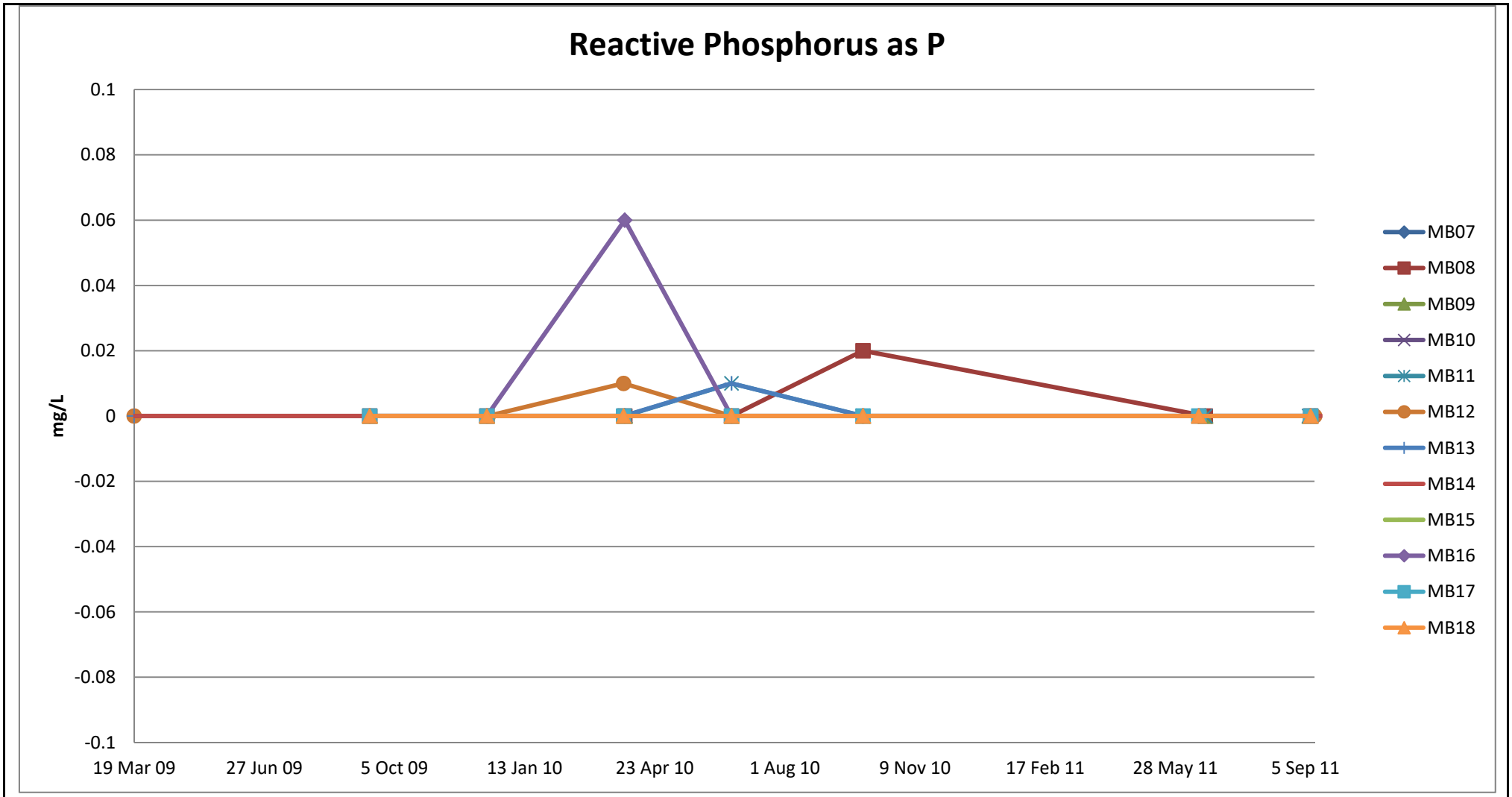


Figure

[Project_Name], Where(WellCode In('MB07' , 'MB08' , 'MB09' , 'MB10' , 'MB11' , 'MB12' , 'MB13' , 'MB14' , 'MB15' , 'MB16' , 'MB17' , 'MB1

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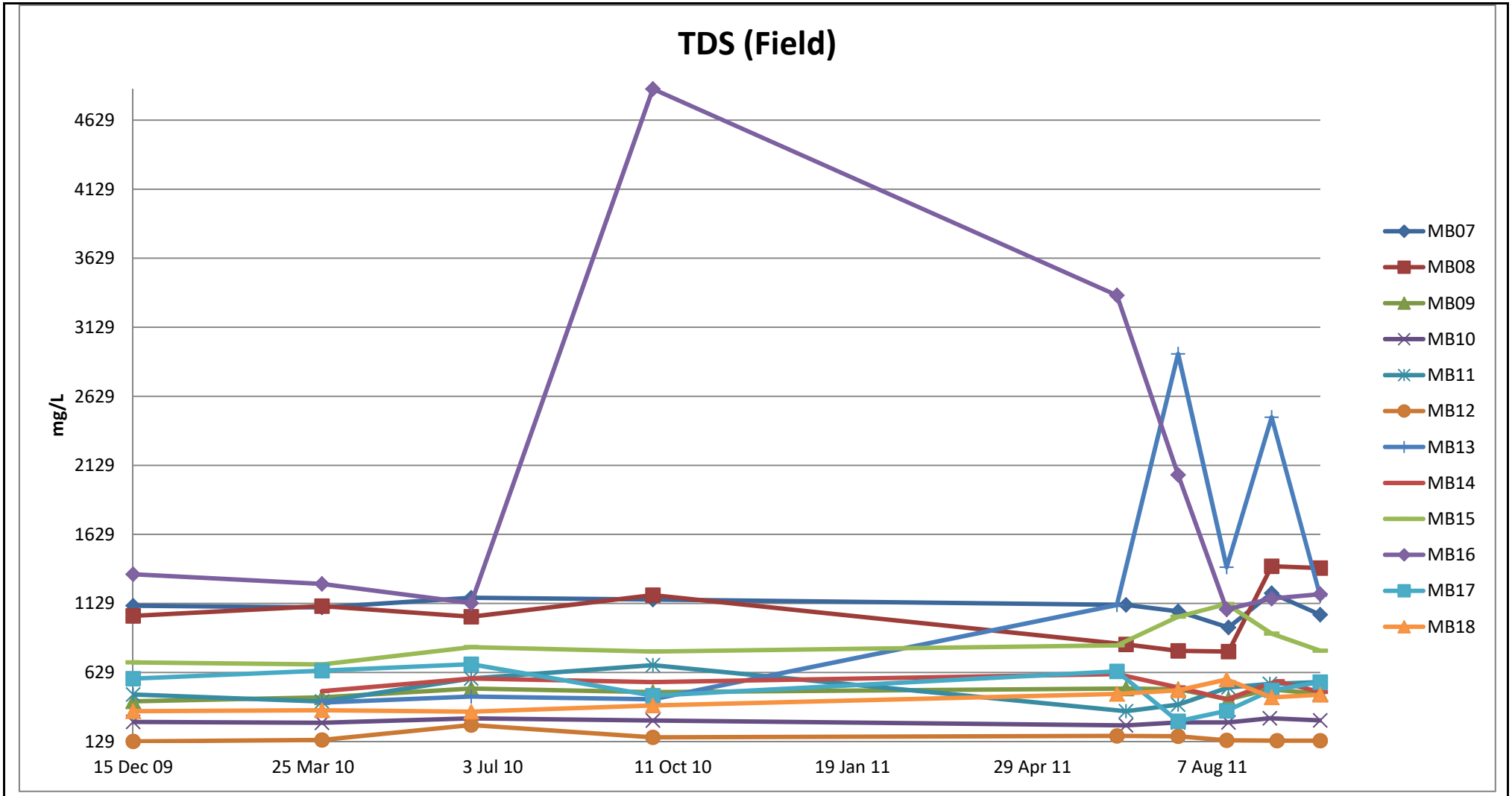


Figure

[Project_Name], Where(WellCode In('MB07' , 'MB08' , 'MB09' , 'MB10' , 'MB11' , 'MB12' , 'MB13' , 'MB14' , 'MB15' , 'MB16' , 'MB17' , 'MB1

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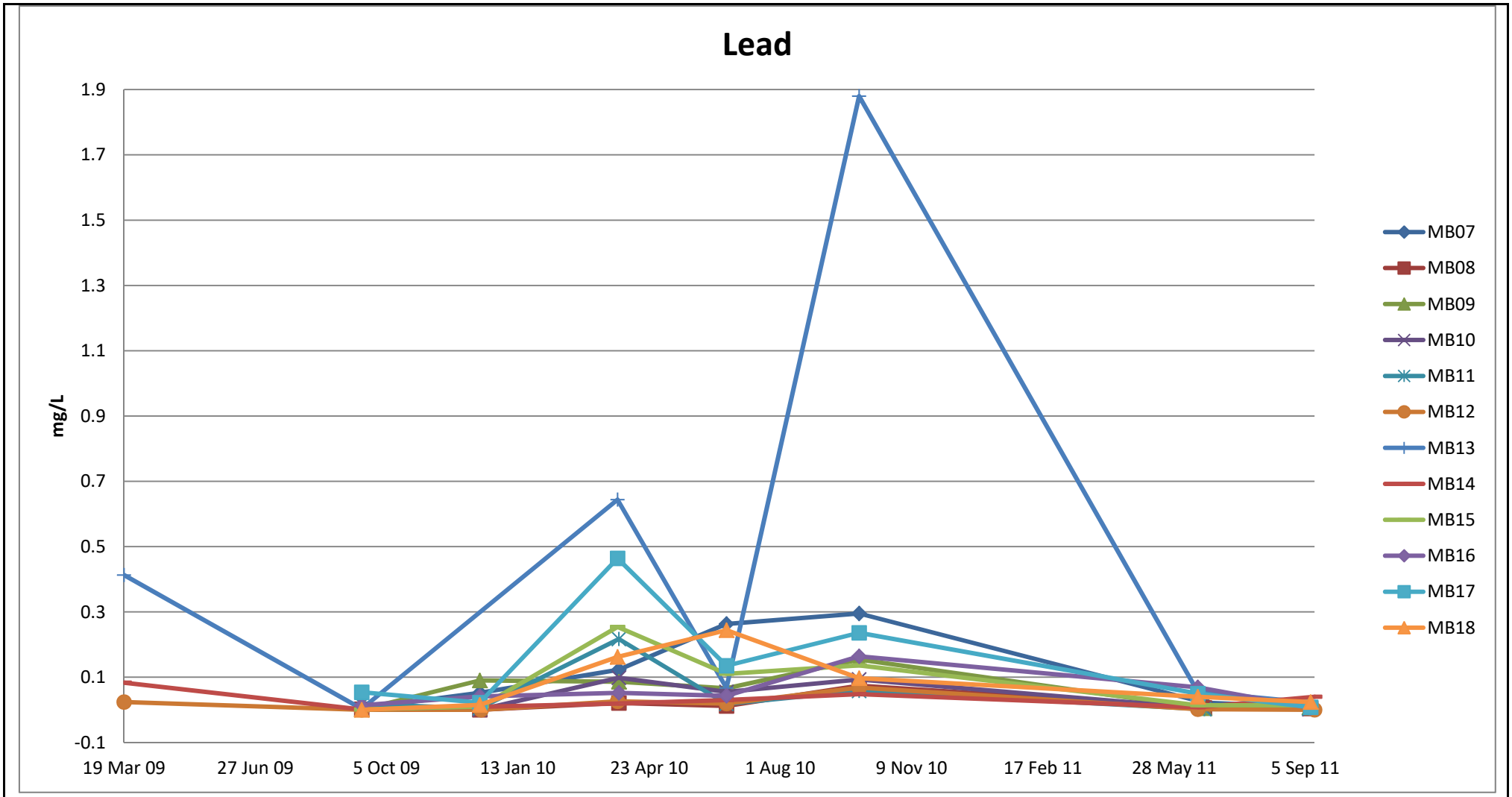


Figure

[Project_Name], Where(WellCode In('MB07' , 'MB08' , 'MB09' , 'MB10' , 'MB11' , 'MB12' , 'MB13' , 'MB14' , 'MB15' , 'MB16' , 'MB17' , 'MB1

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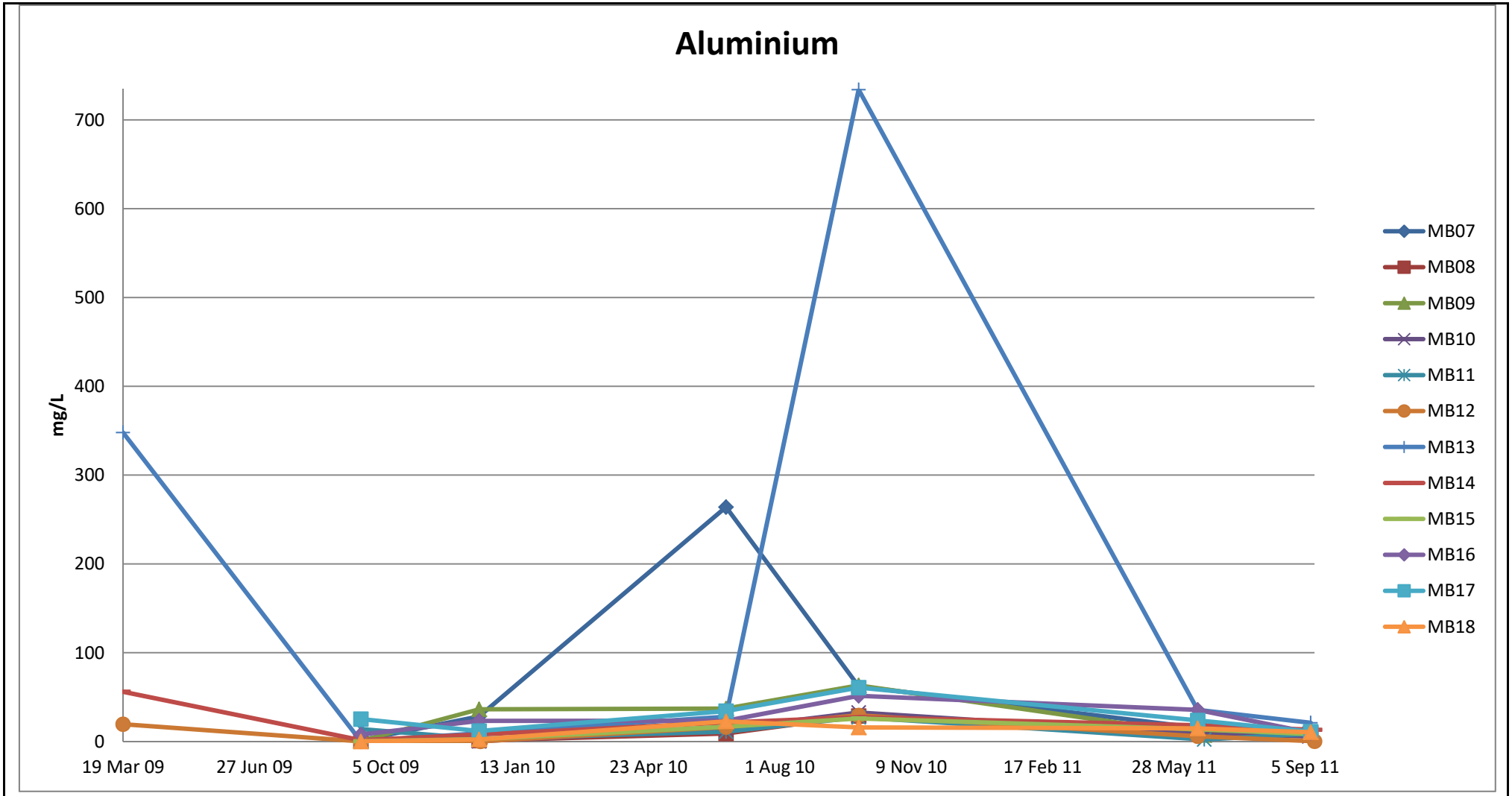


Figure

[Project_Name], Where(WellCode In('MB07' , 'MB08' , 'MB09' , 'MB10' , 'MB11' , 'MB12' , 'MB13' , 'MB14' , 'MB15' , 'MB16' , 'MB17' , 'MB1

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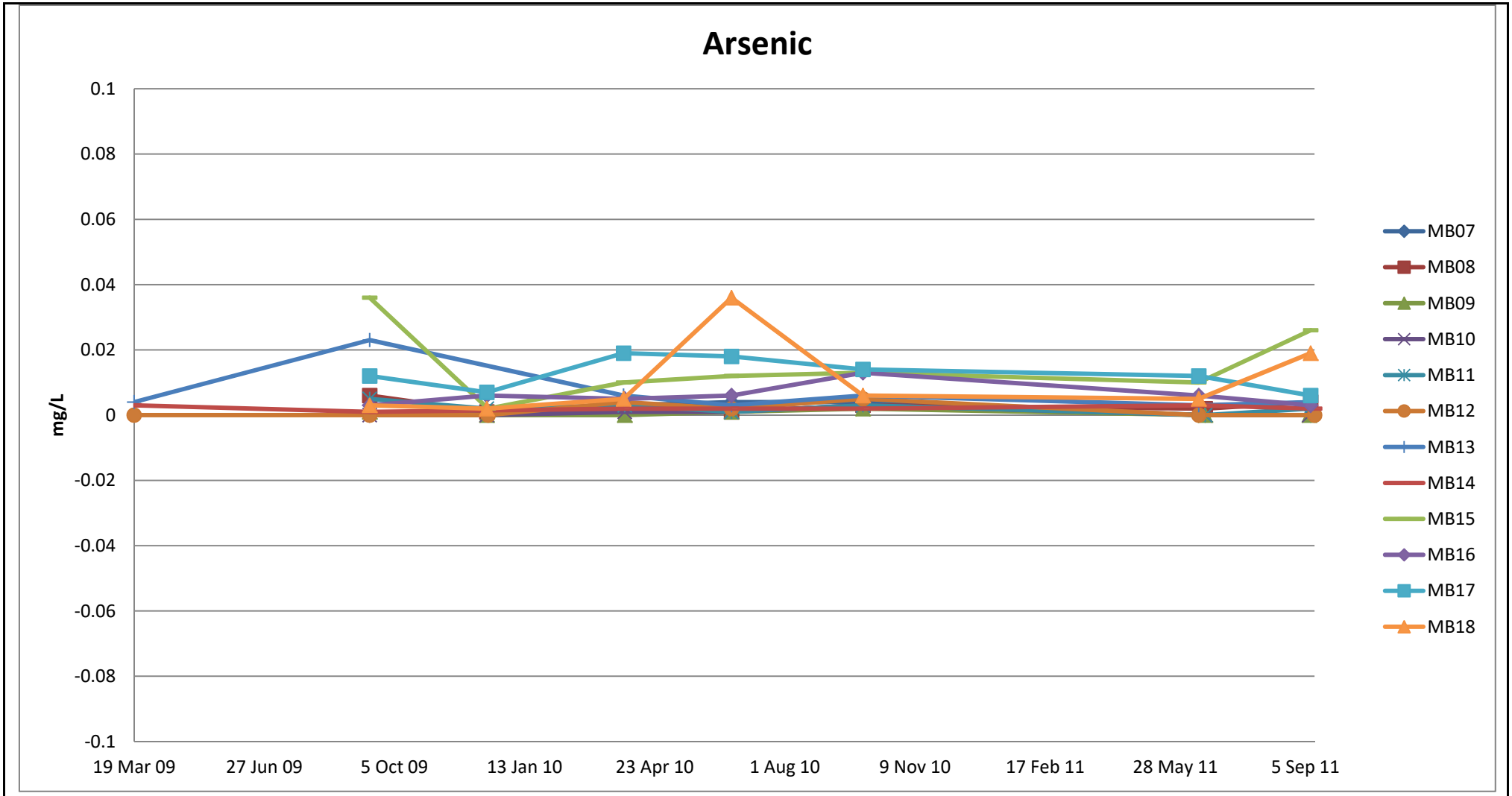


Figure

[Project_Name], Where(WellCode In('MB07' , 'MB08' , 'MB09' , 'MB10' , 'MB11' , 'MB12' , 'MB13' , 'MB14' , 'MB15' , 'MB16' , 'MB17' , 'MB1

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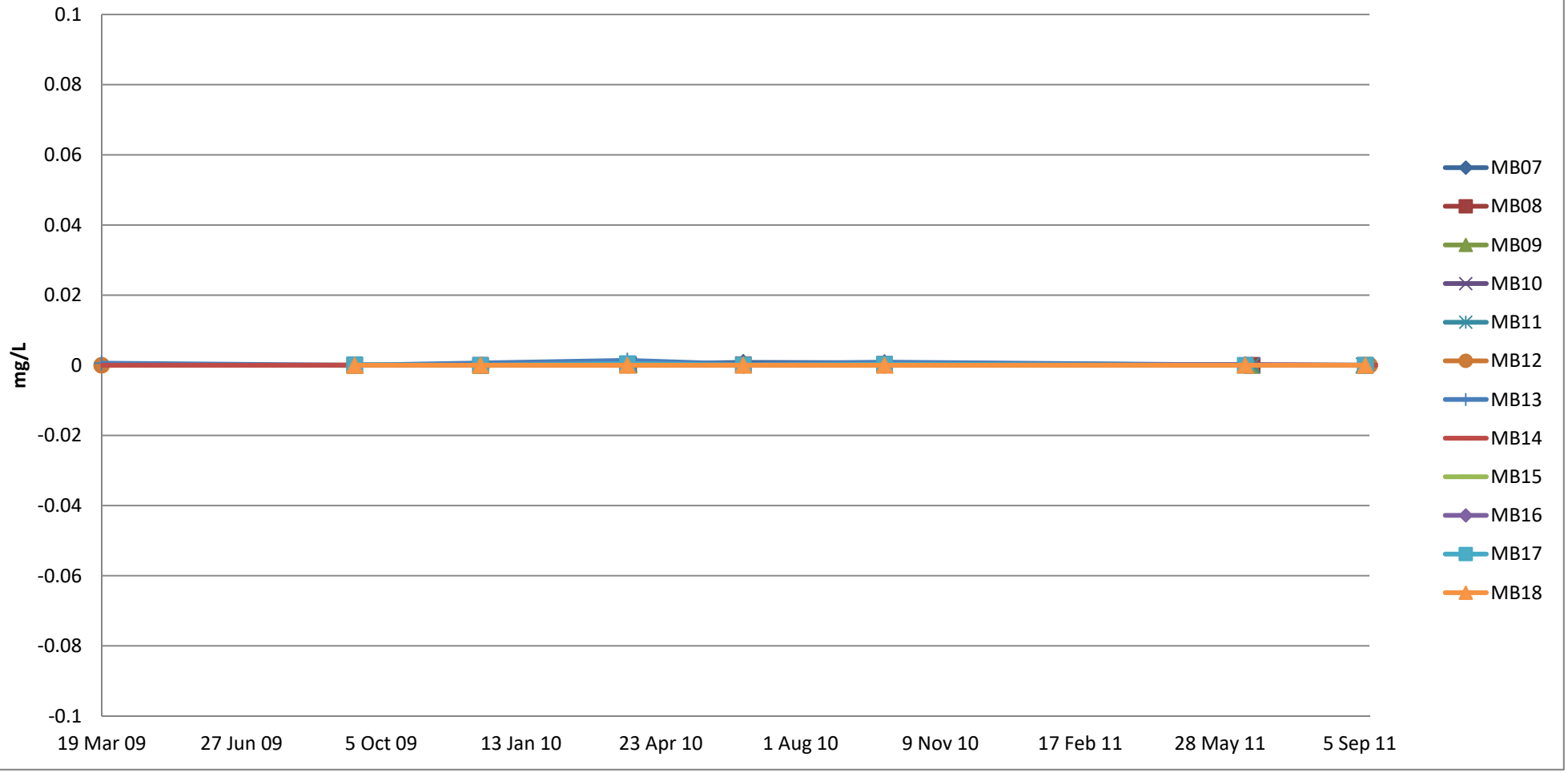
Figure

[Project_Name], Where(WellCode In('MB07' , 'MB08' , 'MB09' , 'MB10' , 'MB11' , 'MB12' , 'MB13' , 'MB14' , 'MB15' , 'MB16' , 'MB17' , 'MB1

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Cadmium

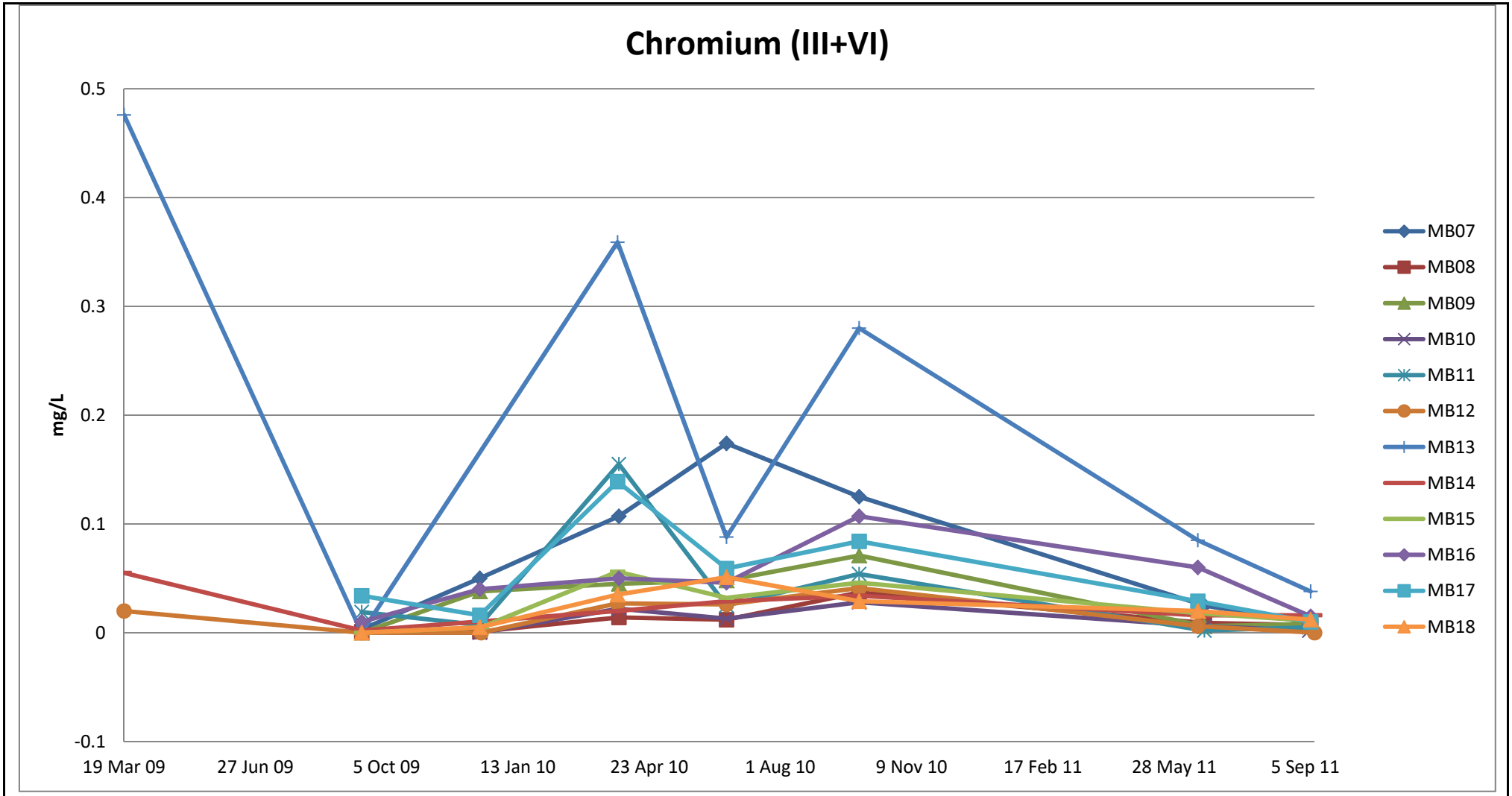


Figure

[Project_Name], Where(WellCode In('MB07' , 'MB08' , 'MB09' , 'MB10' , 'MB11' , 'MB12' , 'MB13' , 'MB14' , 'MB15' , 'MB16' , 'MB17' , 'MB1

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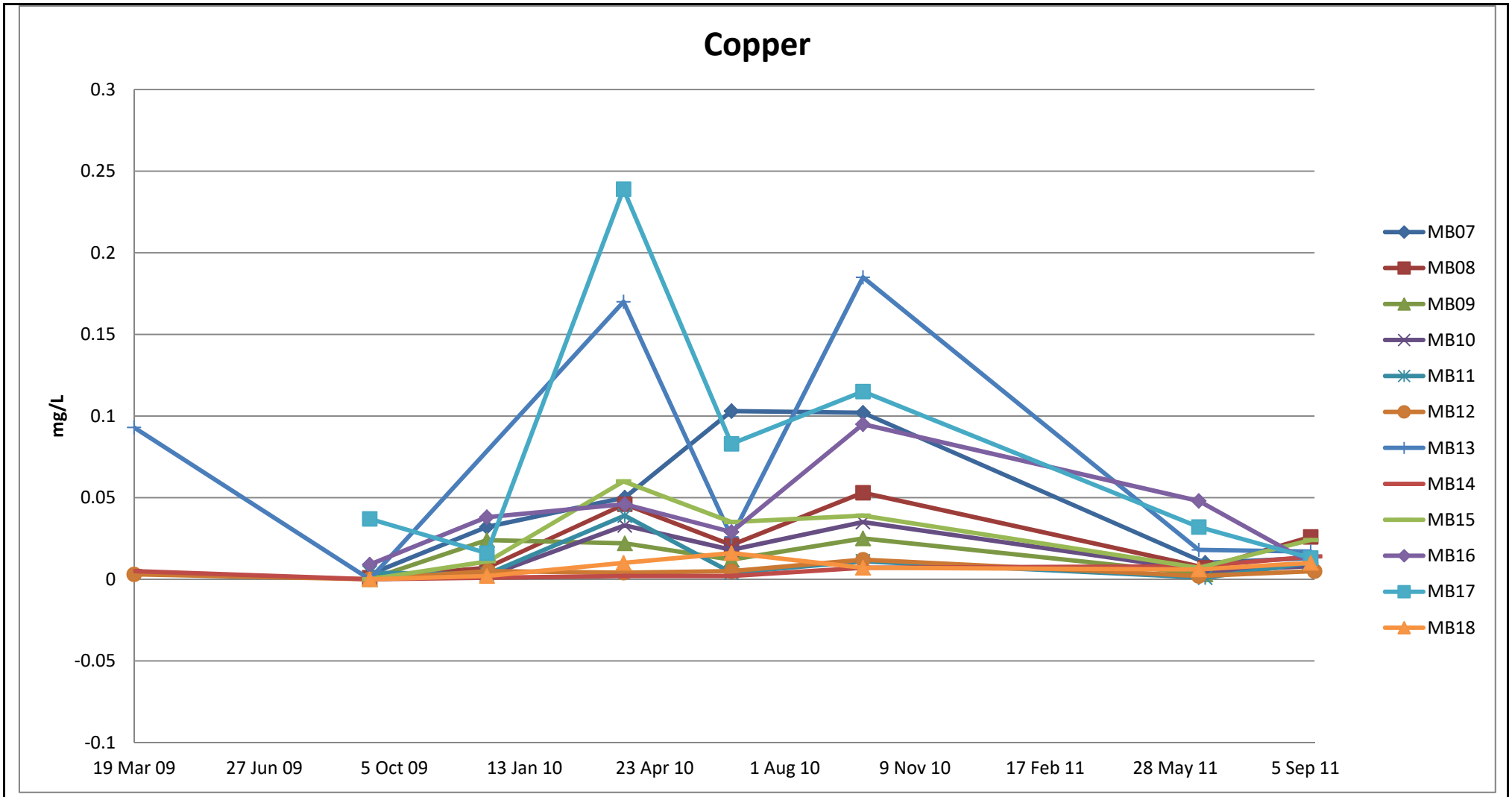


Figure

[Project_Name], Where(WellCode In('MB07' , 'MB08' , 'MB09' , 'MB10' , 'MB11' , 'MB12' , 'MB13' , 'MB14' , 'MB15' , 'MB16' , 'MB17' , 'MB1

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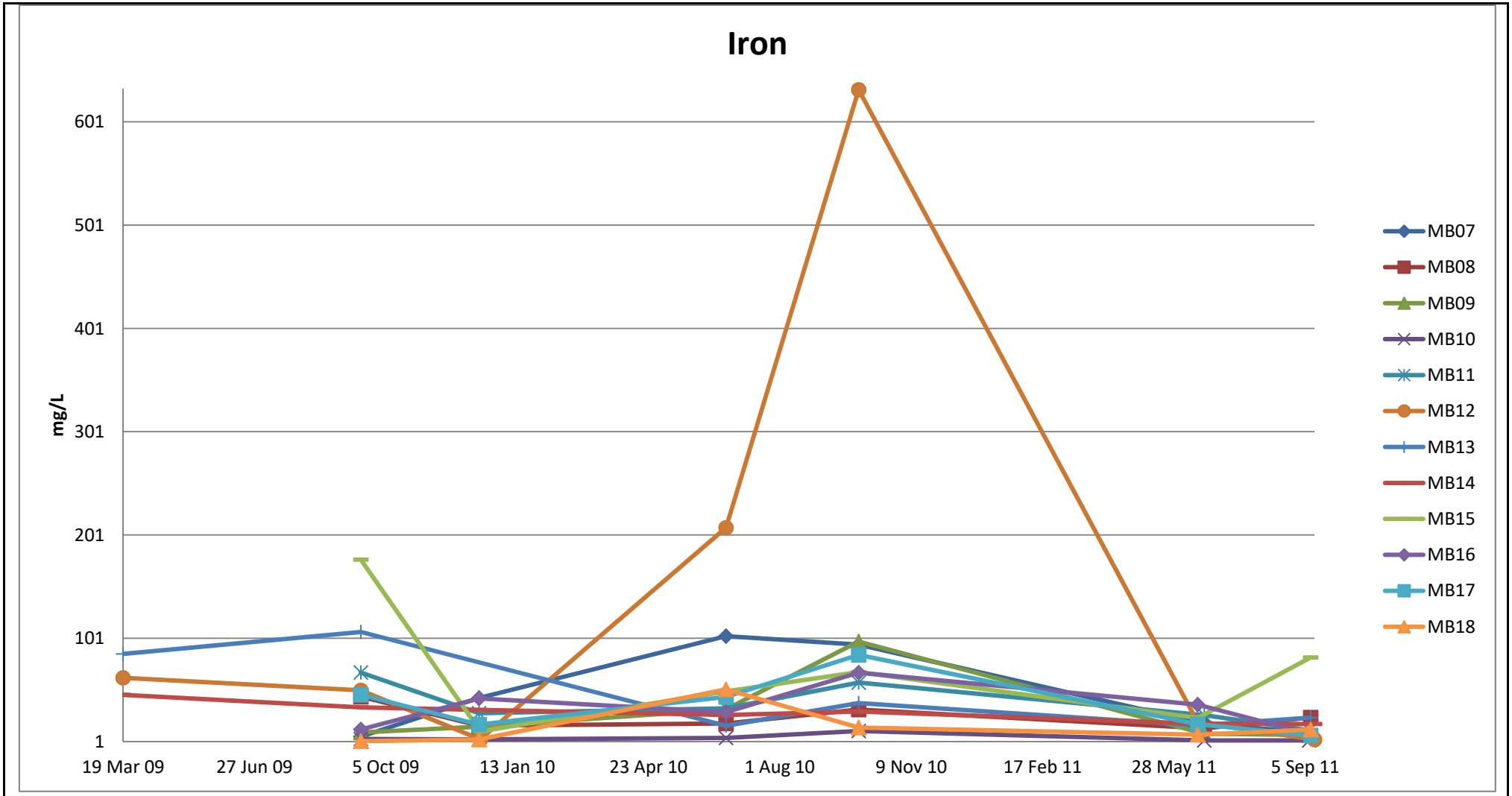


Figure

[Project_Name], Where(WellCode In('MB07' , 'MB08' , 'MB09' , 'MB10' , 'MB11' , 'MB12' , 'MB13' , 'MB14' , 'MB15' , 'MB16' , 'MB17' , 'MB1

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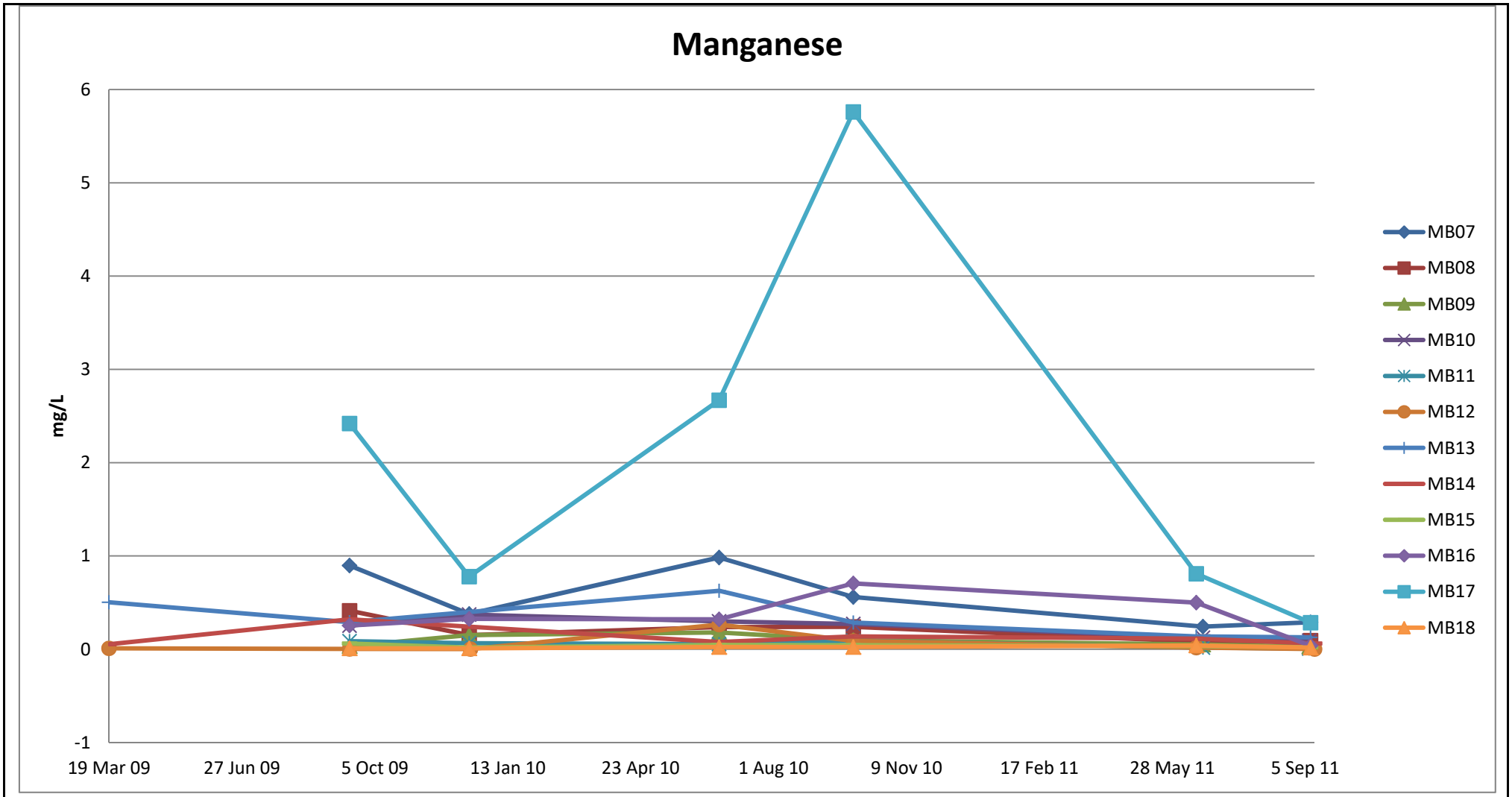


Figure

[Project_Name], Where(WellCode In('MB07' , 'MB08' , 'MB09' , 'MB10' , 'MB11' , 'MB12' , 'MB13' , 'MB14' , 'MB15' , 'MB16' , 'MB17' , 'MB1

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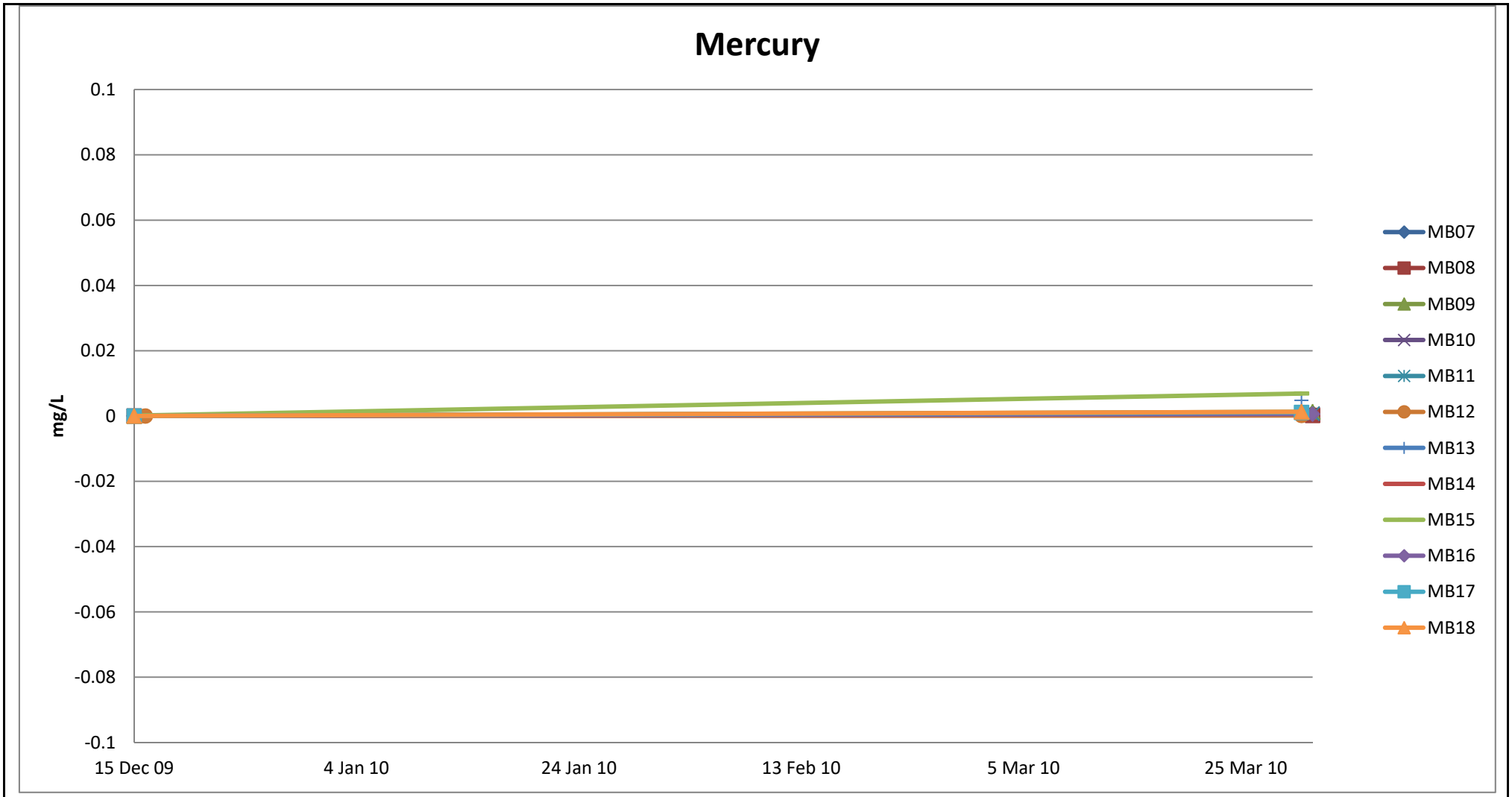


Figure

[Project_Name], Where(WellCode In('MB07' , 'MB08' , 'MB09' , 'MB10' , 'MB11' , 'MB12' , 'MB13' , 'MB14' , 'MB15' , 'MB16' , 'MB17' , 'MB1

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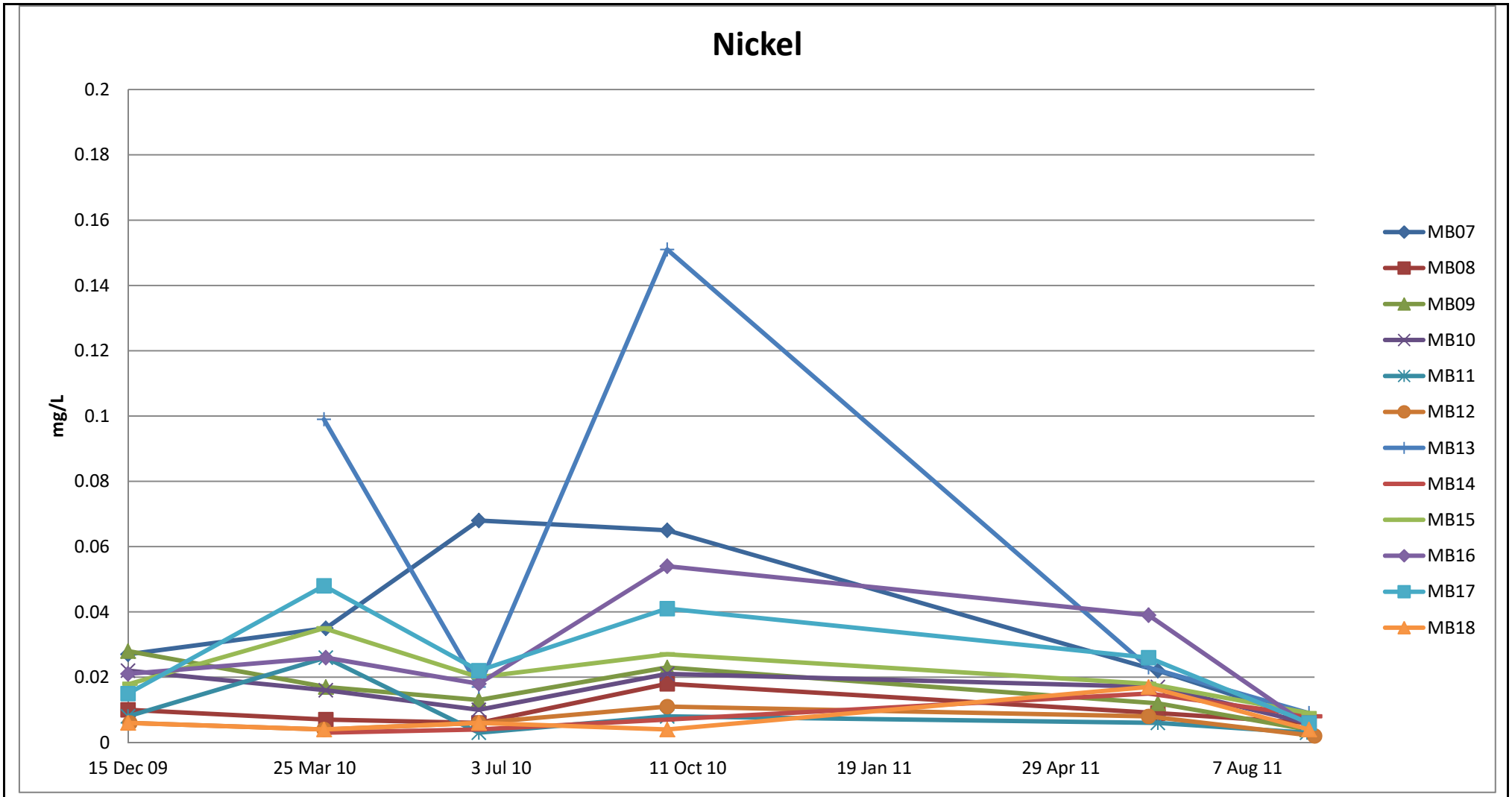


Figure

[Project_Name], Where(WellCode In('MB07' , 'MB08' , 'MB09' , 'MB10' , 'MB11' , 'MB12' , 'MB13' , 'MB14' , 'MB15' , 'MB16' , 'MB17' , 'MB1

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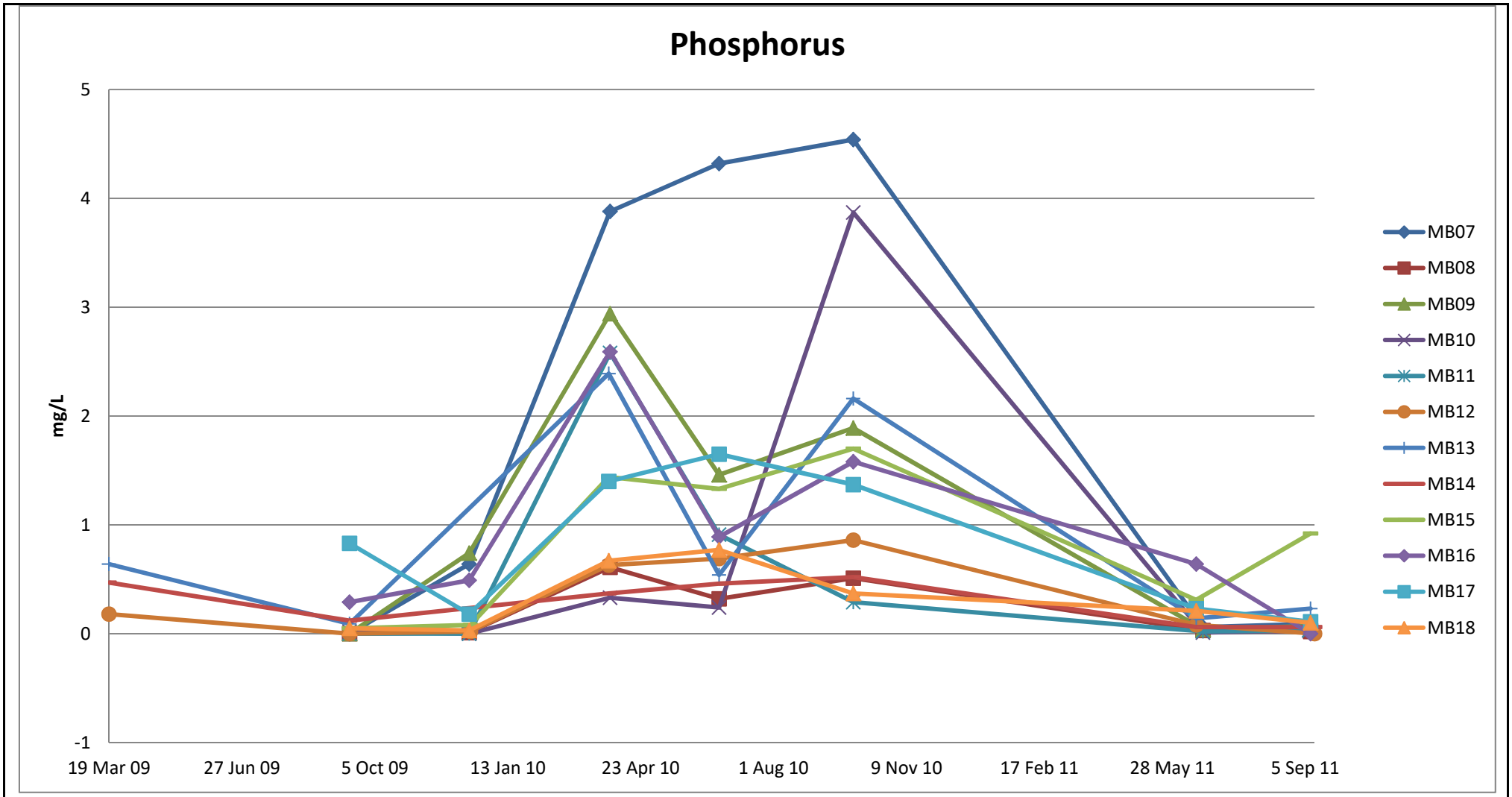


Figure

[Project_Name], Where(WellCode In('MB07' , 'MB08' , 'MB09' , 'MB10' , 'MB11' , 'MB12' , 'MB13' , 'MB14' , 'MB15' , 'MB16' , 'MB17' , 'MB1

Date:	Drawn:
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Original:	Rev:
File Reference:	

ESDAT

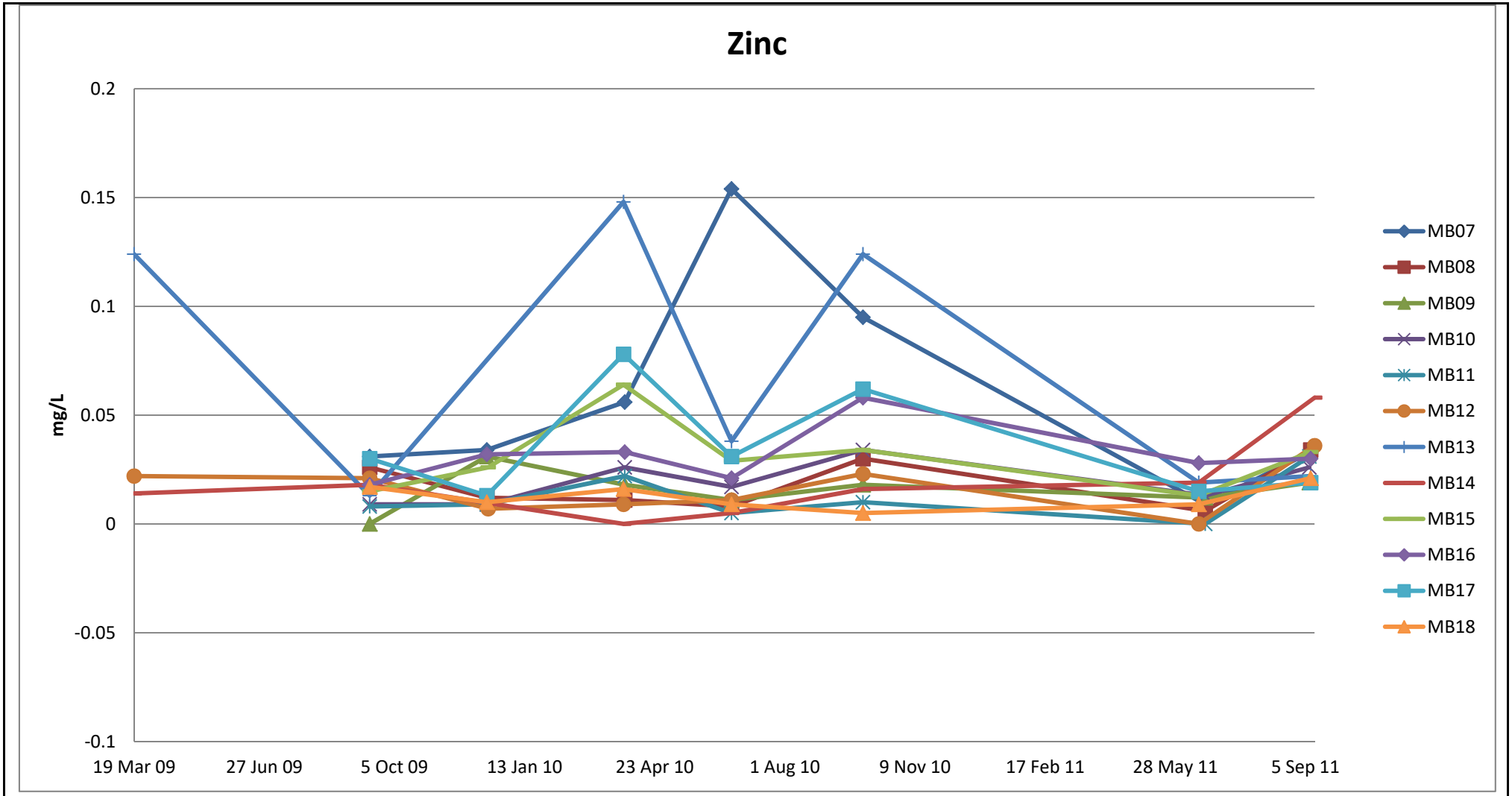


Figure

[Project_Name], Where(WellCode In('MB07' , 'MB08' , 'MB09' , 'MB10' , 'MB11' , 'MB12' , 'MB13' , 'MB14' , 'MB15' , 'MB16' , 'MB17' , 'MB1

Date:	Drawn:
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Original:	Rev:
File Reference:	

ESDAT



Figure

[Project_Name], Where(WellCode In('MB07' , 'MB08' , 'MB09' , 'MB10' , 'MB11' , 'MB12' , 'MB13' , 'MB14' , 'MB15' , 'MB16' , 'MB17' , 'MB1

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Original:	Rev:
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ESDAT

APPENDIX D - Water consumption estimates

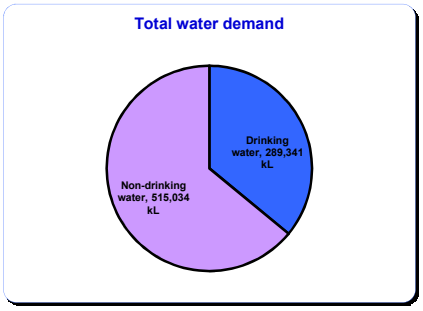
Water Balance Results

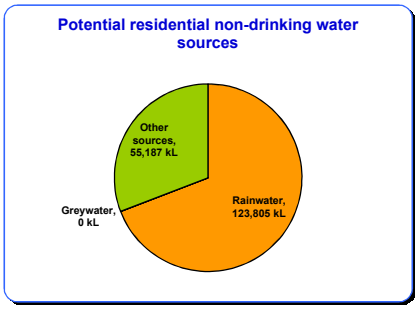
Name of developer	**Peet Ltd**
Name of development	**Mundijong North**
Date of entry	**11 December 2014**
Location of development	**Mundijong**
Total development area (m²)	**1,993,809**

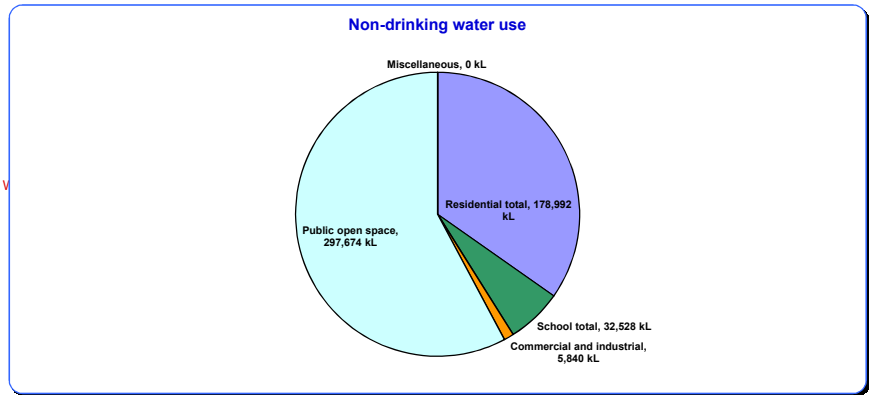
	DEMAND (kL/year)	REQUIRED SUPPLY (kL/year)	
		Drinking water	Non-drinking water
Residential indoor	317,318	260,201	57,117
Residential outdoor	136,938	15,063	121,875
Residential total	**454,256**	**275,264**	**178,992**
Total residential use (kL / person / year)	**80**	**49**	**32**
School irrigation	31,538	0	31,538
School non-irrigation	3,300	2,310	990
School total	**34,838**	**2,310**	**32,528**
Commercial and industrial	**14,600**	**8,760**	**5,840**
Public open space	**300,681**	**3,007**	**297,674**
Miscellaneous	**0**	**0**	**0**
Development total	**804,375 kL**	**289,341 kL**	**515,034 kL**
Total development use (kL / person / year)	**142**	**51**	**91**

Potential residential non-drinking water sources (kL/year)

Rainwater	Greywater	Other sources
123,805	0	55,187
22	0	10







Appendix E – Stormwater modelling parameters and results

Pre-development surface water modelling

A surface water model of the pre-development conditions of the catchment surrounding Precinct E2 was developed using the 2D module of the XP Storm stormwater modelling software. XP Storm is an urban drainage design software package capable of hydrologic and hydraulic modelling of urban catchments. The 2D module of XP Storm models 2- dimensional flow over a grid, rather than via a series of discrete nodes and links. Topographical data, rainfall information and infiltration losses and catchment roughness parameters are input into the 2D module to determine the runoff generated by the catchment and the flow paths and extent of inundation.

Input data sources are as follow:

- Topographical data – Department of Water (DoW) Light Detection and Ranging (LIDAR) survey information, extracted in October 2011.
- Design rainfall – Based on Australin Rainfall and Runoff 1987.
- Pre development Infiltration losses – Based on Cardno Whitby LWMS
- Catchment Delineation – Based on GHD Mundijong Whitby District Structure Plan DWMS

The following sections outline the parameters used in the pre-development modelling.

Design rainfall

Design storm durations varied between 1 hour and 72 hours are utilised to determine the critical duration event for both 5yr and 100yr ARI, and to size the bio-retention areas for the post-development scenario. Design rainfall Intensity Frequency Duration (IFD) data was created using the Bureau of Meteorology's online IFD-generator tool.

The data used for the Mundijong site is presented in Table E.1 below.

Table E.1 - IFD design data

ARI	Duration					
	Intensity (mm/hr)					
	1 hour	6 hour	12 hour	24 hour	48 hour	72 hour
1 year	17.3	-	-	-	-	-
5 year	27.2	8.7	5.6	3.6	2.3	1.7
100 year	48.1	15.0	9.7	6.3	4.1	3.1

Catchment properties

The built up portion of the pre-development catchment consisted of a very small percentage of the total contributing area. For simplicity, the predevelopment catchment assumed undeveloped condition for all areas.

The catchment parameters for the various land uses included in the modelling are outlined in Table E.2 below.

Table E.2 - Land use and infiltration losses

Land use	Manning's roughness	Initial loss (mm)	Continuing loss (mm/hr)
Existing rural (Sand-Sparse Vegetation)	0.2	17.5 mm	2.5 mm/hr
Existing rural (Clay-Sparse Vegetation)	0.2	5 mm	1.5 mm/hr

Peak flow rates

The critical pre-development 5yr and 100yr ARI storm events are:

- 5yr ARI – 1.88m^3/s (9.45 L/s/ha)
- 100yr ARI – 4.01m^3/s (20.11L/s/ha)

Refer to Section 2.7 for discussion on the allowable flow rate.

Post-development surface water modelling

Post and pre development stormwater modelling was undertaken on the same platform. The following sections outline the parameters used in the design of the post-development drainage basins and open drains.

Design rainfall adopted is the same as pre-development model.

Catchment properties

The catchment parameters for the various land uses included in the modelling are outlined in Table E.3 and Table E.4 below.

Table E.3 - Post-development land uses

Post-development land use	% impervious	Total Catchment area (pervious and impervious)
Residential lots	30 %	97.2 ha
Road reserve	80 % [1]	41.5 ha
Soldiers Road reserve	50 % [2]	6.5 ha
POS	5 %	29.8 ha
Schools	5 %	7.5 ha

Note:

1. An impervious fraction of 80% is sufficient to allow for the full pavement width, crossovers, footpaths on both sides of the road, and approximately 25-30% of lots to have fully paved front verges.
2. "Soldiers Road reserve" includes rail and robertson road, there is a higher percentage of permeable area than the typical road reserve.

Table E.4 - Manning's n and infiltration losses

Landuse	Manning's roughness	Initial loss (mm)	Continuing loss (mm/hr)
Impervious surfaces	0.014	17 mm[1]	0 mm/hr
Pervious surfaces	0.03	15 mm	4 mm/hr

Note:

1. Initial loss of 1yr 1hr ARI event as all urnoffs are retained either using soakwells or bio retention swales.

Peak allowable flow rates

The post-development modelling has allowed for flow from external catchments. Refer to Section 2.7 and Table 2-6 for external inflow included into the post development model.

The storage basins through the site were designed to attenuate post-development runoff to within these allowable levels. The required areas for flood attenuation in the POS areas are shown in Table E.5 below, and also in Figure 5.1.

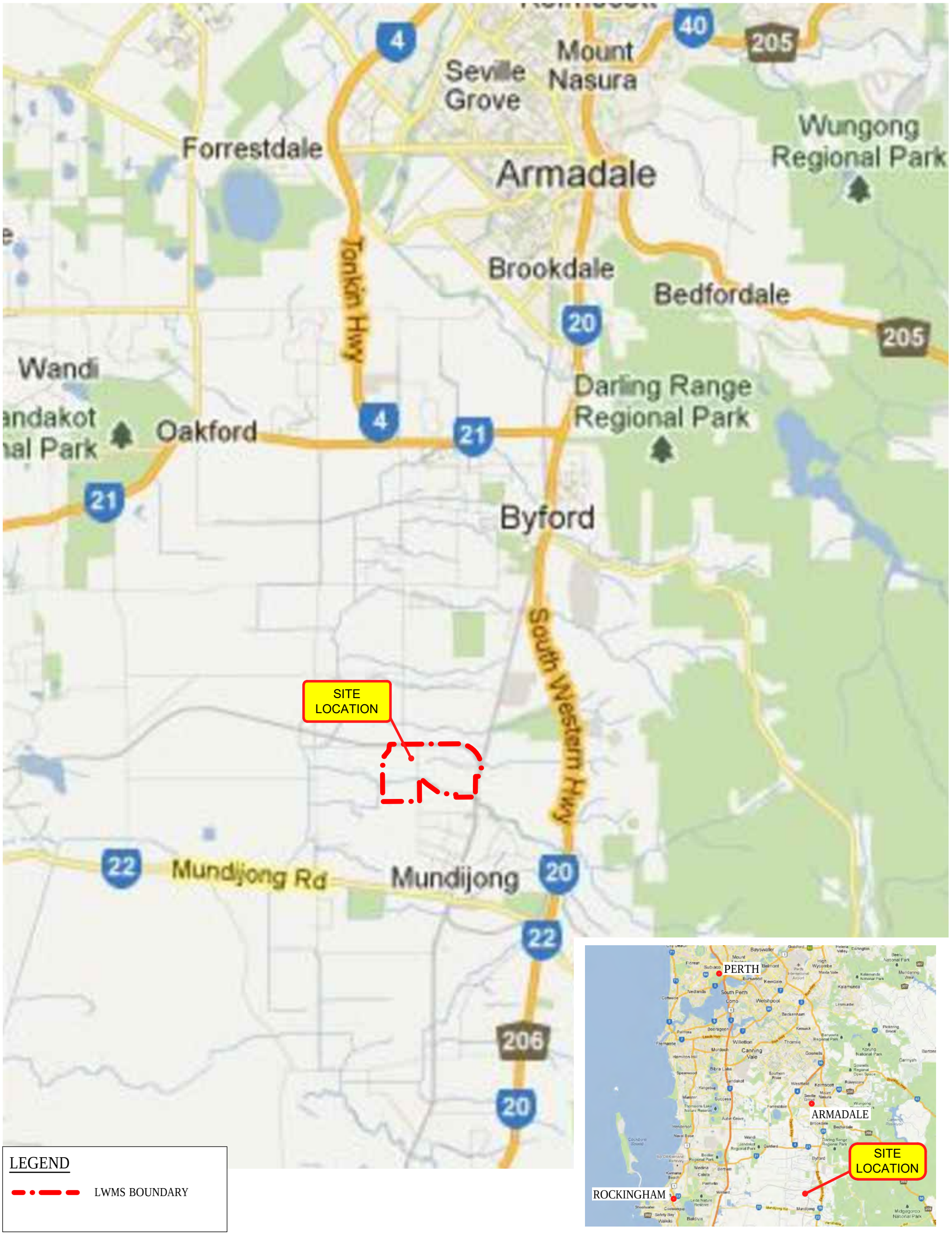
Table E.5 - Required bioretention and flood storage areas

Basin ref	1yr 1hr ARI bioretention area	5yr ARI flooded area	100yr ARI flooded area
1A	1,000 m²	6,600 m²	6,700 m²
1B	1,100 m²	1,900 m²	online
2	1,000 m²	2,700 m²	online
3	700 m²	2,000 m²	online
4	900 m²	2,600 m²	2,800 m²
5	600 m²	1,500 m²	online
6	2,300 m²	18,200 m²	19,000 m²
7	2,200 m²	8,600 m²	9,000 m²
8	1,000 m²	3,400 m²	3,700 m²
9	900 m²	1,400 m²	1,600 m²
10	500 m²	3,600 m²	online
11	400 m²	900 m²	online
12	700 m²	1,400 m²	1,400 m²
13	2,100 m²	9,600 m²	10,000 m²
14	1,500 m²	3,400 m²	3,800 m²
15	1,500 m²	6,900 m²	7,600m²
16	1,300 m²	5,400 m²	6,100m²
17	1,200 m²	2,400 m²	online
18	1,200 m²	2,900 m²	2,800 m²

Table E.6 below shows the peak flow rates from each of the basins through the subdivision. The 5YR ARI is slightly higher than the peak allowable flow rate whereas the critical 100YR ARI is well within the peak allowable flow rate. (Refer Table 2-8)

Table E.6 - Peak post-development flow rates from flood storage areas

Catchment	Modelled Discharge	
	5yr ARI	100yr ARI
	m3/s	m3/s
1A	0.011	0.110
1B	0.211	0.327
2	0.122	0.255
3	0.122	0.205
4	0.057	0.196
5	0.083	0.143
6	0.190	0.385
7	0.069	0.194
8	0.077	0.158
9	0.085	0.169
10	0.006	0.019
11	0.097	0.157
12	0.074	0.195
13	0.079	0.258
14	0.297	0.485
15	0.061	0.183
16	0.035	0.046
17	0.199	0.295
18	0.016	0.058
Total	**1.891**	**3.838**



LEGEND

LWMS BOUNDARY

WAVE INTERNATIONAL PTY LTD.
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306 Murray Street
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PEET LIMITED
MUNDIJONG NORTH LWMS

SITE LOCALITY PLAN

Job Number 2680-24
Revision A
Date FEBRUARY 2015

FIGURE 1.1



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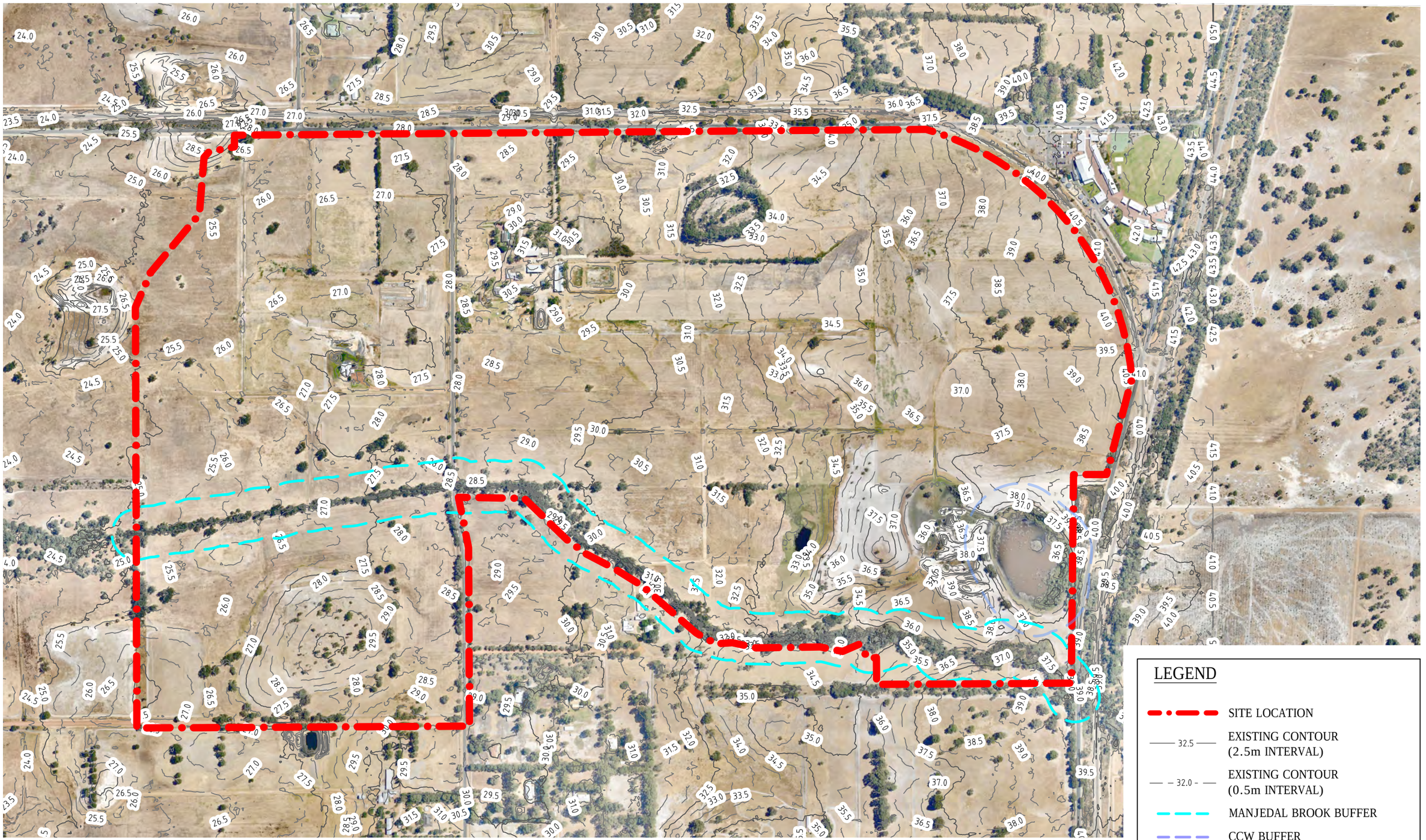
PEET LIMITED
MUNDIJONG NORTH LWMS

LOCAL STRUCTURE PLAN LAYOUT

Job Number	2680-24
Revision	A
Date	FEBRUARY 2015

FIGURE 1.2

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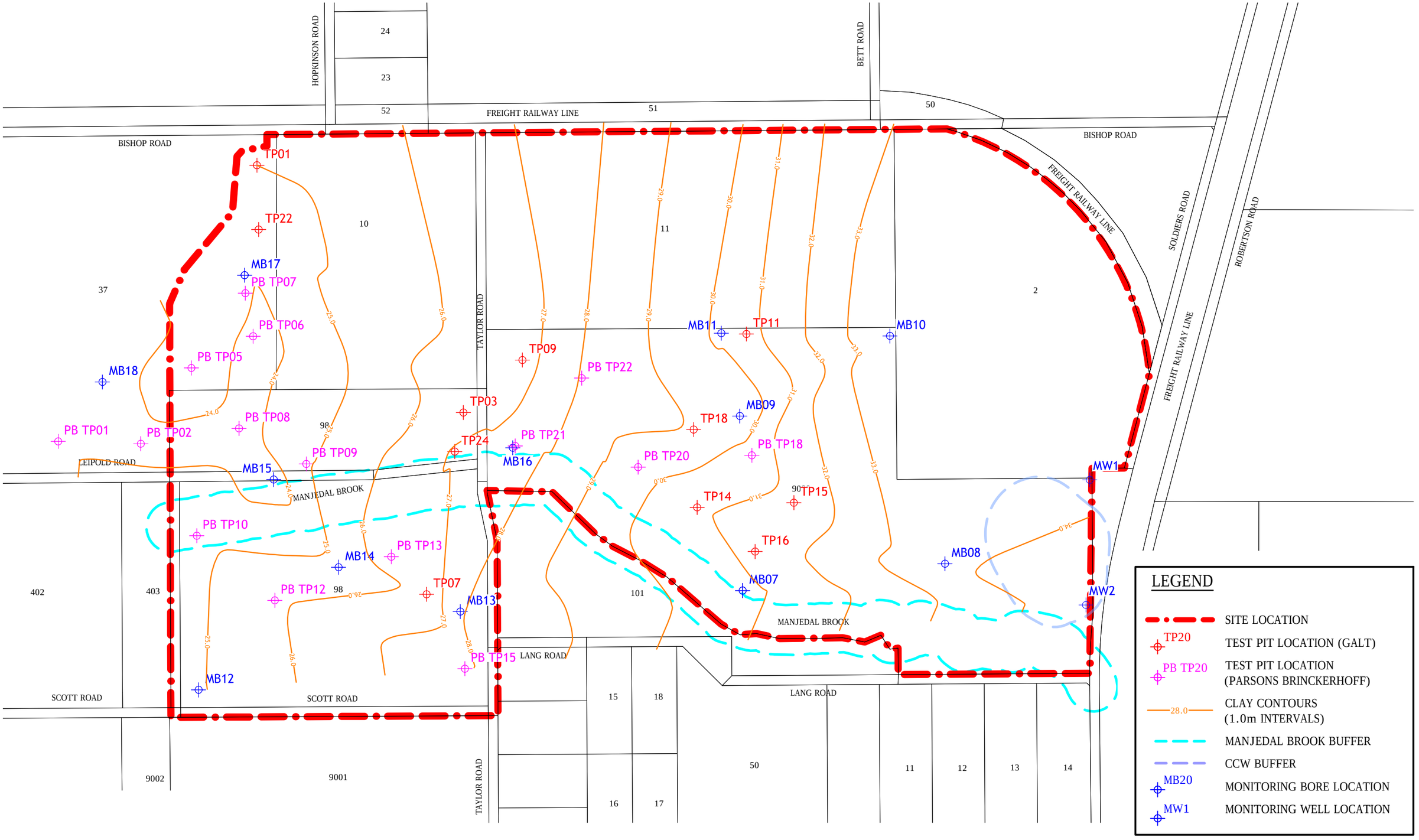
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EXISTING CONTOURS AND AERIAL PHOTO

Job Number	2680-24
Revision	A
Date	FEBRUARY 2015

FIGURE 2.1

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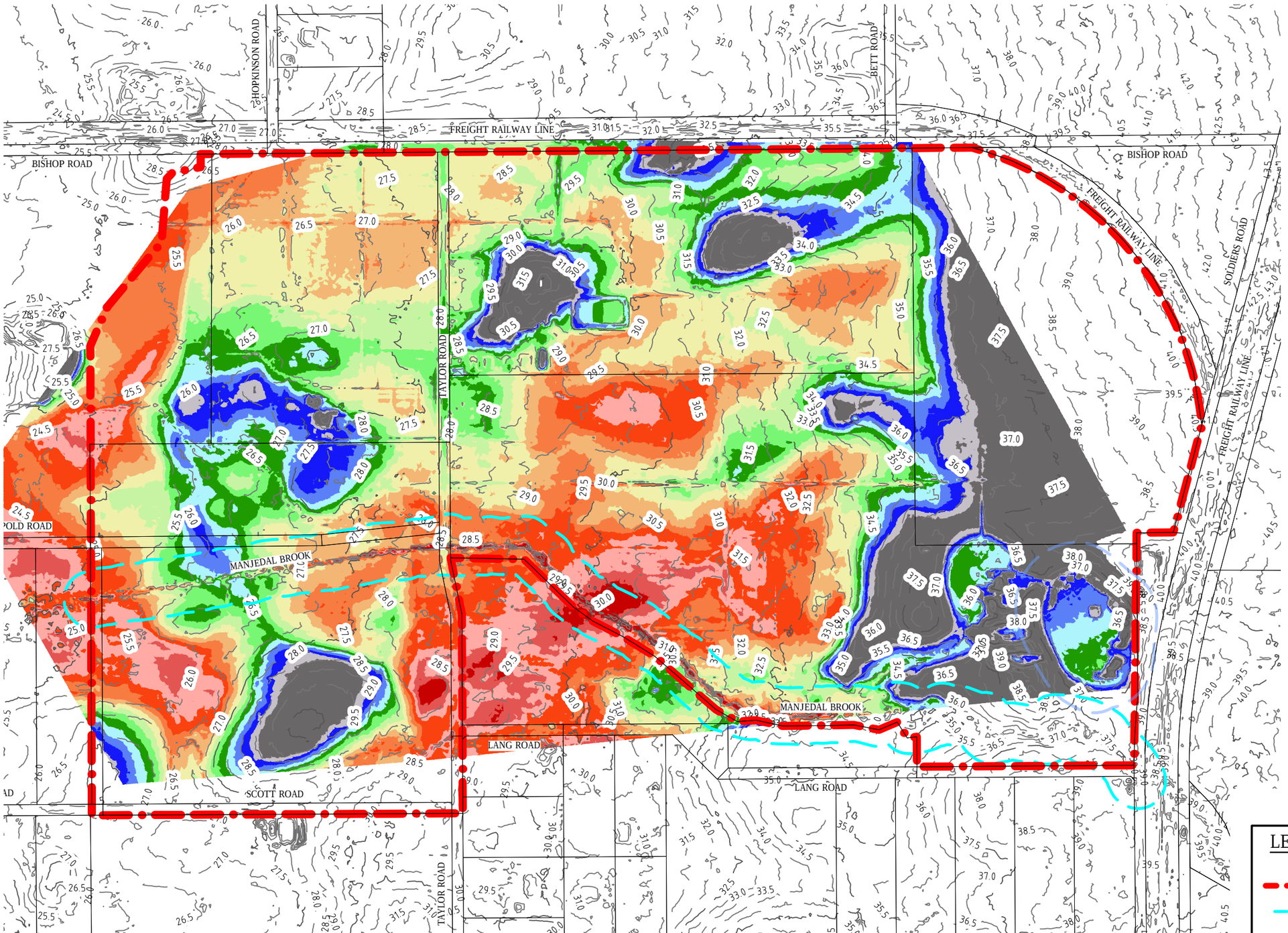
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GEOTECHNICAL TEST PIT LOCATIONS AND CLAY CONTOURS

Job Number	2680-24
Revision	A
Date	MARCH 2015

FIGURE 2.2

C:\projectwise\wrk\pwdata\nsmith\dms01389\2680-40-SKT-CI-24202.dwg - nelson smith - 13/03/2015



DEPTH TO CLAY LAYER			
0m	TO	0.20m	
0.20m	TO	0.40m	
0.40m	TO	0.60m	
0.60m	TO	0.80m	
0.80m	TO	1.00m	
1.00m	TO	1.20m	
1.20m	TO	1.40m	
1.40m	TO	1.60m	
1.60m	TO	1.80m	
1.80m	TO	2.00m	
2.00m	TO	2.20m	
2.20m	TO	2.40m	
2.40m	TO	2.60m	
2.60m	TO	2.80m	
>2.80m			

LEGEND

- SITE LOCATION
- MANJEDAL BROOK BUFFER
- CCW BUFFER

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MUNDIJONG NORTH LWMS

DEPTH TO CLAY LAYER

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Date	MARCH 2015

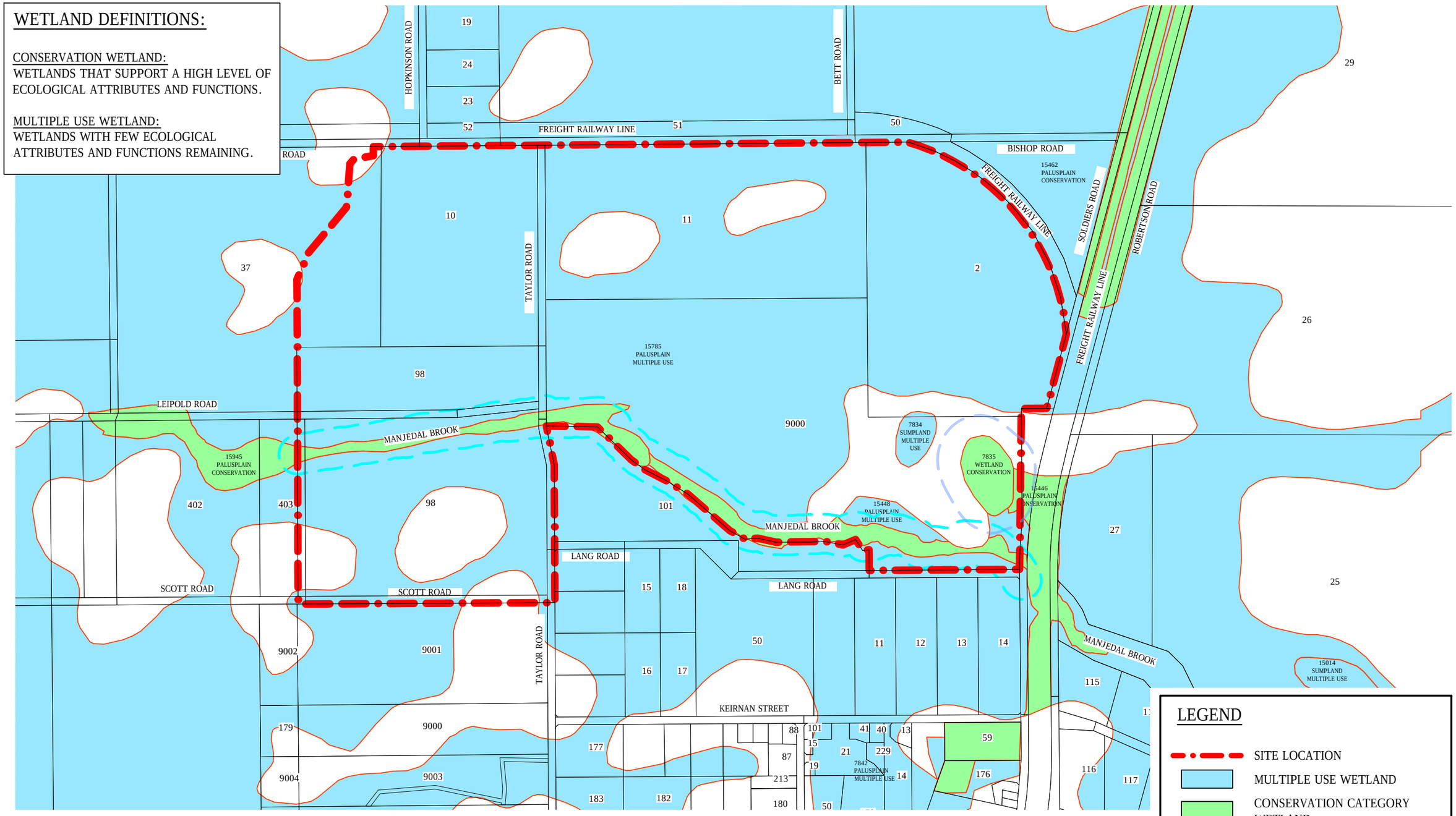
FIGURE 2.3

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WETLAND DEFINITIONS:

CONSERVATION WETLAND:
WETLANDS THAT SUPPORT A HIGH LEVEL OF ECOLOGICAL ATTRIBUTES AND FUNCTIONS.

MULTIPLE USE WETLAND:
WETLANDS WITH FEW ECOLOGICAL ATTRIBUTES AND FUNCTIONS REMAINING.



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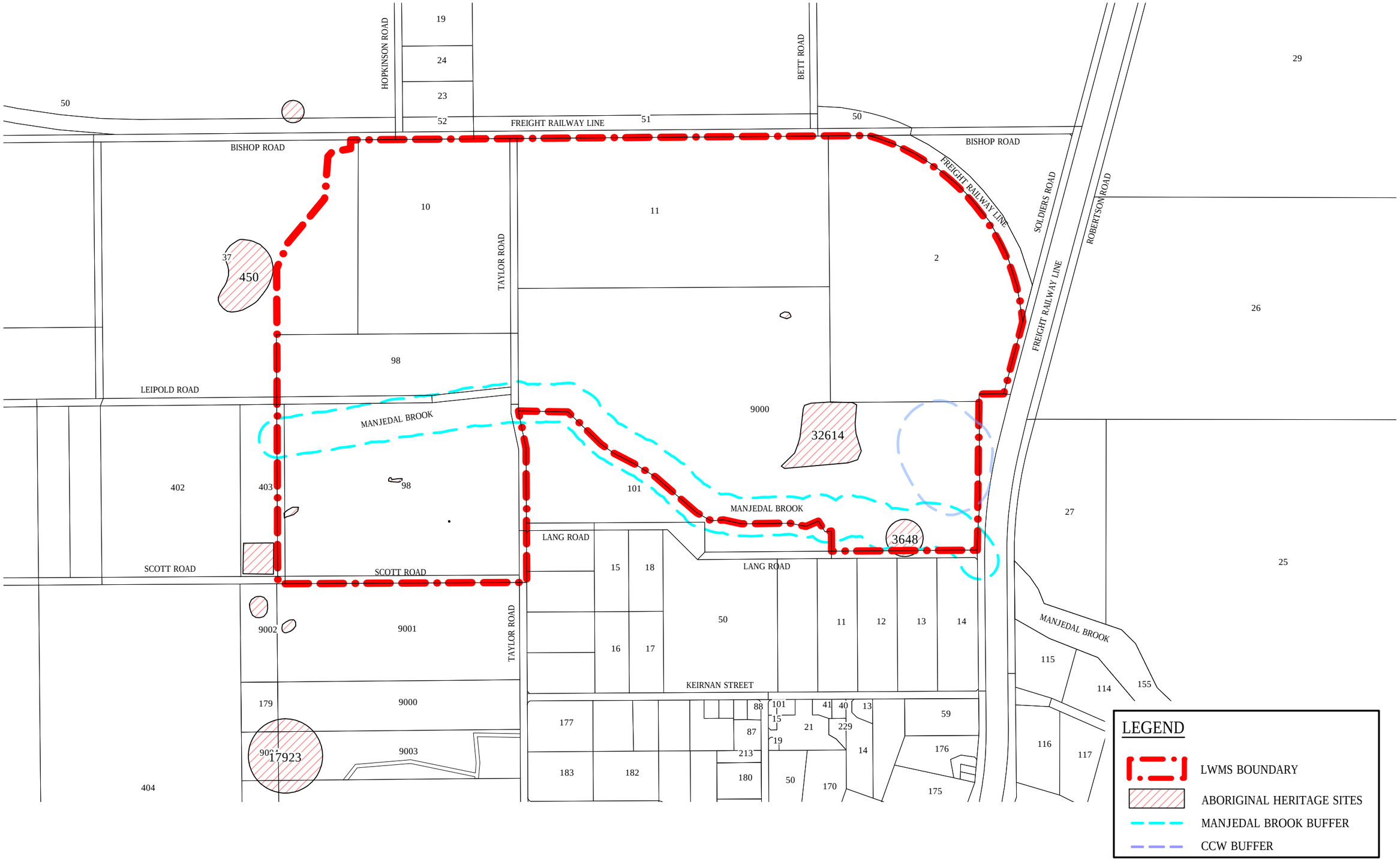
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DEC WETLAND MAPPING

Job Number	2680-24
Revision	A
Date	FEBRUARY 2015

FIGURE 2.4

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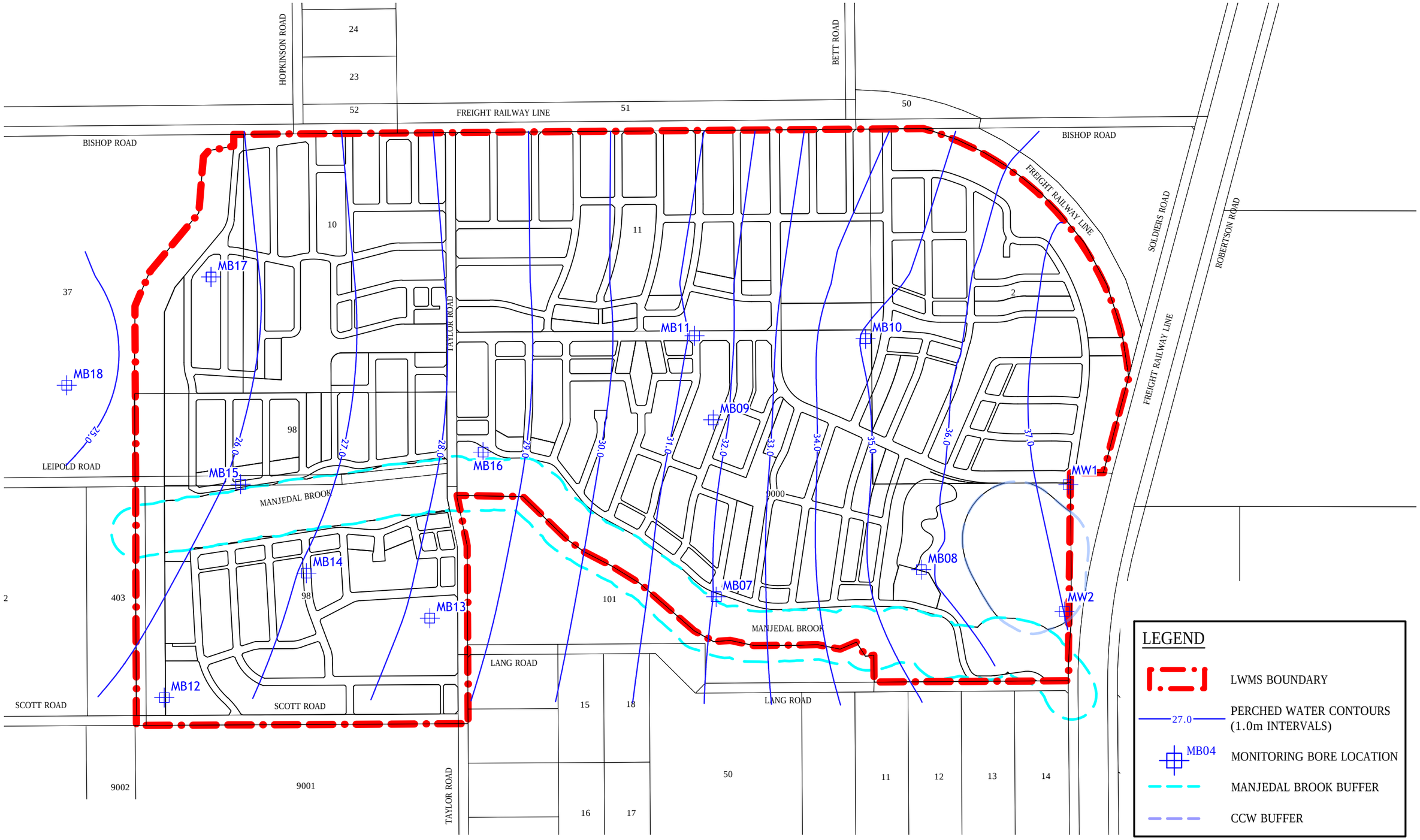
PEET LIMITED
MUNDIJONG NORTH LWMS

ABORIGINAL HERITAGE SITES

Job Number	2680-24
Revision	A
Date	FEBRUARY 2015

FIGURE 2.5

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LEGEND

- LWMS BOUNDARY
- 27.0 — PERCHED WATER CONTOURS (1.0m INTERVALS)
- MB04 — MONITORING BORE LOCATION
- MANJEDAL BROOK BUFFER
- CCW BUFFER

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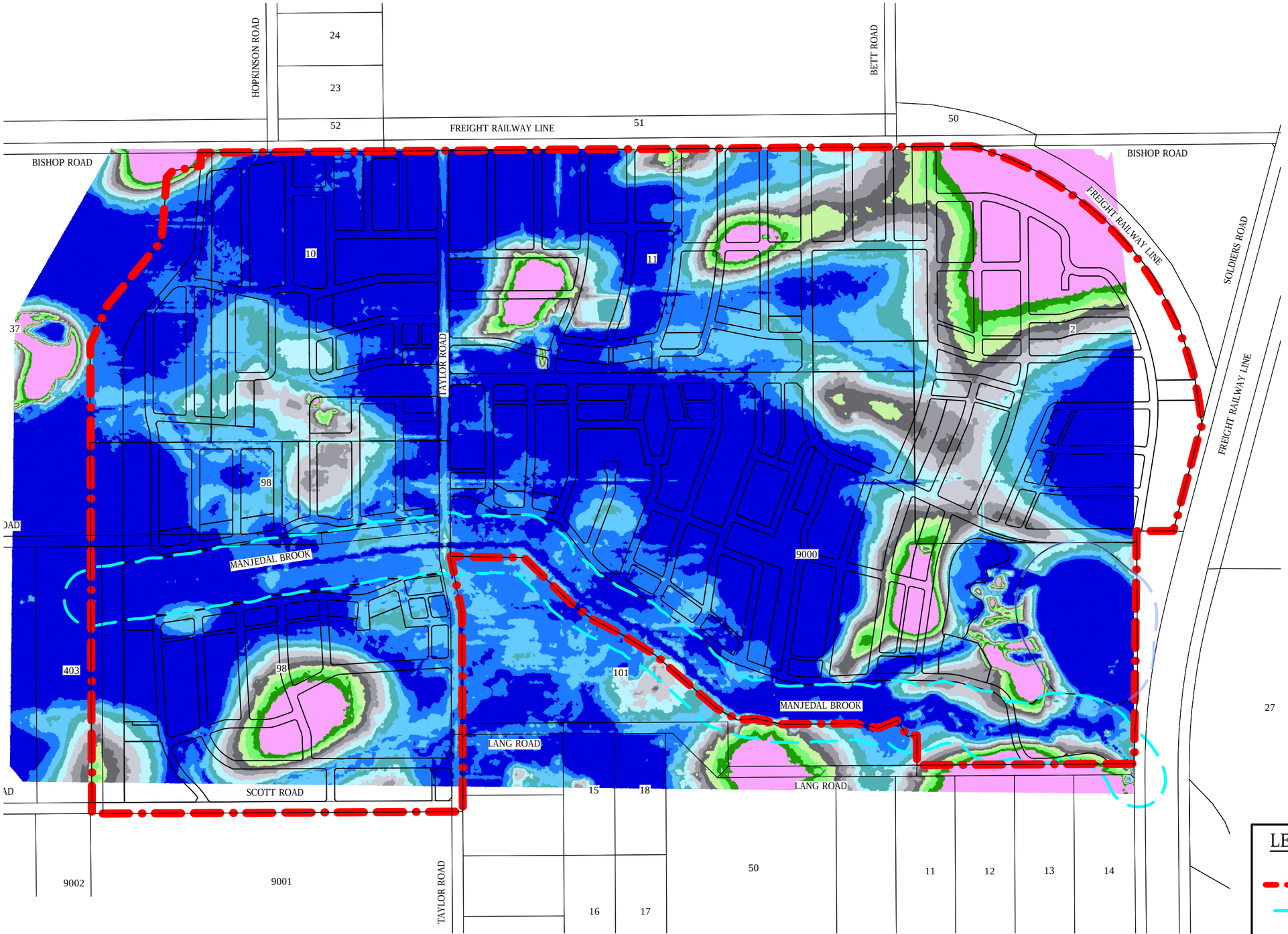
PEET LIMITED
MUNDIJONG NORTH LWMS

Job Number	2680-24
Revision	A
Date	MARCH 2015

GROUNDWATER BORE LOCATIONS AND PRE-DEVELOPMENT PERCHED WINTER WATER LEVELS

FIGURE 2.6

C:\projectwise\wrk\pwdata\nsmith\dms01389\2680-40-SKT-CI-24206.dwg - nelson smith - 13/03/2015



DEPTH TO GROUNDWATER			
INUNDATED			
0.20m	TO	0.40m	
0.40m	TO	0.60m	
0.60m	TO	0.80m	
0.80m	TO	1.00m	
1.00m	TO	1.20m	
1.20m	TO	1.40m	
1.40m	TO	1.60m	
1.60m	TO	1.80m	
1.80m	TO	2.00m	
>2.00m			

LEGEND

- SITE LOCATION
- MANJEDAL BROOK BUFFER
- CCW BUFFER

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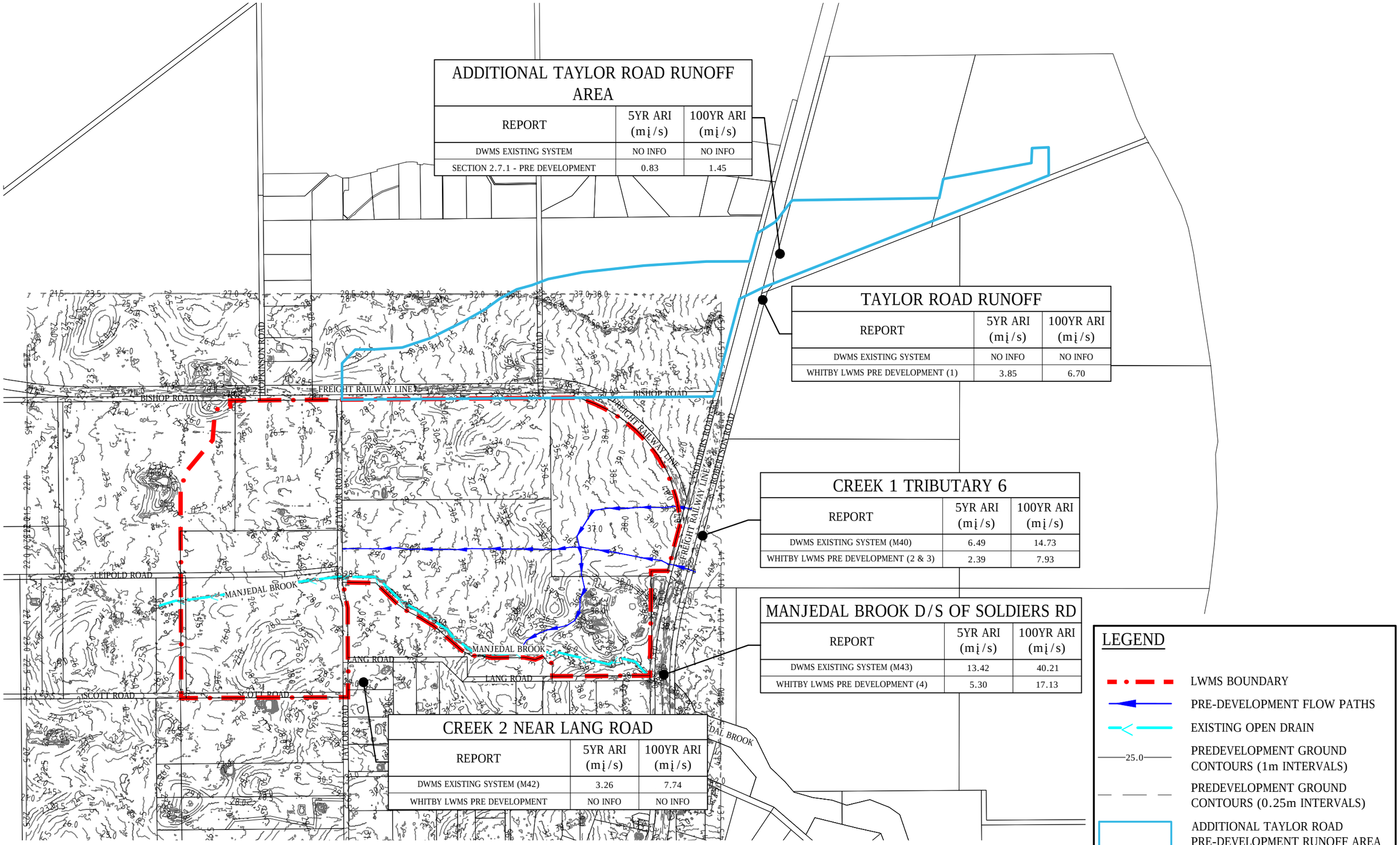
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DEPTH TO PRE-DEVELOPMENT
PERCHED WINTER WATER LEVELS

Job Number	2680-24
Revision	A
Date	MARCH 2015

FIGURE 2.7

C:\projectwise\wrk\pwdata\nsmith\dms01389\2680-40-SKT-CI-24207.dwg - nelson smith - 10/03/2015



ADDITIONAL TAYLOR ROAD RUNOFF AREA		
REPORT	5YR ARI (mį/s)	100YR ARI (mį/s)
DWMS EXISTING SYSTEM	NO INFO	NO INFO
SECTION 2.7.1 - PRE DEVELOPMENT	0.83	1.45

TAYLOR ROAD RUNOFF		
REPORT	5YR ARI (mį/s)	100YR ARI (mį/s)
DWMS EXISTING SYSTEM	NO INFO	NO INFO
WHITBY LWMS PRE DEVELOPMENT (1)	3.85	6.70

CREEK 1 TRIBUTARY 6		
REPORT	5YR ARI (mį/s)	100YR ARI (mį/s)
DWMS EXISTING SYSTEM (M40)	6.49	14.73
WHITBY LWMS PRE DEVELOPMENT (2 & 3)	2.39	7.93

MANJEDAL BROOK D/S OF SOLDIERS RD		
REPORT	5YR ARI (mį/s)	100YR ARI (mį/s)
DWMS EXISTING SYSTEM (M43)	13.42	40.21
WHITBY LWMS PRE DEVELOPMENT (4)	5.30	17.13

CREEK 2 NEAR LANG ROAD		
REPORT	5YR ARI (mį/s)	100YR ARI (mį/s)
DWMS EXISTING SYSTEM (M42)	3.26	7.74
WHITBY LWMS PRE DEVELOPMENT	NO INFO	NO INFO

LEGEND

- LWMS BOUNDARY
- PRE-DEVELOPMENT FLOW PATHS
- EXISTING OPEN DRAIN
- 25.0 — PREDEVELOPMENT GROUND CONTOURS (1m INTERVALS)
- PREDEVELOPMENT GROUND CONTOURS (0.25m INTERVALS)
- ADDITIONAL TAYLOR ROAD PRE-DEVELOPMENT RUNOFF AREA

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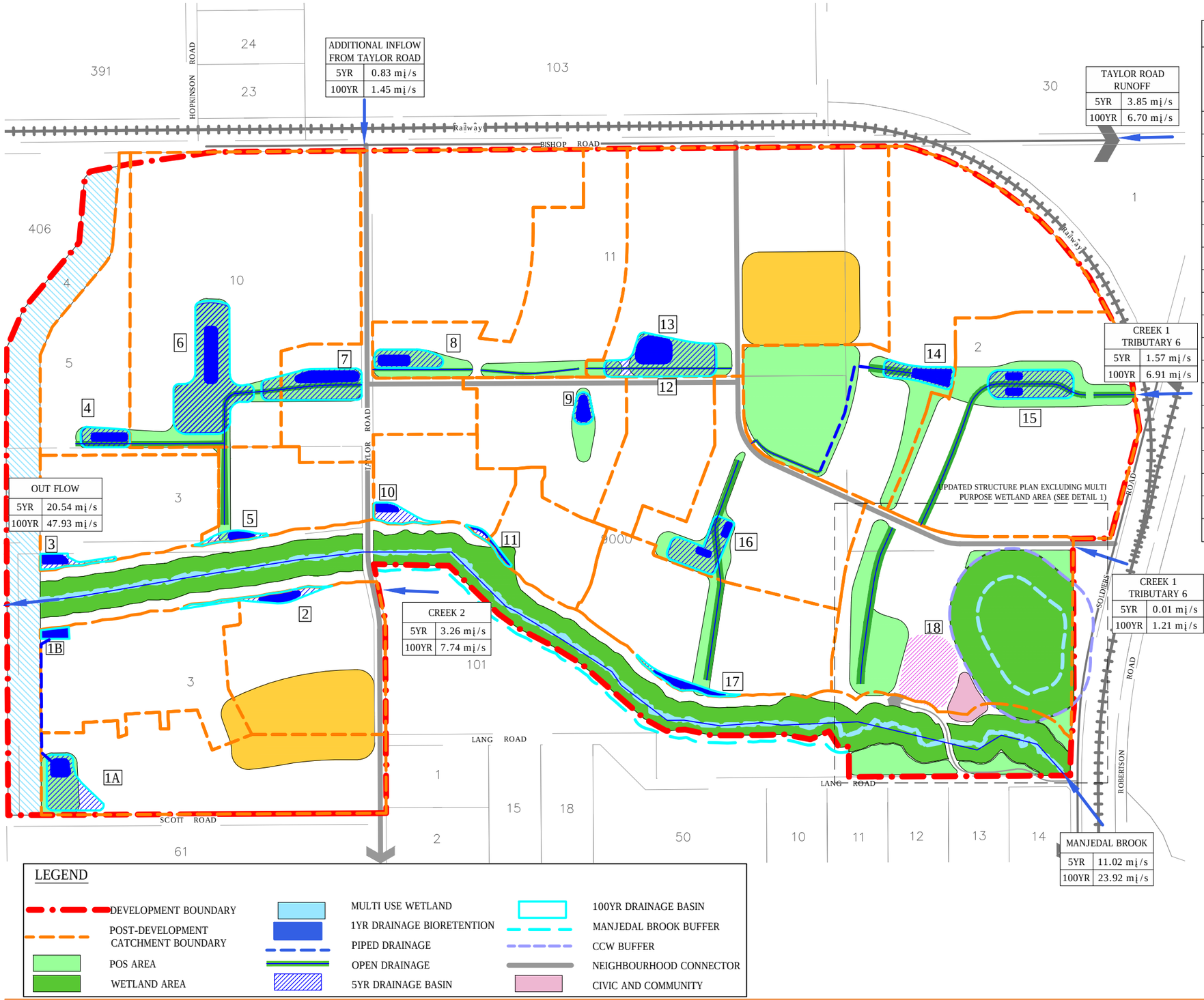
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MUNDIJONG NORTH LWMS

PRE-DEVELOPMENT SURFACE WATER FLOW PATHS

Job Number	2680-24
Revision	A
Date	MARCH 2015

FIGURE 2.8

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BASIN INFORMATION								
BASIN NUMBER	BASIN OUTLET SIZE (mm)	MIN BASIN INVERT LEVEL	MIN SUBSOIL INVERT LEVEL	1YR AREA (mł)	5YR AREA (mł)	5YR TWL (mAHD)	100YR AREA (mł)	100YR TWL (mAHD)
1A	100	26.60	26.90	1000	6600	27.40	6700	27.50
1B	450	25.54	25.84	1100	1500	26.34	1500	26.74
2	350	26.76	27.06	1000	2300	27.56	2500	27.76
3	350	25.54	25.84	700	1600	26.34	1800	26.64
4	200	27.59	27.89	900	2600	28.29	2800	28.59
5	300	26.43	26.73	600	1300	27.13	1500	27.33
6	300	27.52	27.82	2300	18200	28.42	19000	28.72
7	200	27.61	27.91	2200	8600	28.41	9000	28.71
8	200	29.05	29.35	1000	3400	29.85	3700	30.15
9	200	30.95	31.25	900	1400	31.85	1600	32.15
10	100	27.65	27.95	500	2100	28.75	2600	29.15
11	450	28.80	29.10	400	900	29.50	1000	29.70
12	200	31.85	32.15	700	1400	32.65	1400	32.65
13	200	31.85	32.15	2100	9600	32.62	10000	32.85
14	350	36.51	36.81	1500	3400	37.41	3800	37.71
15	200	37.75	38.05	1500	6900	38.65	7600	39.15
16	150	33.60	33.90	1300	5400	34.30	6100	34.80
17	400	32.65	32.95	1200	2400	33.35	2800	33.75
18	SYSTEM PART OF CCW							

NOTE:
THE DEVELOPMENT OF CATCHMENT 18 IS SUBJECT TO A SECTION 18 APPLICATION UNDER THE ABORIGINAL HERITAGE ACT 1972. SHOULD THIS AREA NOT BE DEVELOPED FOR RESIDENTIAL PURPOSES, BASIN 18 WILL NOT BE REQUIRED.

LEGEND

- DEVELOPMENT BOUNDARY
- POST-DEVELOPMENT CATCHMENT BOUNDARY
- POS AREA
- WETLAND AREA
- MULTI USE WETLAND
- 1YR DRAINAGE BIORETENTION
- PIPED DRAINAGE
- OPEN DRAINAGE
- 5YR DRAINAGE BASIN
- 100YR DRAINAGE BASIN
- MANJEDAL BROOK BUFFER
- CCW BUFFER
- NEIGHBOURHOOD CONNECTOR
- CIVIC AND COMMUNITY

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POST DEVELOPMENT
DRAINAGE MANAGEMENT

Job Number	2680-24
Revision	C
Date	JANUARY 2016

FIGURE 5.1

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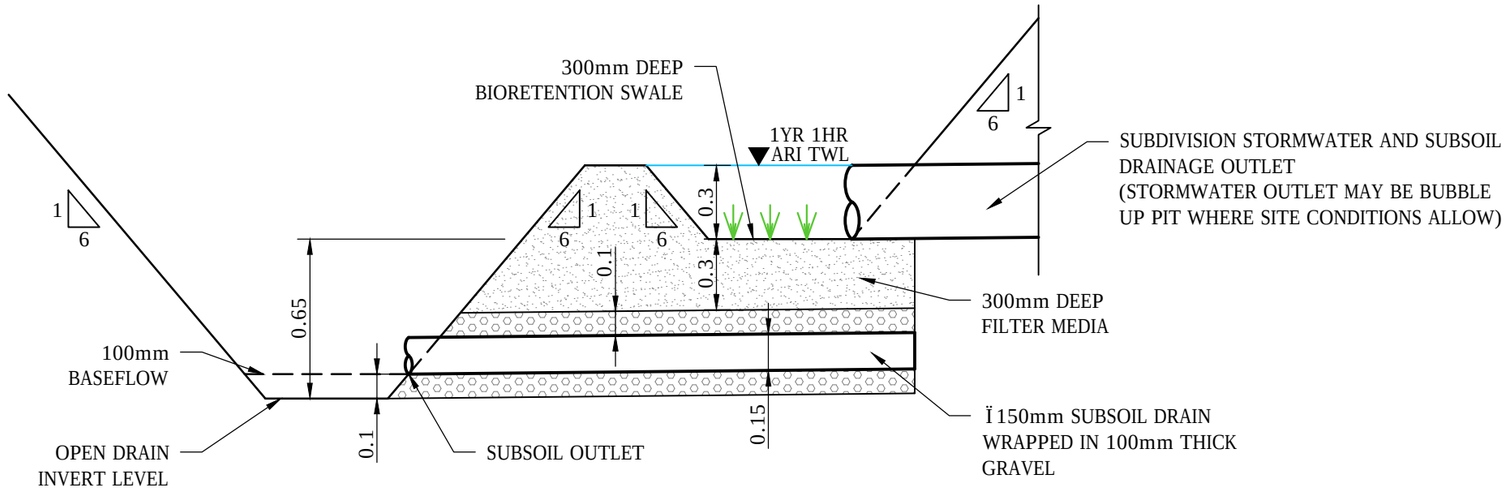
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POST DEVELOPMENT
5YR AND 100YR FLOOD DEPTHS

Job Number 2680-24
Revision A
Date FEBRUARY 2015

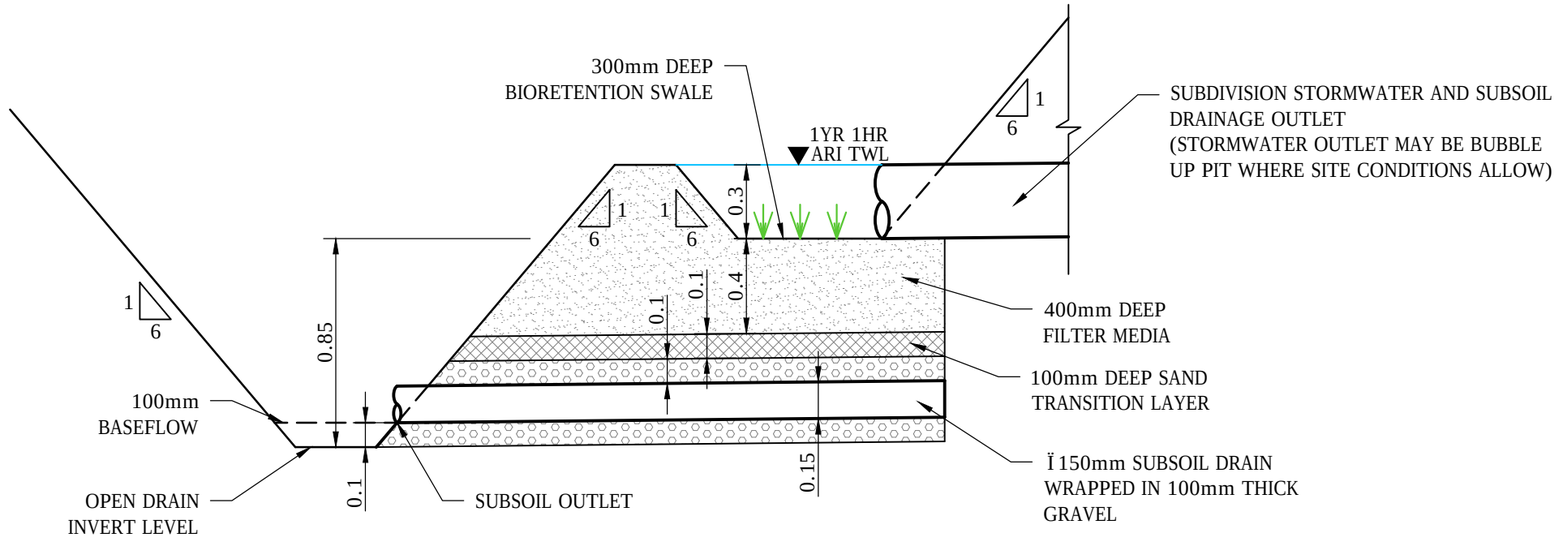
FIGURE 5.2

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OPTION 1 - WAVE DESIGN

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OPTION 2 - SHIRE OF SERPENTINE JARRAHDALE DESIGN

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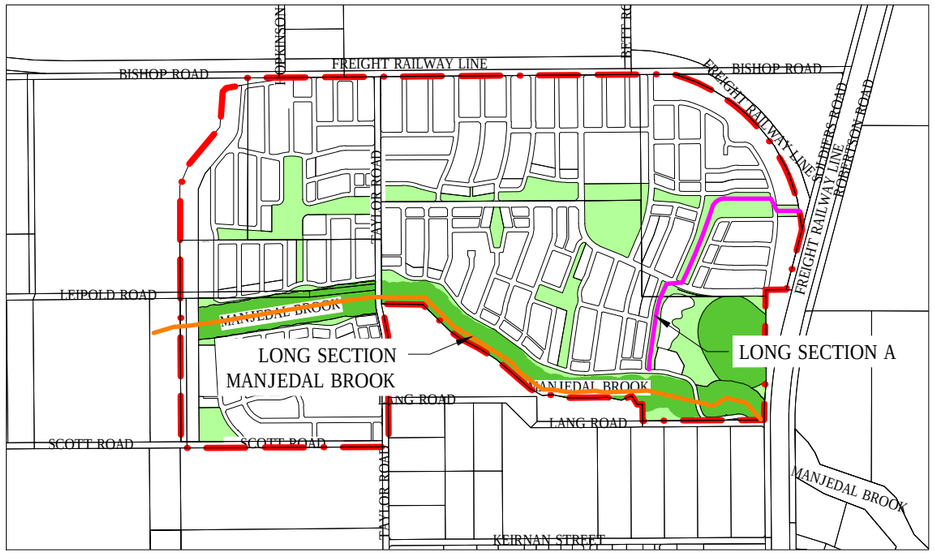
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BIORETENTION SWALE
INDICATIVE CROSS SECTION

Job Number	2680-24
Revision	B
Date	FEBRUARY 2016

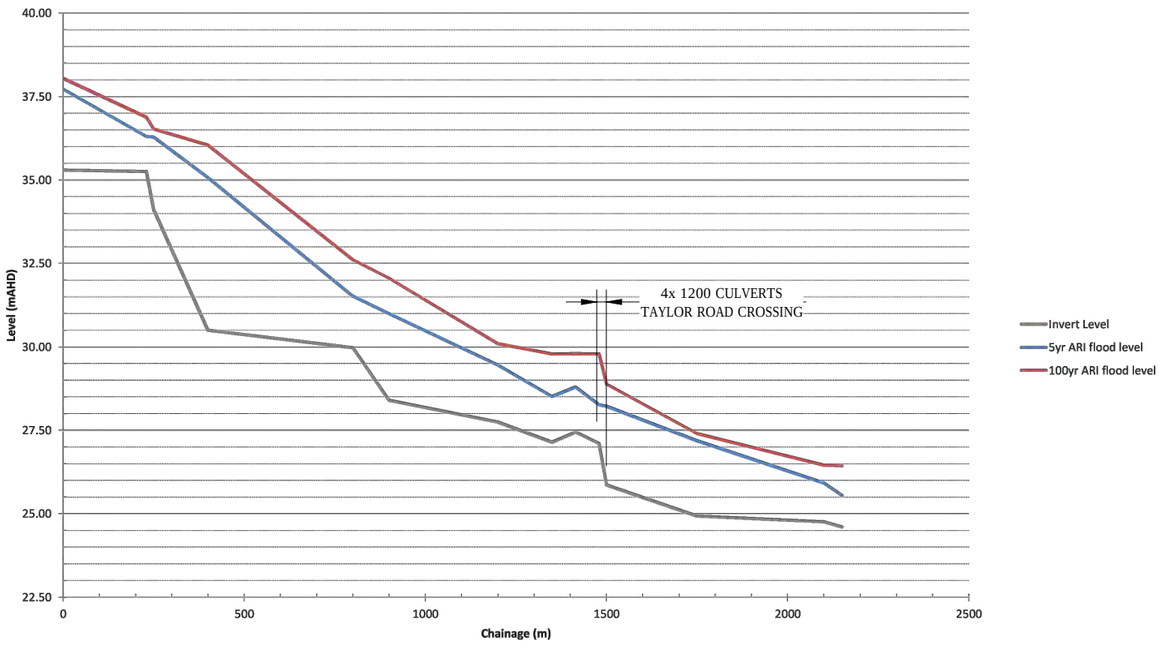
FIGURE 5.3

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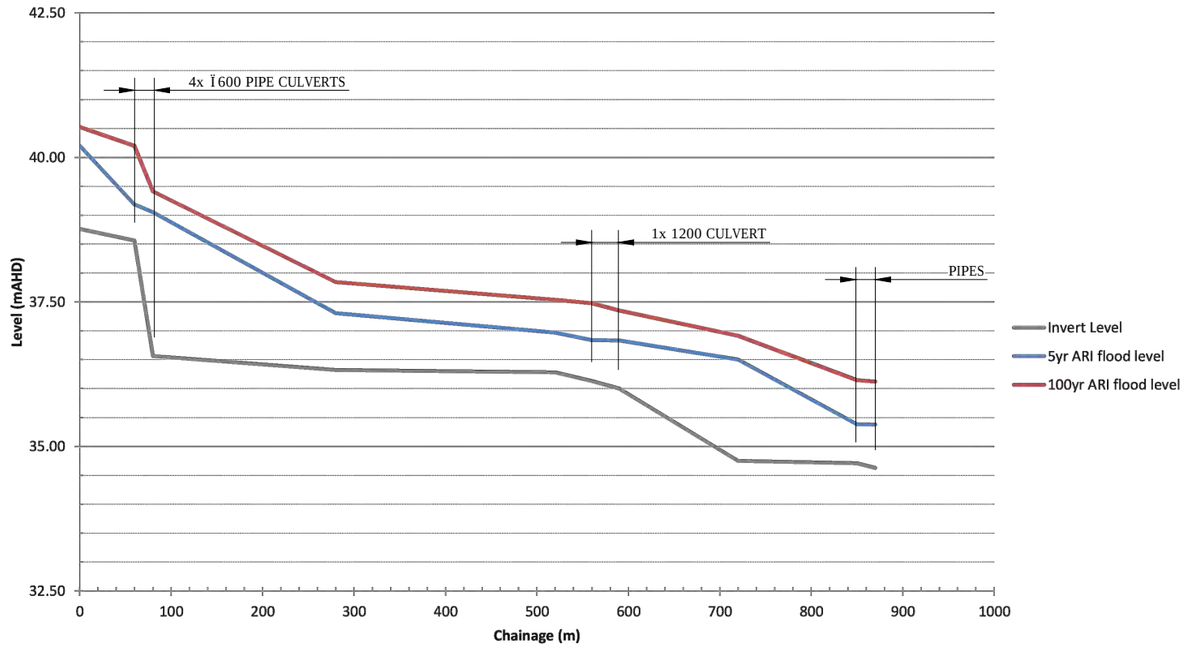
DRAINAGE PLAN

SCALE 1:20000



LONG SECTION MANJEDAL BROOK

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LONG SECTION A

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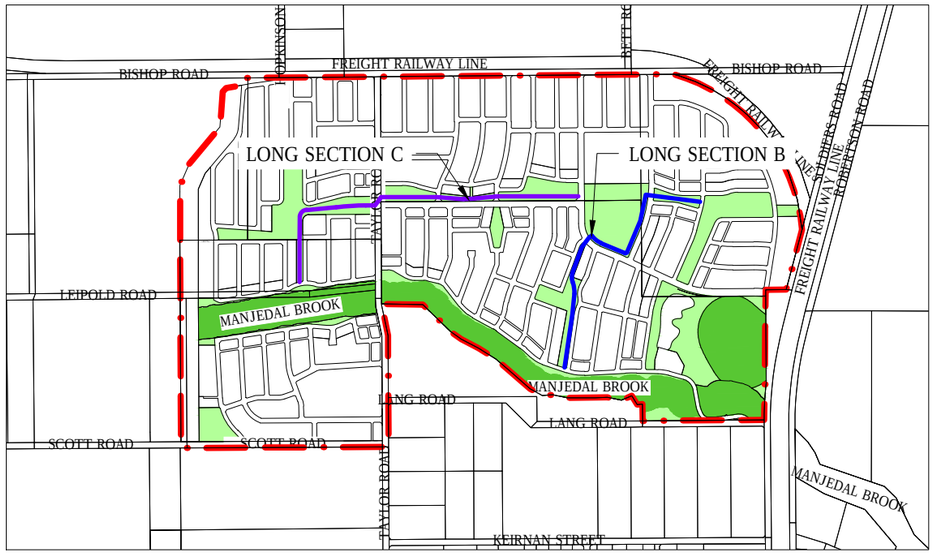
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INDICATIVE OPEN DRAIN
LONG SECTIONS - SHEET 1 OF 2

Job Number	2680-24
Revision	A
Date	FEBRUARY 2015

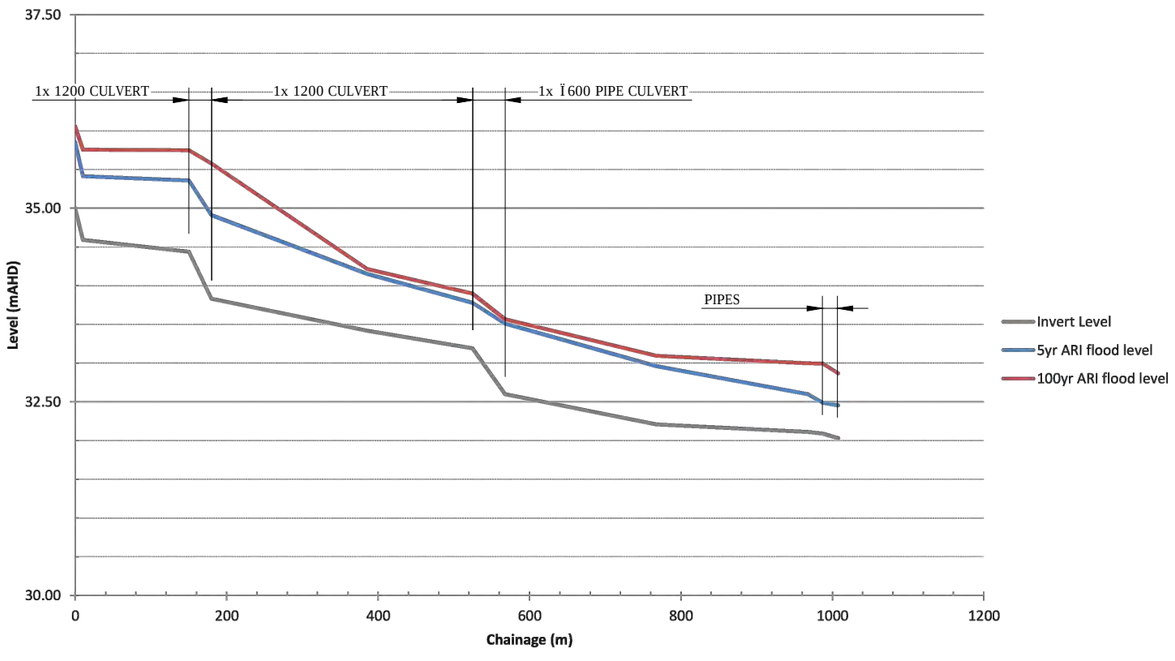
FIGURE 5.4

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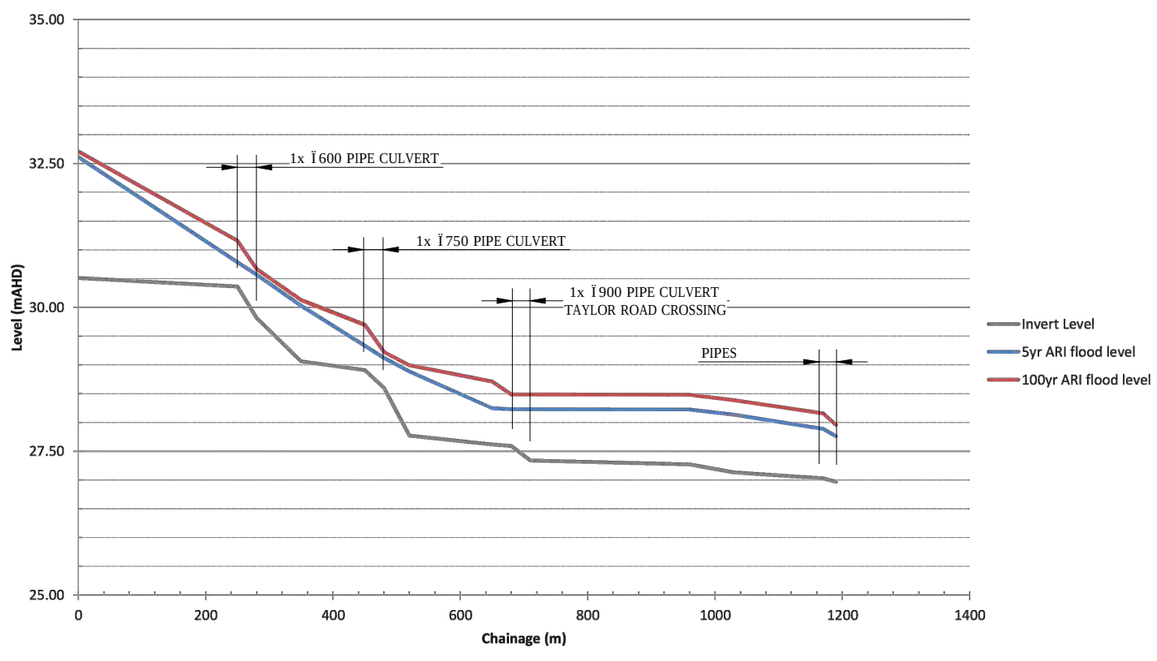
DRAINAGE PLAN

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LONG SECTION B

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LONG SECTION C

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INDICATIVE OPEN DRAIN
LONG SECTIONS - SHEET 2 OF 2

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FIGURE 5.5

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INDICATIVE SUBSOIL DRAINAGE LAYOUT

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FIGURE 5.6

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INDICATIVE ROAD RUN-OFF
BIORETENTION SWALES LAYOUT PLAN

Job Number	2680-24
Revision	A
Date	FEBRUARY 2015

FIGURE 5.7

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INDICATIVE POST-DEVELOPMENT MONITORING BORE LOCATIONS

Job Number	2680-24
Revision	A
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FIGURE 6.1

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Appendix D

Bushfire Management Plan

Bushfire Management Plan

Taylor Road, Mundijong Local Structure Plan

Project No: EP15-036(02)

Prepared for Peet Mundijong Syndicate
May 2023



Document Control

Doc name:	**Bushfire Management Plan Taylor Road, Mundijong Local Structure Plan**				
Doc no.:	**EP15-036(02)—002c VMK**				
Version	**Date**	**Author**		**Reviewer**	
1	February 2016	Anle Tieu	AT	Kirsten Knox	KK
		Vanessa Keating	VMK	Rohan Carboon	RC
	Draft report for client review/comment.				
A	February 2016	Vanessa Keating	VMK	Jen Longstaff	JL
	Updated following comment from project team.				
B	May 2023	Sophie McClintock	SAM	Kirsten Knox	KK
				Anthony Rowe	AJR
	Updated to address revised structure plan – minor changes to layout – and to align with latest version of the *Guidelines for Planning in Bushfire Prone Areas* (Version 1.4).				
C	May 2023	Kirsten Knox	KK	Anthony Rowe	AJR
	Minor updates following project team review				

Disclaimer:

This document has been prepared in good faith and is derived from information sources believed to be reliable and accurate at the time of publication. Nevertheless, it is distributed on the terms and understanding that the author is not liable for any error or omission in the information sources available or provided to us, or responsible for the outcomes of any actions taken based on the recommendations contained herein. It is also expected that our recommendations will be implemented in their entirety, and we cannot be held responsible for any consequences arising from partial or incorrect implementation of the recommendations provided.

This document has been prepared primarily to consider the layout of development and/or the appropriate building construction standards applicable to development, where relevant. The measures outlined are considered to be prudent minimum standards only based on the standards prescribed by the relevant authorities. The level of bushfire risk mitigation achieved will depend upon the actions of the landowner or occupiers of the land and is not the responsibility of the author. The relevant local government and fire authority (i.e. Department of Fire and Emergency Services or local bushfire brigade) should be approached for guidance on preparing for and responding to a bushfire.

Notwithstanding the precautions recommended in this document, it should always be remembered that bushfires burn under a wide range of conditions which can be unpredictable. An element of risk, no matter how small, will always remain. The objective of the Australian Standard AS 3959-2018 is to "prescribe particular construction details for buildings to reduce the risk of ignition from a bushfire while the front passes" (Standards Australia 2018). Building to the standards outlined in AS 3959 does not guarantee a building will survive a bushfire or that lives will not be lost.

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Executive Summary

Peet Mundijong Syndicate Ltd (Peet) has engaged Emerge Associates to prepare a Bushfire Management Plan (BMP) to support a structure plan over Lot 2 Bishop Road and Lots 3, 5,10, 11, and 9000 Taylor Road and the service corridor (Lots 1, 2 and 4), Mundijong. This area is herein referred to as "the site" and is proposed to be developed for residential purposes. The site is located approximately 37 kms south east of the Perth Central Business District (CBD), within the Shire of Serpentine Jarrahdale. It is found within the Mundijong-Whitby District Structure Plan (DSP) area which was endorsed by the Western Australian Planning Commission (WAPC) in April 2011, and guides the future development of the Mundijong-Whitby area.

The site is currently zoned 'Urban' under the provisions of the Metropolitan Region Scheme (MRS) and 'urban development' under the Shire of Serpentine Jarrahdale Town Planning Scheme No. 2 (LPS No.2).

The site is located within a 'bushfire prone area' under the state-wide *Map of Bush Fire Prone Areas* prepared by the Office of Bushfire Risk Management (OBRM) (2021). The identification of a site within an area declared as bushfire prone necessitates further assessment of the determined bushfire risk affecting the site in accordance with *Australian Standard 3959:2018 Construction of buildings in bushfire prone areas* (AS 3959), and the satisfactory compliance of the proposal with the policy measures described in *State Planning Policy 3.7 Planning in Bushfire Prone Areas* (SPP 3.7) (WAPC 2015) and the *Guidelines for Planning in Bushfire Prone Areas Version 1.4* (the Guidelines) (DPLH & WAPC 2021).

The purpose of a structure plan under the *Planning and Development Act 2005* is to provide guidance to the for the layout of a subsequent application for subdivision following the zoning and intended purpose of land identified in a region or local planning scheme.

The purpose of this bushfire management plan (BMP) is to assess the bushfire hazards, both within and nearby the site (bushfire risk) , and identify the 'management' strategies (risk treatments) required to demonstrate the capability for the development of the land to comply with the intent of SPP 3.7 - *to preserve life and reduce the impact of bushfire on property and infrastructure.* The policy intent is met by demonstrating compliance with the policy objectives, and policy measures informed by the bushfire protection criteria in the Guidelines and satisfaction of its four elements. Each element in the bushfire protection criteria can be met by utilising an acceptable solution or a performance principle.

This BMP has followed the requirements of SPP 3.7 to identify bushfire risk and the bushfire protection measures that will make the land suitable for its intended purpose. As part of this, a bushfire hazard level (BHL) assessment and a Bushfire Attack Level (BAL) assessment involving the classification of vegetation within 150 m of the site has been undertaken in accordance with AS 3959.

The BHL assessment for the existing conditions indicates that the majority of the site is subject to a 'moderate' bushfire hazard as it is largely cleared paddock areas. As part of assessing the long-term bushfire risk to the site, vegetation classifications have been detailed for the post-development scenario. It is anticipated that portions of the future public open space (POS) areas within the site will

be maintained to achieve low threat in accordance with Section 2.2.3.2 of AS 3959. Other areas of POS, associated with the conservation category wetlands and their buffer have been assumed to be a bushfire hazard with a vegetation classification applied (and outlined below). The following bushfire hazards were identified as applicable to the site following residential development:

- Forest (Class A) vegetation, associated with Manjedal Brook and the conservation category wetland situated within the southern portion of the site, is assumed to remain in the long-term.
- Woodland (Class B) vegetation, situated north, west and south-east of the site associated with road verges and rural residential properties.
- Scrub (Class D) vegetation situated within the southern portions of the site, associated with areas proposed to be revegetated (adjacent to Manjedal Brook and the conservation category wetland) as well as remnant vegetation to the north-west, west and east, associated with unmanaged vegetation situated within Bishop Road and Soldiers Road reserves and external lot boundaries.
- Grassland (Class G) vegetation surrounding the site, associated with areas used for agricultural purposes, including grazing and pasture, as well as a railway corridor in the north-east.

All classified vegetation outside the site, is assumed to remain in its existing condition and therefore pose a bushfire risk to the site in the long-term. Areas to the south form part of the Mundijong-Whitby DSP and could eventually be developed for residential purposes, and therefore may only be a temporary hazard.

Compliance Assessment

The outcomes of this BMP demonstrate that as development progresses, it will be possible for an acceptable solution to be adopted for each of the applicable bushfire protection criteria outlined in the Guidelines. This includes:

- **Location:** The site is largely subject to a moderate bushfire hazard level based on existing conditions. The proposed development is at a higher order strategic planning stage, and the site will, overall, include sufficient area to enable all habitable buildings to achieve BAL-29 or lower in the post-development scenario (i.e. following implementation of clearing/vegetation modification) to accommodate future residential development. The majority of the site will be subject to BAL-LOW upon completion of development, and has included consideration of future revegetation.
- **Siting and Design:** The site generally accommodates a suitable asset protection zone (APZ) for all proposed development cells (future lots) through the provision of a perimeter public road network and or public open space, enabling the majority of lots to achieve BAL-29 or less. A small portion of the development cells within the site in the north-east, south-west and west may be subject to BAL-FZ and BAL-40 as a result of identified bushfire hazards, predominantly associated with adjacent rural landholdings, rail corridor or road reserves. The western and north-eastern most lots may require in-lot setbacks to accommodate the appropriate separation (8 m) from grassland vegetation within the Water Corporation services corridor and railway corridor respectively, but the indicated development layout suggests this is achievable and can be considered when lot layout is addressed at future subdivision stages.

- **Vehicular Access:** Vehicle access to multiple destinations can be provided, with the site providing direct access to Taylor Road through the centre, Bishop Road to the north and Soldiers Road to the east, which provide access to the Byford and Mundijong town sites. Two permanent no-through roads are proposed within the structure plan. The proposed permanent no-through roads are less than 200 m in length and can meet the acceptable solution.
- **Water:** The proposed future residential development will be serviced by a reticulated water network and provision of hydrants.

The management/mitigation measures to be implemented through the future development of the site, as discussed in this BMP, demonstrate that the acceptable solutions and the intent of each element can be met. Accordingly, having regard to clause 6.11 of SPP 3.7, the precautionary principle has been satisfied.

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Appendices

Appendix A

Taylor Road, Mundijong – Local Structure Plan (Taylor Burrell Barnett 2023)

Appendix B

Taylor Road, Mundijong – Landscape Masterplan (Emerge Associates 2023)

List of Abbreviations

Table A1: Abbreviations – General terms

General terms	
AHD	Australian Height Datum
AS	Australian Standard
APZ	Asset Protection Zone
BAL	Bushfire Attack Level
BMP	Bushfire Management Plan
BPAD	Bushfire Planning and Design
Developable land	*Position Statement: Planning in bushfire prone areas - Demonstrating Elements 1: Location and Element 2: Siting and design* (DPLH 2019) has outlined that 'developable land' is "*land that can accommodate a habitable dwelling and would not generally include areas of BAL-40 and/or BAL-FZ, areas within the local government setback and areas subject to environmental constraints*".
ESA	Environmentally Sensitive Area
EAW	Emergency access way
FDI	Fire Danger Index
FSAR	Fire Service Access Route
FZ	Flame Zone
Habitable building	As defined in Planning and Development (Local Planning Schemes) Regulations 2015, a 'habitable building' is *"a permanent or temporary structure on land that* – (a) is fully or partially enclosed; and (b) has at least one wall of solid material and a roof of solid material; and (c) is used for a purpose that involves the use of the interior of the structure by people for living, working, studying or being entertained"
SLIP	Shared Location Information Platform
TEC	Threatened ecological community

Table A2: Abbreviations – Organisations

Organisations	
DBCA	Department of Biodiversity Conservation and Attractions
DFES	Department of Fire and Emergency Services
DPLH	Department of Planning, Lands and Heritage
DWER	Department of Water and Environment Regulation
EPA	Environmental Protection Authority
OBRM	Office of Bushfire Risk Management
WAPC	Western Australian Planning Commission
WASAT	Western Australian State Administrative Tribunal

Table A3: Abbreviations – Legislation and policies

Legislation	
AS 3959	Australian Standard 3959-2018 Construction of buildings in bushfire prone areas
Guidelines	Guidelines for Planning in Bushfire Prone Areas version 1.4 (DPLH & WAPC 2021)
NCC	National Construction Code
SPP 3.7	*State Planning Policy 3.7 Planning in Bushfire Prone Areas* (WAPC 2015)

Table A4: Abbreviations – Planning and building terms

Planning and building terms	
LPS	Local Planning Scheme

Table A5: Abbreviations – units of measurement

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

1 Introduction

1.1 Background

Peet Mundijong Syndicate Ltd (Peet) has engaged Emerge Associates to prepare a Bushfire Management Plan (BMP) to support a structure plan over Lot 2 Bishop Road and Lots 3, 5,10, 11, and 9000 Taylor Road and the service corridor (Lots 1, 2 and 4), Mundijong. This area is herein referred to as "the site" and is proposed to be developed for residential purposes. The proposed structure plan is provided in **Appendix A**. The site is approximately 37 kms south east of the Perth Central Business District (CBD), and is located within the Shire of Serpentine Jarrahdale. It is found within the Mundijong-Whitby District Structure Plan (DSP) area which was endorsed by the Western Australian Planning Commission (WAPC) in April 2011, and guides the future development of the Mundijong-Whitby area.

The site is approximately 199 ha in size and has been historically cleared for broad scale agricultural land uses including dairy farming and more recently grazing. The site is bound by Soldiers Road to the east, Bishop Road to the north, the Tonkin Highway road reserve to the west and Manjedal Brook and Scott Road to the south, as shown in **Figure 1**.

The site is located within a 'bushfire prone area' under the state-wide *Map of Bush Fire Prone Areas* prepared by the Office of Bushfire Risk Management (OBRM) (2021), as shown in **Plate 1**. The identification of a site within an area declared as bushfire prone necessitates a further assessment of the determined bushfire risk affecting the site in accordance with *Australian Standard 3959:2018 Construction of buildings in bushfire prone areas* (AS 3959), and the satisfactory compliance of the proposal with the policy measures described in *State Planning Policy 3.7 Planning in Bushfire Prone Areas* (SPP 3.7) (WAPC 2015) and the *Guidelines for Planning in Bushfire Prone Areas Version 1.4* (the Guidelines) (DPLH & WAPC 2021).

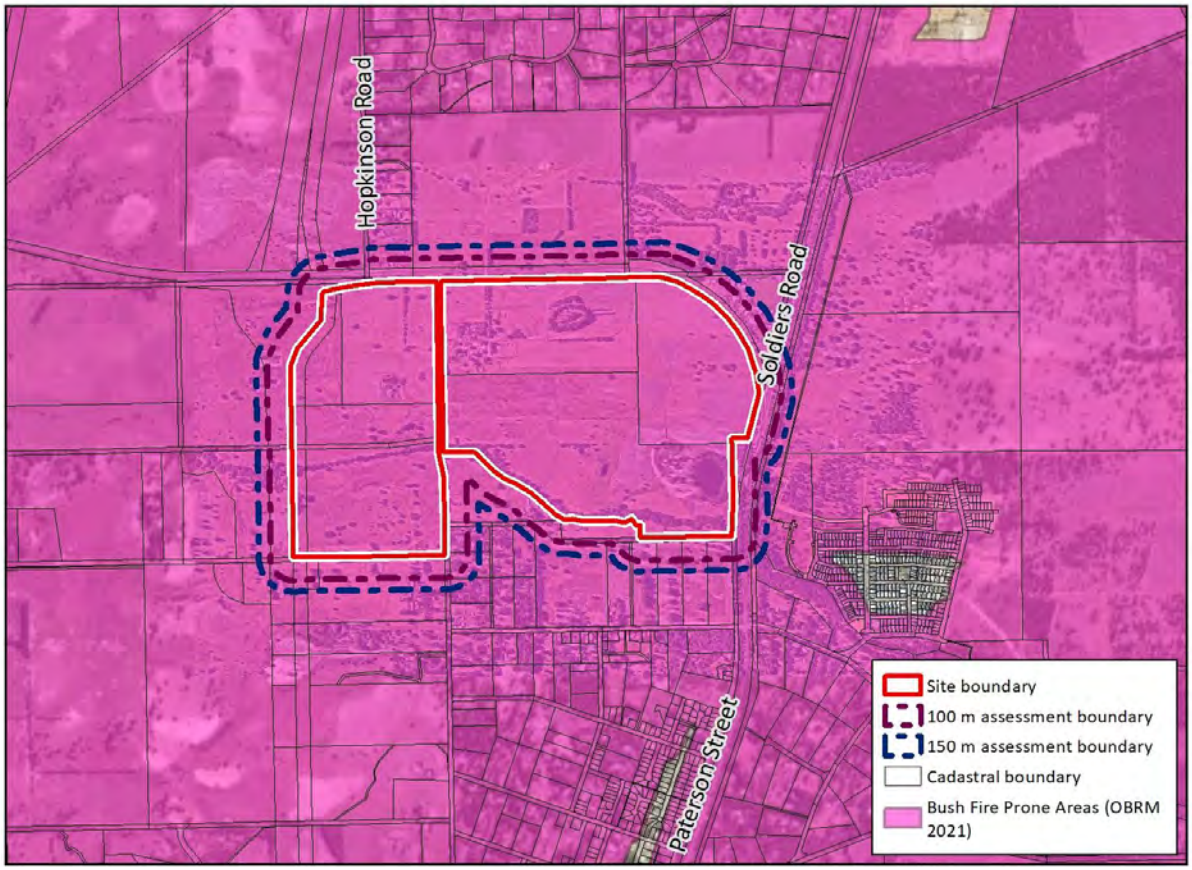


Plate 1: Areas within and surrounding the site identified as 'bushfire prone areas' (as indicated in purple) under the state-wide Map of Bush Fire Prone Areas (OBRM 2021).

The purpose of SPP 3.7 and the policy intent is to preserve life and reduce the impact of bushfire on property and infrastructure through effective risk-based land use planning. Importantly, it is risk-based, requiring a methodical approach to identify and evaluate the hazards and provide the treatments to ameliorate these hazards to an acceptable level. SPP 3.7 requires that the determining authority give consideration to the precautionary principle (clause 6.11 in SPP 3.7) and they must be satisfied that the potential for significant adverse impacts can be adequately reduced or managed. In particular:

> *SPP 3.7 does not require that there be no increase at all in the threat of bushfire to people property or infrastructure. Rather, as is seen in clause 2 of SPP 3.7, the intention of the policy is to 'implement effective, risk¬based land use planning and development to preserve life and* ***reduce the impact of bushfire on property and infrastructure'****.* (emphasis added) [1]

1.2 Aim of this report

The aim of this BMP is to assess bushfire hazards within the site and nearby areas and ensure that the threat posed by any identified hazards can be appropriately mitigated and managed and demonstrate satisfaction of clause 6.11 of SPP 3.7 (the precautionary principle). This BMP has been prepared as an update to a previous BMP (prepared using an earlier version of the Guidelines) and addresses the requirements of SPP 3.7 (WAPC 2015), the Guidelines (DPLH & WAPC 2021) and

[1] Harmanis Holdings No. 2 Pty Ltd and Western Australian Planning Commission [2019] WASAT 43 (Harmanis).

AS 3959 (Standards Australia 2018). The document provides an assessment of the general bushfire management strategies to be considered as part of the future residential development within the site and includes:

- Overview of the proposed development (see **Section 1.4**).
- An assessment of the existing classified vegetation in the vicinity of the site (within 150 m) and consideration of bushfire hazards that will exist in the post-development scenario (**Section 3**).
- Commentary on how future development can achieve the bushfire protection criteria outlined within the Guidelines (**Section 5**).
- An outline of the roles and responsibilities associated with implementing this BMP (see **Section 6**).

1.3 Statutory policy and framework

The following key legislation, policies and guidelines are relevant to the preparation of a bushfire management plan:

- *Bush Fires Act 1954*
- *Fire and Emergency Services Act 1998*
- *Planning and Development Act 2005* and associated regulations
- *Building Act 2011* and associated regulations
- *State Planning Policy 3.7 Planning in Bushfire Prone Areas* (WAPC 2015)
- *Guidelines for Planning in Bushfire Prone Areas Version 1.4* (DPLH & WAPC 2021)
- *Australian Standard AS 3959 – 2018 Construction of buildings in bushfire prone areas* (Standards Australia 2018)

1.4 Description of the proposed development

The proposed structure plan (Taylor Burrell Barnett Town Planning & Design), as shown in **Appendix A**, provides a framework for future urban development within the site. The purpose of a structure plan under the *Planning and Development Act 2005* is to provide guidance for the layout of a subsequent application for subdivision following the zoning and intended purpose of land identified in a region or local planning scheme. Following development, the site is proposed to support:

- Residential lots of varying density, to provide a range of lot sizes and lifestyle options
- Two primary school sites
- Public road reserves
- Areas of public open space (POS), incorporating appropriate drainage reserves
- Remnant waterway and wetland areas with the accommodation of associated buffer areas
- A 60 m wide service corridor ('Water Corporation service corridor') adjacent to the future Tonkin Highway road reserve west of the site.

The site is currently zoned 'Urban' under the provisions of the Metropolitan Region Scheme (MRS) (shown in **Plate 2**) and 'urban development' under the Shire of Serpentine Jarrahdale Town Planning Scheme No. 2 (LPS No.2).

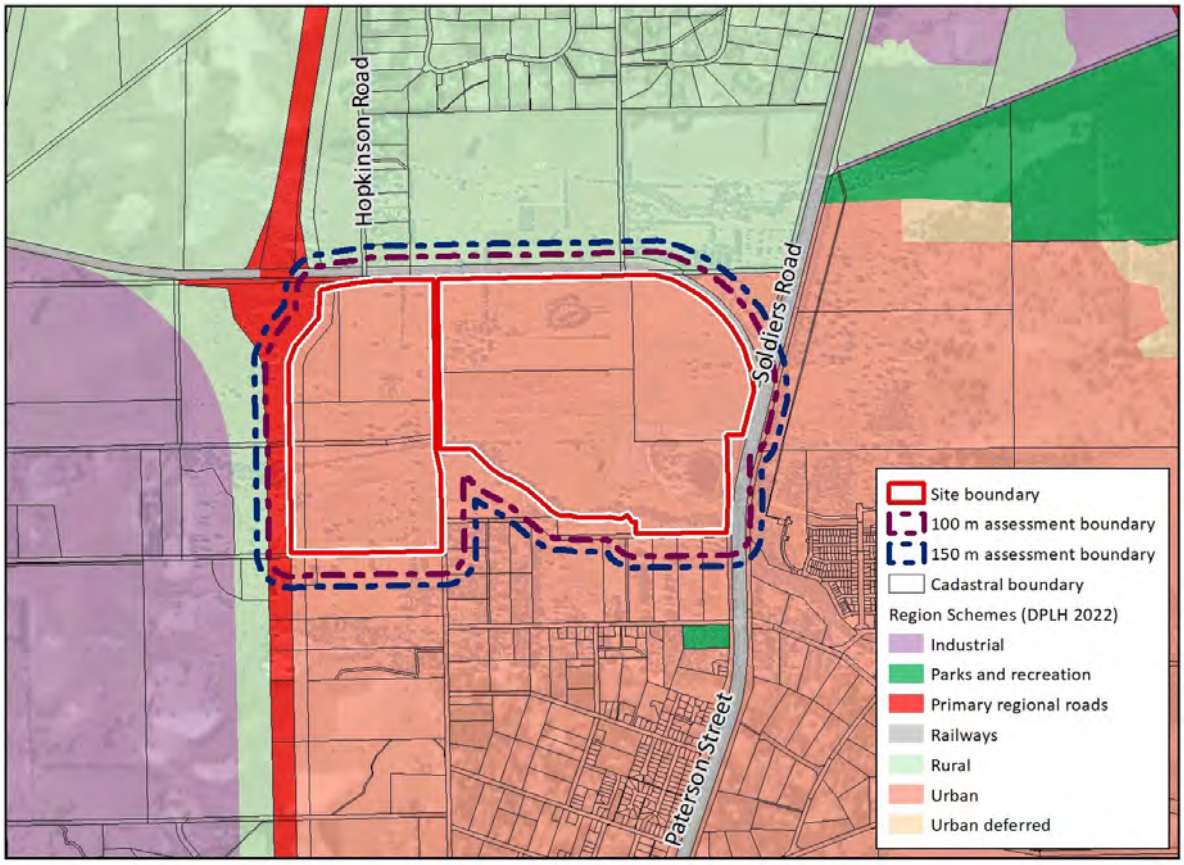


Plate 2: Metropolitan Region Scheme Zoning, in and surrounding the site.

1.5 Description of land characteristics

The site is generally flat, with a gentle downward slope from the east to the west of the site. Elevation ranges from 40 metres Australian Height Datum (m AHD) in the north-eastern corner to 26 m AHD in the west of the site. Topographic contours for the site are shown in **Figure 1**.

Based on a review of available historic aerial photography, the site has historically been cleared of native vegetation (prior to 1953) for broad scale agriculture, including dairy farming and livestock grazing. The majority of the site is cleared with scattered trees, however, portions of remnant vegetation are found within the site but are largely restricted to vegetation within Manjedal Brook and on the fringes of wetland areas in the southern extent of the site, as shown in **Figure 1**.

A review of the Geomorphic Wetlands of the Swan Coastal Plain dataset (DBCA 2020) indicates that two conservation category wetlands (CCWs) are identified within the site, namely Manjedal Brook in the southern portion and a wetland in the south-west corner of the site (unique feature identification (UFI) 14945, 7835). These are shown in **Figure 1.** In addition, a multiple use wetland (MUW) (UFI 16021) is mapped across the majority of the site.

2 Environmental Considerations

In accordance with the *Bushfire Management Plan – BAL Contour* template prepared by the Department of Planning, Lands and Heritage (DPLH) (2018), this BMP has considered whether there are any environmental values that may require specific consideration through either protection, retention or revegetation. To support this, a review of publicly available databases have been undertaken, with particular reference to the Shared Location Information Platform (SLIP) databases and investigations undertaken to support the structure plan, including a Spring Flora and Vegetation Survey (vegetation survey) (Emerge Associates 2017). A summary of the search results has been provided in **Table 1**.

Key environmental considerations for future development of the site and management of bushfire risk include the conservation category wetlands associated with Manjedal Brook and a wetland within the southern and southeast portion of the site.

Table 1: Summary of potential environmental considerations that may be associated with the site (based on a search of the SLIP databases)

Key environmental feature (information in brackets refers to mapping data source)	Yes / no / potentially occurring within the site	If yes / potentially, describe the value that may be impacted
Conservation category wetlands and buffers (DBCA-019)	Yes	Conservation category wetlands (CCWs) were identified within the southern portion of the site (unique feature ID 15446 and 7835). These features are associated with a waterway and sumpland proposed to be retained, and 50 m buffers for each have been accommodated within the structure plan.
RAMSAR wetlands (DBCA-010)	No	Not applicable. No RAMSAR wetlands are located within or adjacent to the site.
Waterways (Hydrography Linear (Hierarchy) (DWER-031))	Yes	Manjedal Brook, a minor tributary and also a CCW, is mapped within the southern portion of the site. This area is currently composed of a remnant trees surrounded by cleared agricultural pastures and is proposed to be retained within a 50 m buffer.
Threatened and priority flora (DBCA-036) (Emerge Associates 2017)	No	The majority of the site has been historically cleared for agriculture purposes, with the exception of the CCW, it is highly unlikely that threatened or priority flora species occur within the site. No threatened or priority flora were recorded within the site during a vegetation and flora survey (Emerge Associates 2017).
Threatened and priority fauna (DBCA-037)	No	A review of publicly available databases indicates that a number of conservation significant fauna species may occur within the site or nearby. No detailed fauna or fauna habitat surveys have been completed for the site, however as outlined above, the site is largely cleared of remnant native vegetation, apart from the CCW features associated with Manjedal Brook and the wetland feature. It is highly unlikely the site would provide important habitat for threatened or priority fauna species given the lack of suitable habitat.

Table 1: Summary of potential environmental considerations that may be associated with the site (based on a search of the SLIP databases) (continued)

Key environmental feature (information in brackets refers to mapping data source)	Yes / no / potentially occurring within the site	If yes / potentially, describe the value that may be impacted
Threatened ecological communities (TEC) (DBCA-038)	No.	No threatened or ecological communities were identified within the site during a vegetation and flora survey (Emerge Associates 2017).
Department of Biodiversity Conservation and Attractions (DBCA) controlled lands or waters (DBCA-011)	No	Not applicable. No DBCA controlled lands or waters exist within or adjacent to the site.
Clearing regulations – Environmentally Sensitive Areas (DWER-046)	Yes	The south and east portions of the site are mapped as an environmentally sensitive area (ESA) likely relating to the CCW (south) and the Soldiers Road reserve (east).

2.1 Native vegetation – modification and clearing

As outlined above, the site has historically been cleared and mainly supports paddock grasses. Native vegetation comprises areas surrounding the wetland in the southwest corner of the site, vegetation aligning with Manjedal Brook, scattered paddock trees as well as remnant trees aligning fences.

No areas of native vegetation outside the site are proposed to be modified or cleared by the proponent as part of the proposed development.

With regard to bushfire management, native vegetation clearing within the site may be required to enable the relevant siting and access requirements of typical subdivision development, as well as the Guidelines, to be achieved and would be associated with clearing to establish:

- Future lots
- Asset protection zones (APZs)
- Public roads
- POS areas.

Where clearing of native vegetation is undertaken in accordance with a future subdivision approval under the *Planning and Development Act 2005*, it is exempt from requiring a clearing permit under Schedule 6 of the *Environmental Protection Act 1986* (EP Act). Additionally, a clearing permit will not be required where other exemptions pursuant to the *Environmental Protection Act 1986* such as those associated with or Section 33 of the *Bush Fires Act 1954* or Environmental Protection (Clearing of Native Vegetation) Regulations 2004 (where outside an ESA) exist, such as those associated with approved buildings and other structures (through building licence).

No clearing of vegetation is assumed within Manjedal Brook or the wetland feature, or in the associated buffer areas.

2.2 Revegetation and landscape plans

It has been assumed that the remnant vegetation associated with Manjedal Brook and the CCW will be protected, retained and where required revegetated, and is identified as 'forest' vegetation. It is also assumed that the 50 m buffer proposed for each feature will be revegetated to a 'scrub classification' (currently composed of cleared paddocks) and a bushfire hazard in the long-term. No management is assumed.

Managed POS areas are proposed within the site. These areas are assumed to be designed, implemented and maintained to achieve low threat in accordance with Section 2.2.3.2 of AS 3959. Management is assumed to be undertake by the proponent and following hand-over, will be the responsibility of the Shire of Serpentine Jarrahdale in perpetuity.

The overall landscape concept plan for the site is provided in **Appendix B**.

3 Bushfire Assessment Results

Bushfire risk for the site has been appropriately considered both in context to the site and potential impact upon the site using AS 3959 and the Guidelines.

The objective of AS 3959 is to reduce the risk of ignition and loss of a building to bushfire. It provides a consistent method for determining a radiant heat level (radiant heat flux) as a primary consideration of bushfire attack. AS 3959 measures the Bushfire Attack Level (BAL) as the radiant heat level (kW/m^2) over a distance of 100 m. AS 3959 also prescribes deemed-to-satisfy construction responses that can resist the determined radiant heat level at a given distance from the fire. It is based on six Bushfire Attack Level (BAL) ratings: BAL-LOW, BAL-12.5, BAL-19, BAL-29, BAL-40 and BAL-FZ.

To support the proposed structure planning process, the following has been undertaken and are discussed further below:

- Bushfire hazard levels (BHL) within and nearby to the site have been determined in accordance with Appendix Two of the Guidelines and based on the pre-development vegetation classification detailed in **Table 2**.
- A method 1 BAL assessment in accordance with AS 3959 has been undertaken to determine the likely BAL ratings, and is based on the post-development vegetation classifications and effective slope detailed in **Table 3**.

3.1 Vegetation classification

Assessing bushfire hazards takes into account the vegetation classifications and exclusions within the site and surrounding area for a minimum of 100 m, in accordance with AS 3959 and the Guidelines. The assignment of vegetation classifications is based on an assessment of vegetation structure, which includes consideration of the various fuel layers of different vegetation types, as outlined in **Plate 3**. The BMP considers vegetation within the site and nearby areas based on current conditions, observed through the site visit (termed 'pre-development'), and changes to that vegetation that will occur as a result of implementing the proposed development (termed 'post-development').

An assessment of existing vegetation and effective slope within the site and surrounding 150 m was undertaken during a site visit in August 2015 in accordance with AS 3959 and the Guidelines and reconsidered as part of the update to this BMP and other investigations.

Each distinguishable pre-development vegetation plot (based on existing conditions) is described in **Table 2** and shown in **Figure 2**. Existing bushfire hazard levels (based on vegetation identified in **Figure 2**) are shown in **Figure 3** and discussed in **Section 3.2.1.** The post-development vegetation classifications are shown in **Figure 4** and are based on the assumptions detailed in **Section 3.2.2**.

Not all vegetation is a classified bushfire risk. Vegetation and ground covers that are exempt from classification as a potential hazard is identified as a low threat under Section 2.2.3.2 of AS 3959. Low threat vegetation includes the following:

a. *Any vegetation that is more than 100 m from the site.*
b. *Single areas of vegetation less than 1 ha in area and not within 100 m of other areas of vegetation being classified.*
c. *Multiple areas of vegetation less than 0.25 ha in area and not within 20 m of the site, or each other, or of other areas of vegetation being classified.*
d. *Strips of vegetation less than 20 m in width (measured perpendicular to the elevation exposed to the strip of vegetation) regardless of length and not within 20 m of the site or each other, or other areas of vegetation being classified.*
e. *Non-vegetated areas, that is, areas permanently cleared of vegetation, including waterways, exposed beaches, roads, footpaths, buildings and rocky outcrops.*
f. *Vegetation regarded as a low threat due to factors such as flammability, moisture content or fuel load. This includes grassland managed in a minimal fuel condition, mangroves and other saline wetlands, maintained lawns, golf courses (such as playing areas and fairways), maintained public reserves and parklands, sporting fields, vineyards, orchards, banana plantations, market gardens (and other non-curing crops), cultivated gardens, commercial nurseries, nature strips and windbreaks.*



Plate 3: The five fuel layers in a forest environment that could be associated with fire behaviour (Gould et al. 2007)

Table 2: Pre-development vegetation classification and/or exclusions

Photo ID:	1	**Plot:**	1
Vegetation Classification or Exclusion Clause			
Forest (Class A) (flat / upslope)			
Description / Justification for Classification			
Plot 1 contains Class A (forest) vegetation, situated within the eastern portion of the site associated with the wetland. The vegetation has a multi-tiered fuel structure, with an overstorey of eucalyptus trees reaching between 10 – 15 metres in height and providing more than 30% foliage cover. The understorey is primarily comprised of sedges and some shrub species.			



Photo ID:	2	**Plot:**	1
Vegetation Classification or Exclusion Clause			
Forest (Class A) (flat / upslope)			
Description / Justification for Classification			
Forest (Class A) situated within the eastern portion of the site associated with the wetland. The vegetation has a multi-tiered fuel structure, with an overstorey of eucalyptus reaching between 10 – 15 metres in height and providing more than 30% foliage cover. The understorey comprises species of myrtaceae, casuarina and sedges.			



Photo ID:	3	**Plot:**	2
Vegetation Classification or Exclusion Clause			
Forest (Class A) (Flat / Upslope)			
Description / Justification for Classification			
Vegetation within Plot 2 consists of a Class A (forest) structure with an overstorey of eucalyptus trees (*Eucalyptus rudis*) or melaleucas over an understorey of unmanaged grassland. The overstorey reaches an approximate height of 15 m. Plot 2 is associated with Manjedal Brook, within the southern portion of the site.			



Table 2: Pre-development vegetation classification and/or exclusions (continued)

Photo ID:	5	**Plot:**	3
Vegetation Classification or Exclusion Clause			
Forest (Class a) (flat / upslope)			
Description / Justification for Classification			
Forest vegetation is located south of the site, primarily consisting of eucalyptus trees aligning the boundary of the indicated landholdings with sporadic grass understorey. The tree canopy consists of approximately 30% of the foliage cover.			



Photo ID:	6	**Plot:**	5
Vegetation Classification or Exclusion Clause			
Scrub (Class D) (flat / upslope)			
Description / Justification for Classification			
Plot 5 contains Class D (scrub) vegetation (right of image), which reaches an approximate height of 4 m to 6 m. The vegetation consists of sedges and perennials, with some melaleuca. The scrub vegetation is situated adjacent west of the wetland within the southeast portion of the site.			



Photo ID:	7	**Plot:**	5
Vegetation Classification or Exclusion Clause			
Scrub (Class D) (flat / upslope)			
Description / Justification for Classification			
Scrub vegetation associated with the wetland is located within the southeast portion of the site. The vegetation consisted of sedges within inundated areas, surrounded by melaeuca vegetation up to 4 m in height.			



Table 2: Pre-development vegetation classification and/or exclusions (continued)

Photo ID:	4	**Plot:**	7
Vegetation Classification or Exclusion Clause			
Grassland (Class B) (flat / upslope)			
Description / Justification for Classification			
Vegetation within Plot 7 consists of unmanaged paddock grasses varying in height, identified as Class G (grassland). Some isolated pockets of eucalyptus trees exist however consist of <10 % foliage cover.			



Photo ID:	8	**Plot:**	7
Vegetation Classification or Exclusion Clause			
Grassland (Class G) (flat / upslope)			
Description / Justification for Classification			
Plot 7 is identified as Class G (grassland) vegetation, and is found across the majority of the site (and surrounding area). The vegetation consists of paddock grass which vary in height. Plot 7 is associated with areas historically cleared and used for agricultural and grazing purposes. Some isolated eucalyptus trees are evident across Plot 7, however is <10% foliage cover.			



Photo ID:	9	**Plot:**	7
Vegetation Classification or Exclusion Clause			
Grassland (Class G) (flat / upslope)			
Description / Justification for Classification			
Grassland vegetation extends across the site. The vegetation consists of paddock grass which vary in height. Plot 7 is associated with areas historically cleared and used for agricultural and grazing purposes. Some isolated eucalyptus trees are evident across Plot 7, however is <10% foliage cover.			



Table 2: Pre-development vegetation classification and/or exclusions (continued)

Photo ID:	10	Plot:	9
Vegetation Classification or Exclusion Clause			
Non-vegetated (exclusion clause 2.2.3.2(e))			
Description / Justification for Classification			
Photo 10 shows a portion of Taylor Road. The road is one of several sealed public roads that have been excluded from classification due to no vegetation being present. A windrow (excluded) appears left of photo and is classed by the underlying grassland, and to the right of photo is open grassland. Plot 9 has been excluded in accordance with Section 2.2.3.2(e) of AS 3959.			



3.2 Assessment outputs

3.2.1 BHL assessment

A BHL assessment has been prepared for the site and surrounding 150 m based on the existing vegetation conditions (see **Figure 2**), with the hazard ratings determined in accordance with Appendix Two of the Guidelines and shown in **Figure 3**.

The outcomes of the assessment indicate that the site and surrounding 150 m assessment area include predominantly moderate bushfire hazards, associated with existing unmanaged grassland. Patches of forest, woodland and scrub vegetation (largely associated with native vegetation within road reserves and along Manjedal Brook) are identified as an extreme hazard. The majority of the vegetation within the site will be modified, and following development, large portions of the site will be subject to a low bushfire hazard.

3.2.2 BAL assessment

3.2.2.1 Assumptions

The BAL assessment for the site has been undertaken in accordance with Method 1 of AS 3959 to determine the maximum heat flux to which future dwellings within the site are likely to be exposed.

The vegetation classification and effective slope applicable to vegetation within or nearby to the site in the post-development scenario have been summarised in **Table 3**. Overall, the BAL assessment is based on the following assumptions:

- **Designated FDI**: 80
- **Flame Temperatures**: 1090 K
- **Vegetation classification**: forest (Class A), woodland (Class B), scrub (Class D) and grassland (Class G), see **Figure 4** and summarised in **Table 3**.
- **Effective slope beneath classified vegetation**: flat/upslope, as outlined in **Figure 4** and summarised in **Table 3**.
- **Setback distances**: as per Table 2.5 in AS 3959 with the relevant distances used to inform the BAL contour plan summarised in **Table 4** and the BAL contour provided in **Figure 5**.
- All vegetation within the site, except for the vegetation and buffers associated with Manjedal Brook and the CCW, will be removed/modified to achieve low threat vegetation as part of future residential development in accordance with the proposed structure plan.
- Vegetation associated with Manjedal Brook and the CCW (in the southeast) is expected to be retained, and where appropriate revegetated and is assumed to achieve a forest (Class A) classification. The 50 m buffers associated with each are assumed to be revegetated to achieve a scrub (Class D) classification.
- Areas of low threat vegetation outside the site will continue to be managed and/or considered to achieve low threat (in accordance with Section 2.2.3.2 of AS 3959) based on the existing maintenance regimes, and/or as per the Shire of Serpentine Jarrahdale Fire Break Notice.
- Classified vegetation that has been identified outside of the site has been assumed to remain in its current state (unless stated otherwise) and will therefore continue to be a bushfire hazard to development within the site.
- Areas of grassland can include up to 10% foliage cover from shrubs and trees, per AS 3959.

Table 3: Summary of the assumed post-development vegetation classification and associated effective slope within the site and 150 m in accordance with Table 2.5 (AS3959)

Plot number (Figure 4)	Pre-development vegetation classification	Post-development vegetation classification	Effective slope
Plot 1	Class A – Forest	Class A – Forest	Flat/upslope
Plot 2	Class B – Forest	Class A – Forest	Flat/upslope
Plot 3	Class B – Forest	Class B – Forest	Flat/upslope
Plot 4	Class D – Woodland	Class D – Woodland	Flat/upslope
Plot 5	Class D – Scrub	Class D – Scrub	Flat/upslope
Plot 6	Class D – Scrub	Class D – Scrub	Flat/upslope
Plot 7	Class G – Grassland	Class G – Grassland. Associated with the Water Corporation services corridor which is assumed to remain as unmanaged grassland vegetation.	Flat/upslope
Plot 8	Class G – Grassland	Class G – Grassland	Flat/upslope
Plot 9	Exclusion 2.2.3.2 (e)	Exclusion 2.2.3.2 (e) – including developed areas within the site and external existing non vegetated areas.	Not applicable
Plot 10	Exclusion 2.2.3.2 (f)	Exclusion 2.2.3.2 (f) – associated with the proposed managed POS areas within the site (excluding Manjedal Brook, the CCW and associated buffers) and external to the site within Court Grammar School and affiliated managed grounds.	Not applicable
Plot 11	Previously Plot 7	Class D – Scrub – associated with the revegetation of the 50 m buffer for Manjedal Brook and the CCW. This area is currently grassland (formerly Plot 6) and will achieve a scrub classification based on typical wetland species, height less than 6 m.	Flat/upslope

3.2.2.2 BAL outputs

Table 4 provides a summary of the setback distances necessary from classified vegetation to achieve the indicated BAL ratings, with the BAL contour plan (**Figure 5**) being a visual representation of these distances. The setback distances are based on the post-development classified vegetation and effective slope (described in **Table 3** and shown in **Figure 4**), and are taken from Table 2.5 of AS 3959.

The BAL assessment completed for the site indicates that that the majority of the areas proposed for residential development (and therefore future habitable buildings) can achieve BAL-29 or below based on the structure plan, as shown in **Figure 5**. The majority of the site is predicted to be subject to BAL-LOW following development of the structure plan.

It is noted that portions of the development cells adjacent to the western boundary of the site (adjacent to the future Tonkin Highway extension/Water Corporation service corridor) north-eastern boundary of the site (adjacent to the railway corridor) and south-west (adjacent Manjedal Brook) include areas subject to BAL-FZ and/or BAL-40. The spatial layout in the structure plan enables habitable buildings to be developed in areas subject to BAL-29 or less based on the likely depth and/or orientation of future lots. It is anticipated that due to either the short fire run and/or the difference in height between future development and areas of hazard including use of a future acoustic wall (e.g. Tonkin Highway and railway corridor), the actual BAL impacts will be significantly less than that predicted using a Method 1 assessment, when assessed using Method 2 of AS 3959. The BAL ratings applicable to future habitable buildings in the western and north-eastern portions of the site will be further considered as part of future subdivision.

Table 4: Setback distances based on vegetation classification and effective slope and Table 2.5 of AS 3959, as determined by the method 1 BAL assessment

Plot number	Vegetation classification (see Figure 4)	Effective slope (see Figure 4)	Distance to vegetation (from Table 2.5 of AS 3959)	BAL rating (see Figure 5)
Plot 1, 2 & 3	Forest (Class A)	Flat/upslope (0°)	< 16 m	BAL-FZ
			16 - < 21 m	BAL-40
			21 - < 31 m	BAL-29
			31 - < 42 m	BAL-19
			42 - < 100 m	BAL-12.5
			> 100 m	BAL-LOW
Plot 4	Woodland (Class B)	Flat/upslope (0°)	< 10 m	BAL-FZ
			10 - < 14 m	BAL-40
			14 - < 20 m	BAL-29
			20 - < 29 m	BAL-19
			29 - < 100 m	BAL-12.5
			> 100 m	BAL-LOW

Table 4: Setback distances based on vegetation classification and effective slope and Table 2.5 of AS 3959, as determined by the method 1 BAL assessment (continued)

Plot number	Vegetation classification (see Figure 4)	Effective slope (see Figure 4)	Distance to vegetation (from Table 2.5 of AS 3959)	BAL rating (see Figure 5)
Plot 5, 6 & 11	Scrub (Class D)	Flat/upslope (0°)	< 10 m	BAL-FZ
			10 - < 13 m	BAL-40
			13 - < 19 m	BAL-29
			19 - < 27 m	BAL-19
			27 - < 100 m	BAL-12.5
			> 100 m	BAL-LOW
Plot 7 & 8	Grassland (Class G)	Flat/upslope (0°)	< 6 m	BAL-FZ
			6 - < 8 m	BAL-40
			8 - < 12 m	BAL-29
			12 - < 17 m	BAL-19
			17 - < 50 m	BAL-12.5
			> 50 m	BAL-LOW

4 Identification of Bushfire Hazard Issues

From a bushfire hazard management perspective, the key issues that are likely to require management and/or consideration as part of future development within the site include:

- Provision of appropriate separation distances from permanent bushfire hazards to ensure a BAL rating of BAL-29 or less can be achieved at future habitable buildings. This includes allowances for the revegetation proposed in the southern portion of the site.
- Provision of appropriate vehicular access to ensure that when development within the site is fully constructed, egress to at least two different destinations will be available to future residents and emergency personnel. This may include the use of temporary no through roads and/or emergency access ways (EAWs) as part of internal staging of the subdivision, until the full road network associated with the structure plan is constructed.
- Provision of appropriate water supply dedicated to firefighting purposes (i.e. reticulated water supply and associated hydrant network).

These issues are considered further in **Section 5.**

4.1 Temporary hazards

As part of staged development within the site, temporary Class C scrub and Class G grassland hazards may be present and result in higher BAL ratings compared to when development is fully progressed. If a minimum 50 m-wide to 100 m-wide area around each stage (where within the proponent's landholding) is managed, resulting BAL ratings can be mitigated. Vegetation will need to be managed by the proponent until the long-term residential development progresses.

4.2 Permanent hazards

Within the site, portions of the proposed POS areas within the delineated buffer zones have been assumed to be a bushfire hazard, with vegetation classifications of forest (Class A), associated with existing remnant vegetation, and scrub (Class D) associated with revegetation areas. The remainder of the POS areas external to the buffer zones are assumed to be managed to achieve low threat in accordance with Section 2.2.3.2 of AS 3959 and have been excluded from classification.

Outside the site, the surrounding 150 m comprises areas of existing classified vegetation, predominantly grassland, assumed to remain in the long-term.

5 Assessment Against the Bushfire Protection Criteria

This BMP provides an outline of the mitigation strategies that will ensure that as development progresses within the site, an acceptable solution can be adopted for each of the bushfire protection criteria detailed within Appendix Four of the Guidelines. The bushfire protection criteria identified in the Guidelines and applicable/addressed as part of this BMP are:

- Element 1: Location of the development
- Element 2: Siting and design of the development
- Element 3: Vehicular access
- Element 4: Water supply.

As part of future development, it is likely that an 'acceptable solution' will be able to address the intent of all four bushfire protection criteria. A summary of how this can be achieved has been provided in **Table 5.**

Table 5: Assessment against the bushfire protection criteria from the Guidelines

Bushfire protection criteria	Proposed bushfire management strategies
Element 1: Location	
A1.1 Development location	The site is within an area that is classed as a moderate bushfire hazard level, associated with the existing cleared paddocks identified as grassland vegetation (Appendix 2 Guidelines v1.4). The site addresses Clause 6.2 (b) of SPP 3.7, which requires development at completion to have a moderate hazard level rating or be able to achieve BAL-29 or less, either before or as part of implementing the proposed structure plan. The future residential development cells will be in areas of low hazard once development is progressed and will be able to achieve BAL-29 or less. The proposal complies with **A1.1**.
Element 2: Siting and design	
A2.1 Asset Protection Zone	All proposed development areas that are intended to support habitable buildings are able to achieve an asset protection zone (APZ) with sufficient separation from classified vegetation to achieve BAL-29 or below. Separation from permanent bushfire hazards is provided within the structure plan through the management of future lots, and the strategic placement of public roads and public open space. Overall, the development cells within the site are suitably sized to accommodate the minimum separation distances (outlined in **Table 4** and shown in **Figure 5**) required to achieve BAL-29 or less at future habitable buildings/developable land[2]. Most development areas will be separated from the classified vegetation by a perimeter road. The exceptions is the area adjoining the future Tonkin Highway extension/Water Corporation service corridor (western boundary of the site) and adjacent to the railway corridor at the north-eastern extent of the site. In these areas the lots will have sufficient developable areas to achieve BAL 29 or below. The proposal complies with **A2.1**.

[2] *Position Statement: Planning in bushfire prone areas - Demonstrating Elements 1: Location and Element 2: Siting and design* Department of Planning, Lands and Heritage (DPLH) 2019, *Position Statement: Planning in bushfire prone areas - Demonstrating Element 1: Location and Element 2: Siting and design*, Western Australian Planning Commission. has outlined that 'developable land' is "*land that can accommodate a habitable dwelling and would not generally include areas of BAL-40 and/or BAL-FZ, areas within the local government setback and areas subject to environmental constraints*".

Table 5: Assessment against the bushfire protection criteria from the Guidelines (continued)

Bushfire protection criteria	Proposed bushfire management strategies
Element 3: Vehicular access	
A3.1 Public roads	Surrounding public roads (i.e. Soldiers Road, Bishop Road, Taylor Road) and all new internal public roads can and will be able to comply with the minimum standards outlined in Appendix Four of the Guidelines (DPLH & WAPC 2021). The structure plan indicates road reserves will likely vary between 13 m and 35 m wide, meeting neighbourhood connectors and access street requirements, as per the Local Government Guidelines for Subdivision Development (IPWEA guidelines) (IPWEA 2017) (refer to **Plate 4** further below). Therefore, the proposal complies with **A3.1**.
A3.2a Multiple access routes	The site has direct frontage to Bishop Road to the north, Scott Road to the south, Soldiers Road to the east and Taylor Road through the centre, providing opportunities to accommodate egress to different destinations as shown in **Figure 1** and **Figure 6**. Multiple access opportunities are provided to each of these existing roads, with the connections generally shown in **Figure 6**. Soldiers Road is a major regional connector, providing egress to the north and south (Byford and Mundijong townsites). Following development of the site, it will form part of a residential built out area. The proposed development complies with **A3.2a**. As part of future planning, future residential development should provide for an interconnected road network which can connect with the existing public road network, ensuring two access routes to at least two different destinations is available to future occupants at all times, and may include the use of temporary emergency access ways (EAWs) as part of staged development. The specific layout for future internal roads and connections to the existing surrounding public roads will be determined as part of future subdivision stages however given the existing public road network surrounding the site, future development can comply with the requirements of the Guidelines.
A3.2b Emergency access way	Given the development will be able to provide egress to at least two different destinations (in line with Acceptable Solution A3.2a), it is unlikely an emergency access way (EAW) will be required. If any EAWs (including temporary EAWs as part of staged development) are proposed they will need to comply with the minimum technical requirements outlined in Appendix Four of the Guidelines, or as agreed with the Shire of Serpentine Jarrahdale, including trafficability, width and length of the road. The proposed structure plan can comply with **A3.2b**.
A3.3 Through-roads	The proposed layout is predominantly a through road arrangement. Two permanent no-through roads are proposed in the site due to site constraints. These no-through roads are less than 200 m in length and can meet the acceptable solution (see **Appendix A** and **Figure 6**). The staging of the development may preclude the formalisation of through roads until completion. Where temporary no through-roads are required as part of staged development, these should also comply with A3.2a and A.3.2b. This will be managed at subdivision. The proposal is able to comply with **A3.3.**

Table 5: Assessment against the bushfire protection criteria from the Guidelines (continued)

Bushfire protection criteria	Proposed bushfire management strategies
Element 3: Vehicular access (continued)	
A3.4a Perimeter roads	The structure plan (see **Appendix A**) provides for internal perimeter roads between development cells and areas identified as a possible bushfire hazard, with the exception of development cells adjoining areas of grassland vegetation to the west associated with the Water Corporation services corridor and north-east adjacent the railway corridor. The required setbacks to these hazards can be accommodated within the development cell and as part of future lot design. In accordance with the Guidelines, a perimeter road is not required for grassland vegetation. There is sufficient area to provide suitable access and/or separation from classified vegetation. The proposed structure plan complies with **A3.4a**.
A3.4b Fire service access route	No fire service access routes are proposed. The proposal utilises perimeter roads to separate the residential development from classifies vegetation and in areas where a perimeter road is not provided, the classified vegetation is grassland – excluded from the requirement for a fire service access route. The structure plan is compliant with **A3.4b**
A3.5 Battle-axe access legs	No battle-axe access lots are proposed envisaged at this stage. A proposal to utilise a battle-axe arrangement will be determined at subdivision. The proposed structure plan is complaint with **A3.5**.
A3.6 Private driveways	Not applicable. If private driveways longer than 70 m are proposed they will need to comply with the requirements of the Guidelines, including Table 6 of the Guidelines.
Element 4: Water	
A4.1 Identification of future water supply	The proposed development is located in an area that is serviced by reticulated water supply, which will be expanded to include the site, as confirmed by Water Corporation. The proposed structure plan is compliant with **A4.1**.
A4.2 Provision of water for fire fighting purposes	Not applicable at this stage in the process. The site will be serviced by a network of reticulated water hydrants as per Water Corporation requirements.

Table 6: Vehicular access technical requirements

TECHNICAL REQUIREMENTS	1 Public roads	2 Emergency access way[1]	3 Fire service access route[1]	4 Battle-axe and private driveways[2]
Minimum trafficable surface (metres)	In accordance with A3.1	6	6	4
Minimum horizontal clearance (metres)	N/A	6	6	6
Minimum vertical clearance (metres)	4.5			
Minimum weight capacity (tonnes)	15			
Maximum grade unsealed road[3]	As outlined in the IPWEA Subdivision Guidelines	1:10 (10%)		
Maximum grade sealed road[3]		1:7 (14.3%)		
Maximum average grade sealed road		1:10 (10%)		
Minimum inner radius of road curves (metres)		8.5		

Notes:
[1] To have crossfalls between 3 and 6%.
[2] Where driveways and battle-axe legs are not required to comply with the widths in A3.5 or A3.6, they are to comply with the Residential Design Codes and Development Control Policy 2.2 Residential Subdivision.
[3] Dips must have no more than a 1 in 8 (12.5% -7.1 degree) entry and exit angle.

Plate 4: Excerpt of Table 6 from The Guidelines (DPLH & WAPC 2021)

5.1 Additional management strategies

5.1.1 Future approval considerations

A BAL assessment has been prepared for the site to demonstrate that best practice management strategies can be adopted through future planning and implementation stages to ameliorate the bushfire hazards (i.e. habitable buildings can be located in areas of BAL-29 or less) that would otherwise impact upon its future development.

It is likely a BMP, or as a minimum a bushfire statement, will be required to support future subdivision for the site, to detail how the proposed development layout has or will address the bushfire protection criteria based on the recommendations outlined within this BMP, as well as to determine the likely BAL ratings applicable to the future habitable buildings based on hazards applicable to that stage of development.

Where proposed to be constructed and within a designated bushfire prone area, future Class 1, 2, 3 and 10a buildings in an area subject to a BAL rating of BAL-12.5 or higher will need to satisfy higher construction standards in accordance with the National Construction Code (NCC) (i.e. AS 3959 or the National Association for Steel-framed Housing (NASH) Standard).

5.1.2 Landscape management

5.1.3 Within the site

Waterway and wetland areas and associated buffers

As detailed in **Section 2.2**, Manjedal Brook and the CCW are assumed to be retained and revegetated (to achieve 'forest' classification), along with the associated 50m buffer areas (assumed to achieve 'scrub' classification). These areas, as shown in **Figure 6,** are assumed to have no ongoing management for bushfire purposes.

Public open space (POS) areas

In accordance with the requirements of the Shire of Serpentine Jarrahdale, all POS areas proposed as part of the development within the site have been identified as a low threat (with the exception of Manjedal Brook, the CCW and associated buffer areas) in accordance with Section 2.2.3.2 (f) of AS 3959. Ongoing management has been assumed in the POS areas for bushfire purposes, identified in **Figure 6**.

The design and construction of POS areas is generally a condition of subdivision approval, and the detailed design will be determined in collaboration with the Shire of Serpentine Jarrahdale as part of the standard development process (and based on typical maintenance requirements for urban/residential areas). A landscape master plan has been prepared and is provided in **Appendix B** showing the intended uses/approach.

Temporary hazards

It is recommended that as part of the staged development within the site and to minimise the impacts of temporary (grassland) hazards on proposed lots, the proponent should manage a minimum 50 m-wide area immediately surrounding each subdivision stage (where within their broader landholding) to a low threat standard in accordance with AS 3959. This would include permanently removing the grass vegetation (the vegetation classification applicable to the site in its current condition) and/or regularly throughout any year mowing/slashing the grass to 100 mm in height or less, and pruning/modifying existing trees/shrubs where required. This would be maintained by the proponent until residential development progresses.

Within public road reserves

The proposed road reserves will be designed and maintained to achieve a low threat in accordance with Section 2.2.3.2 (e) and (f) of AS 3959, as shown in **Figure 4** and will be the responsibility of the proponent initially until handover to the Shire of Serpentine Jarrahdale.

5.1.3.1 Surrounding the site

Court Grammar School

Areas of managed vegetation associated with the school grounds (see **Figure 4)** will continue to be managed to low threat in accordance with Section 2.2.3.2 (e) and (f) of AS 3959.

Road reserves

Areas of existing road reserves will continue to be maintained by the Shire of Serpentine Jarrahdale and or Main Road Western Australia in accordance with the existing maintenance regimes.

Within private landholdings

The private landholdings surrounding the site are assumed to be managed by the applicable landowners in accordance with the Shire of Serpentine Jarrahdale firebreak notice in perpetuity.

5.1.4 Shire of Serpentine Jarrahdale annual firebreak notice

The Shire of Serpentine Jarrahdale releases a firebreak notice annually (or as required) to provide a framework for bushfire management within the Shire. The Shire of Serpentine Jarrahdale is able to enforce this order in accordance with Section 33(1) of the *Bush Fires Act 1954* and landowners will need to ensure compliance with the fire break notice, as published, or any directions provided by the Shire of Serpentine Jarrahdale.

Following development for residential purposes, all lots will be required under the firebreak notice to:

- Remove all hazardous material from the whole of the land except living trees. In the area remaining, vegetation is to be maintained to a height no greater than 10 centimetres; this includes piles of timber, branches and other vegetation.
- Tree branches shall be removed or pruned to ensure a clear separation of at least 3 metres from the eaves of all buildings and 5 metres above the top of the roof. Branches that may fall on the house must also be removed.

In addition, all lots subject to an approved bushfire management plan through subdivision will be required to comply with that plan. Based on this BMP, and similar provisions applying, all areas within the site will need to be managed to achieve low threat in accordance with Section 2.2.3.2 of AS 3959.

5.1.5 Vulnerable or high-risk land uses

Currently two primary schools are proposed within the site as part of the structure plan and would be defined as vulnerable land uses under SPP 3.7.

Where high-risk or vulnerable land uses are proposed in the future, these will need to address the requirements of policy measure 6.6 of SPP 3.7, including the assessment of bushfire risk and/or the preparation of an emergency evacuation plan (for vulnerable land uses) or risk management plan (for high-risk land uses) where subject to a BAL rating greater than BAL-LOW. This will be dealt with as part of future detailed planning stages (development approval). The location of the site in an area of

largely moderate bushfire hazard (which will transition to low with residential development) and connection to the public road network, including Soldiers Road, Bishop Road and Taylor Road, means key considerations such as separation from bushfire hazards and emergency access will be able to be addressed.

5.1.6 Public education and preparedness

Community bushfire safety is a shared responsibility between individuals, the community, government and fire agencies. DFES has an extensive Community Bushfire Education Program including a range of publications, a website and Bushfire Ready Groups. The DFES website (https://www.dfes.wa.gov.au/bushfire/prepare/) provides a range of materials to help the community prepare for and survive the bushfire season.

The Shire of Serpentine Jarrahdale provides bushfire safety advice to residents available from their website. Professional, qualified consultants also offer bushfire safety advice and relevant services to residents and businesses in high-risk areas in addition that that provided in this BMP.

In the case of a bushfire in the area, advice would be provided to residents and businesses by DFES, the DBCA and/or the Shire of Serpentine Jarrahdale on any specific recommendations with regard to responding to the bushfire, including evacuation if required. It is recommended that future residents make themselves aware of their responsibilities with regard to preparing for and responding to a potential bushfire that may impact them, their family and property, regardless of the BAL rating their properties are subject to.

6 Responsibilities for Implementation and Management of Bushfire Measures

Subject to the approval of the proposed structure plan, development within the site for residential purposes will be implemented through the preparation of future subdivision application(s).

Table 6 outlines the future responsibilities of the proponent (developer) and the Shire of Serpentine Jarrahdale associated with implementing the proposed structure plan, with reference to future mitigation measures to be accommodated as part of subdivision (in particular, consideration of spatial layout requirements). These responsibilities will need to be considered as part of the subsequent planning process.

Additional bushfire mitigation responsibilities will be required at the subdivision for the residential development of the site, including responsibilities for future lot owners.

Table 6: Responsibilities for the implementation of this BMP

Proponent – to support the scheme amendment, structure plan and future subdivision		
No.	Implementation and management actions	Timing
1	Following approval of the structure plan, prepare a BMP or bushfire statement (as required) in accordance with SPP 3.7, the Guidelines (as updated) and AS 3959 to support future subdivision within portions of the site that are designated as bushfire prone areas under the *Map of Bush Fire Prone Areas*. This should be based on the following: Areas of bushfire hazard To prepare this BMP, it has been assumed, to provide a conservative assessment of bushfire risk, that the following hazards will exist in the long-term (shown as assumed future bushfire hazard'): • The existing vegetation associated with the conservation category wetland will be protected and maintained in its current condition. The 50 m buffer to the wetland is assumed to be revegetated to achieve a 'scrub' classification. • The existing classified vegetation associated with Manjedal Brook will be protected and maintained in its current condition. Some revegetation may occur, but would not change the 'forest' classification. The 50 buffer is assumed to be revegetated to achieve a 'scrub' classification. Landscaping All future public open space areas not assumed to be a bushfire hazard will be designed and managed to achieve low threat in accordance with Section 2.2.3.2 of AS 3959. Asset protection zones (APZs) All habitable buildings should achieve BAL-29 or less. Asset protection zones will be required around future habitable buildings to achieve BAL-29 or lower. These will be installed within areas of managed public open space/public road reserves or within lots (e.g. as carparks, drive ways, manicured lawn/gardens etc). Building construction requirements Where designated bushfire prone, future Class 1, 2, 3 and associated 10a buildings will need to be constructed in accordance with BAL ratings determined in accordance with AS 3959.	To support future structure planning and/or subdivision.

Table 6: Responsibilities for the implementation of this BMP (continued)

Proponent – to support the scheme amendment, structure plan and future subdivision (continued)		
No.	Implementation and management actions	Timing
1	Vehicle access • All public roads are to be constructed in accordance with the requirements of the Guidelines. • All future development will be able to achieve two access routes upon completion of development. • Where no-through roads are required, these are to meet the requirements of Appendix Four of the Guidelines, including: o Will achieve public road requirements as per A3.2 of Appendix Four in the Guidelines, unless agreed otherwise with the Shire of Serpentine Jarrahdale; and o The turnaround area will achieve the dimensions outlined in Figure 24 of Appendix Four of the Guidelines. Water supply The development will be serviced by a reticulated water supply and a network of hydrants.	To support future structure planning and/or subdivision.
Shire of Serpentine Jarrahdale - ongoing		
No.	Implementation and management actions	Timing
1	Monitoring vegetation fuel loads in public reserves and liaising with relevant stakeholders to maintain fuel loads at minimal fuel levels, where required/applicable.	Ongoing, as required.
2	Maintaining public road reserves under their management to appropriate standards, where required/applicable.	Ongoing, as required.
3	Monitoring compliance with the Shire of Serpentine Jarrahdale annual firebreak notice and enforcing requirements as required.	Ongoing, as required.

7 Applicant Declaration

7.1 Accreditation

This BMP has been prepared by Emerge Associates who have a number of team members who have undertaken Bushfire Planning and Design (BPAD) Level 1 and Level 2 training and are Fire Protection Association of Australia (FPAA) accredited practitioners. Emerge Associates have been providing bushfire risk management advice for more than 10 years, undertaking detailed bushfire assessments (and associated approvals) to support the land use development industry.

Anthony Rowe is a Fire Protection Association of Australia (FPAA) Level 3 Bushfire Planning and Design (BPAD) accredited practitioner (BPAD no. 36690) with over ten years' experience.

7.2 Declaration

I declare that the information provided is true and correct to the best of my knowledge.

Signature:



Name: Anthony Rowe

Company: Emerge Associates

Date: 31/05/2023

BPAD Accreditation: Level 3 BPAD no. 36690

8 References

8.1 General references

Department of Biodiversity, Conservation and Attractions (DBCA) 2020, Geomorphic Wetlands, Swan Coastal Plain (DBCA-019).

Department of Planning, Lands and Heritage (DPLH) 2019, Position Statement: Planning in bushfire prone areas - Demonstrating Element 1: Location and Element 2: Siting and design, Western Australian Planning Commission.

Department of Planning, Lands and Heritage, and Western Australian Planning Commission, (DPLH & WAPC) 2021, Guidelines for Planning in Bushfire Prone Areas Version 1.4, Perth, Western Australia.

Enmerge Associates (Emerge Associates) 2017, Spring Flora and Vegetation Survey - Taylor Road, Mundijong EP15-036(06)--008 RAO, Version 1.

Institute of Public Works Engineering Australasia (IPWEA) 2017, Local Government Guidelines for Subdivisional Development, West Perth.

Office of Bushfire Risk Management (OBRM) 2021, Map of Bush Fire Prone Areas, Landgate, https://maps.slip.wa.gov.au/landgate/bushfireprone/.

Standards Australia 2018, AS 3959:2018 Construction of buildings in bushfire-prone areas, Sydney.

Western Australian Planning Commission (WAPC) 2015, State Planning Policy 3.7 Planning in Bushfire Prone Areas, Perth.

8.2 Online references

The online resources that have been utilised in the preparation of this report are referenced in **Section 8.1**, with access date information provided in **Table R-1**.

Table R 1 Access dates for online references

Reference	Date accessed	Website or dataset name
(OBRM 2021)	1 April 2023	Map of Bushfire Prone Areas

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Figures

Figure 1: Site Location and Environmental Considerations

Figure 2: Pre-Development AS 3959 Vegetation Classifications

Figure 3: Pre-Development Bushfire Hazard Level

Figure 4: Post-Development AS 3959 Vegetation Classifications and Effective Slope

Figure 5: Bushfire Attack Level Contour Plan

Figure 6: Spatial Representation of Bushfire Management Strategies

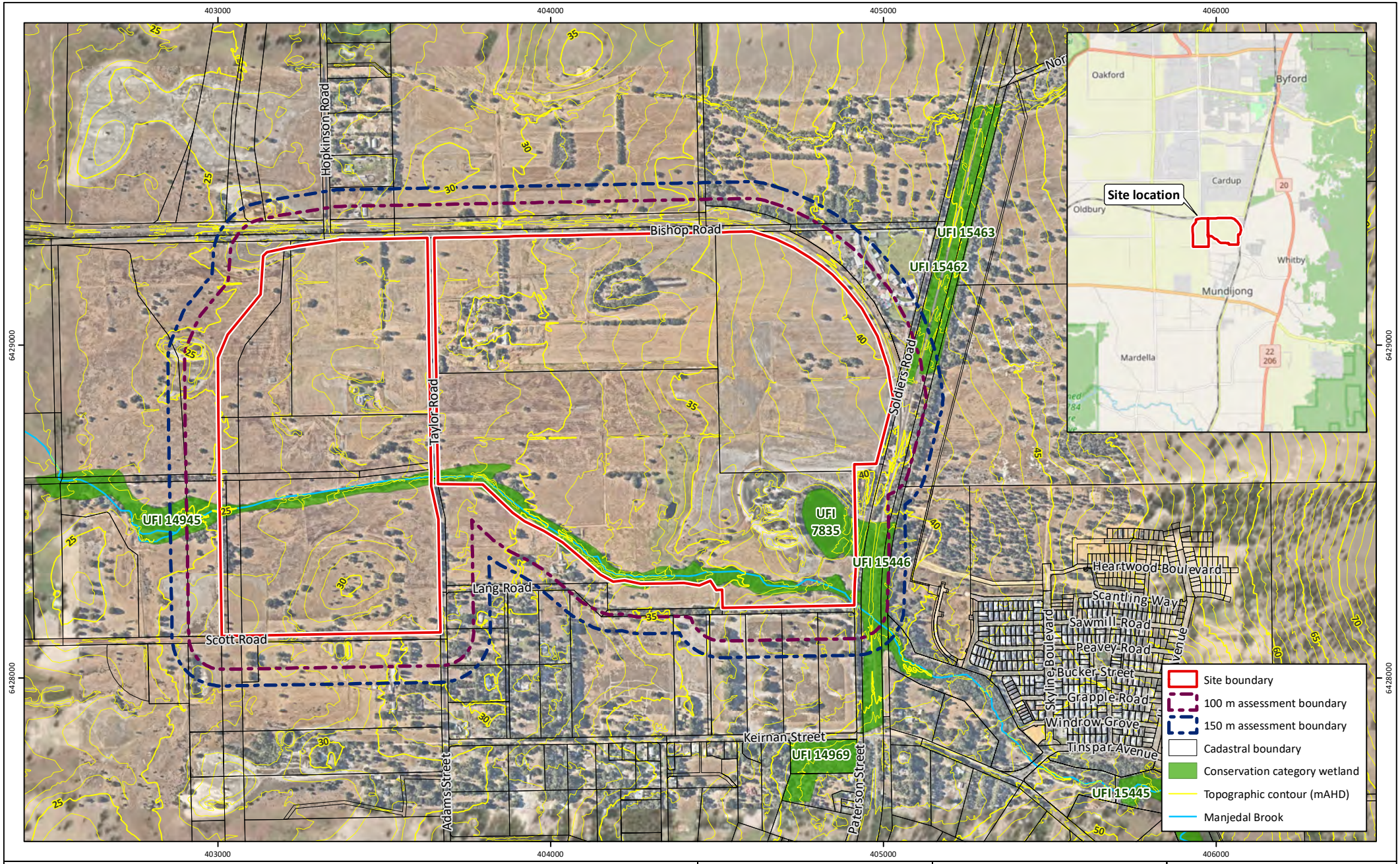


Figure 1: **Site Location and Environmental Considerations**

Project:	Bushfire Management Plan Taylor Road, Mundijong
Client:	Peet Mundijong Syndicate Ltd

Plan Number:
EP15-036(02)--F63

Drawn:	WJC
Date:	30/03/2023
Checked:	SAM
Approved:	KK
Date:	01/05/2023

N

0 200 400 600
Metres

Scale: 1:15,000@A4

GDA 1994 MGA Zone 50

emerge ASSOCIATES

While Emerge Associates makes every attempt to ensure the accuracy and completeness of data, Emerge accepts no responsibility for externally sourced data used
©Landgate (2023). Nearmap Imagery date: 26/02/2023

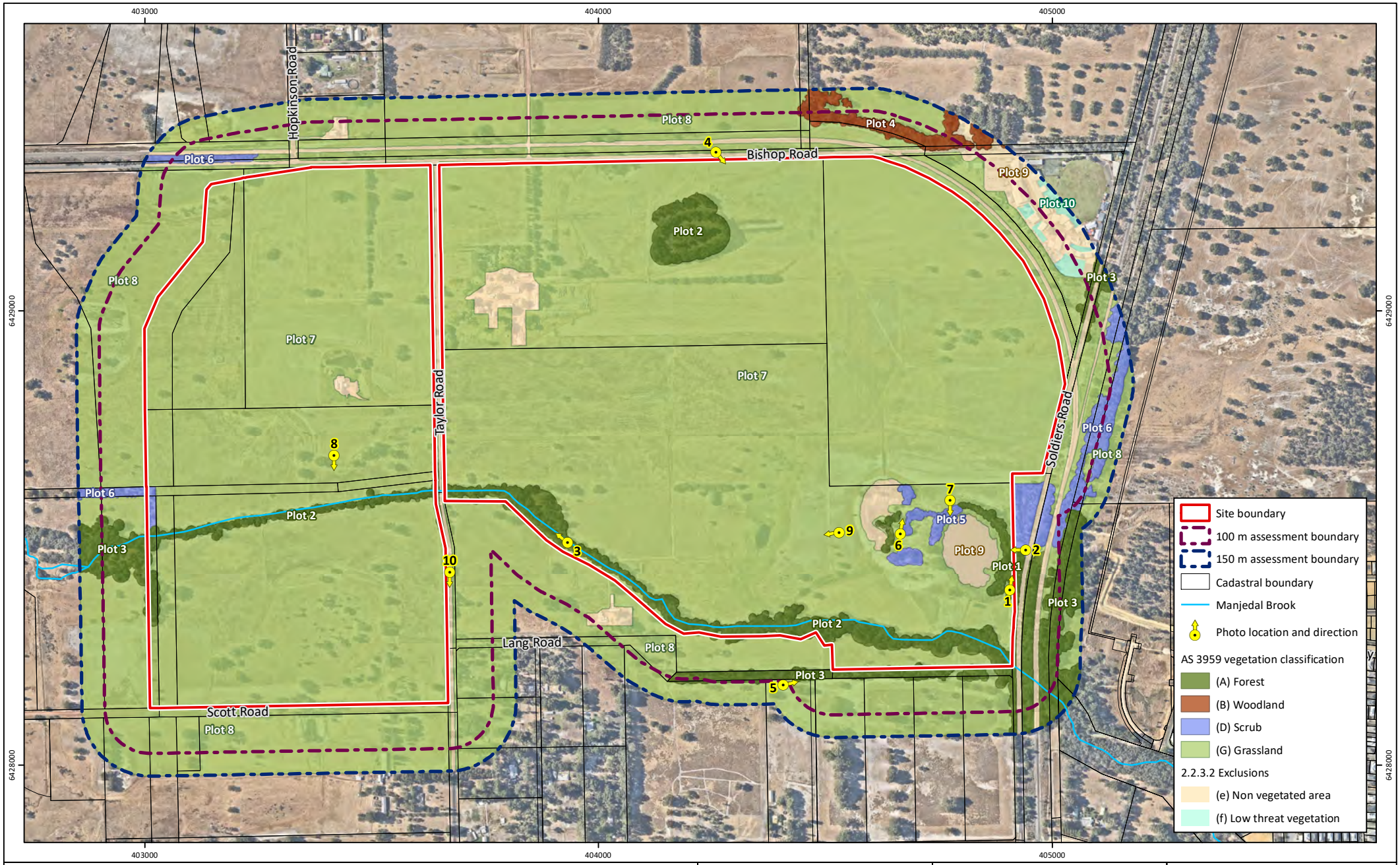


Figure 2: Pre-Development AS 3959 Vegetation Classifications

Project:	Bushfire Management Plan Taylor Road, Mundijong
Client:	Peet Mundijong Syndicate Ltd

Plan Number:
EP15-036(02)--F64a

Drawn:	WJC
Date:	30/03/2023
Checked:	SAM
Approved:	KK
Date:	01/05/2023

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Metres

Scale: 1:11,000@A4

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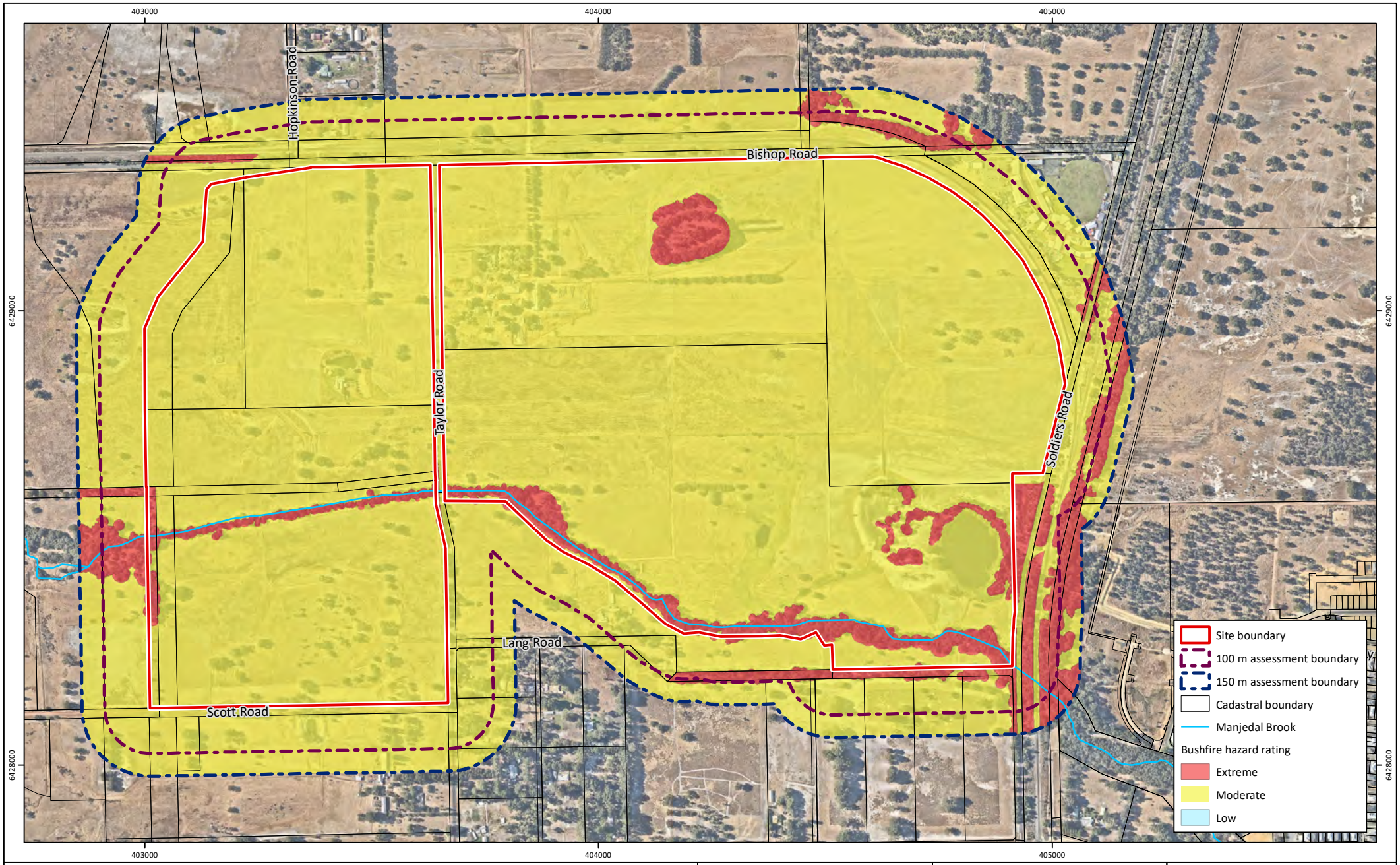


Figure 3: Pre-Development Bushfire Hazard Level

Project: Bushfire Management Plan
Taylor Road, Mundijong
Client: Peet Mundijong Syndicate Ltd

Plan Number:
EP15-036(02)--F65

Drawn:	WJC
Date:	30/03/2023
Checked:	SAM
Approved:	KK
Date:	01/05/2023

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Metres

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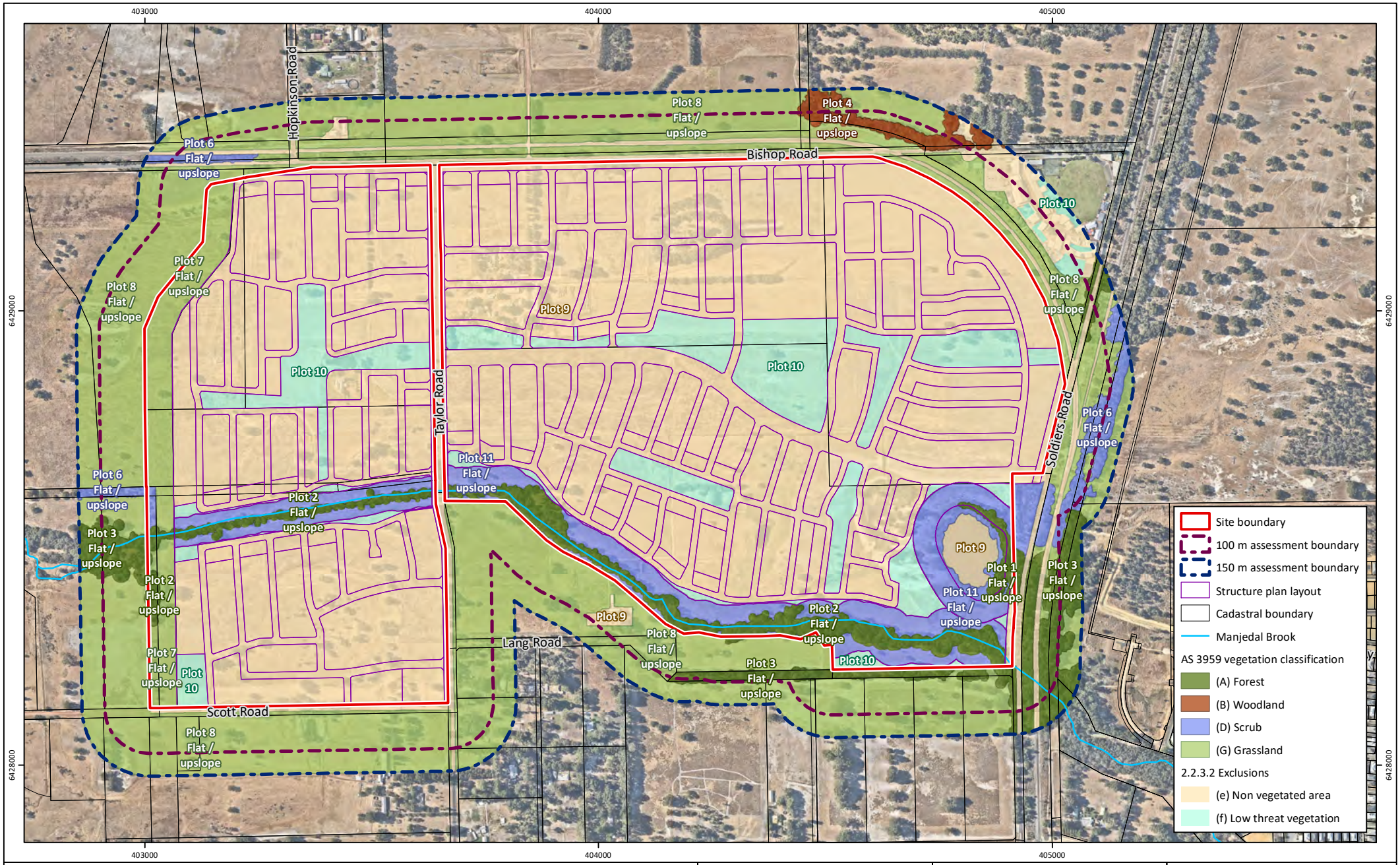


Figure 4: **Post-Development AS 3959 Vegetation Classifications and Effective Slope**

Project: Bushfire Management Plan
Taylor Road, Mundijong

Client: Peet Mundijong Syndicate Ltd

Plan Number:
EP15-036(02)--F66

Drawn:	WJC
Date:	30/03/2023
Checked:	SAM
Approved:	KK
Date:	01/05/2023

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Metres

Scale: 1:11,000@A4

GDA 1994 MGA Zone 50

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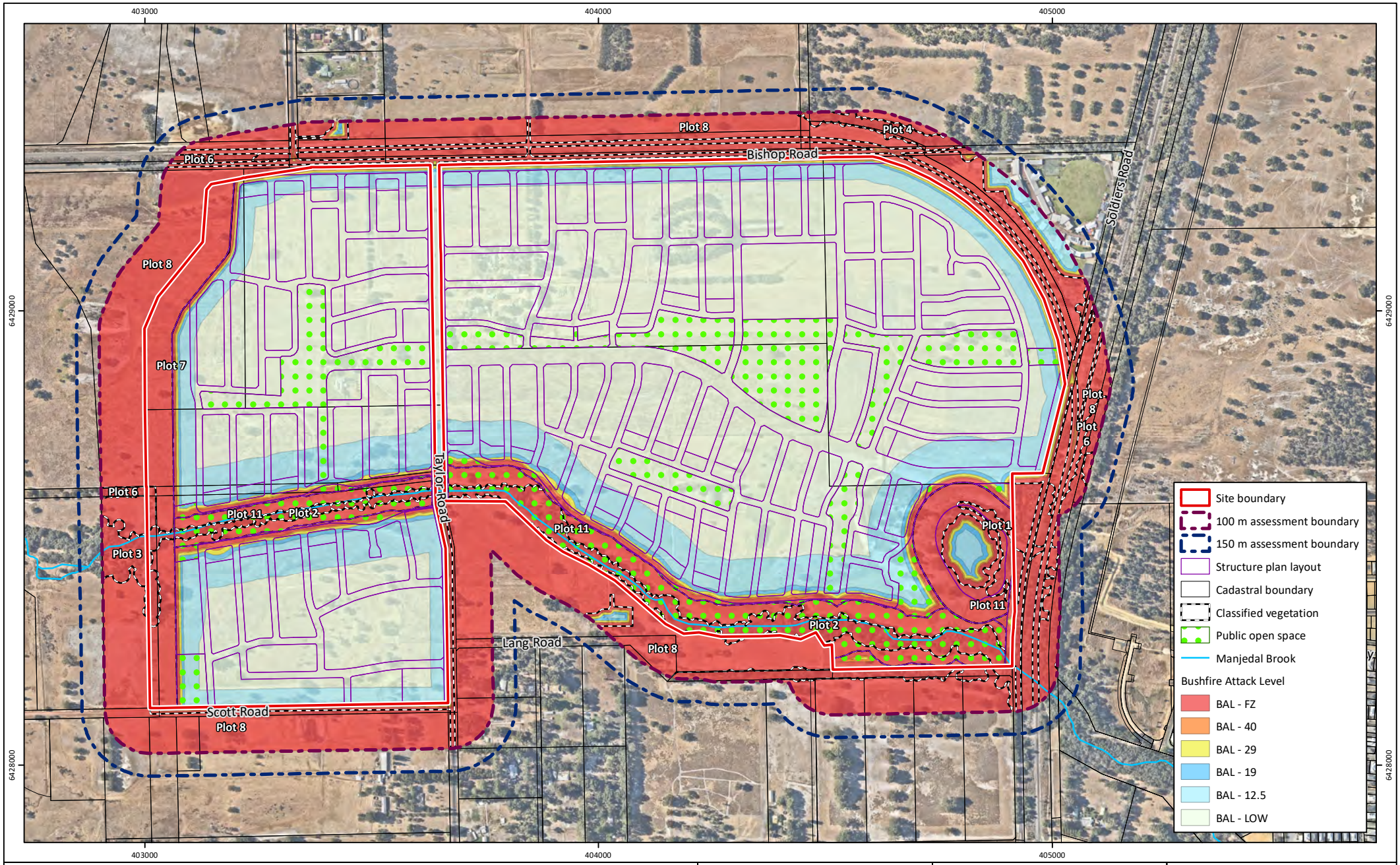


Figure 5: Bushfire Attack Level Contour Plan

Project: Bushfire Management Plan
Taylor Road, Mundijong
Client: Peet Mundijong Syndicate Ltd

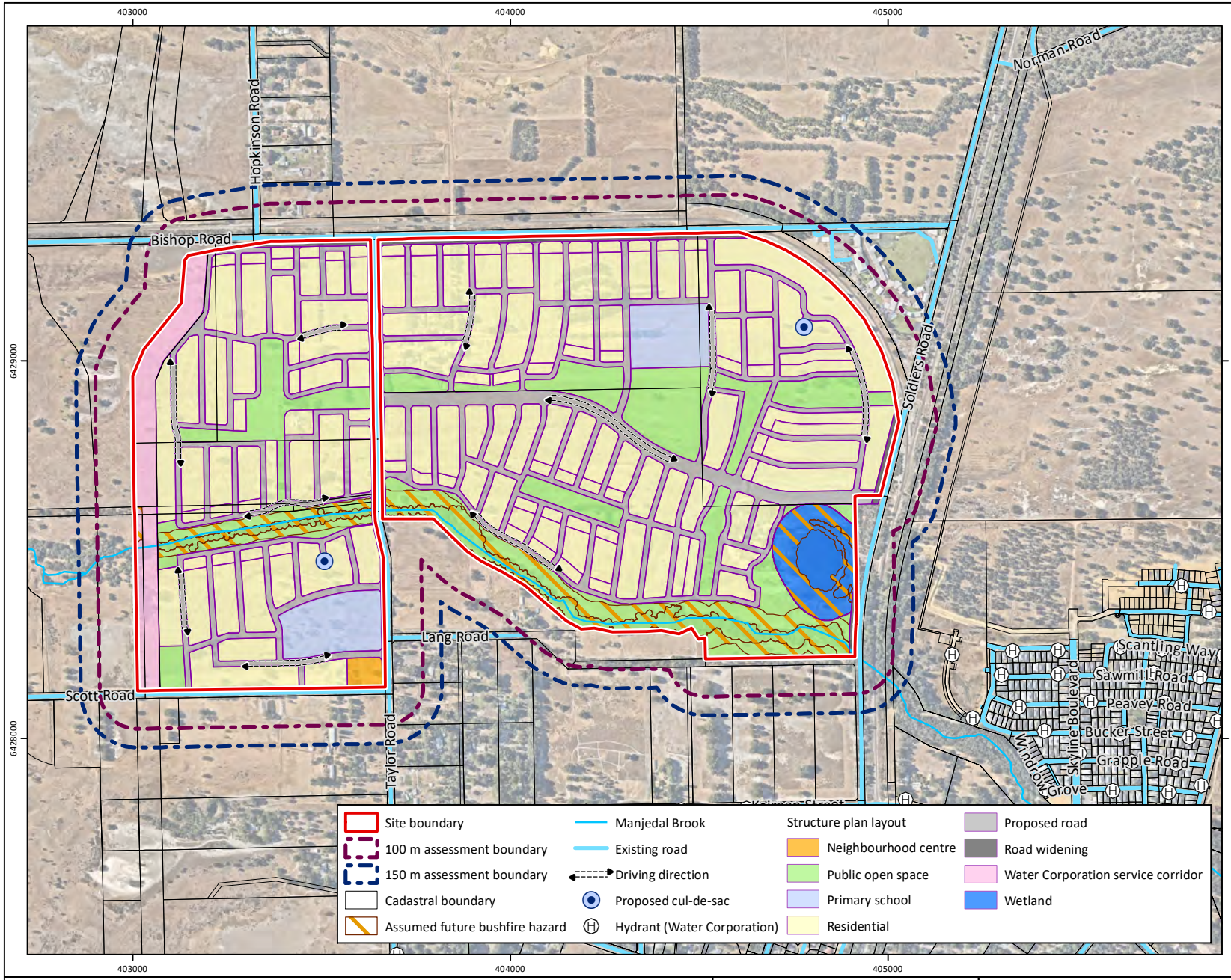
Plan Number:
EP15-036(02)--F67
Drawn: WJC
Date: 30/03/2023
Checked: SAM
Approved: KK
Date: 01/05/2023

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Scale: 1:11,000@A4
GDA 1994 MGA Zone 50

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Areas of bushfire hazard

To prepare this BMP, it has been assumed, to provide a conservative assessment of bushfire risk, that the following hazards will exist in the long-term (shown as 'assumed future bushfire hazard'):

- The existing vegetation associated with the conservation category wetland will be protected and maintained in its current condition. The 50 m buffer to the wetland is assumed to be revegetated to achieve a 'scrub' classification.
- The existing classified vegetation associated with Manjedal Brook will be protected and maintained in its current condition. Some revegetation may occur, but would not change the 'forest' classification. The 50 buffer is assumed to be revegetated to achieve a 'scrub' classification.

Landscaping

All future public open space areas not assumed to be a bushfire hazard will be designed and managed to achieve low threat in accordance with Section 2.2.3.2 of AS 3959.

Asset protection zones (APZs)

All habitable buildings should achieve BAL-29 or less. Asset protection zones will be required around future habitable buildings to achieve BAL-29 or lower. These will be installed within areas of managed public open space/public road reserves or within lots (e.g. as carparks, drive ways, manicured lawn/gardens etc).

Building construction requirements

Where designated bushfire prone, future Class 1, 2, 3 and associated 10a buildings will need to be constructed in accordance with BAL ratings determined in accordance with AS 3959.

Vehicle access

- All public roads are to be constructed in accordance with the requirements of the Guidelines.
- All future development will be able to achieve two access routes upon completion of development.
- Where no-through roads are required, these are to meet the requirements of Appendix Four of the Guidelines, including:

+Will achieve public road requirements as per A3.2 of Appendix Four in the Guidelines, unless agreed otherwise with the Shire of Serpentine Jarrahdale; and
+The turnaround area will achieve the dimensions outlined in Figure 24 of Appendix Four of the Guidelines.

Water supply

The development will be serviced by a reticulated water supply and a network of hydrants.

Figure 6: Spatial Representation of Bushfire Management Strategies

Project: Bushfire Management Plan
Taylor Road, Mundijong
Client: Peet Mundijong Syndicate Ltd

Plan Number:
EP15-036(02)--P68
Drawn: WJC
Date: 31/03/2023
Checked: SAM
Approved: KK
Date: 19/04/2023

N

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Metres
Scale: 1:15,000@A4
GDA 1994 MGA Zone 50

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Appendix A

Taylor Road, Mundijong – Local Structure Plan
(Taylor Burrell Barnett 2023)

Legend

- STRUCTURE PLAN BOUNDARY
- RESIDENTIAL (R10)
- RESIDENTIAL (R25-40)
- RESIDENTIAL (R40-60)
- NC — CENTRE - NEIGHBOURHOOD
- PUBLIC OPEN SPACE AND DRAINAGE
- ENVIRONMENTAL CONSERVATION
- PUBLIC PURPOSES
  Denoted as:
  IS - Infrastructure Services
  E(PS) - Education, Primary School
  E(HS) - Education, High School
- PRIMARY REGIONAL ROAD
- INTEGRATOR ARTERIAL
- NEIGHBOURHOOD CONNECTOR
- AREA SUBJECT TO FUTURE INVESTIGATION (FREIGHT RAIL REALIGNMENT)

Notes

1. The location of local roads, public open space, civic and community sites and neighbourhood centre sites are indiciative only and subject to refinement at subdivision stage.
2. Area subject to future investigation to consider appropriate planning responses for the proposed freight rail realignment. and does not constitute a Structure Plan pursuant to the *Planning and Development (Local Planning Scheme) Regulations 2015 Schedule 2 - Deemed provisions* until such time as a subsequent Structure Plan amendment has been lodged and assessed to the satisfaction of the WAPC.
3. The Structure Plan provides for an at-grade connection to Whitby Town Centre and identifies this area as also subject to further investigation for a grade-separated railway crossing.



Structure Plan

TAYLOR & BISHOP ROAD, MUNDIJONG

A Peet Limited Project

DRAFT

scale: 1:7000@A3
0 50 100m

plan: 06/066/043H
date: 11/03/2024
aerial: n/a

Taylor Burrell Barnett Town Planning & Design
Level 7, 160 St Georges Terrace, Perth WA 6000
e: admin@tbbplanning.com.au
p: (08) 9226 4276

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Appendix B

Taylor Road, Mundijong – Landscape Masterplan
(Emerge Associates 2023)

BISHOP ROAD, MUNDIJONG
LANDSCAPE MASTERPLAN

DWG **MJ01-01**
REV **D**
DATE **APRIL-23**

0 30 60 90 120 130 m

SCALE **1 : 6000 @ A3**

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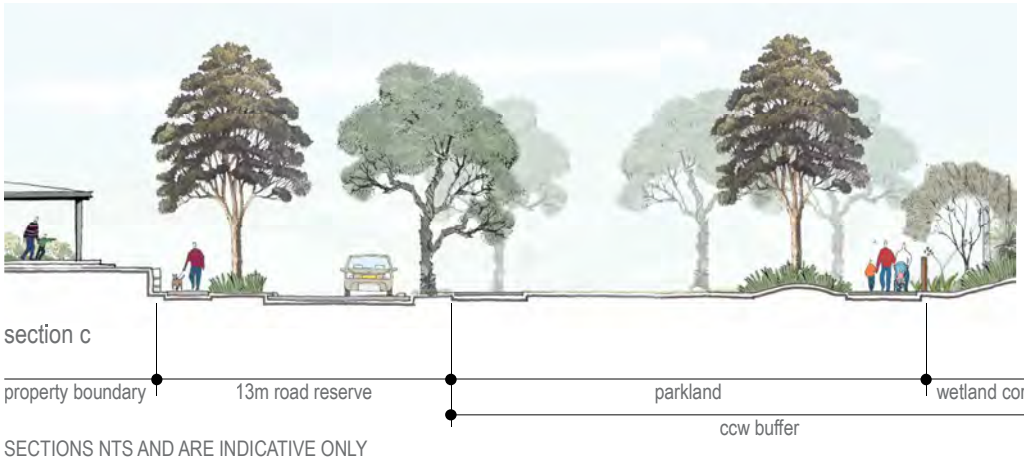
U:\CURRENT PROJECTS\Peet Bishop Road\(MJ-01) Drawings\(MJ-01) Concept Plans, Scans and Graphics\Landscape\Overall Project Plans\LSP- POS Concepts\2023 Mundijong Masterplan Inlay.indd

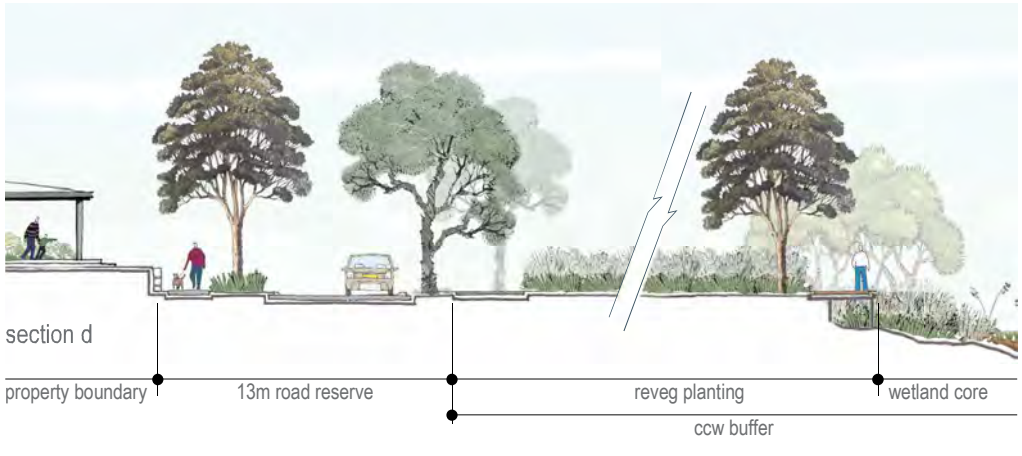












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WETLAND POS

DWG MJ01-02
REV D
DATE APRIL-23
0 5 10 15 20 25 m
SCALE 1 : 1000 @ A3

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BISHOP ROAD, MUNDIJONG

MANJEDAL BROOK INTERFACE POS

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WETLAND CONNECTION POS CONCEPT

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EAST - WEST POS CONCEPT

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Appendix E

Ethnographic & Aboriginal Heritage Report

Ethnosciences

ABN 47 065 099 228

Aboriginal Heritage

Final report on an Aboriginal archaeological assessment and section 16 test excavations for a proposed residential land development, Lots 37, 98 and 9000 Bishop Road, Mundijong, Perth Metropolitan Area, Western Australia

Prepared for Peet Limited and
the Department of Aboriginal Affairs

April 2014

Jo-Anne Thomson
Dr Diana Neuweger



THOMSON
CULTURAL
HERITAGE
MANAGEMENT

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Disclaimer

The results, conclusions and recommendations contained in this report are based on information available at the time of its preparation. Whilst every effort has been made to ensure that all relevant data has been collated, the authors can take no responsibility for omissions and/or inconsistencies that may result from information becoming available after this reports completion.

Spatial Accuracy

Locations were recorded using a Garmin hand held GPS unit using the datum GDA94. Coordinates contained in this report are MGA Zone 50 and are accurate to ± 10 m.

EXECUTIVE SUMMARY

Peet Limited (Peet) propose to develop 1.59 sq km (159 hectares) of land for a residential subdivision at Lots 37, 98 and 9000 Bishop Road, Mundijong, approximately 40 km southeast of Perth, in the greater Perth metropolitan region of Western Australia (see Figure 1).

Thomson Cultural Heritage Management (TCHM) was commissioned by Ethnosciences on behalf of Peet in March 2012 to undertake an archaeological assessment of the landholdings for the proposed residential development (the project area). The archaeological assessment has involved archaeological survey, detailed site recording and test excavations undertaken under section 16 permit 527 (22 October 2012).

In summary, two previously recorded Aboriginal Sites, DAA Id 3648 Soldiers Road Mundijong and DAA Id 450 South-East Corridor 03, plus six newly recorded archaeological sites, including three artefact scatters with subsurface archaeological deposit (MJ-01, MJ-02, MJ-04), one artefact scatter with potential archaeological deposit (MJ-03), two modified trees (MJ-08 and MJ-09) and a newly recorded extension to DAA Id 3648 (previously referred to as MJ-05) are located within Lots 37, 98 and 9000 Bishop Road Mundijong.

Based on the results of the archaeological assessment and test excavations, it is **recommended** that:

- MJ-01, MJ-02, MJ-03, MJ-04, DAA Id 3648 (including the MJ-05 extension), MJ-08, MJ-09 and DAA Id 450 South-East Corridor 03 may meet the requirements of section 5 of the *Aboriginal Heritage Act 1972* and therefore should not be impacted upon in any way without Ministerial consent under section 18 of the AHA;
- a 30 m buffer be applied around sites MJ-08 and MJ-09 during construction;
- Peet develop and implement an Aboriginal Heritage Management Plan (AHMP); and
- Peet implement suitable controls to prevent any impacts on archaeological sites during earthworks, including adequate physical demarcation of site boundaries and effective management processes such as ground disturbance permits and operator inductions.

Should at any stage Peet wish to disturb MJ-01, MJ-02, MJ-03, MJ-04, DAA Id 3648 (including the MJ-05 extension), MJ-08 or MJ-09 and an application is made for consent to use the land under section 18 of the *Aboriginal Heritage Act 1972*, it is **further recommended** that Peet:

- consult with the appropriate Nyungar Elders and Aboriginal Consultants about any proposed section 18 application, mitigation and salvage strategies and the management of any excavated or salvaged materials;
- cap the portion of DAA Id 3648 (including MJ-05) located within the current conservation zone and proposed public open space with geotextile fabric to ensure its long term conservation, prior to any landscaping being undertaken in this area; and
- develop and implement a public interpretation plan for DAA Id 3648 Soldier's Road Mundijong (including MJ-05), to be incorporated into the proposed public open space surrounding the lakes.

It is also **recommended to the Department of Aboriginal Affairs** that the boundary for DAA Id 3648 Soldier's Road Mundijong (including the MJ-05 extension) be updated to reflect the boundary included in the site description included in this report.

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1.0 INTRODUCTION

Peet Limited (Peet) propose to develop 1.59 sq km (159 hectares) of land for a residential subdivision at Lots 37, 98 and 9000 Bishop Road, Mundijong, approximately 40 km southeast of Perth, in the greater Perth metropolitan region of Western Australia, see Figure 1.

Thomson Cultural Heritage Management (TCHM) was commissioned by Ethnosciences in March 2012 on behalf of Peet to undertake an archaeological assessment of the landholdings for the proposed residential development (the project area). The archaeological assessment has involved archaeological survey, detailed site recording and test excavations, undertaken under section 16 permit 527 (22 October 2012). TCHM subcontracted Dr Diana Neuweger of Archaeo Logical Pty Ltd as the Excavation Director for the test excavation component of the work.

The archaeological survey was undertaken by TCHM archaeologists Ms Jo-Anne Thomson and Ms Christine Martin over ten days between 14 March and 16 May 2012. Dr Edward McDonald also assisted with the survey on 21 March 2013. Four newly recorded artefact scatters, MJ-01, MJ-02, MJ-03 and MJ-04 and an extension to Aboriginal Site DAA Id 3648 Soldiers Road (MJ-05) and two modified trees (MJ-08 and MJ-09) were located and recorded in detail to section 18 standards during the surveys. Subsequent concept planning undertaken by Peet indicated that archaeological sites MJ-01, MJ-02, MJ-04 and the extension to DAA Id 3648 (MJ-05) will be impacted by the proposed residential development.

An understanding of each site's subsurface content was required in order to adequately assess the archaeological significance of each artefact scatter site for the purpose of a section 18 application. A section 16 permit was applied for in August 2012 and was granted in October 2012 (see Thomson et al., 2012 for details of the section 16 research plan). Test excavations were undertaken at MJ-01, MJ-02, MJ-04 and DAA Id 3648 (MJ-05) between 7 and 23 January 2013. Dr Diana Neuweger and Ms Jo-Anne Thomson undertook the excavation with representatives from two related Nyungar families (Walley and Nannup families), representing the Bilya Noongar Organisation and the Winjan Aboriginal Corporation respectively.

Ethnosciences has conducted the ethnographic assessment and Indigenous community consultation regarding the results of the archaeological assessment and is reported on under a separate cover (McDonald and Thomson, 2012).

This report should also be read in conjunction with the results from the archaeological investigations undertaken on behalf of Peet at Lot 50 Cockram Street, Mundijong (referred to in previous reports as Lot 50 Mundijong Road) which are reported on under separate covers (McDonald and Thomson, 2012, Thomson and Neuweger, 2014).

1.1 Scope of work

The objectives of the archaeological assessment were to:

- conduct an archaeological survey of the proposed Peet Mundijong residential subdivision, to locate any Indigenous archaeological sites as defined under section 5 of the *Aboriginal Heritage Act 1972*;
- record any Aboriginal archaeological sites located to section 18 standard, including the assessment of potential subsurface components;

- assess the archaeological significance of any sites located;
- make recommendations for the management, mitigation or salvage of any sites located within Peet's Mundijong residential development; and
- report on the results in a format to meet DAA section 16 permit reporting requirements.

1.2 Section 16 permit

The test excavations were undertaken under a section 16 permit (number **527**) granted to Thomson Cultural Heritage Management by the Department of Aboriginal Affairs on (22 October 2012), see Appendix 2. The permit conditions allowed for:

> E. Undertake an excavation of any of the site(s) described hereunder for the purposes of evaluating the archaeological potential of the site(s).
>
> F. Management of the cultural material collected/located.

For the following locations:

> DAA 3648 (Soldiers Road, Mundijong) and six recently recorded places of Aboriginal archaeological interest in four residential development lots owned by Peet Pty Ltd in North Mundijong (Lot 50 Mundijong Road and Lots 37, 98 and 9000 Bishop Road, North Mundijong).

The section 16 permit is valid until 22 October 2013 with the final report due for submission to DAA on 22 October 2014.

1.3 Project details

Peet's North Mundijong residential land development comprises four lots including: Lots 37, 98 and 9000 Bishop Road and Lot 50 Cockram Street. Mundijong is located in the Shire of Serpentine-Jarrahdale, approximately 40km south east of Perth's Central Business District, 16km south of the Armadale Regional Centre and 25km east of the Rockingham Regional Centre. It is located approximately 25 km east of the Indian Ocean coast line and approximately 3.5 km from the foot of the Darling Scarp (see Figure 1).

Lots 37, 98 and 9000 Bishop Road are located to the north of the Mundijong town site, on the southern alignment of Bishop Road and west of Soldiers Road (see Figure 2). The combined area of the three lots is approximately 1.59 sq km. This development is being managed by Peet Mundijong Syndicate Limited and will comprise 850 residential lots, 30 cottage lots and 4 group housing sites with the potential for a total of 64 dwellings. The project will feature a commercial/mixed use site and proposed primary school site.

This report should be read in conjunction with the results from the archaeological investigations undertaken at Lot 50 Cockram Street which are reported on under separate covers (McDonald and Thomson, 2012, Thomson and Neuweger, 2014).

1.4 Affected Aboriginal people

The project area is located in the Gnaala Karla Booja (WC98/58) native title claim area and Gnaala Karla Booja native title claimants were involved in the archaeological work through two regionally-based Aboriginal organisations: the Bilya Noongar Organisation and the Winjan Aboriginal Corporation.

1.5 Acknowledgements

The following people contributed to the conduct of the archaeological assessment and test excavations:

- Mr Clarry Walley, Bilya Noongar Organisation
- Mr John Michael, Bilya Noongar Organisation
- Mr John Abraham, Bilya Noongar Organisation
- Mr Harry Nannup Senior, Winjan Aboriginal Corporation
- Mr Franklin Nannup, Winjan Aboriginal Corporation
- Mr Harry Nannup Junior, Winjan Aboriginal Corporation
- Mr Scott Beckett, excavator driver, SJ Mini Excavators
- Mr Clay Thomas, Peet
- Dr Eddie McDonald, Ethnosciences
- Dr Warren Mitchell, Senior Heritage Officer, DAA
- Dr Moya Smith, WA Museum
- Ms Alice Beale, WA Museum
- Associate Professor Joe Dortch, Eureka UWA
- Mr Sam Lang, Owner of Lot 9000 Bishop Road
- Professor Karl-Heinz Wyroll, UWA for providing geomorphologic reference material
- Mr Rick Piovesan, Geotechnician, Galt Geotechnics

Jo-Anne Thomson and Christine Martin conducted the archaeological surveys, undertook the section 18 level recording of the surface components of the sites and catalogued the excavated artefacts. Jo-Anne Thomson also assisted with the excavation and wrote the background, methodology, results, site descriptions and discussion chapters. Christine Martin conducted the soil analysis and undertook editing of the report. Diana Neuweger directed the test excavations, undertook the data analysis, wrote the analysis chapter and contributed to the methodology and discussion chapters.

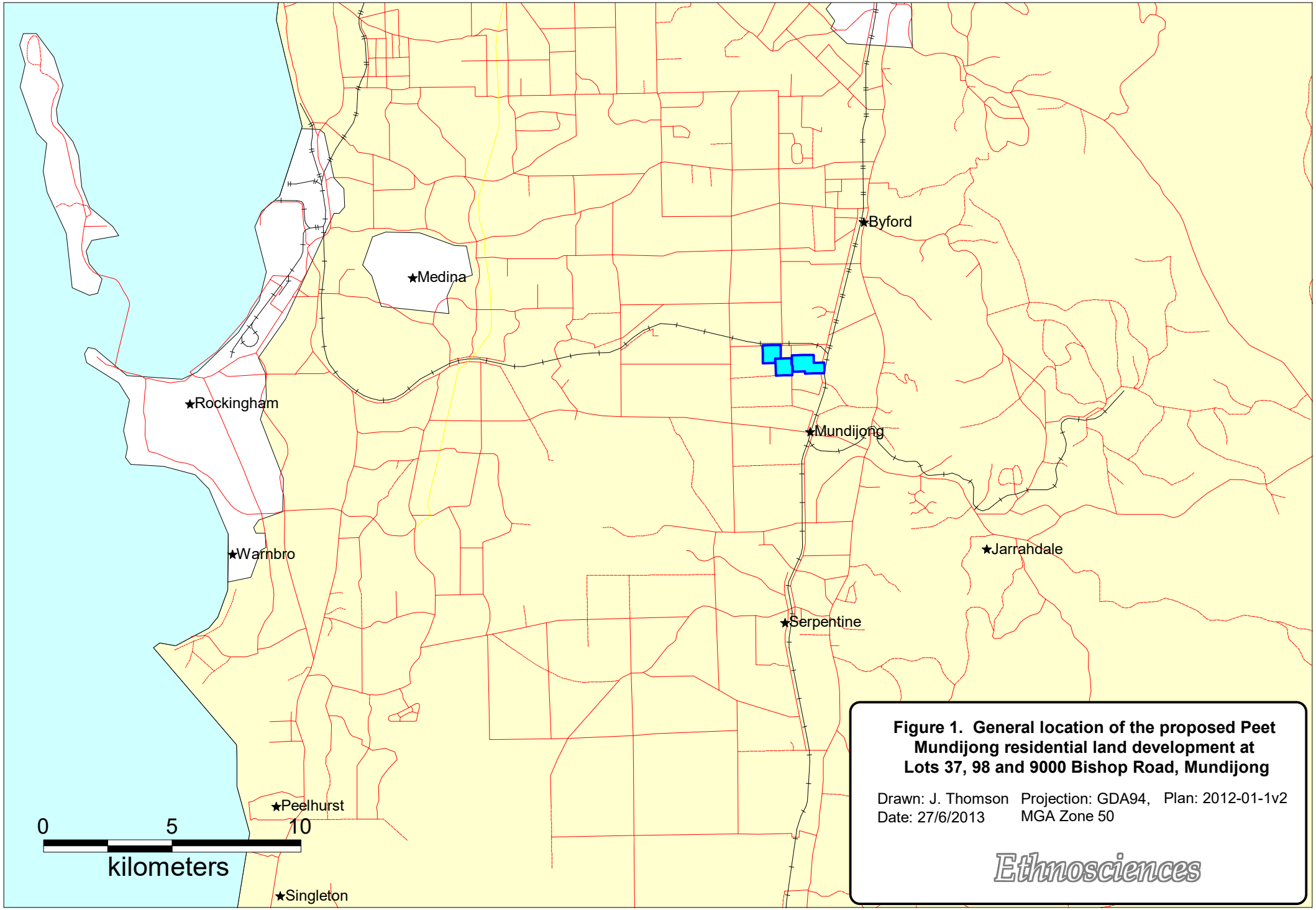


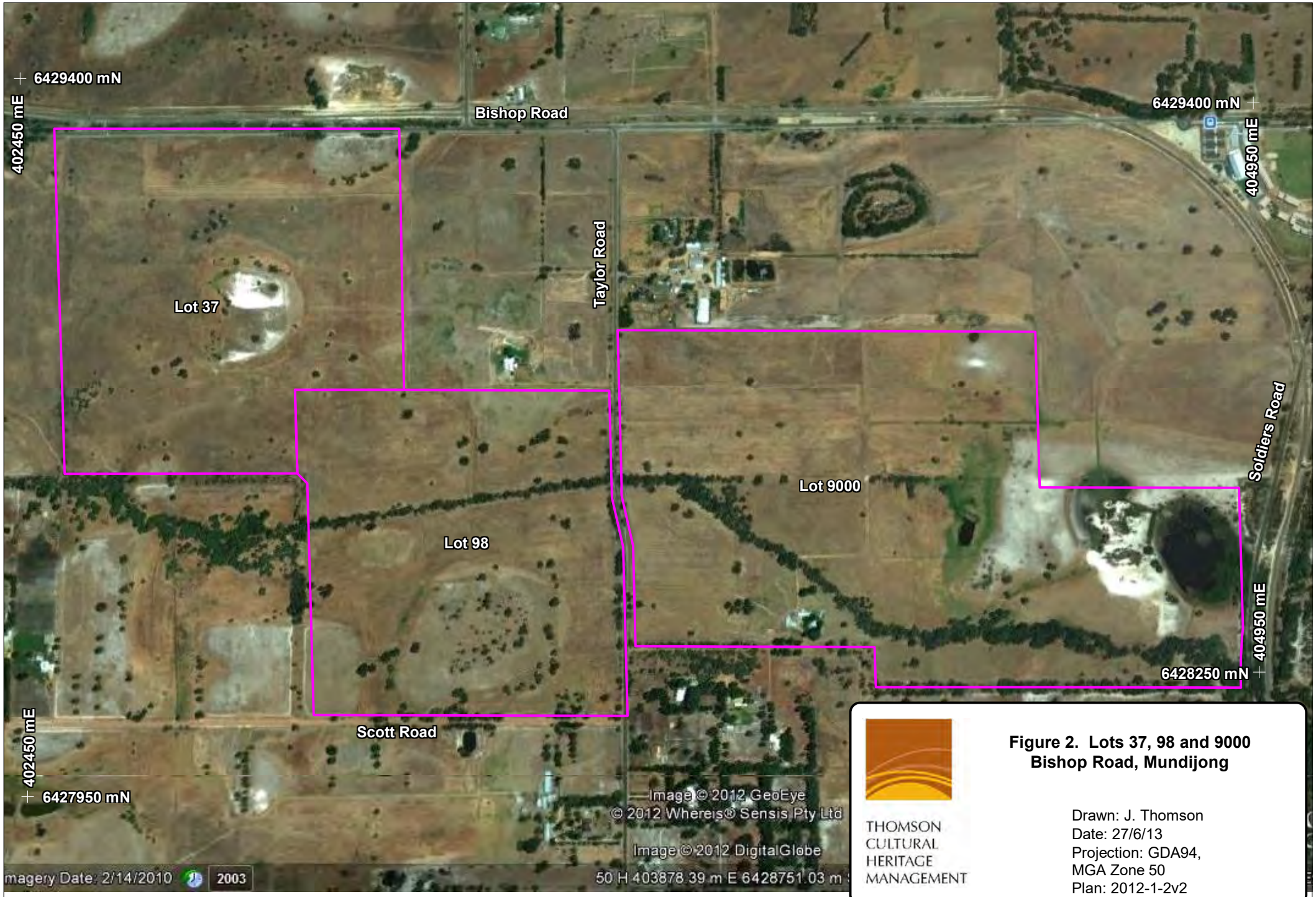
Figure 1. General location of the proposed Peet Mundijong residential land development at Lots 37, 98 and 9000 Bishop Road, Mundijong

Drawn: J. Thomson
Date: 27/6/2013

Projection: GDA94, MGA Zone 50

Plan: 2012-01-1v2

Ethnosciences



THOMSON CULTURAL HERITAGE MANAGEMENT

Figure 2. Lots 37, 98 and 9000 Bishop Road, Mundijong

Drawn: J. Thomson
Date: 27/6/13
Projection: GDA94, MGA Zone 50
Plan: 2012-1-2v2

2.0 BACKGROUND

In order to design an appropriate methodology for the archaeological survey and assessment, a desktop review was undertaken of the following information and resources:

- applicable Indigenous heritage legislation;
- Department of Aboriginal Affairs (DAA) Aboriginal Heritage Inquiry System (AHIS);
- existing archaeological consultancy reports; and
- other published and unpublished resources.

A summary of the results is presented below.

2.1 Applicable legislation

Relevant legislation for the purpose of this Indigenous archaeological survey includes:

- Western Australian *Aboriginal Heritage Act 1972*;
- Commonwealth *Aboriginal and Torres Strait Islander Heritage Protection Act* 1984;
- Commonwealth *Environment Protection and Biodiversity Conservation Act* 1999.

The *Aboriginal Heritage Act 1972* (the AHA) makes provision for 'the preservation on behalf of the community of places and objects customarily used by or traditional to the original inhabitants of Australia or their descendants, or associated therewith, and for purposes incidental thereto'. A place may be assessed as an Aboriginal Site under section 5 and an object as an Aboriginal Object under section 6 of the AHA.

Section 5 defines the places to which the Act applies as:

a) any place of importance and significance where persons of Aboriginal descent have, or appear to have, left any object, natural or artificial, used for, or made or adapted for use for, any purpose connected with the traditional cultural life of the Aboriginal people, past or present;
b) any sacred, ritual or ceremonial site, which is of importance and special significance to persons of Aboriginal descent;
c) any place which, in the opinion of the Committee, is or was associated with the Aboriginal people and which is of historical, anthropological, archaeological or ethnographic interest and should be preserved because of its importance and significance to the cultural heritage of the State;
d) any place where objects to which this Act applies are traditionally stored, or to which, under the provisions of this Act, such objects have been taken or removed.

The Department of Aboriginal Affairs, whom administers the AHA, has created threshold tests for places being assessed under section 5, see Appendix 3.

Section 6 defines the objects to which the AHA applies as:

1) Subject to subsection (2a), this Act applies to all objects, whether natural or artificial and irrespective of where found or situated in the State, which are or have been of sacred, ritual or ceremonial significance to persons of Aboriginal descent, or which are or were used for, or made or adapted for use for, any purpose connected with the traditional cultural life of the Aboriginal people past or present.

2) Subject to subsection (2a), this Act applies to objects so nearly resembling an object of sacred significance to persons of Aboriginal descent as to be likely to deceive or be capable of being mistaken for such an object.

2a) This Act does not apply to a collection, held by the Museum under section 9 of the Museum Act 1969, which is under the management and control of the Trustees under that Act.

3) The provisions of Part VI do not apply to an object made for the purpose of sale and which —

(a) is not an object that is or has been of sacred significance to persons of Aboriginal descent, or an object so nearly resembling such an object as to be likely to deceive or be capable of being mistaken for the same; or

(b) is an object of the kind referred to in paragraph (a) that is disposed of or dealt with by or with the consent of the Minister.

Under section 17 of the AHA, it is an offence to:

a) Excavate, destroy, damage, conceal or in any way alter any Aboriginal site;
b) In any way alter, damage, remove, destroy, conceal, or deal with in a manner not sanctioned by relevant custom, or assume possession, custody or control of, any object on or under an Aboriginal site;

unless it has been authorised by the Registrar of Aboriginal Sites under section 16 or by the Minister under section 18 of the AHA.

The Commonwealth *Aboriginal and Torres Strait Islander Heritage Protection Act* 1984 protects places of significance to Indigenous Australians and is administered through the Federal Department of Environment, Water, Heritage and the Arts. The Act offers protection for significant places or objects through ministerial decision. Aboriginal people who believe that a place or object is threatened and that State Government processes offer inadequate protection can apply to the Australian Government Environment Minister to protect the place or object.

The Commonwealth *Environment Protection and Biodiversity Conservation* Act 1999 protects the environment, particularly matters of National Environmental Significance. It streamlines the national environmental assessment and approvals process, protects Australian biodiversity and integrates management of important natural and cultural places.

2.2 Environment

The environmental setting is of primary significance to the archaeological investigation of the project area.

2.2.1 Geology

The project area is located on the central Swan Coastal Plain at the base of the Darling Scarp.

The dominant geological element in south western Australia is the Archaean-aged Yilgarn Block, which forms the nucleus of the Western Australian Shield (Johnstone et al., 1973). The shield extends from near the south coast of Western Australia for 900 km to the north and has an east-west width of 700 km. Around this nucleus, belts of younger Precambrian rocks have accreted, including granite and gneiss with dolerite dykes, and its western margin is marked by the deep Mesozoic graben of the Perth Basin.

The Perth Basin is an elongate north-south rift-trough with a series of sub-basins, shelves, troughs and ridges. The basin overlies the Pinjarra Orogen and contains a sedimentary succession up to 15 km thick that mostly accumulated from the early Permian to the late Cretaceous, with a veneer of Neogene sediments (Freeman and Donaldson, 2006). There are very few outcrops of Perth Basin strata south of Perth, as much of the area is covered by Cenozoic deep-weathering products or Pleistocene to Holocene aeolian sand deposits.

The eastern margin of the Perth Basin is defined by the Darling Scarp, the surface expression of the Darling Fault and the colluvial foothills of the Darling Range. The scarp represents the dissected remnants of a sand covered wave-cut platform known as the Ridge Hill Shelf, which is the eastern boundary of Tertiary and Quaternary marine erosion (McPherson and Jones, 2005). The Darling Range comprises Archaean igneous and metamorphic rocks, capped by an extensive lateritic crust which has been dissected by later drainage (Hook, 2001). Basement rocks underlying the lateritic profile include granite and banded and migmatitic gneiss, paragneiss, and granitic gneiss and metamorphosed argillite and felsic to mafic volcanic rocks (Freeman and Donaldson, 2006).

The Cardup Group, an exotic suite of rocks, is located along the scarp between Mundijong and Perth which consists of generally low-grade metamorphic rocks formed by relatively low pressure and temperature metamorphism of sedimentary rocks (metasediments) although some sections appear unmetamorphosed and include shale, sandstone and siltstone with dolerite intrusives. The lowermost unit of the Cardup Group unconformably overlies the granitic gneiss of the Yilgarn Craton.

Local geology is particularly relevant to archaeology of the Swan Coastal Plain, as summarised by Hook:

> The Darling Range provided the only source of stone, with the exception of fossiliferous chert, for Aboriginal people occupying the Swan Coastal Plain. The Darling Range provided a number of stone types suitable for implement manufacture. The lithologies utilised ranging from the coarse and hard rocks granite, gneiss and dolerite to the finer rocks quartz, crystal quartz, feldspar, mylonite and silcrete... The historical and archaeological evidence suggests that the coarser stone such as granite gneiss and dolerite was used for *Kodj* and grindstones. Finer stone with better conchoidal fracturing characteristics, predominantly small pieces of quartz, was used for hafting in knives and spears (Meagher and Ride 1980: 77). (Roth 1903: 58) states that both the quartz and stone for the *kodj* came from the Darling Range. Stone was transported and Grey (1841: 266) and Salvado (1977: 149) list stone, including quartz and "stone for hatchets" as being carried in women's bags for subsequent use in fabrication... (Hook, 2001: 4-5).

2.2.2 Soils

The Swan Coastal Plain physiographic unit is a narrow 20–30 km wide strip generally low in relief and comprised mainly of Quaternary and Aeolian sediments which form a series of coastal dunes that are overlying or situated adjacent to alluvial deposits (Anderson, 1984). These dune systems vary in orientation, physical characteristics and age. The youngest systems occur at the west and increase in age towards the east. The geomorphic systems comprise (from west to east):

- **Quindalup dune system** – the youngest system, comprised of calcareous sands occurring as both beach ridges and parabolic dunes that trend north–south.
- **Spearwood dune system** – a core of aeolian limestone (Cottesloe Limestone) overlain by limestone-derived yellow and brown sands of varying depths (Karrakatta Sands). Some permanent lakes occur in chains parallel to the coast, some are saline and brackish, whilst

lakes situated along the boundary between the Spearwood and Bassendean Dunes are all fresh;

- **Bassendean dune system** – a 15 km wide belt of low, vegetated sand dunes and sand plains with pale, highly leached white and grey quartz sands with interdunal swamps and lakes. The dunes to the north of Perth generally have greater topographic relief than to the south of Perth. The dunes have probably accumulated as shoreline deposits and coastal dunes during interglacial periods of high sea level and originally consisted of mostly lime (calcareous) sand and minor, fine grained black heavy mineral concentrations. Carbonate material has been completely leached leaving dunes consisting entirely of quartz sand. This system was formed mainly during the middle to late Pleistocene; and
- **Pinjarra plain** – a piedmont and valley flat alluvial plain consisting predominantly of clayey alluvium that has been transported by rivers and streams from the Darling and Dandaragan Plateaus (also referred to as the Guildford formation). Approximately 1.5 to 25 km wide, this system is located between the Bassendean Dunes and the Darling Scarp, but also abuts the Spearwood Dunes south of Perth.

SMEC (2009: 68) reports that there are three soil complexes within the Mundijong-Whitby Structure Plan study area including Forrestfield, Pinjarra and Bassendean. Within the current project area, the Pinjarra and Bassendean soils are predominant. SMEC (2009: 99) describes the Pinjarra soils within the study area as comprising 'alluvial materials deposited across the plain extending from north to south adjacent to the Forrestfield group, including through the centre of the Shire to its Western boundary'. They also note that in isolated pockets, the alluvial soils are overlain by windblown sand typical of the Bassendean System.

2.2.3 Hydrology

The major hydrological features of the Swan Coastal Plain comprise several major watercourses, such as the Swan and Canning Rivers, which are flanked by clayey floodplains and river terraces of recent origin. Other wetlands, including a north-south oriented chain of swamps and lakes, have formed in the inter-dunal swales of the Bassendean Dune System, in the interbarrier depressions between the Spearwood and Bassendean Dune Systems, and within the Spearwood Dune System.

SMEC (2009) identify three types of wetland present within the local region around Mundijong, including:

- Plausiplain – a seasonally waterlogged flat;
- Sumplands – a seasonally inundated basin of variable size and shape; and
- Creeks – a seasonally inundated channel.

Both SMEC (2009) and GHD (2009:8) highlight that the Mundijong-Whitby area is known to experience regular water logging in the low-lying areas of the study area, such as on the plausiplains. This inundation is due to a combination of persistent winter rainfall elevating the shallow water table, which rises to the surface and inundates vast areas of the flat terrain, as well as sparse drainage, with insufficient capacity that does not allow runoff to leave the area. There is also the potential for wetlands within the study area to receive additional flood water from outside their natural catchment by overtopping of drains and watercourses.

One water course and two small wetland lakes are located within the current project area. Manjedal Brook runs east-southeast to west-northwest through Lots 9000, 98 and 37 Bishop Road. The two

small wetland lakes are located in the southeast corner of Lot 9000. Cardup Brook and Gingagup Brook are located just outside the survey area to the northeast. A significant proportion of the current project area is comprised of plausiplain wetland (see Figure 3), interspersed by elevated sandy rises or dunes of Bassendean sands.

2.2.4 Flora and fauna

The project area is situated within the Drummond Sub District vegetation system of the South West Botanical Province (Beard, 1990). SMEC (2009:25) describe the general vegetation of the Pinjarra plain as represented by *Corymbia calophylla* (marri) open forest and the Bassendean System by banksia low woodland, generally *Banksia attenuata* (slender banksias), *Banksia menziesii* (firewood banksias), *Banksia ilicifolia* (holly leaf banksias), *Eucalyptus todtiana* (coastal blackbutt) and *Nuytsia floribuna* (Christmas tree).

SMEC (2009:16) report that the current project area includes only remnants of the Guildford and Forrestfield vegetation complexes due to previous land clearing. There are remnants of both vegetation systems along the Manjedal Brook in Lot 9000, and the Guildford system along the western boundary of Lot 98 (see Figure 6 in SMEC 2009: 32). SMEC (2009:31) characterise the vegetation complexes present within the current project area as follows.

- Forrestfield vegetation system: ranges from open forest of *E. calophylla – E. Wandoo – E. Marginata* to open forest of *E. Marginata – E. Calophylla – C. Fraseriana – Banksia sp*. Fringing woodland of *E. rudis* in the gullies that dissect this landform;
- Guildford vegetation system: comprises a mixture of open forest to tall open forest of *E. calophylla – E. Wandoo – E. marginata* and woodland of *E. wandoo* (with rare occurrences of *E. lane-poolei*). Minor components include *E. rudis – M. rhaphiophylla*.

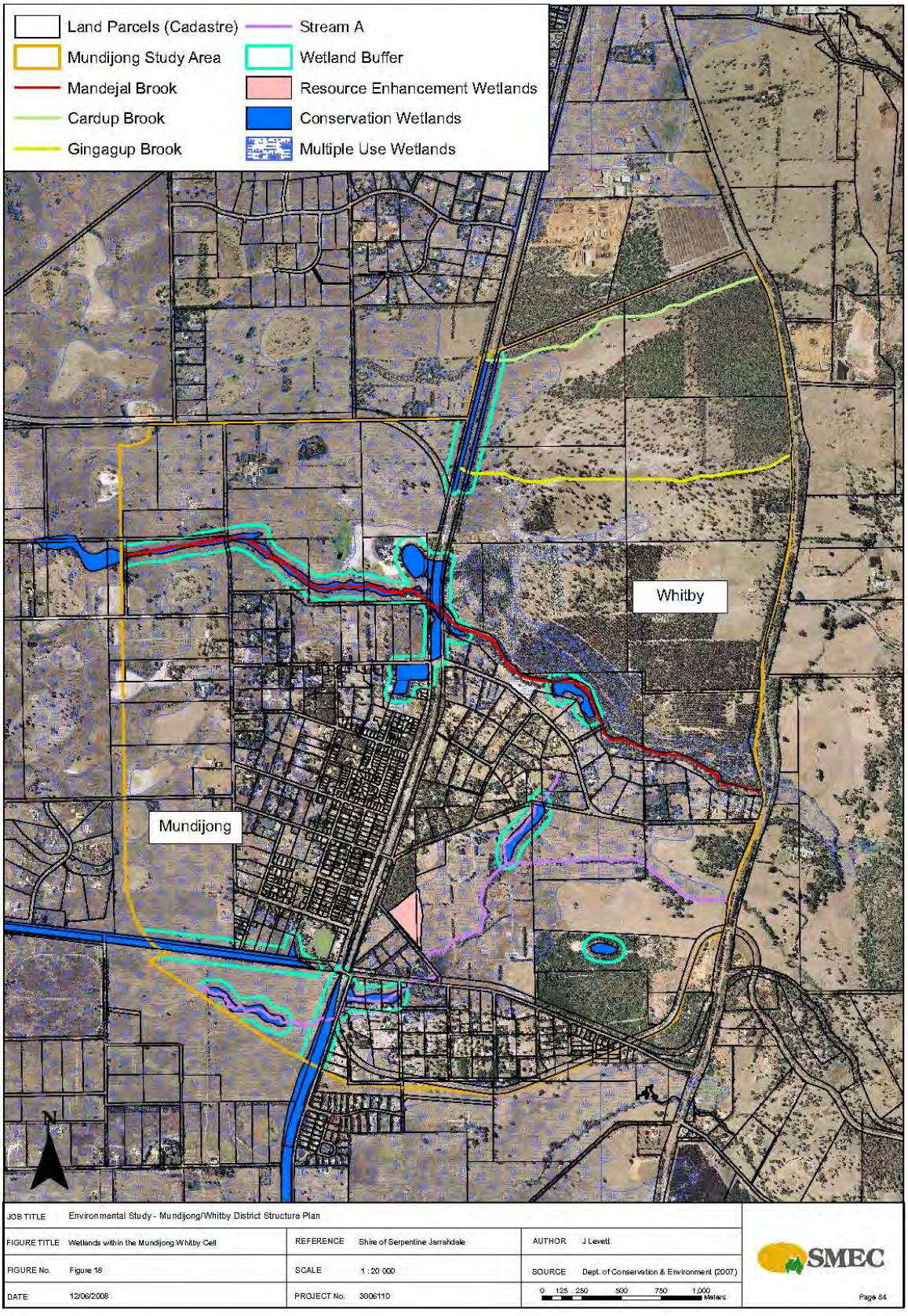
SMEC (2009: 47) indicated that despite the previous vegetation clearance, local flora studies suggest that to the east (towards the base of the Darling Range) a rich and diverse suite of faunal assemblages still exists. Key fauna identified include the Brush tail Possum, Brush-tailed Phascogale, Chuditch and Western Grey kangaroo. The wetland located in Lot 9000 also supports a wide variety of fauna including birds.

2.2.5 Previous land use

SMEC (2009) report that approximately 87% of land within the local Mundijong region has been previously cleared of vegetation, with agriculture being the main clearance-related land use activity. Historically Mundijong was also a major junction along the South West rail network.

In a review of historic aerial photos from 1953 to 2006, SMEC noted that during the 1950s and 1960s, land use within the project area predominantly comprised low density agriculture with some residential development. Past and current agricultural activity has included land clearing, ground excavation of some areas for landfill and rubbish dumps, construction of tracks, fences, farm infrastructure and buildings, running of stock and growing crops. SMEC note the historical presence of dairy and poultry farms and a timber mill. Other noted changes in the use of the landscape included the extension of residential housing along Paterson Street in Mundijong in the 1970s, the appearance of pine plantations in the 1980s and extension of residential developments in the 2000s.

Figure 3. Geomorphic wetland regimes (source: SMEC 2009: 84)



2.3 Previous archaeological investigations

The desktop review found that a number of previous archaeological assessments have been conducted within the local region[1] surrounding the project area for a variety of development and infrastructure projects including 330 kV and 22 kV power transmission lines, optic fibre cable, natural gas pipeline, road developments, mining infrastructure and processing facilities and light industrial subdivisions. In addition, several broad-scale regional archaeological studies have been undertaken relating to the Swan Coastal Plain, which are useful for developing the research agenda for this assessment and interpreting the survey and test excavation results.

2.3.1 Regional archaeology

Archaeological research on the Swan Coastal Plain has focused primarily on the themes of antiquity, social, demographic and occupation patterns over time, site spatial distribution patterns, site characterisation and stone tool technologies. A short summary of these themes is presented below.

Antiquity

The southwest region of Western Australia has well established chronologies of human occupation from the Pleistocene onwards (Dortch, 1984, Dortch, 1974, Dortch, 1979b, Dortch, 1979a, Dortch and Merrilees, 1971, Dortch and Merrilees, 1973). The majority of dates for the southwest region have been gained from rock shelter or cave sites, however, on the Swan Coastal Plain very few rock shelter sites exist. The majority of sites that have been excavated on the Swan Coastal Plain have comprised open sites located mainly within the Bassendean sands geomorphic unit (Bowdler et al., 1991, Strawbridge, 1987). Based on the results of these excavations, Bowdler et al. (1991) have commented that on the Swan Coastal Plain there is a 'consistent lack of good stratified sites' and 'with respect to open sites, only three to five are known with any kind of stratigraphic integrity, and these are not all straightforward cases' (Bowdler et al., 1991: 21,24). Of these five stratified sites, four are located within the Swan River Alluvial Deposits and the fifth (Walyunga) is located in a unique geomorphic context in 'a sand dune part of the Yoganup formation, comprising fossil shoreline sands on the Ridge Hill Shelf' (Bowdler et al. 1991:24).

To date, no stratified open sites have been located within the Bassendean sands. Anderson (1983: 50) suggests that this is mainly due to the geomorphology of the Bassendean dune system, which she describes as 'a stable core with a superficial mobile layer of continually reworking sands' and through the process of deflation artefacts which may have been deposited at sites over a considerable time period now occur on one level.

Sites that have been dated on the Swan Coastal Plain include DAA Id 4299 Upper Swan Bridge (39,500 $\pm$ 2300 BP and >31,500 BP)[2], DAA Id 3967 Helena River A-C (29,000 BP to 2120 BP), DAA Id 3382 Walyunga (8,260 BP to 1,330 BP), DAA Id 4404 Orchestra Cave (6,500 BP – 1,730 BP), DAA Id 4073 Millendon 05 (~8,000 BP), DAA Id 3294 North Lake North (2,300 BP), DAA Id 3648 Soldiers Road (1,620 BP). The Upper Swan and Walyunga sites are of particular significance as they have both been interpreted as representing phases of cultural and technological shifts. At Upper Swan, Pearce and Barbetti (1981) found a divergence in the artefact assemblage from the 'Australian core-tool and

[1] Within a 5 km radius of the project area.

[2] Pearce and Barbetti (1981) provisionally take the mean date of 38,000 BP as an age for the artefact layer.

scraper tradition' found in sites of similar age in eastern Australia and view these differences as reflecting a cultural difference or cultural changes occurring around 40,000 BP. Similarly at Walyunga, Pearce (1979) reports the introduction of backed tools and flat adzes after a period of aridity and shortly after the sea reached its present level, thus representing a link between changes in environment and tool technologies.

Due to the shortage of dateable archaeological sites on the Swan Coastal Plain, Hallam (1986, 1987) developed a relative dating scheme for surface artefact scatters based on the presence/absence of temporal markers such as fossiliferous chert[3]. Strawbridge reports that

> Studies on sea level changes in the region (Veeh et al.: 1979; Playford & Leech: 1977) indicate that the sea level reached its present level around 6000-6500 years BP. Artefacts of Eocene chert have been found frequently among artefact assemblages from sites on the Swan coastal plain but no source of this material is exposed west of the Darling fault line. Eocene chert has been found at shallow depths in offshore drilling cores (Glover, 1979).
>
> This suggests that the outcrops of Eocene chert were available when the sea level was lower and that the source is west of the current coastline and was submerged in the mid-Holocene. It should be borne in mind, however, that some reuse of quarried material probably occurred after the source was submerged. Research into sites in the Perth metropolitan region has attempted to use the presence of chert artefactual material in sites as a chronological indicator (Strawbridge, 1987: 13).

Using such chronological markers, Hallam (1987) defined four primary phases of occupation, see Table 1. These phases have been critiqued and refined by Schwede (1990) based on whole of assemblage analyses. Schwede (1990) has also highlighted the difficulties relating to the use of fossiliferous chert as a chronological marker.

Table 1. Occupation phases for the Swan Coastal Plain, comparison of Hallam's and Schwede's definitions

Phase	Hallam (1987)	Schwede (1990)
Early	Pre-5000 BP. Assemblages containing artefacts made of Eocene fossiliferous chert	4600–40000 BP. Absence of backed pieces, larger flake and platform sizes
Middle	5000–1000 BP. Assemblages containing backed artefacts and elements of the 'Australian Small Tool Tradition'	3000–4600 BP. Presence of backed pieces, significant differences in debitage from late phase sites. Associated with introduction of microlith technology to the Swan Coastal Plain.
Late	Post-1000 BP. Quartz-rich assemblages with high proportions of waste flakes	0-3000 BP. Characterised by flake assemblages with no significant variation in flake shape and platform size, increase in small edge-damaged pieces.
Final	Post-contact. Artefacts made on European materials such as glass or ceramics	Post-contact. Artefacts made on European materials such as glass or ceramics

Site distribution

Analysis of site distribution data collected during the Swan Area Archaeological Survey (SAAS) project directed by Hallam (1986, 1987) identified the following spatial and temporal patterns in site distribution across the Swan Coastal Plain.

[3] Also referred to as Eocene chert or Bryozoans chert.

- In all phases, virtually no sites are located within the zone of the most seaward dunes (Quindalup);
- the limestone belt (Spearwood) has relatively few sites, most of those are towards its eastward margin;
- the majority of sites lie to the east, on the coastal sand plain (Bassendean Sands) and on the alluvium of the Pinjarra Plain;
- the foothills appear to be well used, but the small sample of the scarp and uplands showed little use.

In addition, Hallam examined the distribution of sites according to artefact population and noted that densities were initially similar in the sand plain and alluvial zones, with the alluvial zone showing higher density in the Middle Phase. The Late Phase saw an increase in numbers on the sand plain due to an increase in smaller sites, whilst the alluvial zones displayed greater concentration of usage into larger sites. Final Phase figures show Europeans becoming the resource and Aboriginal usage of the landscape peaking around homesteads and in the fertile alluvial zone (Hallam, 1987:20–23).

Anderson's (1984) subsequent study used additional data from surveys at North Dandalup, South Canning, Perth Airport, Avon headwaters and the Canning River catchment area to build on the results of the SAAS project. Anderson (1984:34) found that the archaeological evidence indicated a greater exploitation, spatially and/or temporally, in the coastal environment than in either the forest or plateau areas. Site density on the Swan Coastal Plain was three to six times greater than forested areas and two to four times that at the Avon headwaters. Sites were mainly located adjacent to water sources across all areas; however whilst sites on the plateau were situated on low-lying and gently sloping ground, sites on the coastal sand plain are commonly located on elevated dunes or sand ridges.

Strawbridge's (1987) computer analysis of SAAS and Anderson's data sites developed the following defining principles for site distribution on the Swan Coastal Plain (after Edwards, 2008: 10). Sites are:

- most likely to be situated on sandy, well drained dune ridges;
- most likely to be located within 350 m of a potential water source, including (in decreasing frequency) swamps, creeks, rivers, lakes, surface water, springs and soaks;
- unlikely to be located in low-lying, poorly drained or seasonally inundated areas; and
- unlikely to be located more than 350 m away from potential water sources.

Strawbridge (1987: 35) attributes the large number of sites located in the Bassendean sands geomorphic zone to a combination of factors, including the greater stability of the formation, greater abundance of resources within the zone and better access to water sources. Strawbridge comments that 'a site is likely to have been returned to and/or occupied for greater lengths of time if it lies close to a reliable, long term supply of water. Such water is also likely to provide increased numbers of plant and animal resources. The amount of archaeological material is likely to greater at sites in close proximity to reliable water sources' (Strawbridge, 1987: 35).

Site characterisation

During the SAAS over 400 sites were recorded, with more than half being interpreted as indicative of ephemeral usage of the landscape by small groups. The remainder of sites included large sites comprised of tens of thousands of surface artefacts such as retouched artefacts, cores, debitage and grinding and percussion material, with the latter few types being interpreted as reflecting the

presence of women and family groups. Thus the large sites were seen as representing occupation for long periods of time by large groups of Aboriginal people (Edwards, 2008:5).

The range of lithic types present on the Swan Coastal Plain is also much broader than in the forest or on the plateau, but relative proportions vary at different sites. Quartz is nearly always dominant, except at a very few sites of the post-contact period where European glass only is found, or where fossiliferous chert, which is the next most prevalent material, occurs in high concentrations. The variable proportion of the latter is attributed to both distance of sites from the probable source of the chert to the west of the present coastline, and to its unavailability when the sea reached its present level in mid-Holocene times. Dolerite and mylonite both occur to a much lesser extent, the former usually as larger tools like steep edged scrapers, hammer stones or grinding material, and the latter possibly as a replacement for fossiliferous chert when it became unobtainable. Silcrete is represented only in very minor quantities. Anderson also notes that except for the fossiliferous chert, all lithic materials had to be transported or traded from beyond the Yilgarn block or from other distant areas (Anderson, 1984:25).

As pointed out above, with regards to the subsurface character of archaeological sites on the Swan Coastal Plain, very few sites with stratified archaeological deposit have been identified and those are stratified are primarily located within the Swan River alluvial zone. No stratified open sites have been located within the Bassendean Sands (Bowdler et al., 1991). Bowdler et al. highlight the impact of the nature of the Bassendean Sands on the integrity of sites, stating that because the Bassendean Sands dune system consisted of a stable core with a superficial mobile layer of continually reworking sands, artefacts which may have been deposited over a long period of time will have become mixed on one level due to continual deflation and reworking (see also Anderson, 1983). In addition, Bowdler et al. argue that the impacts of European farming practices have further served to disturb any site integrity. Despite this, there is evidence to suggest that there is potential for subsurface artefactual material to be present in both open sites and areas with no archaeological surface expression within the Bassendean Sands (see Anderson, 1983, Thomson and Neuweger, 2014 for example).

Stone tool technologies

Few stone tool technology analyses have been conducted on artefacts from the Swan Coastal Plain (Schwede, 1990, Pearce, 1979, Bird, 1985). Bird (1985) has highlighted that the predominant use of quartz for the manufacture of artefacts on the Swan Coastal Plain, and it's particular fracturing properties, have led to some significant differences in the artefact assemblage composition and technological processes to those manufactured in other regions from rocks such as chert. Specifically, Bird notes that as the available pieces of quartz are generally small in size, methods to flake it are constrained and necessitate the use of anvils and bipolar flaking techniques. The irregularities of quartz's internal structure also means that very large quantities of debris and debitage can be produced during the flaking process and much of this debris does not exhibit evidence of conchoidal fracture, but rather lots of small angular pieces (Bird, 1985). This can have some significant implications for artefact identification and assemblage analysis.

Pearce (1979) examined the distribution of small tools within Western Australia, specifically backed tools, flat adzes and micro scrapers. Pearce (1979: 171) commented that in morphological terms, tools from the south-western region of Western Australia are on average small in size, have mainly squat asymmetric shapes and are usually made of quartz. Pearce found that backed tools occur less

frequently in Western Australia than in eastern Australia and proposes a later development of this tool technology in the west. He argues that the backed tool tradition was introduced into Western Australia by 4,000 BP probably somewhere along the eastern border of the State and reached the western coast by about 3,200 BP then disappearing out of dated sequences several hundred years before European contact (Pearce, 1979: 169). Pearce (1979: 173) also suggests a possible trend towards smaller sizes of backed tools in upper layers of excavated sites. With regards to flat adzes, Pearce proposes that the section of the Darling Scarp around Bullsbrook and Walyunga may have been a 'centre of popularity for the flat adze industry' after being introduced around 3,200–4,600 BP and utilised until after European contact (Pearce, 1979: 170).

Schwede's (1990) PhD research focused on comparing assemblages from both dated and undated artefact scatter sites from the Swan Coastal Plain. This research identified a number of changes in quartz manufacturing technologies over time including statistically significant differences in artefact size, shape and platform between assemblages from the Late phase (0–3000 BP) and those from 3000 BP to 40,000 BP. Schwede also observed the appearance of backed artefacts and an increase in edge damage or rejuvenation flakes after 4600 BP. Such changes are attributed by Schwede to a reorganisation of stone working technology during the mid-Holocene associated with the introduction of backed artefact technology.

Social organisation

The aim of Hallam's (1986) study was to relate population to resources by mapping demographic patterns across different ecological zones and sub-zones for successive phases of Aboriginal occupation of the Swan Coastal Plain and its immediate hinterland (Anderson 1984:1). Hallam combined ethnographic data with archaeological survey and excavated data in order to adopt a social rather than exclusively and mechanistically environmental approach to changing Aboriginal adaptations and life patterns (Strawbridge, 1987:11). The conclusions from Hallam's SAAS study indicated that the Swan Coastal Plain with its lakes and swamps, along with the alluvial zone with similar wetlands and rich alluvial soils, attracted the heaviest use and exploitation over time. However, Hallam argues that at all periods the seaward margin failed to show significant usage, and although detail shifts between phases, the general picture of densities being highest near the scarp and lowest towards the sea holds throughout (Hallam, 1987:23).

Anderson (1984) refined Hallam's model and proposed a land-use model that 'delineates a flexible but structured usage of the resources of the Swan Coastal Plain, the central and northern jarrah forest, and the western plateau area, and which allows for the movement between areas required by social and ritual activities' (Anderson, 1984:37). Anderson (1984:34) interpreted the distribution of site types and sizes in the three environmental zones as reflecting actual resources available to Aboriginal people in those respective environments, the period of the year when they were obtainable, and the more intangible facets of the Aboriginal life way, which laid such stress on social and ritual activities. The Swan Coastal Plain had food resources to sustain a relatively large population for most of the year, which would explain the existence of the major sites found on the plain (Anderson, 1984:35).

Anderson's model proposed that during summer and autumn, Aboriginal groups gathered on the coastal plain around estuaries, wetlands, swamps and other water sources in order to exploit their resources. Hence, the major sites on the Swan Coastal Plain were generated as a result of annual visits to the area. During winter and spring, groups would disperse into the forest and plateau areas

in order to relieve pressure on the water-based resources. The relatively small size of sites within those two areas is seen as reflecting high group mobility necessitated by less predictable resources and pursuit of game animals. During spring groups gradually moved back to the coastal areas (Anderson, 1984; Edwards, 2008).

In a critique of Anderson's model, Schwede (1990) suggests that the Jarrah forest was used by both coastal and plateau groups primarily as sources for stone and food year round, as well as the river valleys of the Canning and Helena Rivers being used as direct travel routes for social, ceremonial or trade purposes. Schwede (1990) proposes that rather than camping in the Jarrah forests during the winter months, the forest was utilised from base camps on the coastal plain during this time.

2.3.2 Previous archaeological studies within the project area

The Department of Aboriginal Affair's (DAA) Aboriginal Heritage Information System (AHIS) indicates that there have been eight previous archaeological surveys undertaken within approximately 5 km of the current project area:

- Quartermaine Consultants (Quartermaine, 1986) – Dampier to Perth gap pipeline: Carnarvon gas pipeline lateral.
- Quartermaine Consultants (O'Connor and Quartermaine, 1989) – Byford-Collie and Ongerup-Jerramungup sections of the Perth to Adelaide optic fibre route. Involved vehicle transects with pedestrian spot checks at regular intervals and at all watercourses along two corridors approximately 140 km and 70 km in length by 100 m wide. Three new sites were located.
- Quartermaine Consultants (Quartermaine and Heine, 1996) – road works at Mundijong Road.
- Blockley and Greenfeld (1995) – South-East corridor structure plan. Archaeological survey of a 20 km long by 100 m wide corridor from Ranford Road in Armadale to Mundijong Road, plus 2263 hectares around Byford and Mundijong town sites. Included vehicle transects along existing roads and tracks and pedestrian inspection of all elevated areas, rivers and other prominent features. Located six previously recorded and four new sites, all artefact scatters. All archaeological material was located on deflated or disturbed sand dunes including isolated artefacts.
- Blockley et al. (1996) – South-East corridor structure plan, revised report. Re-examined the survey corridor previously surveyed by Blockley and Greenfeld (1995) in further detail. Located seven new sites, all artefact scatters.
- McDonald Hales and Associates (Prince et al., 1996) – Byford village, Byford. Located nineteen archaeological sites, all artefact scatters. Sites primarily located on elevated sand rises, dunes or exposed areas.
- McDonald Hales and Associates (Burke et al., 1998) – Byford village, Byford.
- McDonald Hales and Associates (Edwards and McDonald, 1999) – Proposed Tonkin Highway extension and Mundijong Road realignment project. Comprised pedestrian transects walked in a zigzag pattern along the length of the corridor, spaced at 10-20m apart, with additional purposive investigation of areas with higher ground surface visibility. Estimated 30% of survey area investigated in total, with poor ground surface visibility (<30%). Sixteen new artefact scatters, seven previously recorded sites and 11 isolated artefacts were located. Edwards and McDonald conclude that the locations of sites conform to Anderson's

predictions regarding site location and composition, that is, larger more complex stone artefact scatters are located in well drained and relatively elevated topographic positions, often in close proximity to wetlands or other drainage features. The isolated artefacts were found mainly in disturbed areas.

Whilst not all surveys conducted comprised systematic pedestrian surveys, collectively the results of the surveys all point to some strong site location spatial patterning within the local region, namely that archaeological sites, in particular artefact scatters, are most likely to be located on or within elevated sand rises, hills or dunes, and within approximately 300 m of a water source.

2.4 Previously reported Aboriginal Sites

A search of the DAA's AHIS was undertaken on 6 March 2012 to confirm the number and nature of any previously located Aboriginal Sites within a 5 km radius of the survey area. The search boundary was defined by a box with the following diagonally opposite corner points (GDA94, MGA Zone 50):

1. 397460 mE 6434378 mN
2. 409908 mE 6421013 mN

The search identified that 58 sites, including 29 Registered Aboriginal Sites[4] and 29 Other Heritage Places[5] are located within a 5 km radius of the project area (see Appendix 3 and Tables 2 and 3)[6].

According to the AHIS search results two Registered Aboriginal Sites are located within the current project area. DAA Id 450 South-East Corridor 03, an artefact scatter, is located within Lot 37 Bishop Road and DAA Id 3648 Soldiers Road Mundijong, an artefact scatter with archaeological deposit, is located in Lot 9000 Bishop Road Mundijong.

2.4.1 DAA Id 450 South-East Corridor 03

Registered Aboriginal Site DAA Id 450 is listed on the AHIS as comprising artefacts/scatter with a reliable location. The site was originally recorded by Blockley & Greenfeld (1995, 1996) and is described as an extensive stone artefact scatter situated on an elevated dune that is significantly eroded on its northern and southern sides. The site is located immediately south of Bishop Road, Mundijong and to the north of Manjedal Brook. The site measures approximately 100 by 150 metres and the majority of artefactual material was found on the northern flank of the dune.

The artefact density was highly variable and ranged from 20/sq m in places to 85/sq m in others. Stone artefacts were made from a wide variety of materials, including quartz, limestone, chert and silcrete, but a large proportion of these were considered to be waste flakes. A minor proportion of the artefact assemblage was comprised of cores, core fragments, retouched/utilised pieces and five possible grindstones (mullers).

[4] Sites that have been assessed by the Aboriginal Cultural Material Committee (ACMC) and placed on the Register of Aboriginal Sites.

[5] Includes sites that have been lodged for assessment, sites that are awaiting an ACMC determination, sites with insufficient information provided to be assessed and places determined not to be sites by the ACMC.

[6] An additional AHIS search was undertaken on 7 May 2013 to confirm the previous results. Other Heritage Place DIA Id 24985 was included in the list of other heritage places on 6 March 2012 but was absent from the list on 7 May 2013. It is assumed that this site may have had a boundary location adjustment during that time.

McDonald Hales and Associates reinspected the site in September 1998 (Edwards and McDonald, 1999). They noted that the site generally conforms to the description provide by Blockley et al. (1996), however, a range of non-Aboriginal historic cultural material was also observed at the site. Edwards and McDonald commented that

> Owing to the disturbance that has occurred to the site, it is difficult to determine whether this material reflects continued Aboriginal camping at this location, or ad hoc rubbish disposal (although the age of the material would argue against this interpretation)... Given the density of material recorded to date, there is a high potential for additional archaeological material to be present across the undisturbed portion of the surrounding dune ridge. This will need to be confirmed by future archaeological investigation. (Edwards and McDonald, 1999: 25)

The site was visited during the current survey on 1 April 2012. The location of the site was confirmed to be in the correct location as listed on the AHIS and is located within Peets landholdings at Lot 37 Bishop Road. The site was in a similar condition to that described by Edwards and McDonald (1999). Peet has subsequently advised that as DAA Id 450 is located within the Tonkin Highway extension reserve corridor; this site will not be impacted by the proposed residential development. Further archaeological investigations were therefore not undertaken at this site.

2.4.2 DAA Id 3648 Soldiers Road Mundijong

DAA Id 3648 was first recorded by Hallam in 1975. It is described as being located in a paddock between two small lakes, adjacent to the road with a winter creek to the south. At that time, the site comprised of white sandy soil that had been cleared for farming, and disturbed by ditch digging and cattle. Hallam estimates that the site contains approximately 30,000 artefacts, of which 95% are made from quartz and the remaining 5% were manufactured from fossiliferous chert, mylonite, granite and other metamorphic rocks, most likely brought down the scarp from the Darling Plateau. Artefacts were located over an area measuring 50 x 30 metres.

Pearce (1979) undertook subsequent investigations at the site in 1975 as part of a Masters dissertation through the University of Western Australia. Pearce describes the site as being located on a low sand bank lying between two small lakes, one and half kilometres north of Mundijong and on the west side of Soldier's Road. Pearce also noted that large trees, one of which had an oval scar, lined the banks of a small creek [Manjedal Brook] that flowed on the southern flank of the site, which was situated on a farming property. The modified tree is not currently listed as a 'site type' or feature in the AHIS listing for this site.

Pearce collected a total of 3133 surface artefacts from six 5 x 5 m sample squares. He commented that artefacts were densest in an eroded gully and on the side of a channel that had been dug to connect the two small lakes. Pearce also excavated a stepped 1 x 1 m trench, to a depth of 75 cm, from which he recovered a further 1781 artefacts. The artefacts were mainly comprised of quartz debris measuring less than 15 mm long. Eleven backed tools were found in the lower half of the trench. The density of artefacts was not uniform in the deposit with two peaks at 20 cm and 60 cm depth. Pearce attributed this to two potential reasons including changes in density of occupation or changes in the rates of erosion and accumulation of sand. Ochre was also located in the trench and one charcoal sample from the 10–20 cm spit returned a date of 1620 ±105 BP (SUA 646). An inspection of the collected artefacts at the WA Museum found that charcoal was also collected from 60-70 cm spit, which was not dated by Pearce.

Table 2. Registered Aboriginal Sites with archaeological components within 5 km radius of the project area

Site Id	Site Name	Site type	Dimensions	Site size (sq m)	distance to water (m)	Topographic unit	Physiographic unit	Site integrity	Artefact density (per sq m)	Assemblage character
396	South-East Corridor 07 / Cardup Siding	Artefact scatter	240 x 65m	15600	180	Low sand dune ridge	Bassendean sands overlying Guildford formation	-	-	-
448	South-East Corridor 01	Artefact scatter	100 x 60m	600	700	Eroded dune ridge	Bassendean sands	-	13	Artefacts = flake (n= 7), flake fragment (n=3), core fragment (n=1), transverse broken flake (n=1), backed blade (n=1) Lithologies = quartz (n=8), fine grained sedimentary material (n=5) also noted at site metamorphic, silcrete, glass
449	South-East Corridor 02	Artefact scatter	15 x 5m	75	430	Low sand dune	Bassendean sands	Disturbed	7	Artefacts = flake (n=3), core fragment (n=3), transverse broken flake (n=1) Lithologies = quartz (n=7)
450	South-East Corridor 03	Artefact scatter	100 x 150m	20670	420	White sand dune	Bassendean Sands	Partially disturbed	20-85	Artefacts = flake (n=4), core fragment (n=1), Transverse broken flake (n=6), longitudinal broken flake (n=5), cores (n=2), grinding implement (n=1) Lithologies = quartz (n=13), fine grained sedimentary material (n=4), Quartzite (n=1), medium grained sedimentary material (n=1)
3648	Soldiers Road, Mundijong	Artefact scatter Archaeological deposit	50 x 30m	1500	0	White sand dune	Bassendean Sands	Partially disturbed	20.8	Artefacts = wide variety of cores, scrapers, bipolar flakes, bipolar cores, flakes and debris Lithologies = quartz, metamorphic, fossiliferous chert, mylonite
16089	Byford 01	Artefact scatter	2 x 5m	10	450	Sandy exposure	Bassendean sands	Partially disturbed	0.8	Artefacts = 8 artefacts Lithologies = quartz (n=5), glass (n=3)
16090	Byford 02	Artefact scatter	3 x 5m	15	570	Sandy exposure	Bassendean sands	Partially disturbed	0.27	Artefacts = 4 artefact Lithologies = quartz (n=4)

Site Id	Site Name	Site type	Dimensions	Site size (sq m)	distance to water (m)	Topographic unit	Physiographic unit	Site integrity	Artefact density (per sq m)	Assemblage character
16091	Byford 03	Artefact scatter	2 x 2.5m	5	500	Sandy exposure	Bassendean sands	Partially disturbed	1.4	Artefacts = 15 artefacts Lithologies = quartz (n=15)
16092	Byford 04	Artefact scatter	1 x 2m	2	450	Sandy exposure	Bassendean sands	Partially disturbed	2	Artefacts = 4 artefacts Lithologies = quartz (n=2), glass (n=2)
16093	Byford 05	Artefact scatter	3 x 5m	15	460	Sand dune deflation	Bassendean sands	Partially disturbed	1.8	Artefact = 27 artefacts Lithologies = chert (n=1), quartz (n=26)
16094	Byford 06	Artefact scatter	-	-	590	Sandy exposure	Bassendean sands	Disturbed	-	Artefacts = hammer stone (n=1), flaked pieces (n=6) Lithologies = granite (n=1), quartz (n=6)
16095	Byford 07	Artefact scatter	2 x 2.5m	5	550	Sandy exposure	Bassendean sands	Disturbed	2	Artefacts = 10 artefacts Lithologies = quartz (n=9), silcrete (n=1)
16096	Byford 08	Artefact scatter	200 x 50m	10000	300	Sandy exposure	Bassendean sands	-	0.4	Artefacts = 66 artefacts Lithologies = quartz (n=62), riverine quartz (n=1), chert (n=1), dolerite (n=1), basalt (n=1)
16097	Byford 09	Artefact scatter Shell	-	-	690	Sandy exposure	-	-	-	1 piece of abalone shell and 8 quartz artefacts
16098	Byford 10	Artefact scatter/ reduction area	1 x 2m	2	500	Gravel exposure	-	-	5	10 dolerite flaked pieces. Non-conjoins
16099	Byford 11	Artefact scatter	1 x 2m	2	640	Gravel exposure	-	-	1.5	3 quartz artefacts
16100	Byford 12	Artefact scatter	4 x 10m	40	250	Sandy exposure	Bassendean sands	-	0.075	**Duplicate of DAA Id 22056 3 quartz artefacts
16101	Byford 13	Artefact scatter	-	-	100	Sandy firebreak	Bassendean sands	Partially disturbed	-	**Duplicate of DAA Id 22057 13 quartz artefacts
16102	Byford 14	Artefact scatter	-	-	15	-	-	-	9	Artefacts = flaked pieces (n=8), hammer stone (n=1) Lithologies = quartz (n=1), riverine quart pebble (n=1)

Site Id	Site Name	Site type	Dimensions	Site size (sq m)	distance to water (m)	Topographic unit	Physiographic unit	Site integrity	Artefact density (per sq m)	Assemblage character
16103	Byford 15	Artefact scatter	-	-	-	Escarpment above tributary	-	-	-	13 artefact recorded
16104	Byford 16	Artefact scatter	-	-	-	Sandy exposure	Bassendean sands	Disturbed	-	Artefacts = hammer stone (n=1), undescribed (n=1) Lithologies = riverine quartz pebble (n=1), quartz (n=11)
16105	Byford 17	Artefact scatter	-	-	-	White sandy deposit	Bassendean sands	-	-	19 quartz artefacts
16106	Byford 18	Artefact scatter	-	-	-	Sandy patch	Bassendean sands	-	-	17 artefacts recorded
16107	Byford 19	Artefact scatter	1 x 2m	2	-	Sandy surface	Bassendean sands	-	5	Artefacts = quartz (n=8), mylonite (n=1), crystal quartz (n=1) No indication of artefact types or size
18187	Tonkin Highway – Mundijong Road Scatter #11	Artefact scatter	-	-	270	Low sandy rise	Bassendean sands overlying Guildford formation	Disturbed	0.02	Artefacts = Debitage (n=16) Artefact size = maximum dimensions rang 6.4 – 23.3mm, mean = 14.6 Lithologies = all artefacts made from quartz
18188	Tonkin Highway – Mundijong Road Scatter #12	Artefact scatter	50 x 40m	200	100	North face of low sand dune ridge	Bassendean sands overlying Guildford formation	Partially disturbed	0.12	Artefacts = debitage (n=23), core fragment (n=1) Size = mean maximum dimension 16.8mm Lithologies = quartz (n=23), mylonite (n=1)
18191	Tonkin Highway – Mundijong Road Scatter #15	Artefact scatter	-	-	40	-	Unidentified loamy sediment unit	Partially disturbed	0.2	Artefacts = total of 8 Lithologies = chert (n=3), quartz (n=3), chalcedony (n=1), silcrete (n=1)
23917	Byford archaeological survey 004	Artefact scatter	20 x 15m	300	110	Low sandy rise	Bassendean sands overlying Guildford formation	Disturbed	0.9	Artefacts = debris (n=23), flake fragments (n=12), complete flakes (n=5), broken flakes (n=3), bipolar flake (n=1), bipolar core (n=1), manuport (n=1) Lithologies = quartz (n=43), rose quartz (n=1), greenstone (n=1), igneous (n=1)

Table 3. Details of Other Heritage Places with archaeological components located within 5 km of the project area

Site Id	Site Name	Register status	Site type	Dimensions	Site size (sq m)	distance to water (m)	Topographic unit	Physiographic unit	Site integrity	Artefact density (per sq m)	Assemblage character
3310	Cardup	Stored	Artefact scatter	-	-	-	-	-	-	-	-
3313	Mundijong	Insufficient information	Artefact scatter	-	-	-	-	-	-	-	-
3590	Whitby	Insufficient information	Artefact scatter	30 x 10m	300	100	Sandy-clay exposure on road verge	-	Disturbed	-	Numerous stone flakes mainly quartz
3591	Yarrabah	Insufficient information	Artefact scatter	40 x 40m	1600	850	Sandy-clay exposure on road verge	-	Disturbed	-	Numerous stone pieces including quartz flakes and retouched scrapers as well as quartz and mylonite backed tools.
17923	If #2	Stored	Isolated artefacts	-	-	-	-	-	-	-	-
18189	Tonkin Highway – Mundijong Road Scatter #13	Stored	Artefact scatter	30 x 20m	600	410	Low sandy rise	Bassendean Sands	-	0.23	No detailed artefact information given
18190	Tonkin Highway – Mundijong Road Scatter #14	Stored	Artefact scatter	Not given	2	1100	Not given	Not given	Disturbed	1.0	Four artefacts recorded, not likely in original context

Site Id	Site Name	Register status	Site type	Dimensions	Site size (sq m)	distance to water (m)	Topographic unit	Physiographic unit	Site integrity	Artefact density (per sq m)	Assemblage character
18192	Tonkin Highway – Mundijong Road Scatter #16	Stored	Artefact scatter	100 x 2m	200	170	Not given	Bassendean sands	Disturbed	0.03	No details
21305	Byford village isolated finds	Stored	Isolated artefacts	-	-	-	-	-	-	-	-
23914	Byford archaeological survey 001	Stored	Artefact scatter Modified tree	33 x 19m	625	80	Low sandy rise	Bassendean sands overlying Guildford formation	Partially disturbed	0.25-1.25, average = 0.05	Artefacts = debris (n=17), complete flakes (n=6), flake fragments (n=6), broken flakes (n=3), possible manuports (n=2) Small in size, ranging between 6.4mm – 29mm (mean = 13.1m) All artefacts made from quartz Artefacts clustered around erosion areas. Modified tree = Marri (?) tree with two scars, had been felled.
23915	Byford archaeological survey 002	Stored	Artefact scatter	6 x 12m	12	20	Sandy exposure/lens	?Pinjarra Plain colluviums	Partially disturbed by stock movement	0.5	Artefacts = Debris (n=3), complete flakes (n=2), bipolar broken flake (n=1) Artefact size = maximum dimension range 5.2-21.3mm, mean size is 11.6mm All artefacts manufactured from quartz
23916	Byford archaeological survey 003	Stored	Artefact scatter	20 x 12m	240	115	Low sandy rise	Bassendean sands overlying Guildford formation	Disturbed	0.1	Artefacts = debris (n=7), complete flakes (n=3), flake fragments (n=2), bipolar flakes (n=1), SPC (n=1) Size = maximum dimension range 7.6-41.3mm, mean = 16.9mm Lithology = all artefact manufactured from quartz

Site Id	Site Name	Register status	Site type	Dimensions	Site size (sq m)	distance to water (m)	Topographic unit	Physiographic unit	Site integrity	Artefact density (per sq m)	Assemblage character
23918	Byford archaeological survey 005	Stored	Artefact scatter	36 x 12m	436	90	Low sandy rise	Bassendean sands overlying Guildford formation	Partially disturbed	0.05	Artefacts = debris (n=10), flake fragments (n=6), bipolar flakes (n=4), bipolar core (n=1), manuport (n=1) Artefact size = maximum dimension range 5 – 25.5mm, mean = 14.6mm Lithologies = all artefacts manufactured from quartz
23919	Byford archaeological survey 006	Insufficient information	Artefact scatter	80 x 3m	240	140	Low sandy rise	Bassendean sands overlying Guildford formation	Partially disturbed	0.125	30 quartz flaked stone artefacts
23920	BAS / Iso - 001	Stored	Isolated artefacts	-	-	-	-	-	-	-	-
23921	BAS / Iso – 002	Stored	Isolated artefacts	-	-	-	-	-	-	-	-
23922	BAS / Iso - 003	Stored	Isolated artefacts	-	-	-	-	-	-	-	-
23923	BAS / Iso - 004	Stored	Isolated artefacts	-	-	-	-	-	-	-	-
23924	BAS / Iso - 005	Stored	Isolated artefacts	-	-	-	-	-	-	-	-
23925	BAS / Iso - 006	Stored	Isolated artefacts	-	-	-	-	-	-	-	-
24979	Nettleton Road 19-09-07/001	Stored	Artefact scatter	3 x 1.5m	4.5	10	Gravel and sand exposure	Bassendean sands overlying Guildford formation	-	0.88	Artefacts = flake fragments (n=2), complete flakes (n=1), debris (n=1) Lithologies = greenstone (n=2), quart (n=2)
24980	Nettleton Road 19-09-07/002	Stored	Artefact scatter	4 x 1m	4	123	Sandy firebreak	-	Partial disturbance	0.75	Artefacts = flakes (n=1), flake fragments (n=1), debris (n=1) Lithologies = quartz (n=3)

Site Id	Site Name	Register status	Site type	Dimensions	Site size (sq m)	distance to water (m)	Topographic unit	Physiographic unit	Site integrity	Artefact density (per sq m)	Assemblage character
24981	Nettleton Road 19-09-07/003	Stored	Artefact scatter	18 x 9m	162	150	Deflated dunes	Bassendean sands overlying Guildford formation	Partial disturbance	0.07	Artefacts = flakes (n=1), broken bipolar flakes (n=1), flake fragment (n=1), debris (n=1) Lithologies = quartz (n=4)
24982	Nettleton Road Isolated Finds	Stored	Isolated artefacts	-	-	-	-	-	-	-	-
24983	Nettleton Road 1-06	Stored	Artefact scatter	35 x 5m	175	147	Deflation area within dunes	Bassendean sands overlying Guildford formation	-	0.03	Artefacts = flakes (n=4), manuport (n=1) Lithologies = quartz (n=4), igneous (n=1)
24984	Nettleton Road 2-06	Stored	Artefact scatter	30 x 9m	270	342	Sandy exposure	Bassendean sands	Disturbed	0.06	17 flaked quartz stone artefacts
24985	Nettleton Road 3-06	Stored	Artefact scatter	13 x 10m	130	490	Sandy exposure	Bassendean sands	Disturbed	0.06	8 quartz flaked stone artefacts

The DAA AHIS location for this site appears to be in the wrong location, as it depicts the site as being located to the south of Manjedal Brook, centred on the coordinate 404710 mE, 6428248 mN. This location was surveyed by systematic pedestrian transects and no artefactual material was located. However, the area to the **north** of Manjedal Brook, as defined by the grid references above, matches previous site descriptions by Hallam (1975) and Pearce (1979) contained in the DAA site file, in terms of both site location and site content.

2.4.3 Archaeological site characterisation

Of the 29 Registered Aboriginal Sites and 29 Other Heritage Places located within a 5 km radius of the project area, 57 have archaeological components. Utilising the limited available information for these sites the following characterisation of archaeological sites within the local region was made.

The most common type of archaeological site feature in the local region is 'artefacts / scatter', see Figure 4. Single occurrences of a reduction area, archaeological deposit, shell and a modified tree have also been recorded within the search area.

Artefact scatters are predominantly low in density (less than 0.1/m^2) and small in size (less than 7500 sq m), see Figure 5. Artefact scatter assemblages are typically dominated by quartz[7] but often include lesser amounts of other materials such as fossiliferous chert, dolerite, basalt, crystal quartz, quartzite, mylonite, silcrete, granite and glass. The majority of scatters recorded comprise debitage including flakes, chips[8], flaked pieces, cores and manuports, with bipolar flaking noted at multiple locations. Very low numbers of retouched flakes and formal tools have been reported within the local region, with backed blades and tools having been reported at three sites including DAA Id 448 South-East Corridor 01, DAA Id 3591 Yarrabah and DAA Id 3648 Soldier's Road Mundijong.

No sites within the search area, apart from DAA Id 3648 Soldier's Road Mundijong, have been reported as having archaeological deposit. From the scarcity of information it is difficult to characterise the subsurface components of archaeological sites within the local region.

Site file information on archaeological sites within the local region indicate that over half the sites have been subject to some form of disturbance associated with European land clearance and landscape modification including farming and agricultural activities, mineral exploration, infrastructure and urban housing developments, see Figure 7.

[7] Assemblages are typically over 90% quartz artefacts with less than 10% other lithologies.

[8] Chips are classified by Hallam as flakes less than 1.5 cm in size.

Figure 4. Types of features commonly contained within archaeological sites within 5 km of the project area

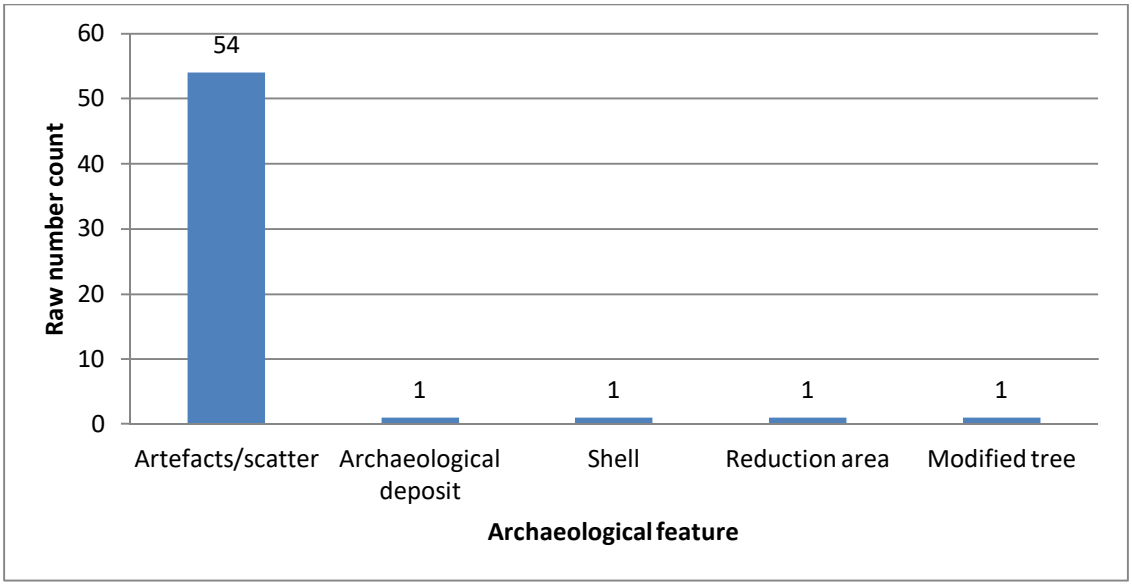


Figure 5. Local region artefact scatter sizes

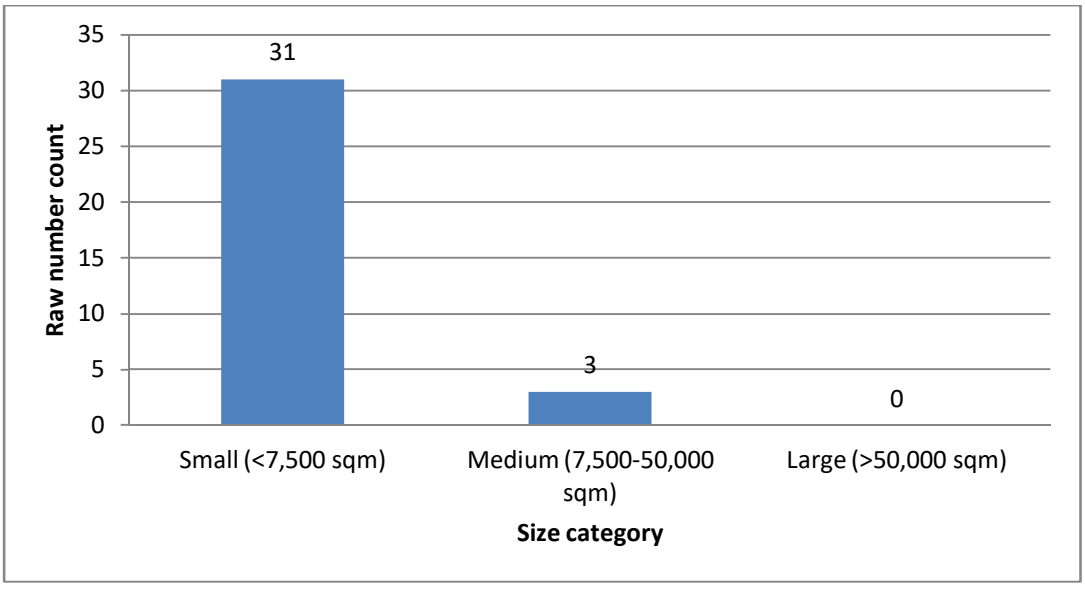


Figure 6. Geomorphologic location of archaeological site features within the local region

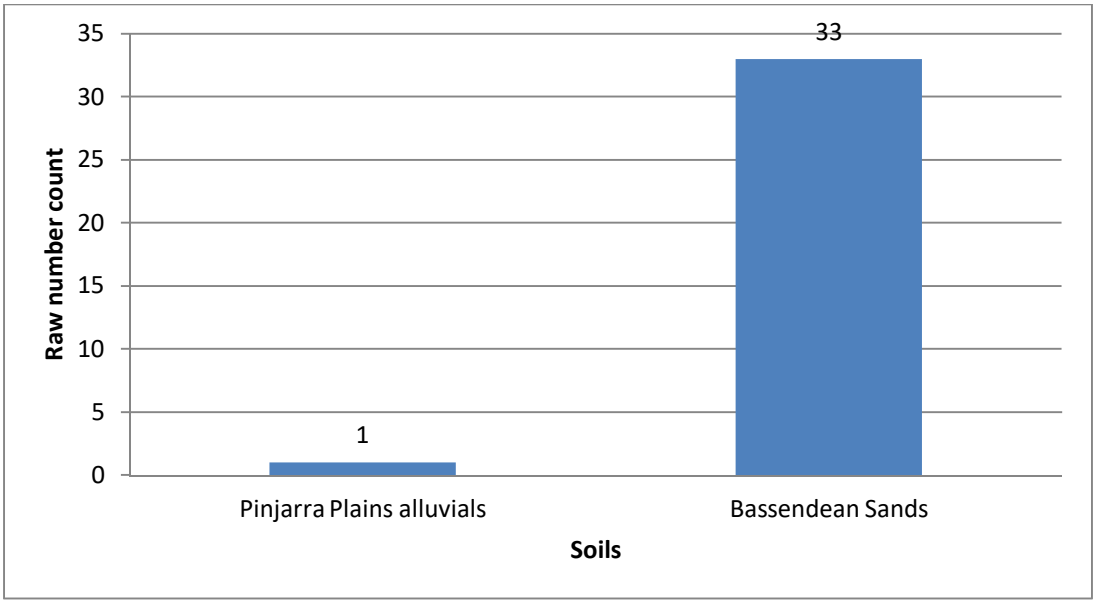
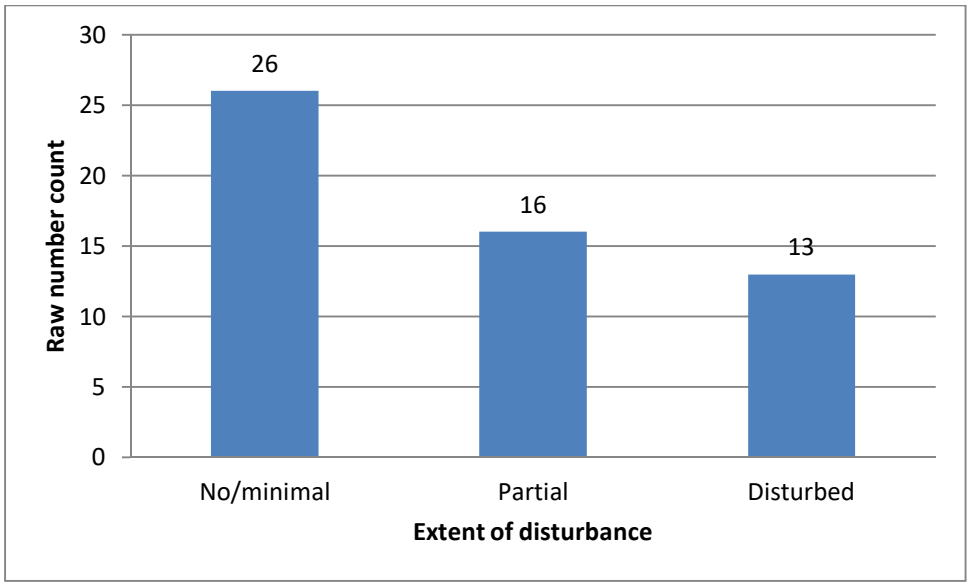


Figure 7. Extent of disturbance to sites within local region



2.4.4 Archaeological site distribution

Site distribution within the local region exhibits strong spatial patterning. The Pinjarra Plains geomorphic unit has generally been considered in conjunction with the Bassendean Sands and, as Hallam identifies, is commonly assumed to contain a significant proportion of the Swan Coastal Plain's archaeological sites. Three recent studies on the Pinjarra Plains have identified distinct spatial patterning with regards to the location of archaeological sites.

Tempus Archaeology (2006) conducted an archaeological survey for a proposed residential development at Byford in 2005. The project area was located within Guildford formation sandy clay soils (a unit of the Pinjarra Plain alluvials) which were overlain by a thin veneer of Bassendean Sands.

Tempus (2006: 1) indicated that the vast majority of the project area would have "formed part of a vast seasonal wetland extending between the Foothills to the east and the Bassendean Dunes to the west" prior to colonisation. Similar to the current project area, the Byford survey area had been cleared of the majority of vegetation and used for agricultural purposes. The Tempus survey examined an area of 367 hectares by a combination of intensive systematic pedestrian survey and purposive pedestrian survey. Eight sites were located, all of which were found within either elevated sand dunes or rises, or on lower-lying sand lenses within the sandy clay formations.

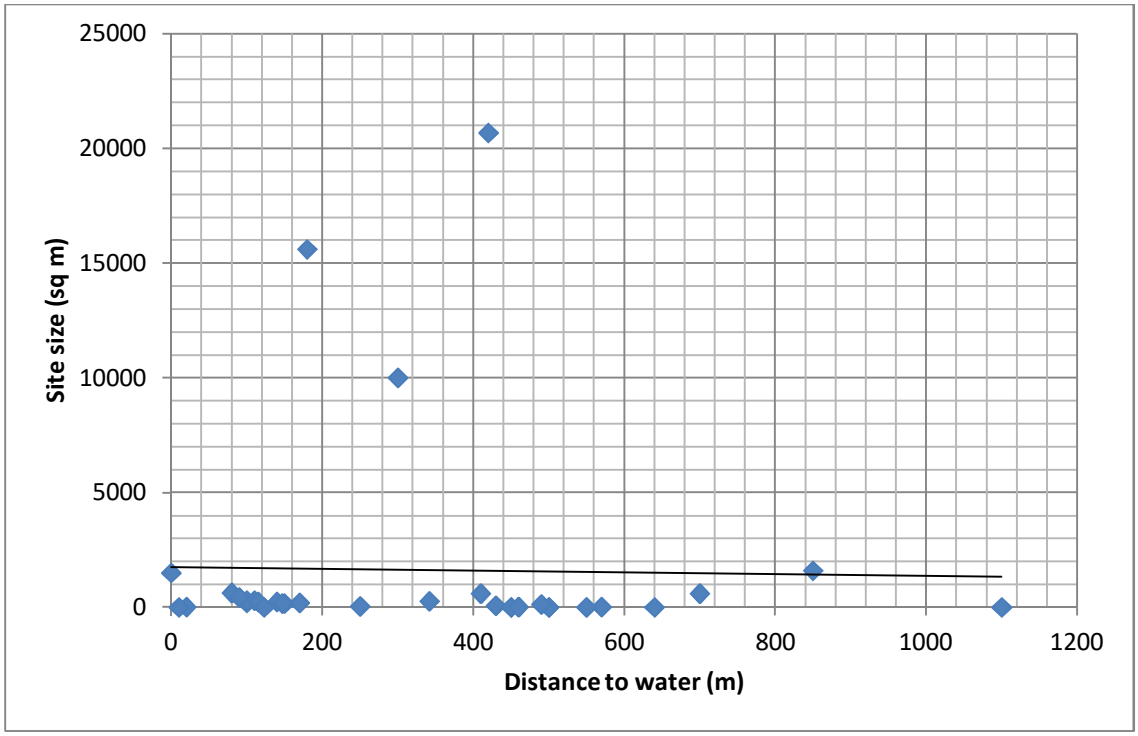
Additional surveys were conducted at Lot 2 Nettleton Road Byford by Tempus Archaeology in 2006 (Edwards, 2007). This survey examined 38 hectares of land which consisted of Bassendean sand dunes and thin lenses of Bassendean sand overlaying Guildford formation plausiplain and alluvials. The survey employed both systematic pedestrian survey transects and additional purposive transects of all fire breaks, tracks and other areas of relatively high ground surface visibility. In total, six archaeological sites were located in the survey area, all of which comprised open flaked stone artefact scatters and all situated on either deflating Bassendean sand dunes or thin lenses of Bassendean sand overlying the alluvial deposits.

Further to this, a survey conducted by Thomson and Neuweger (Thomson, 2011) at Pinjarra, approximately 40 km south of the current project area, provides a specific examination of site distribution within the Pinjarra Plain plausiplains geomorphic system. This survey examined an area of 3.457 sq km (345.7 hectares) which consisted of low-lying wetland subject to seasonal inundation, interspersed with elevated white Bassendean sand rises and remnant dunes. Similar to the current project area, the Pinjarra survey area had been previously used for agricultural purposes. This area was intensively surveyed by systematic pedestrian transects spaced at 20 m apart, with additional purposive examination of all elevated sand rises and dunes. The survey not only confirmed the association of artefact scatters and sites with elevated sand rises and dunes within the Pinjarra Plain plausiplain geomorphic context, but further elucidated that within these sand dunes, surface artefacts were consistently exposed on the tops and eastern slopes of the sand rises and dunes. Very few isolated artefacts were located within the low-lying plausiplain areas. Sites located within this project area have subsequently been excavated by Gavin Jackson Cultural Resource Management and the publication of results was pending at the time of writing this report.

Considering the consistency in results between these studies and also with Strawbridge's GIS-based predictions that sites are mostly likely to be situated on sandy, well-drained dune ridges and unlikely to be situated within in low-lying, poorly drained or seasonally inundated areas, it is more than plausible to hypothesise that within the Pinjarra Plains geomorphic unit, all elevated Bassendean sand dunes, hills and rises overlaying the alluvial plausiplain will have high potential for containing archaeological material, whilst the low-lying plausiplain areas will conversely have low potential for locating any archaeological material.

With regards to distance to water, sites within the local region generally conform to the regional trend of larger sites being located closer to water sources (see Figure 8), however, it should be noted that there are issues with the particular analysis due to variations in classification of water sources and the impacts of historic landscape modifications.

Figure 8. Comparison of site size vs distance to water



2.5 Non-Indigenous heritage

SMEC's (2009:136-137) environmental assessment report reviewed the Register of Heritage Places and Municipal inventory for non-Indigenous historical places. This review indicated that there are no sites listed in the Register of Heritage Places within the study area. Thirteen sites were listed on the Shire of Serpentine-Jarrahdale's municipal heritage inventory, however, none of these sites are located within the project area.

2.6 Summary of desktop findings

In summary, the desktop review found that:

- The western margin of the project area have been the subject of a previous archaeological survey conducted by McDonald Hales and Associates for the South-East corridor structure plan (Blockley and Greenfeld, 1995, Blockley et al., 1996) and proposed Tonkin Highway extension and Mundijong Road realignment project (Edwards and McDonald, 1999).
- Two previously recorded Registered Aboriginal Sites are located within the current project area: DAA Id 450 South-East Corridor 03, an artefact scatter, and DAA Id 3648 Soldiers Road Mundijong, an artefact scatter with archaeological deposit.
- DAA Id 3648 Soldiers Road Mundijong has been the subject of previous archaeological investigations by Pearce (1979). The site is located around two small remnant freshwater lakes and was estimated to contain approximately 30,000 artefacts. Pearce excavated eleven backed tools from the site and found two peaks of artefact concentrations at 20 cm and 60 cm depth. Ochre was also located in the trench and one charcoal sample from the 10–20 cm spit returned a date of 1620 ±105 BP (SUA 646).

- The most common type of archaeological sites in the local region is 'artefacts / scatter'. Single occurrences of a reduction area, archaeological deposit, shell and a modified tree have also been recorded within the search area.
- Regional archaeological research and assessments have indicated that artefact scatters on the Swan Coastal Plain are more commonly small in size, low–medium density, dominated by quartz with some potential for fossiliferous chert, dolerite, granite, silcrete, crystal quartz, quartzite or glass, and comprised predominantly of debitage with very few specialised or 'formal' tool types.
- The spatial distribution of sites in the local region is largely determined by the geomorphic setting, as the majority of sites are located either on Bassendean sands or within lenses of Bassendean sands overlying Pinjarra Plain alluvials. Larger, denser sites are also located close to water sources such as swamps and lakes.

3.0 METHODOLOGY

This section outlines the methodological approach and methods used for both the survey and excavation components of the field work. The methodology and methods presented here have taken into account the nature of the previously recorded and newly recorded archaeological sites, the unique issues relating to each site, current West Australian *Health and Safety Regulations*, as well as previous excavation work undertaken by Pearce in 1975 at Aboriginal Site DAA Id 3648 Soldiers Road Mundijong.

3.1 Research design

A research agenda was developed for the initial field surveys which was subsequently refined as part of the development of the section 16 research plan for the test excavations (Thomson et al., 2012) and related feedback provided by Dr Warren Mitchell, Senior Heritage Officer, Department of Indigenous Affairs.

The following research questions were posed in order to guide field investigations and assessment of archaeological significance. The questions are intended to assist in articulating the archaeological signature of the area including the spatial distribution of sites, site types and activities undertaken within the sites and the local region, the effects of taphonomic and other disturbances on the archaeological record and resource use. The research questions also assisted in the assessment of archaeological significance.

3.1.1 Surface component

The research questions posed for the surface survey were (from Thomson, 2012c):

1. Is the hypothesis that sites are located on elevated Bassendean white sand dunes or rises, and/or adjacent to water sources supportable?
2. Is Thomson's (2011) finding that artefacts within sites located on sandy rises and dunes are predominantly located on the top and eastern slopes correct?
3. Is there an association between dune aspect or erosion surface orientation and artefact types/densities?
4. Is there an association between dune altitude and artefact types and/or densities?
5. What is the variability between sites in terms of artefact type, lithology and size?
6. What activities can be identified at the site?
7. How does the high density of sites within the survey area compare with the regional context?
8. What does the apparent site distribution indicate? To what degree is it skewed by concentrated urban development? (after Strawbridge, 1987)
9. Is the level of reduction of fossiliferous chert greater away from the coast (the predicted source location)?
10. Does the amount of fossiliferous chert within an assemblage decrease or increase with proximity to the coast (i.e. the proposed source), or proximity to other water sources?
11. What is the level and character of variability between sites classified according to Hallam/Schwede's four phases?

3.1.2 Subsurface investigations

The subsurface research questions posed below aimed to determine a number of relevant points in relation to the artefact scatters involved in the proposed testing. The main aim of the subsurface investigations was to determine the full extents of the sites. Due to the nature of the sand dunes in the Swan Coastal Plain it was also of interest to determine whether the proposed areas of high and low archaeological potential, as identified through the predictive model for the surface survey (see below), in fact conform with the landscape as it is currently seen. The research questions were also based on the requirement to better understand the sites identified, prior to determining the nature and method of their future management.

The proposed subsurface research questions were:

12. What is the archaeological significance and nature, and the spatial extent and distribution of the newly recorded sites MJ-01, MJ-02, MJ-03, MJ-04 and MJ-06? Specifically,
    a. Is the surface area of the deflations at the sites an accurate representation of the sites' size and artefact distribution?
    b. Is the artefact types identified on the surface representative of the subsurface artefacts?
    c. Is the lithic raw material identified on the surface representative of the subsurface raw materials identified?
    d. Is the density per metre of surface artefacts representative of the subsurface density?
13. What is the extent of the subsurface deposit at DAA 3648 Soldier's Road Mundijong (MJ-05)?
    a. Is the surface area of the deflations at the site an accurate representation of the site's size and artefact distribution?
    b. Is the artefact types identified on the surface representative of the subsurface artefacts?
    c. Is the lithic raw material identified on the surface representative of the subsurface raw materials identified?
    d. Is the density per metre of surface artefacts representative of the subsurface density?
14. Pearce's (1979) excavations at DAA Id 3648 Soldier's Road Mundijong suggested that two distinct stratigraphic units were present within the study area – an upper layer of 'loose sandy matrix' and a lower layer comprising a 'compact' matrix of sand, that were unique from one another. This issue was not addressed by Pearce and therefore allows for the formulation of the hypothesis that there are two distinct stratigraphic units in the area.
    a. Is this hypothesis correct?
    b. Are there any discernible stratigraphic differences within the sites?
    c. Do all artefact scatters contain the same stratigraphic layers?
    d. If there are no discernible stratigraphic layers is there any evidence of denser layers of artefactual material?
    e. Is there any evidence of taphonomic process sorting or moving the artefacts?
15. How do sites MJ01, MJ-02, MJ-03, MJ-04 and MJ-06 compare with site DAA Id 3648 (MJ-05)?
    a. Does the previously registered site, which has different raw materials in its surface expression, show a significant difference in artefact type and lithic raw material type to the MJ01–MJ06 sites?

b. Is there any indication that there are more complex processes or different activities occurring at the sites with multiple lithic raw materials types?
c. Is there a link between site size/density/complexity, as indicated from the two registered sites which are over 200m by 200m and DAA Id 3648 Soldier's Road Mundijong?

16. Can the comparative analyses of the data from sites MJ-01, MJ-02, MJ-03, MJ-04, MJ-06 and DAA Id 3648 (MJ-05) provide a basis for the development of predictive modelling techniques that allow future heritage consultants working within the local region to *a priori* estimate:
    a. The location of archaeological sites and sites with archaeological deposit?
        i. Is there any artefactual material present in the areas identified as low potential?
        ii. Do the areas identified as moderate or high potential have distinct boundaries?
        iii. Is there any relationship between artefact location and density and the Bassendean Sand Dunes?
    b. The size/area/extent of a site from the quantity and distribution of artefacts present in the deflation zones?
    c. The potential for sub-surface deposits to be present at a site based upon the quantity and distribution of artefacts present in the deflation zones.

The above questions will be able to be answered by the data collected from the testing strategy proposed below.

3.2 Survey methods

Based on the scope of work, results of the desktop review and other previous archaeological surveys within the local region, and taking into consideration the limited timeline and budget allocated to complete the archaeological assessment, the archaeological assessment employed a purposive sampling methodology, which was based on the predictive model developed for the local Pinjarra Plains geomorphic unit, see section 3.2.1 below.

The proposed methodology was submitted to the Department of Indigenous Affairs Heritage and Culture Branch (DAA) for comment in early March 2012. A proposed sampling methodology was provided to the Department of Aboriginal Affairs, Heritage and Culture Branch for comment in early March 2012. A meeting was held with DAA staff Dr Kathryn Przywolnik (Registrar of Aboriginal Sites), Ms Christine Lewis (Manager Heritage South) and Mr Aidan Ash (Senior Heritage Advisor) on 7 March 2012 to discuss the methodology. A subsequent email from Ms Lewis following the meeting (12 March 2012) indicated that DAA regarded the proposed methodology to be 'a reasonable approach to the proposed heritage work and the research questions it raises are considered relevant for section 18 purposes' and suggested that 'it would be beneficial for any section 18 Notice to have information about possible subsurface material in the land area for the application'.

3.2.1 Pinjarra Plains site distribution predictive model

Based upon the results of several archaeological investigations undertaken within the Pinjarra Plains geomorphic unit (outlined in section 2.4.4 above), the following hypothesis was formulated:

- all elevated sand dunes, hills and rises will have high potential for containing archaeological material;

- areas adjacent to semi-permanent and permanent water sources, such as rivers and lakes will have medium to high potential for containing archaeological material; and
- low-lying plausiplain areas will have low potential for locating any archaeological material.

3.2.2 Identifying sample areas for surface survey

The site distribution model was used to guide the selection of survey sample areas within the project area. Aerial photography, environmental and soils maps were also used to select sample areas.

Areas of high archaeological potential were determined to include:

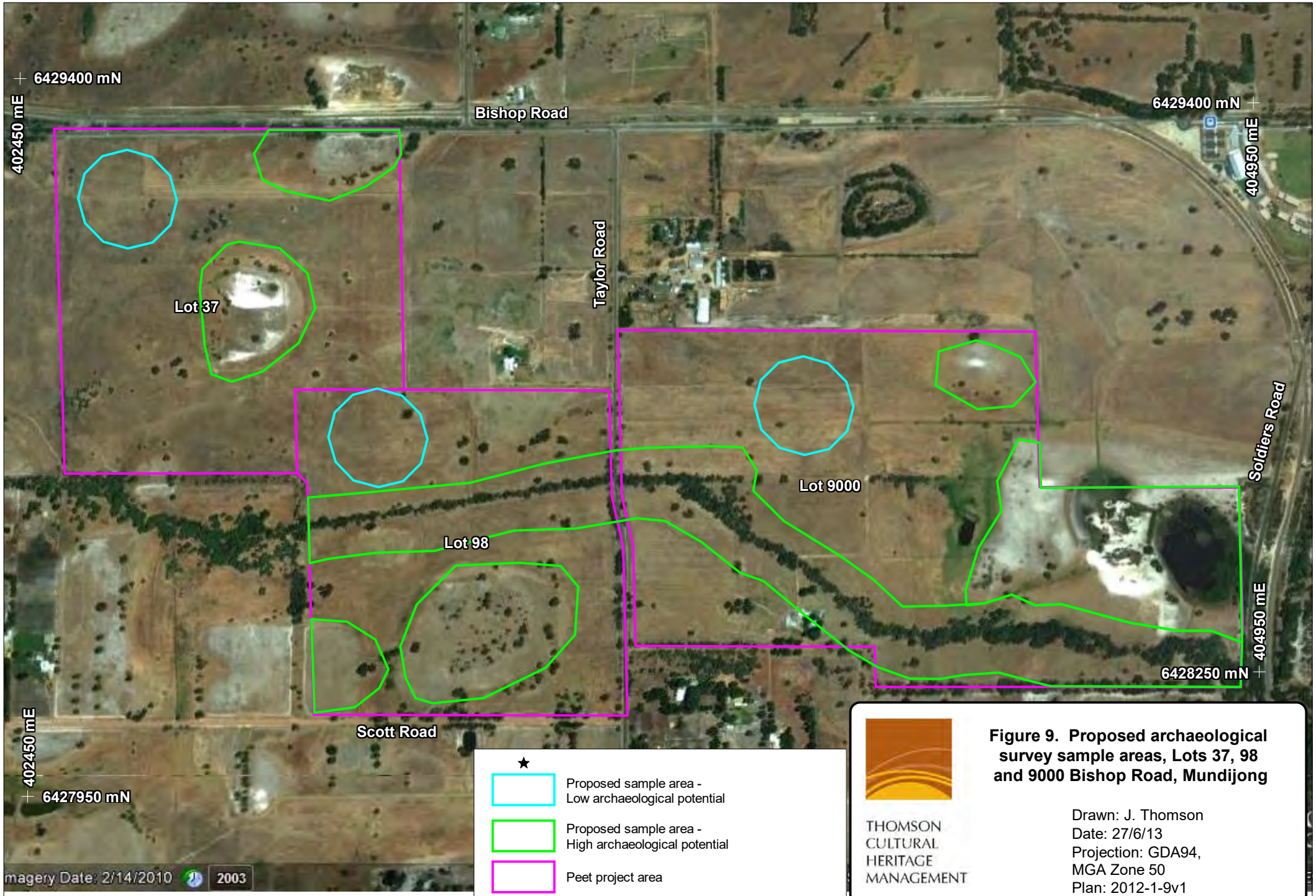
- all elevated sand rises, hills and dunes located within the project area;
- a corridor of approximately 30 m width adjacent to Manjedal Brook; and
- elevated sand rises adjacent to the two lakes located at Lot 9000 Bishop Road.

Areas of low archaeological potential included areas demarcated as plausiplain in Figure 3, above.

All areas identified as having high archaeological potential were selected for survey. In addition, several 100m by 100 m control sample areas within areas of low archaeological potential were also included to in order to avoid sampling bias. It was proposed that approximately 0.72 sq km (45% of the total project area at Lots 37, 97 and 9000 Bishop Road) would be subject to archaeological inspection. Figure 9 shows the locations of sample areas selected for survey.

3.2.3 Surface survey

The archaeological survey of the sample areas of high and low archaeological potential involved intensive pedestrian survey, with parallel transects spaced between 5-10m and oriented either north–south or east–west, depending on the shape and situation of the survey area. Given the nature of the terrain, vegetation and infrastructure such as electric fences, parallel transects were not always achievable. The survey aimed to give comprehensive coverage of the sample areas.



THOMSON CULTURAL HERITAGE MANAGEMENT

Figure 9. Proposed archaeological survey sample areas, Lots 37, 98 and 9000 Bishop Road, Mundijong

Drawn: J. Thomson
Date: 27/6/13
Projection: GDA94, MGA Zone 50
Plan: 2012-1-9v1

3.3 Site identification, recording and analysis methods

The scope of work requires that all sites located during the survey will be recorded to section 18 level, which comprises sufficient detail about each site to aid the DAA and Aboriginal Cultural Materials Committee in the decision making process under sections 5, 6 and 39 of the *Aboriginal Heritage Act 1972*. Specific recording methods and variables are determined by several factors including comparability and the relevance and appropriateness of site and artefact variables recorded to answer or contribute to the research questions identified above.

3.3.1 Site type

From previous research undertaken within the Swan Coastal Plain and local region, the following archaeological site types[9] or features may be expected:

- Artefacts/scatter
- Archaeological deposit
- Modified tree
- Grinding material
- Shell
- Historic
- Skeletal material / burial

See Appendix 5 for full definitions of site types.

Background scatter

In Western Australia, distinctions are often drawn between artefact scatter 'sites' (dense, localised concentrations of archaeological material) and 'isolated artefacts' or 'background scatter' (random, sparse distributions of artefacts present within a landscape). Within the Swan Coastal Plain, the commonly accepted definition of a 'site' is where two or more different artefacts, or different classes of artefacts, are presence within a radius of 5 m of each other. Isolated artefacts are defined as being spatially discrete and are unlikely to reflect any purposeful activity (Edwards, 2008:13).

3.3.2 Site scale

The following definitions will be used during this assessment to classify artefact scatter sites.

Site size

- Small: sites that measure less than 7,500 sq m
- Medium: sites that measure between 7,500 sq m and 50,000 sq m
- Large: sites that measure >50,000 sq m

Artefact density

- Low: <0.1/m^2
- Medium: 0.1 – 1/m^2
- High: >1/m^2

Raw material diversity

- Low: >90% of one raw material

[9] Based on DAA's site type classification within the AHIS.

- Medium: two raw material types >10% each
- High: three or more raw material types >10% each

3.3.3 Section 18 level site recording

The scope of work required that any archaeological sites located be recorded to section 18 level. This entails recording sufficient information about each site to:

a) allow DAA to assess whether the place constitutes a site under section 5 or an object under section 6 of the AHA;
b) identify the location and extent of the site, including its subsurface extent where applicable;
c) identify the key features and site components;
d) present a detailed characterisation of the site's artefactual assemblage; and
e) assess the current archaeological significance of the site.

Specifically, the following information was to be recorded, in line with the standards outlined in the DAA's *Draft Guidelines for Aboriginal Heritage Assessment in Western Australia* and *Draft Spatial Standards*, and the research design outlined above:

- location and boundary of the site, including multiple GPS coordinates to define a polygon representative of the site's boundary
- site type
- environmental context
- site description including nature of site, major cultural features, site dimensions, orientation and size
- a sample of the artefact assemblage including artefact density, lithology, types and metrics;
- an estimate of the total number of artefacts within the site
- assessment of the site's sub-surface content (where applicable) through a combination of probe holes, test pits, and mechanical excavation trenches
- site condition and integrity including the nature and origin of any disturbance to the site
- site plan and profile
- photographs of the site and its context

Site boundaries were established through a combination of pedestrian transects, landscape analysis based on satellite photography and previous site plans, and the use of a systematic grid of sample squares placed across the site. Methods employed for subsurface testing are outlined below.

3.3.4 Site analysis

Based on the research questions identified above, the following artefact analyses methods were employed.

- Site size comparison is undertaken using MapInfo data gained from DAA and available unpublished survey reports. Site size is classified according to the categories in section 3.2.2.
- Density is calculated using the following formula. **Density = MNF/Area** (where area = total recorded ground surface in sq m). Average density of artefact scatters can then be compared to other sites on the Pinjarra Plain and within the local region.
- Distance to water is calculated from the centre of the recorded site to the closest potable water source (namely swamp and lake areas). This analysis is undertaken using MapInfo and

data sets obtained from DAA and the Australian Government Office of Spatial Information. Topographic data was only available at the time of analysis at the scale of 1:250,000.

3.4 Artefact identification and recording methods

The primary types of artefacts that could be expected to be located during the survey include:

- flaked stone artefacts
- ground stone artefacts
- manuports
- historic material such as ceramics, European glass etc.

An overview of artefact identification and methods for recording the main types of artefacts is included in Appendix 6.

3.5 Test excavation methods

The excavation methodology was designed with the research questions in mind and to be compliant with the *Occupational Health and Safety Act 1984* as well as the Commission of Health and Safety *Excavation Code of Practice 2005.* The methodology also took into consideration the work undertaken previously at DAA Id 3648 Soldiers Road Mundijong by Pearce (1979) and attempted to make the current excavations comparable to the results from Pearce's 1975 excavation. Excavation methods included a combination of test pits, probe holes and mechanically excavated trenches to assess the subsurface extent and content of the sites MJ-01, MJ-02, MJ-04 and MJ-05.

Everyone from the excavation team was involved in the digging and sieving and it was taken in turns to do the various tasks associated with the excavation of these pits.

3.5.1 Probe holes

Probe holes were dug in order to determine the extent of archaeological deposit for each site. Probe holes were two spade widths wide by two spade widths long (approximately 400 mm by 400 mm). A sample of the material excavated from the probe holes was sieved through 3 mm sieves, and any artefactual material located was bagged and retained. A grid, centred on the test square excavated, was set out across the sand dune within which each site was located. Pin flags were placed at 10 m intervals along each cardinal direction. The landform was then used as a guide to determine which probe holes were to be dug, for example, where the land form dropped down away from the sand dune a probe was located on the 10 meter flag closest to the visible edge of the sand dune. Where probe holes were dug and no artefacts were identified, the team moved closer to the known site until artefact(s) were identified within a probe hole. In this way the subsurface extent of the sites were accurate to within 10 metres. Probe holes were only dug until artefacts were found, and the depths of the probe holes do not reflect stratigraphic layers or change in stratigraphic units.

Each probe hole was backfilled by shovel using the residual sieved sand.

Plate 1. Excavation and sieving of a probe hole at DAA Id 3648 (MJ-05) (L to R: Mr Harry Nannup Jnr, Mr Franklin Nannup and Ms Jo Thomson)



3.5.2 Test squares

Test squares comprised 1 m by 1 m pits excavated by hand in 100 mm spits[10]. All artefactual material and charcoal samples excavated from the test squares were sieved through 3 mm sieves, bagged in plastic zip lock bags, labelled and retained. Finds from each spit were bagged separately and any *in situ* charcoal recovered was wrapped in aluminium foil and also bagged separately. Each square was excavated to the point where it became impossible or dangerous to dig any further, due to collapse of the pits walls.

Each test square was backfilled by shovel using the residual sieved sand.

Plate 2. Excavation of Test Square at MJ-02 (L to R: Mr John Abraham, Dr Diana Neuweger, Mr Clarry Walley and Mr John Michael)



[10] It should be noted that actual spit depths were slightly arbitrary between test squares and mechanically excavated trenches and have been corrected to represent the same 100 mm units. For example, 'spit 15' means a spit with a maximum depth of 1500 mm. For surface artefacts collected from within a deflated area, they have been referred to as DEF. Artefacts with an 'NA' depth were recovered from a wall collapse or cleaning buckets and do not have a secure depth that could be recorded for them.

Plate 3. Sieving and excavation at MJ-02
(L to R: Mr John Abraham, Mr Clarry Walley, Ms Jo Thomson and Mr John Michael excavating)



Plate 4. Backfilling of Test square E at MJ-01
(L to R: Mr Franklin Nannup, Dr Diana Neuweger and Mr Harry Nannup Jnr)



3.5.3 Mechanical excavator trenches

It became obvious early on in the excavation that hand excavated pits were not going to allow the full stratigraphy of the dunes to be examined, due to the unstable nature of the deposits and the risk of collapse associated with the hand excavation of small test pits. An excavator trench was therefore employed at all sites to determine the full stratigraphic profile of the site and whether there were additional artefact-bearing layers lower than the base of the hand dug pits.

A mini-excavator was employed for the work, operated by Mr Scott Beckett of SJ Mini Excavators. A suitable place for the trenches was determined in consultation with the excavator driver and the excavation team. The mechanically excavated trenches were approximately 2 m long by 600 mm wide. The excavator removed sand in approximately 100 mm spits and placed the contents of each spit into separate piles. An approximately 10% sample of each spit was sieved, to determine presence or absence of artefacts. Soil samples were collected from each spit.

The mechanically excavated spits were not as accurate as the hand dug pits in terms of depth control, however, depth measurements were taken for each mechanically excavated spit with a

hand tape, and dumpy levels were taken at the top and base of each pit so that the trenches can be compared to the hand dug pits.

Each mechanically excavated trench was backfilled by the excavator using the residual sieved sand from the trench.

Plate 5. Excavation of trench G with the spits placed on individual tarps for separate sieving



3.6 Analysis methods

3.6.1 Artefact analysis

The methodology for recording and cataloguing the artefacts was designed in line with the research questions.

Classification

Classification of flaked stone artefacts into type categories followed two principal schemes developed by Hiscock (2000) and McCarthy (McCarthy, 1976, see also Holdaway and Stern, 2004). Whilst Hiscock's scheme is the most commonly employed typology used in Western Australia consulting archaeology, the use of McCarthy's scheme allows for comparison with artefact recording undertaken as part of the Swan Area Archaeological Survey and other works such as Pearce (1979). McCarthy's scheme was based partly on tool morphology, ethnographic observation and mode of manufacture (Holdaway and Stern, 2004). Bird and Frankel's (2005) classification scheme for quartz debris was also employed to classify the quartz debris component into sub-types for analysis.

Lithology

Lithology of artefacts was determined by the comparison of artefacts with a lithology catalogue developed by Jo-Anne Thomson (TCHM) for Swan Coastal Plain artefacts. The catalogue is based upon nomenclature assigned to lithologies within artefact collections at the WA Museum (including DAA Id 3648 Soldier's Road collection) and other geological resources (Lapidus, 1987).

3.6.2 Soil analysis

Samples of soil were taken from each spit of all the mechanically excavated trenches. Each sample was tested for pH using a soil pH testing kit and the colour was recorded using a Munsell soil colour chart.

3.6.3 Faunal analysis

No faunal material was recovered from any of the sites.

3.6.4 Carbon dating

Four carbon samples were submitted to Beta Analytic Inc., Florida USA, for radiocarbon dating, see Table 22 in the results section for details. The radiocarbon dating method comprised standard Accelerator Mass Spectrometry (AMS) dating. All four samples comprised charred organic material and were pre-treated with the acid-alkali-acid (AAA) method. Calibrations were calculated using the latest (2009) calibration database.

See Appendix 7 for Beta Analytic's overview of AMS dating methods.

3.6.5 Taphonomic analysis

The weight and size distribution of artefacts in each spit were analysed to determine if any taphonomic processes resulted in the sorting of artefacts within the deposit.

3.7 Archaeological significance assessment methods

Heritage significance is the degree to which a place, object or activity possesses a certain valued attribute. Archaeological significance is a subset of a place's overall heritage significance and comprises the range of values attributed to a place, site or object by the archaeological community of practice. See Appendix 8 for a more detailed discussion on the complexities of significance assessments.

Any sites located during this inspection were assessed for archaeological significance in terms of research potential in reference to the research questions outlined above in section 3.1 and in reference to Bickford and Bowdler's (Bowdler, 1984a, Bickford and Sullivan, 1984b) questions identified in Appendix 8. In addition, research potential is also considered in light of a site's integrity and condition, internal complexity, ability to be placed into a temporal context, and its potential for technological, spatial and microscopic analysis (such as residue and use wear analysis) and it's connectedness to other sites within the local and regional context.

It is re-emphasized here that evaluating archaeological significance is always contextual and will depend on and be determined by what the contemporary research agenda at the time is, what the current regional profile of representativeness of a particular site type is, what scale the assessment is being made at and how well the significance of a site is articulated. As Bowdler (1984b) identified, archaeological significance is a 'mutable' and changeable quality and therefore, the significance attributed to a site today may be subject to change in the future.

4.0 RESULTS

4.1 Archaeological survey

The archaeological survey was conducted by TCHM between March and May 2012 for the proposed north Mundijong residential development (Thomson, 2012b, McDonald and Thomson, 2012). The survey employed a purposive sampling methodology, which was based on a predictive model developed for the local Pinjarra Plains geomorphic unit, see section 3.2 above.

The project area consisted of an operating farm across three Lots. Lots 37 and 98 were located on the west of Taylor Road whilst Lot 9000 was located on the eastern side of Taylor Road and to the west of Soldiers Road. The project area was divided into multiple fenced paddocks with numerous roads and tracks, dam, water tank, hay bales, dairies and other farm buildings and infrastructure. Livestock including cattle and horses were present within the project area at the time of survey.

Manjedal Brook dissects Lots 98 and 9000 and two minor drainage lines cut across the southern portion of Lot 98. Two remnant freshwater lakes are present in the southeast corner of Lot 9000. The eastern lake is relatively intact whilst the western lake has been partially disturbed through an attempt to fill the lake in utilising part of the surrounding sand dune. This disturbance was noted by Hallam and Pearce at the time DAA Id 3648 Soldiers Road Mundijong was recorded. There was water in both lakes at the time of survey and the lakes appeared to support a large array of bird life. The remains of a turtle were observed around the lake as well as numerous fresh water mollusc shells, suggesting the lakes would have supported a diverse resource base for Aboriginal people in pre-European and contact times.

A large proportion of the project area was comprised of low lying, loamy Pinjarra Plains alluvial soils. One large semi-exposed white sand dune was located within Lot 37, two large sandy elevations were located in the centre and southern portion of Lot 98, and two large sand rises were located in the eastern half of Lot 9000.

Vegetation coverage across the project area comprised mainly open grass cover, including Rye grass and Lupin (*Lupinus*), and occasional scattered trees, including Marri (*Eucalyptus calophylla*) and Jarrah (*E. marginata*) within the paddocks. *Melaleuca–Eucalyptus* woodland surrounded the two freshwater lakes and lined the banks of Manjedal Brook and the two minor drainage lines in Lot 98.

Visibility ranged across the project area. In some low lying paddocks the heavy vegetation rendered visibility at less than 5% whereas in other areas, particularly the elevated sandy areas, visibility was higher, ranging between 20% and 100%. On average it is estimated that visibility was around 20%.

The archaeological survey area comprised seven areas of high archaeological potential, totalling 0.6245 sq km (39 % of the total project area). Three areas of approximately 130 m by 130 m were surveyed by close-spaced pedestrian transect within the areas of low archaeological potential, comprising approximately 0.0507 sq km (3 % of project area). The survey areas combined covered 42% of the total project area. Approximately 54 line km of transects were walked in total across the project area during the field work. It is estimated that approximately 0.108 sq km[11] (7% of the total survey area) was subject to archaeological inspection. Taking into account the influence of vegetation on survey efficacy, using Hiscock's (1988) survey intensity formula (A1=LxWxV)[12], the

[11] Assuming a 2m wide corridor of vision.
[12] L = survey area length; W = width of area surveyed; V = % of ground surface visible.

actual area viewed is estimated to be 0.0216 sq km (1.4% of the total survey area). See Plate 6 to Plate 12, Figure 10 and Table 4 for survey area coordinates.

Plate 6. View south from Lot 37 towards Manjedal Brook



Plate 7. View east across Lot 9000 towards DAA Id 3648 Soldiers Road Mundijong and the Darling Scarp



Plate 8. View east of the southern portion of Lot 98 with graded sandy firebreak



Plate 9. View west of Lot 9000, area south of Manjedal Brook



Plate 10. View southeast of Lot 9000 towards Manjedal Brook



Plate 11. View of minor drainage line in Lot 98



Plate 12. View west of graded firebreak at Lot 98. Note the gradation of alluvial soils into white Bassendean sands along transect line.



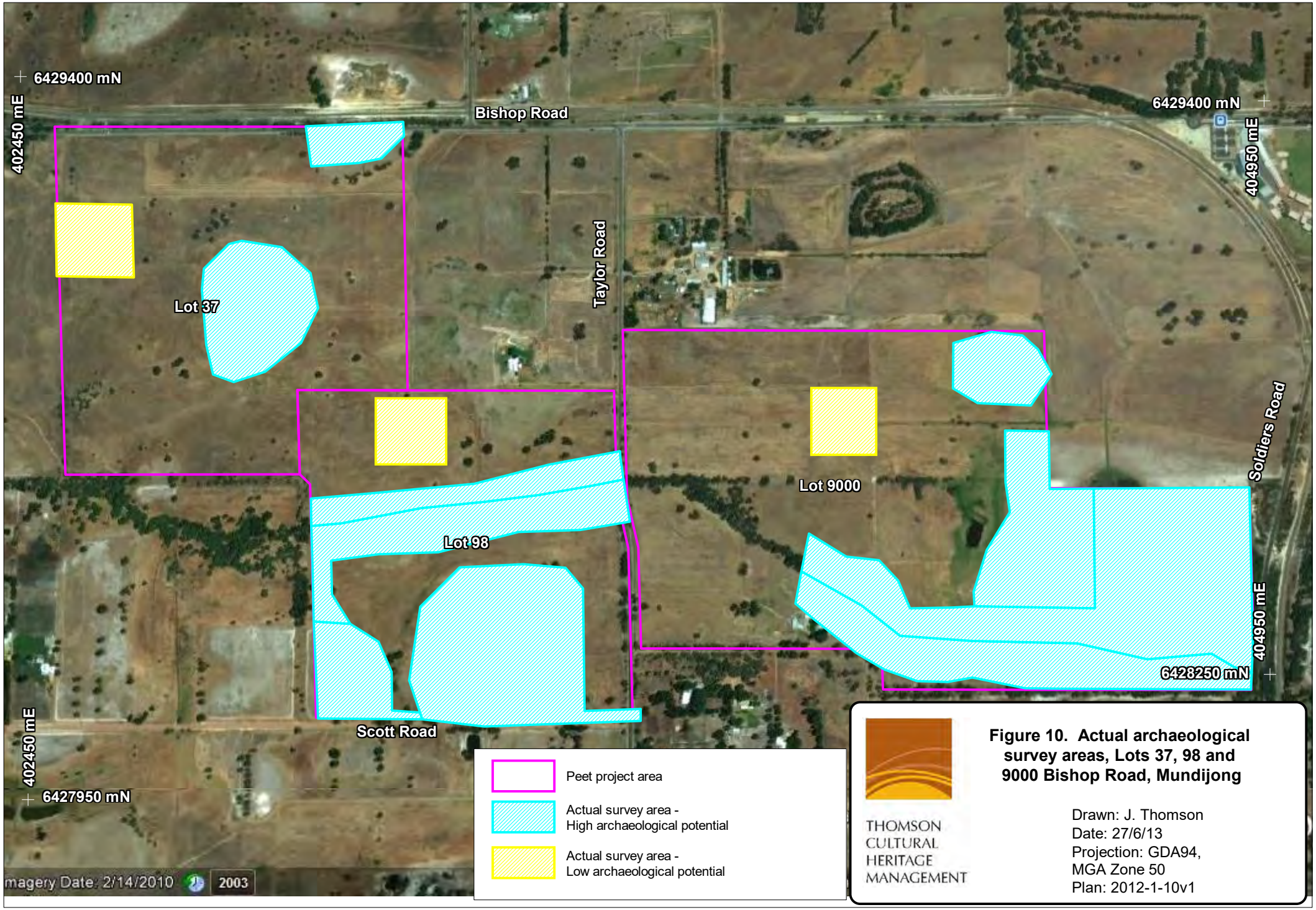


Figure 10. Actual archaeological survey areas, Lots 37, 98 and 9000 Bishop Road, Mundijong

Drawn: J. Thomson
Date: 27/6/13
Projection: GDA94,
MGA Zone 50
Plan: 2012-1-10v1

Table 4. Lots 37, 98 and 9000 Bishop Road archaeological survey area boundary coordinates

Survey Area	Archaeological Potential	Lot #	Area (sq km)	Node	Easting (mE)	Northing (mN)
1	High	9000	0.023	1	404320	6428902
				2	404396	6428926
				3	404459	6428920
				4	404491	6428893
				5	404517	6428844
				6	404475	6428780
				7	404368	6428783
				8	404319	6428811
2	Low	9000	0.017	1	404034	6428806
				2	404164	6428806
				3	404164	6428674
				4	404034	6428674
3	High	9000	0.1516	1	404600	6428615
				2	404912	6428624
				3	404913	6428253
				4	404878	6428264
				5	404833	6428289
				6	404704	6428276
				7	404563	6428305
				8	404207	6428313
				9	404352	6428305
				10	404131	6428372
				11	404010	6428438
				12	404026	6428514
				13	404101	6428469
				14	404166	6428464
				15	404204	6428424
				16	404228	6428368
				17	404358	6428375
				18	404600	6428375
4	Low	98	0.0185	1	403158	6428769
				2	403299	6428769
				3	403299	6428638
				4	403158	6428638
5	High	98	0.031	1	403025	6428565
				2	403353	6428601
				3	403504	6428642
				4	403647	6428672
				5	403654	6428615
				6	403484	6428581
				7	403247	6428550
				8	403087	6428516
				9	403026	6428510
6	Low	37	0.022	1	402518	6429147
				2	402671	6429147
				3	402674	6429002
				4	402519	6429001

Survey Area	Archaeological Potential	Lot #	Area (sq km)	Node	Easting (mE)	Northing (mN)
7	High	37	0.05	1	402866	6429073
				2	402891	6429079
				3	402972	6429068
				4	403029	6429017
				5	403044	6428948
				6	403009	6428876
				7	402936	6428818
				8	402872	6428796
				9	402831	6428810
				10	402810	6428979
				11	402815	6429022
8	High	98	0.105	1	403323	6428433
				2	403452	6428441
				3	403536	6428436
				4	403571	6428395
				5	403571	6428150
				6	403684	6428156
				7	403684	6428132
				8	403370	6428115
				9	403244	6428126
				10	403219	6428204
				11	403243	6428352
9	High	98	0.027	1	403244	6428126
				2	403241	6428140
				3	403184	6428143
				4	403184	6428220
				5	403159	6428280
				6	403102	6428315
				7	403029	6428318
				8	403035	6428124
10	High	98	0.056	1	403026	6428510
				2	403087	6428516
				3	403247	6428550
				4	403484	6428581
				5	403654	6428615
				6	403666	6428531
				7	403566	6428512
				8	403442	6428506
				9	403281	6428462
				10	403160	6428456
				11	403065	6428442
				12	403066	6428374
				13	403102	6428315
				14	403029	6428318

Survey Area	Archaeological Potential	Lot #	Area (sq km)	Node	Easting (mE)	Northing (mN)
11	High	9000	0.06	1	404423	6428729
				2	404511	6428729
				3	404511	6428613
				4	404600	6428615
				5	404600	6428375
				6	404358	6428375
				7	404356	6428404
				8	404383	6428489
				9	404430	6428565
				10	404423	6428625
12	High	37	0.013	1	403023	6429312
				2	403219	6429324
				3	403220	6429295
				4	403174	6429250
				5	403130	6429240
				6	403033	6429231
13	High	9000	0.0722	1	404010	6428438
				2	404131	6428372
				3	404207	6428313
				4	404352	6428305
				5	404563	6428305
				6	404704	6428276
				7	404833	6428289
				8	404878	6428264
				9	404913	6428253
				10	404911	6428219
				11	404458	6428212
				12	404352	6428232
				13	404302	6428222
				14	404240	6428223
				15	404175	6428245
				16	404120	6428276
				17	403997	6428373

4.1.1 Archaeological material located during survey

Two previously recorded sites, DAA Id 450 (South-East Corridor 03/Bishop Road) and DAA Id 3648 (Soldiers Road) and five artefact concentrations, MJ-01, MJ-02, MJ-03, MJ-04 and MJ-05 were located during the survey, see Table 5 and Figure 11. Subsequent investigations have revealed that MJ-05 is an extension of DAA Id 3648 Soldiers Road Mundijong and therefore the two sites are treated as one below. Fourteen isolated artefacts were also recorded during the survey.

The surface components of sites DAA Id 3648 (including MJ-05), MJ-01, MJ-02, MJ-03 and MJ-04 were recorded in detail to section 18 standard. Detailed recording involved the systematic sampling and recording of the visible surface artefacts within these sites, including the recording of artefact metrics and the determination of the extent of the visible surface expression of the sites. DAA Id 450 was not further recorded as the site has been previously recorded in detail and will not be impacted upon by the proposed development. Site descriptions are provided in section 5.0 below.

The survey results confirmed the predictive model, as all artefactual material including isolated artefacts were located on elevated white Bassendean sand lenses above the low-lying plausiplain alluvial soils.

4.2 Archaeological excavation

Excavation of artefact scatters MJ-01, MJ-02, MJ-04 and DAA Id 3648 (MJ-05 extension) was undertaken between 4 January 2013 and 23 January 2013 (excluding weekends). The excavations comprised a combination of hand dug test pits and mechanically excavated trenches, see section 3.5 above for more details on excavation methodology.

The subsurface testing program confirmed that all artefact scatters had subsurface components that extended beyond their visible surface components and that MJ-05 is part of previously recorded DAA Id 3648 Soldier's Road Mundijong. Two radiocarbon dates were obtained from test square D at MJ-05.

Two additional archaeological sites, comprising two modified trees (MJ-08 and MJ-09), were located within the project area during the excavation fieldwork. One modified tree (MJ-08) was referred to by Pearce (1979) in his description of DAA Id 3648, however, the modified tree does not appear to be included in the AHIS listing for the site. Both modified trees are described as separate sites in section 5.0 below.

Table 5. Archaeological sites located within Lots 37, 98 and 9000

Site number / name	Site type	Site size (sq m)	Location (boundary pt)	Easting	Northing	Impact of proposed development
MJ-01	Artefact scatter with archaeological deposit	16,580	1	404353 mE	6428903 mN	Complete disturbance by residential development
			2	404385 mE	6428920 mN	
			3	404436 mE	6428920 mN	
			4	404455 mE	6428910 mN	
			5	404478 mE	6428873 mN	
			6	404479 mE	6428856 mN	
			7	404475 mE	6428833 mN	
			8	404467 mE	6428815 mN	
			9	404442 mE	6428795 mN	
			10	404381 mE	6428788 mN	
			11	404355 mE	6428795 mN	
			12	404329 mE	6428809 mN	
			13	404322 mE	6428845 mN	
			14	404322 mE	6428849 mN	
			15	404336 mE	6428880 mN	

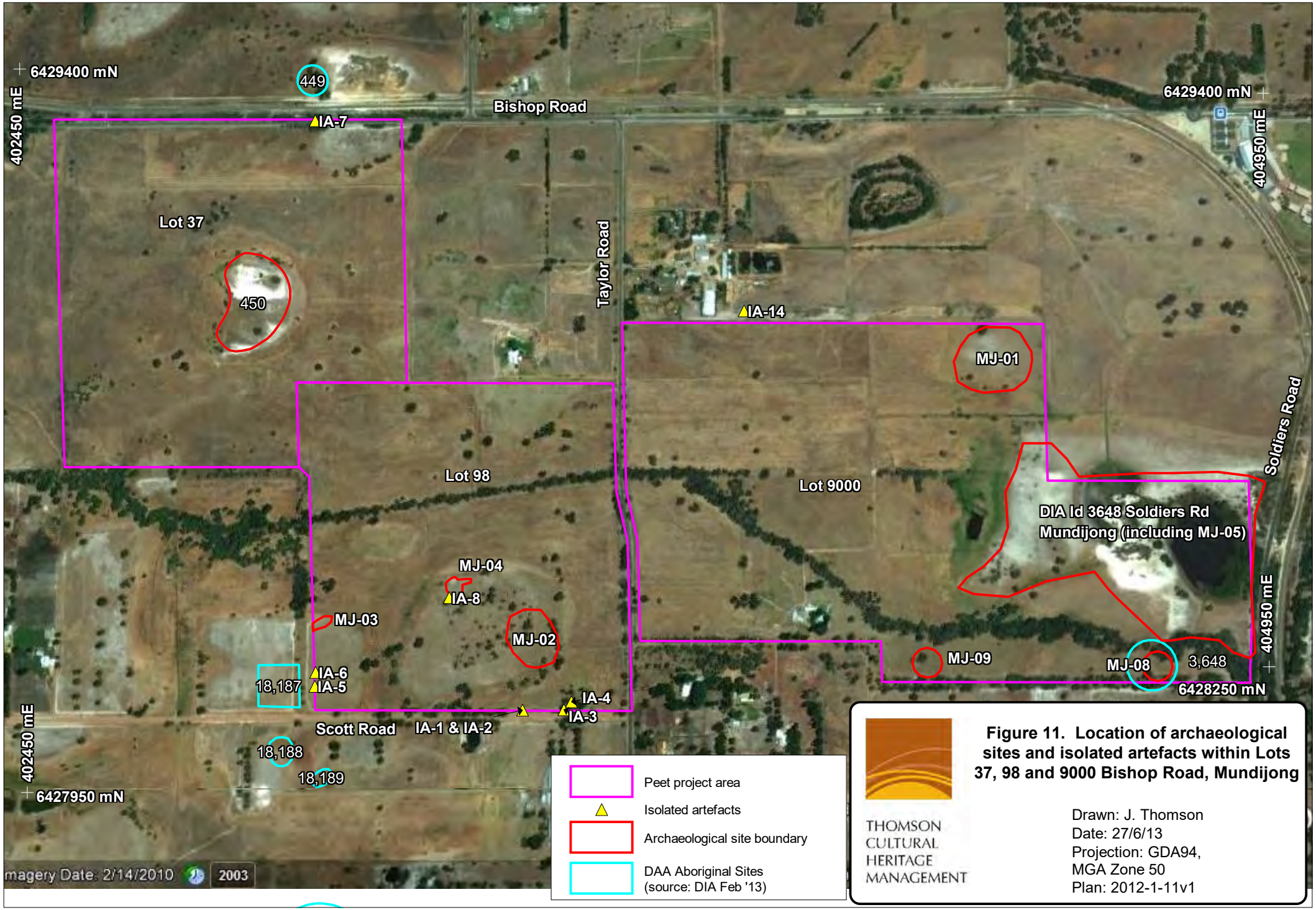
Site number / name	Site type	Site size (sq m)	Location (boundary pt)	Easting	Northing	Impact of proposed development
MJ-02	Artefact scatter with archaeological deposit	9,354	1	403425 mE	6428320 mN	Potential impact by proposed school within the residential development
			2	403452 mE	6428335 mN	
			3	403486 mE	6428336 mN	
			4	403506 mE	6428312 mN	
			5	403519 mE	6428284 mN	
			6	403521 mE	6428260 mN	
			7	403511 mE	6428231 mN	
			8	403485 mE	6428221 mN	
			9	403457 mE	6428223 mN	
			10	403430 mE	6428248 mN	
			11	403416 mE	6428276 mN	
			12	403420 mE	6428306 mN	
			13	403472 mE	6428219 mN	
MJ-03	Artefact scatter with potential archaeological deposit	664	1	403050 mE	6428314 mN	No impact by Peets development Potential future impact by services corridor
			2	403066 mE	6428314 mN	
			3	403064 mE	6428304 mN	
			4	403053 mE	6428294 mN	
			5	403032 mE	6428287 mN	
			6	403028 mE	6428284 mN	
			7	403027 mE	6428298 mN	
			8	403035 mE	6428305 mN	
MJ-04	Artefact scatter with archaeological deposit	1,342	1	403305 mE	6428395 mN	Complete disturbance by residential development
			2	403312 mE	6428398 mN	
			3	403317 mE	6428398 mN	
			4	403320 mE	6428393 mN	
			5	403337 mE	6428395 mN	
			6	403347 mE	6428395 mN	
			7	403345 mE	6428388 mN	
			8	403337 mE	6428385 mN	
			9	403330 mE	6428383 mN	
			10	403330 mE	6428375 mN	
			11	403327 mE	6428360 mN	
			12	403322 mE	6428350 mN	
			13	403315 mE	6428350 mN	
			14	403305 mE	6428358 mN	
			15	403297 mE	6428373 mN	
			16	403295 mE	6428385 mN	
			17	403297 mE	6428388 mN	

Site number / name	Site type	Site size (sq m)	Location (boundary pt)	Easting	Northing	Impact of proposed development
DAA Id 3648 (including MJ-05)	Artefact scatter with archaeological deposit	149,900	1	404460 mE	6428688 mN	Partial disturbance by residential development, part of the site is located within the wetland conservation zone, earmarked for public open space
			2	404516 mE	6428690 mN	
			3	404547 mE	6428659 mN	
			4	404571 mE	6428624 mN	
			5	404703 mE	6428619 mN	
			6	404755 mE	6428628 mN	
			7	404788 mE	6428629 mN	
			8	404912 mE	6428621 mN	
			9	404943 mE	6428621 mN	
			10	404945 mE	6428617 mN	
			11	404921 mE	6428549 mN	
			12	404915 mE	6428398 mN	
			13	404922 mE	6428278 mN	
			14	404911 mE	6428267 mN	
			15	404878 mE	6428277 mN	
			16	404849 mE	6428301 mN	
			17	404793 mE	6428305 mN	
			18	404752 mE	6428299 mN	
			19	404734 mE	6428302 mN	
			20	404647 mE	6428380 mN	
			21	404628 mE	6428400 mN	
			22	404601 mE	6428434 mN	
			23	404504 mE	6428412 mN	
			24	404426 mE	6428380 mN	
			25	404357 mE	6428384 mN	
			26	404326 mE	6428397 mN	
			27	404343 mE	6428417 mN	
			28	404377 mE	6428440 mN	
			29	404412 mE	6428475 mN	
			30	404427 mE	6428519 mN	
			31	404423 mE	6428590 mN	
			32	404445 mE	6428635 mN	
MJ-08	Modified tree	-	1	404725 mE	6428247 mN	Possible impact by proposed road reserve
MJ-09	Modified tree	-	1	404263 mE	6428244 mN	No impact by Peets development

4.3 Storage and management of excavated archaeological material

All excavated archaeological and potential archaeological material was removed off site for analysis and is currently temporarily stored at Thomson Cultural Heritage Management's premises until a permanent storage location is decided upon by the Bilya Noongar and Winjan Aboriginal Corporations. The artefacts, charcoal samples, soil samples and other associated materials are stored in labelled plastic, non-acidic zip lock bags within non-acidic plastic shoe box containers in a locked filing cabinet.

The artefact collection shown to the excavation team by Mr Sam Lang was as of January 2013 located at Lang Farm, Lang Road, Mundijong.


6429400 mN
402450 mE
449
Bishop Road
IA-7
Lot 37
450
Taylor Road
IA-14
MJ-01
Lot 98
Lot 9000
Soldiers Road
DIA Id 3648 Soldiers Rd
Mundijong (including MJ-05)
MJ-04
IA-8
MJ-03
MJ-02
MJ-09
MJ-08
3,648
404950 mE
6428250 mN
18,187
IA-6
IA-5
IA-4
IA-3
Scott Road
IA-1 & IA-2
18,188
18,189
6427950 mN
Peet project area
Isolated artefacts
Archaeological site boundary
DAA Aboriginal Sites
(source: DIA Feb '13)
THOMSON
CULTURAL
HERITAGE
MANAGEMENT
Figure 11. Location of archaeological sites and isolated artefacts within Lots 37, 98 and 9000 Bishop Road, Mundijong
Drawn: J. Thomson
Date: 27/6/13
Projection: GDA94,
MGA Zone 50
Plan: 2012-1-11v1
magery Date: 2/14/2010
2003

5.0 SITE DESCRIPTIONS

5.1 MJ-01 – Artefact scatter with archaeological deposit

5.1.1 Grid References

The site extents are bounded by the following coordinates.

1.	404353 mE	6428903 mN	9.	404442 mE	6428795 mN
2.	404385 mE	6428920 mN	10.	404381 mE	6428788 mN
3.	404436 mE	6428920 mN	11.	404355 mE	6428795 mN
4.	404455 mE	6428910 mN	12.	404329 mE	6428809 mN
5.	404478 mE	6428873 mN	13.	404322 mE	6428845 mN
6.	404479 mE	6428856 mN	14.	404322 mE	6428849 mN
7.	404475 mE	6428833 mN	15.	404336 mE	6428880 mN
8.	404467 mE	6428815 mN			

Test square E was located at:

404381 mE 6428851 mN

Mechanical Excavator trench F was located at:

404369 mE 6428853 mN

The probe holes were located at the following coordinates.

1PS60	404381 mE	6428788 mN
1PS70	404381 mE	6428781 mN
1PW60	404322 mE	6428845 mN
1PW70	404314 mE	6428845 mN
1PN68	404385 mE	6428920 mN
1PE60	404444 mE	6428854 mN
1PE100	404478 mE	6428856 mN
1PE120	404496 mE	6428857 mN

5.1.2 Location

MJ-01 is located in the northeast corner of Lot 9000 Soldiers Road, Mundijong. It is approximately 655 m west of Soldiers Road and 480 m south of Bishop Road. Sites MJ-05 and DAA Id 3648 Soldiers Road Mundijong are located 240 m to the south and southeast respectively. See Figure 11.

5.1.3 Environment

The artefact scatter is located on a low, white sandy rise above low-lying plausiplain. The rise has an elevation of approximately 38 m above sea level and has a centrally located, east-facing deflation area. The area around the site has been previously cleared. The rise is relatively intact and the site has been subject to some minor disturbance by pastoral activities and grazing stock. The ground surface comprised fine white sand and visibility at the time of recording was approximately 80 %.

Manjedal Brook is located 520 m to the south of the site and a small freshwater lake is located approximately 470 m to the southwest of the site. The lake held water at the time of the field work. The surrounding low-lying plausiplain would have been inundated seasonally during the winter months.

5.1.4 Site description

MJ-01 is a large open stone artefact scatter with subsurface deposit. The site's extent including its subsurface component is 133 m (north–south) by 157 m (east–west), totalling approximately 16,580 sq m. The artefact scatter has a high artefact density and a medium level of raw material diversity. It is estimated that the site may contain approximately 20,000 artefacts.

Surface component

Artefacts were visible on the surface over an area of 30 m (east–west) by 20 m (north–south), or 383 sq m, in an east facing deflation within the sandy rise. A 14.6 % sample of the site's surface expression was examined and 83 artefacts were recorded, see Appendix 9 for artefact details.

Based on the data collected from 56 sample squares, 1 m by 1 m in size, the average artefact density is high (1.48/sq m) and the estimated total surface artefact population is 567 artefacts. Artefact types recorded within the site comprised debris (n=32, 38.6%), flaked pieces (n=25, 30%), flakes (n=18, 21.7%), longitudinally broken flakes (n=5, 6%), manuports (n=2, 2.4%) and a transversely broken flake (n=1, 1.3%), see Figure 12. The majority of artefacts were small in size and light in weight – in total 45 artefacts (52%) weighed <0.1g, and 74 artefacts weighed under 1g (89%), see Figure 14. No retouch was observed on any of the artefacts recorded. Artefacts were primarily made from white quartz (n=62, 76%), crystal quartz (n=18, 21%) and minor amounts of dolerite (n=2, 2%) and pink quartz (n=1, 1%), see Figure 13.

Plate 13. Site MJ-01, view east of deflation with Christine Martin



Plate 14. Site MJ-01, view east of baseline with Christine Martin



Plate 15. Site MJ-01 sample square N16

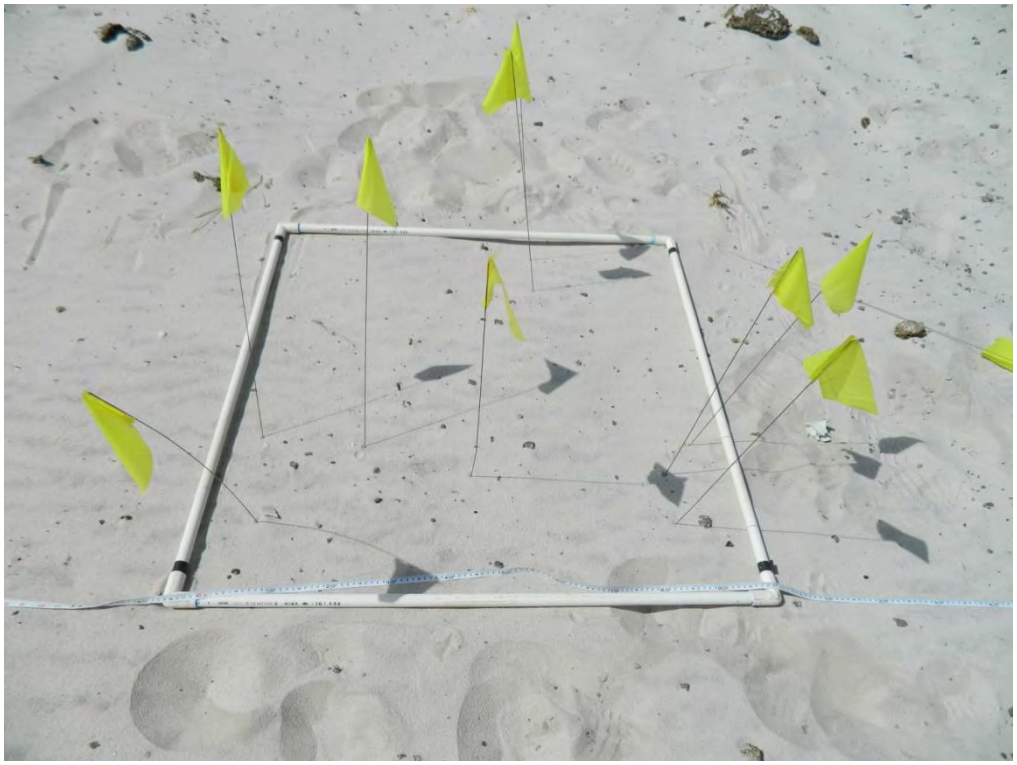


Plate 16. Site MJ-01 quartz flaked piece, sample square N11



Plate 17. Site MJ-01 quartz flake, sample square N11



Subsurface extent

Eight probe holes were dug across the site to determine the extent of subsurface artefacts, see Table 6. Testing of the northern extent of the site was constrained by a fence and the adjacent paddock was occupied by cattle at the time of fieldwork and hence was not accessed. The probe hole tests indicated that subsurface artefacts extend across the entire raised dune area, approximately 100 m to the east and 60 m to the north, west and south of the deflation area, see Figure 15.

Soil across the majority of the site comprised light grey sand overlain by a brown humic layer. On the eastern side orange sand was present and contained artefacts. The sand became damper with depth, reflecting the shallow water table within the local region.

Table 6. Probe hole data for MJ-01

Probe hole	Artefact present	Depth	Notes
1PS60	Yes	470mm	Brown humic over light grey
1PS70	No	500mm	Brown humic over light grey- sand very damp
1PW60	Yes	470mm	Brown humic over light grey- slightly damp
1PW70	No	490mm	Brown humic over light grey
1PN68	Yes	450mm	Pale loose grey in fire break- next north another paddock with cows
1PE60	Yes	450mm	Brown humic over light grey
1PE120	No	450mm	Orange sand
1PE100	Yes	490mm	Orange sand

Plate 18. MJ-01 probe hole 1PW70 with the light grey sand found across the site



Plate 19. MJ-01 probe hole 1PE100 with orange sandy deposit



Subsurface stratigraphy

One hand excavated test pit (Test square E) and one mechanically excavated trench (Excavator trench F) were dug at MJ-01 to determine the nature of subsurface deposit.

Test square E

Test square E was dug on 18 January 2013, by the whole excavation team. This test square was located within the central area of the deflation and was dug in 8 spits to a depth of 900 mm. Artefacts were recovered from spits 1 and 2, and from spits 4–6 inclusive. Artefacts were therefore identified within Test square E above 600 mm depth. This test square had no stratigraphic variation as it contained one single deposit of pale white sand. Test square E was abandoned at 900 mm depth due to instability of the pit walls.

Plate 20. MJ-01 test square E, located at the base of the deflation

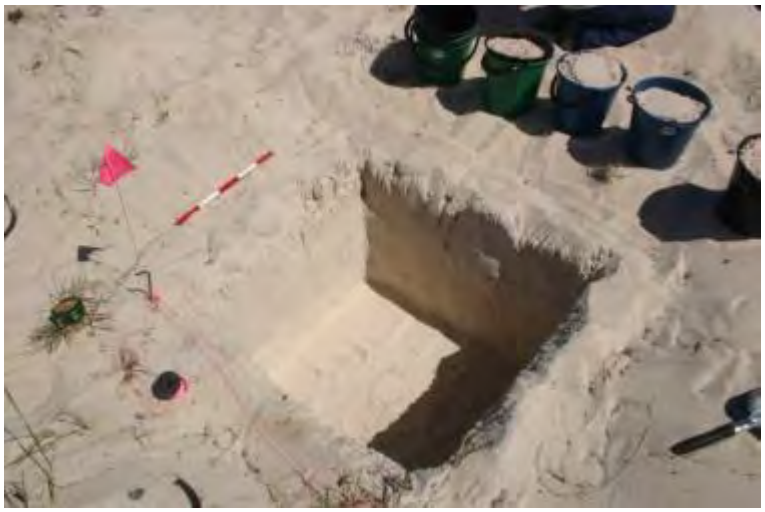


Plate 21. MJ-01, completion of test square E at 900 mm



Excavator trench F

Excavator trench F was excavated on 22 January 2013. The trench was located on the western edge of the deflation at the highest point of the sandy rise and was dug to a depth of 2 metres. Artefacts were recovered from spits 1–7 inclusive and also within Spit 11 and Spit 14. The results of the excavator trench indicated that artefacts were located **below** the deepest level of Test square E.

The stratigraphy evident within Excavator trench F is overviewed in Table 7. The depths of each layer vary across the site, however, there are three general distinct layers comprising:

- An upper humic layer that is brown in colour and is a result of the farming practices now occurring on the site.
- A sandy layer that comprises the dune formation across site, this is a pale white sand at the top that grades into an orange sand at the bottom, there is no clear break in the colour change and thus is considered one deposit.
- Lateritic soil which is a dark orange colour and sits below the sand dune formation.

Table 7. Summary of Excavator trench F stratigraphy

Depth	Content
0.00-0.37m	mixed humic sandy layer including small grass rootlets
0.37- 0.82m	white sandy layer as identified in deflation
0.82- 1.75m	sand slowing grading into a darker orange, some small pieces of charcoal seen in orange sand
1.75m	Laterite, a dark orange-brown hard compact sand difficult to remove with excavator

The pH levels within the trench ranged from 4.5 to 6.5, indicating that all the sands at the site were acidic and sands at depth were strongly acidic. Comparison of soil samples against the Munsell (2009) soil colour chart indicated that there is little variation in colour within the deposit at MJ-01 and changes in colour correlated with changes in soil pH. Overall the sand within the excavator trench was medium course or medium sand. See Table 8 for details.

Table 8. Summary of soil samples from Excavator Trench F

Spit	pH	Munsell	Comments
1	6.5	10YR7/2	Medium-coarse sand
2	6.5	10YR7/2	Medium-coarse sand
3	6.5	10YR7/2	Medium-coarse sand
4	6	10YR7/2	Medium-coarse sand
5	6	10YR6/1	Medium-coarse sand
6	5.5	10YR6/1	Medium-coarse sand
7	4.5	10YR4/2	Medium-coarse sand
8	4.5	10YR3/1	Medium-coarse sand
9	5	10YR5/3	Medium-coarse sand
10	4.5	10YR5/2	Medium-coarse sand
11	6	10YR7/3	Medium sand
12	6	10YR7/3	Medium sand
13	6.5	10YR7/4	Medium sand
14	6.5	10YR7/4	Medium sand
15	6.5	10YR6/4	Medium sand
16	6.5	10YR6/4	Medium sand
17	6.5	10YR6/6	Medium sand
18	6.5	10YR6/6	Medium sand
19	6.5	10YR6/6	Medium sand
20	6.5	10YR6/6	Medium sand
21	6.5	10YR4/6	Medium sand
base	6.5	10YR4/6	Medium sand

Plate 22. MJ-01, Excavator trench F, southern face



Subsurface assemblage

In total, approximately 2.8 m^3 was excavated at MJ-01 and 77 artefacts were recovered from its subsurface deposit[13]. Fifty two artefacts were recovered from Test square E, whilst 22 were recovered from Excavator trench F and three from the probe holes, see Appendix 9. Based on the density from the test square, it is estimated that the subsurface artefact density is approximately 58 artefacts per cubic meter.

In the test square artefacts were mainly concentrated in spits 1 and 2 (0–200 mm depth), with single artefacts being located in spits 4, 5 and 6 (between 300–600 mm depth). No artefacts were recovered from the test pit below 600 mm, however, artefacts were located in the excavator trench down to a depth of 1500 mm.

Artefact types recovered from the subsurface deposit comprised debris (n=34, 44.1%), flaked pieces (n=22, 28.5%), flakes (n=13, 16.8%), longitudinally broken flakes (n=2, 2.6%), transversely broken flakes (n=2, 2.6%), a core (n=1, 1.3%), a longitudinally and transversely broken flake (n=1, 1.3%), a retouched flake (n=1, 1.3%) and a retouched flaked piece (n=1, 1.3%). Two tools were identified within the assemblage including a flat edged scraper and a bladelet. The flat edged scraper, which was manufactured from smokey quartz (see Plate 23), was recovered from spit 1, whilst the crystal quartz bladelet was recovered from cleaning spoil from spits 1 and 2. None of the artefacts recovered from MJ-01 were observed to have any cortex, indicating that they are all tertiary or late stage reduction artefacts which are associated with trimming and resharpening tools or bifacial reduction activities.

Artefact lithologies were dominated by quartz and included white quartz (n=44, 57.1%), crystal quartz (n=21, 27.2%), smokey quartz (n=10, 12.9%), fossiliferous chert (n=1, 1.3%) and quartzite (n=1, 1.3%). Whilst quartz appears at all depths within the deposit, the single piece of fossiliferous chert recovered was located within spit 6 (600 – 700 mm depth), which is consistent with Hallam's interpretations of the use of fossiliferous chert on the Swan Coastal Plain (1987, Hallam, 1986). Crystal quartz is also present within the assemblage down to a depth of 700 mm whilst smokey quartz and quartzite appear only at 200 mm depth and above, indicating that these lithologies were used in relatively recent times.

The majority of the subsurface artefacts from MJ-01 were small in size and light in weight. In total, 52 artefacts (67.5%) weighed <0.1g and 21 artefacts (27.3%) weighed between 0.1g and 0.3g. The heaviest artefact recovered was a core at 1.6g. The average weight of subsurface artefacts was 0.16g. The length of subsurface artefacts at MJ-01 were all less than 20 mm, with the majority (n=63, 81.8%) measuring less than 10 mm. Due to the small sample size it is difficult to detect any trends in variation in artefact size over time and there appears to consistently be small artefacts at all depths, therefore indicating a lack of obvious size sorting between spits.

[13] Including from the test square, excavator trench and probe holes. Note that only a portion of the excavator trench and probe hole sediments were sieved, whilst all of the sediment from the test excavation was sieved.

Plate 23. MJ-01, spit 1 smokey quartz flat edged scraper (scale = 1 cm)



Comparison of surface and subsurface assemblages

Overall, the density of artefacts was higher within the surface deflation area than subsurface. This is most likely a result of the erosion of sand and re-deposition and mixing of artefacts from several different layers within the one layer at the base of the deflation.

The surface and subsurface assemblages were very similar in composition in terms of artefact types, proportions of artefact types and artefact weight, see Table 9.

The main points of difference between the assemblages were that there were no retouched/utilised artefacts identified on the surface and whilst manuports were identified within the deflated area, there were no manuports recovered from the subsurface deposit. There was also some variation between raw material types, with white quartz and crystal quartz being the only raw materials common to both the surface and subsurface assemblages.

The surface assemblage also showed greater variation in both weight and maximum length measurement than the subsurface artefacts, see Table 10. Seven percent of surface artefacts were longer than the subsurface assemblage. The surface assemblage displayed greater diversity in platform and termination types, as well as higher overall percentage of diagnostic platforms and terminations, see Table 11. The most common platform type in the surface assemblage was faceted and flaked in the subsurface assemblage. The most common termination type in both assemblages was feather, with stepped and hinged being the next common. Overall, the surface material shows more diversity in the platform type but the information for surface and subsurface in the termination types is consistent.

Table 9. MJ-01, comparison of surface and subsurface artefact and raw material types

Artefact type	Surface	Subsurface	Raw material type	Surface	Subsurface
Debris	38.5%	44.1%	White quartz	74.7%	57.1%
Flaked pieces	30.1%	28.5%	Crystal quartz	21.7%	27.2%
Retouched flaked piece	0.0%	1.3%	Dolerite	2.4%	0.0%
Flake	21.6%	16.8%	Pink quartz	1.2%	0.0%
Retouched Flake	0.0%	1.3%	Foss. Chert	0.0%	1.3%
Longitudinally broken Flake	6.0%	2.6%	Quartzite	0.0%	1.3%
Manuport	2.4%	0.0%	Smokey Quartz	0.0%	12.9%
Transversely broken Flake	1.2%	2.6%			
Cores	0.0%	1.3%			
Longitudinally & transversely broken flake	0.0%	1.3%			

Table 10. MJ-01, comparison of surface and subsurface artefact weight and maximum length

Weight (g)	Surface	Subsurface	Length (mm)	Surface	Subsurface
0-5g	80	77	0-5	14	27
5-10g	2	0	5-10	41	36
25-30g	1	0	10-15	17	11
			15-20	5	3
			20-25	2	0
			25-30	2	0
			30-35	1	0
			35-40	1	0
Total	83	77	Total	83	77

Table 11. MJ-01, comparison of surface and subsurface artefact platform and termination types

Platform Type	Surface	Subsurface	Termination Type	Surface	Subsurface
Crushed	1	0	Crushed	1	0
Faceted	9	3	Feather	17	12
Flaked	8	16	Hinged	2	1
Focalised	6	0	Outré passé	0	0
Indeterminate	1	0	Stepped	6	4
Total	25	19	Total	26	17

5.1.5 Site interpretation

Based on the dominance of debris and flaked pieces in the surface assemblage of the site, the low number of formal tools, artefact density, small size of the debitage, and late stage reduction evident within the assemblage, it is likely that MJ-01 represents an occupation site where activities such as core reduction and tool trimming and re-sharpening were undertaken. As residue analysis was not undertaken it is difficult to ascertain whether plant or faunal processing activities were also undertaken on the site. Plant and animal resources would have been readily available within the surrounding plausiplain wetland areas and nearby fresh water lakes.

The low–moderate level of artefact diversity, medium level of raw material diversity and proximity to a permanent water source indicate that MJ-01 would have been visited on numerous occasions for substantial periods of time. It is highly likely that MJ-01 would have been associated with the

regular, long term occupation of DAA Id 3648 Soldier's Road Mundijong and may represent an outlier activity area.

As no carbon samples were available for dating at MJ-01, radiocarbon dating of the subsurface deposit was not undertaken. Utilising a combination of Hallam (1987) and Schwede's (1990) relative dating scheme for the Swan Coastal Plain, MJ-01 is classified as 'Middle Phase' with an estimated lower date of approximately 4600 BP. This could be tested in the future through optically stimulated luminescence (OSL) dating.

All of the stone material on site was procured elsewhere and brought onto site. The fossiliferous chert would have been transported over 23 km from a now submerged deposit off the coast, whilst the dolerite and quartzite would have been obtained from quarries within the Darling Scarp and/or Plateau, indicating that the people utilising MJ-01 would have ranged over a relatively large area between the Darling Plateau and the coastline. The large amount of artefacts with complex platforms, indicating preparation of materials prior to flaking, also implies that raw materials were being conserved during occupation of MJ-01.

5.1.6 Statement of archaeological significance

MJ-01 is an open stone artefact scatter with a subsurface deposit, situated on a Bassendean sand dune which during the wet months would have been surrounded by inundated wetland. MJ-01 can be classified as 'Middle Phase', according to Hallam (1987) and Schwede's (1990) relative dating scheme, with occupation dating back to around 4600 BP. MJ-01 represents a task-specific activity area, where people undertook core reduction and tool maintenance activities, potentially associated with the regular, long term occupation of nearby DAA Id 3648 Soldier's Road Mundijong adjacent to the two fresh water lakes and Manjedal Brook.

MJ-01 is assessed as being of importance and significance to the community due to its archaeological and scientific values. The site possesses archaeological research potential as the data that has been collected from this site can contribute to a significant proportion of the research questions identified above in section 3.1, including questions 1–12 and 14–16, however, the collected data does not necessarily provide substantially different information to the existing Swan Coastal Plain knowledge base. The site has relatively good integrity, some ability to be placed within a relative temporal context and whilst it is not a rare site type, it is a good representative example of a Pinjarra Plains open artefact scatter with subsurface deposit. The site's proximity and connectedness with DAA Id 3648 Soldier's Road Mundijong also suggests an increased degree of importance.

It is the opinion of the authors that MJ-01 constitutes an Aboriginal Site within the meaning of section 5a of the *Aboriginal Heritage Act 1972*.

5.1.7 MJ-01 recommendations

It is **recommended** that Peet and its contractors are:

- advised of the existence and location of archaeological site MJ-01; and
- informed that MJ-01 may meet the requirements of section 5 of the *Aboriginal Heritage Act 1972* and therefore it should not be impacted upon in any way.

Should at any stage Peet wish to disturb MJ-01 and an application is made for consent to use the land under section 18 of the *Aboriginal Heritage Act 1972*, it is **further recommended** that:

- no further physical archaeological investigations of MJ-01 are required; and
- Peet consults with the appropriate Nyungar Elders and Aboriginal Consultants about any proposed section 18 application, mitigation and salvage strategies and the management of excavated and salvaged materials.

Figure 12. Summary of artefacts recorded within MJ-01

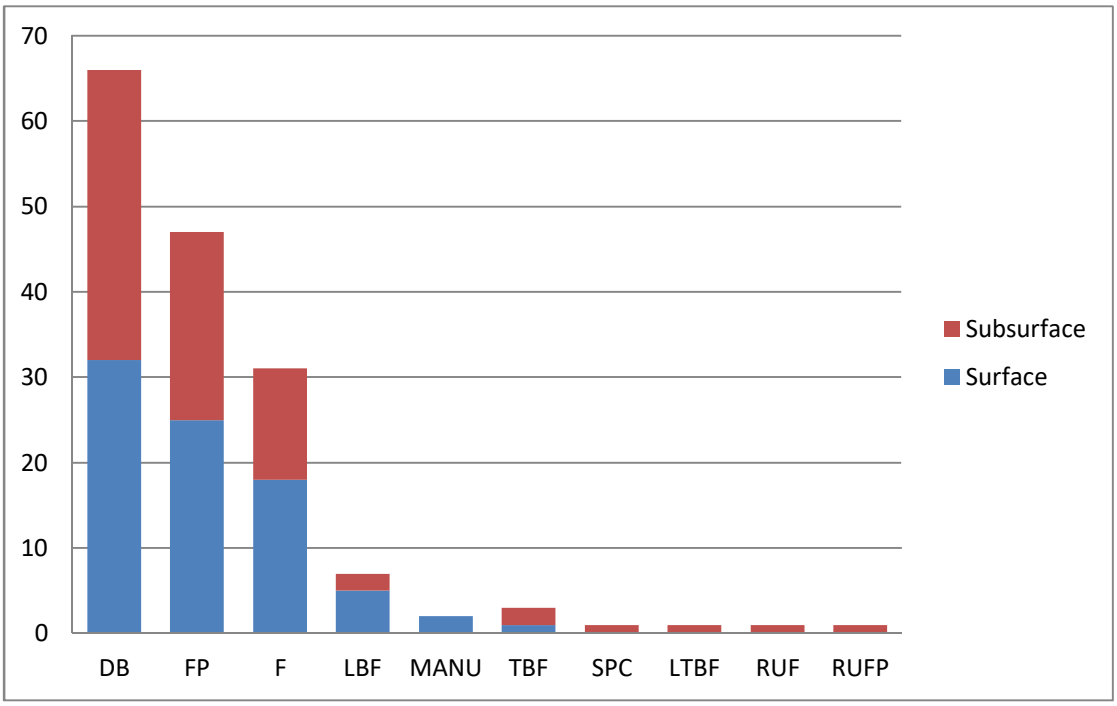


Figure 13. Summary of lithologies present within MJ-01 artefact sample

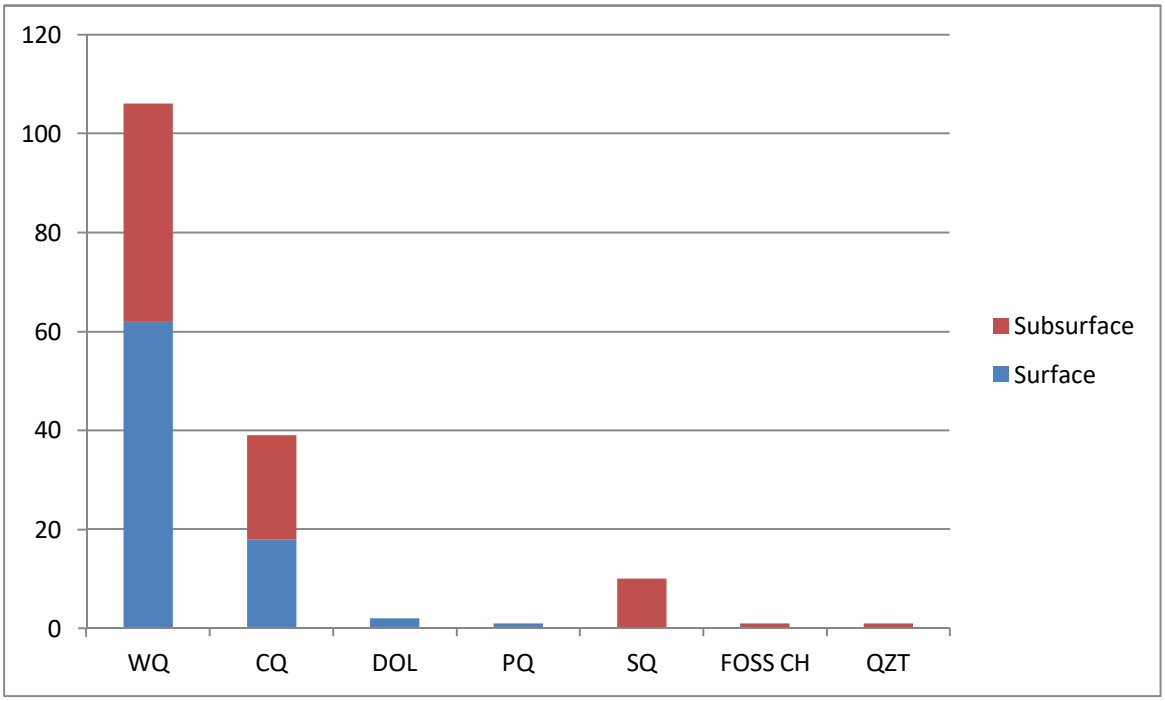
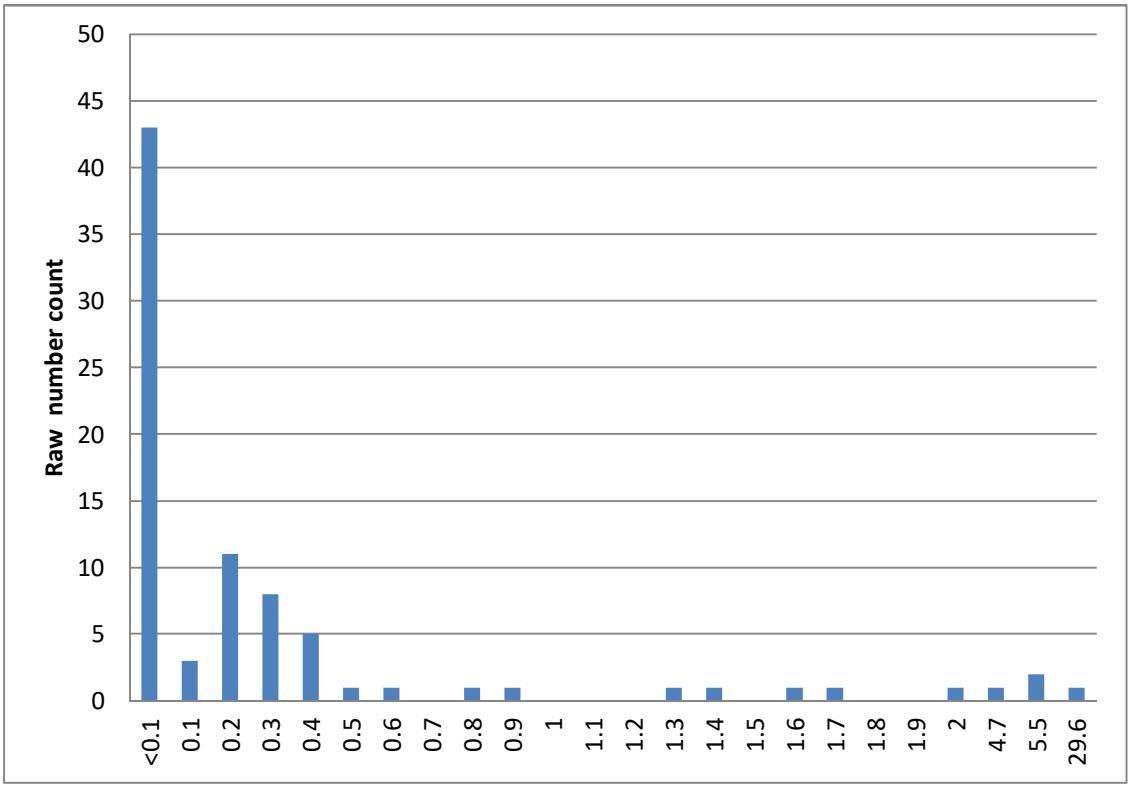


Figure 14. MJ-01 sampled artefact weights (surface component)



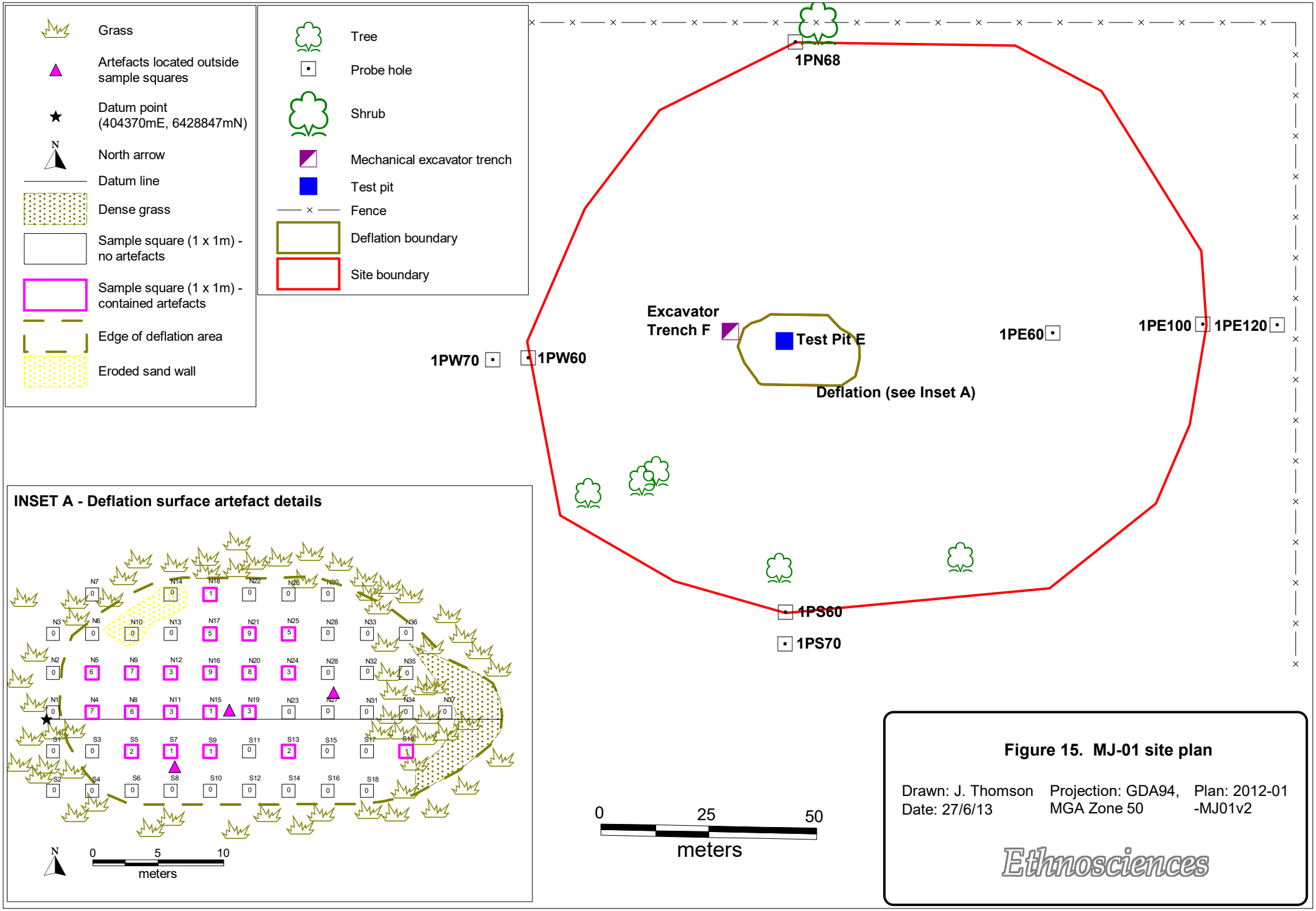


Figure 15. MJ-01 site plan

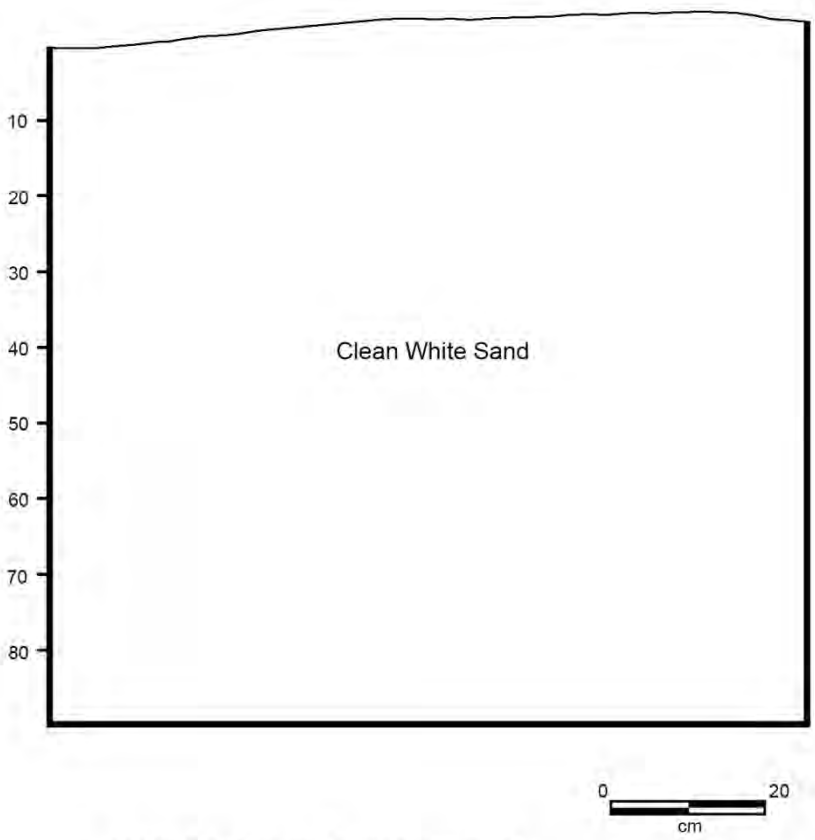
Drawn: J. Thomson
Date: 27/6/13

Projection: GDA94, MGA Zone 50

Plan: 2012-01 -MJ01v2

Ethnosciences

Figure 16. MJ-01 test square E section (drawn by D. Neuweger)



5.2 MJ-02 – Artefact scatter with archaeological deposit

5.2.1 Grid References

The site extents are bounded by the following coordinates.

1.	403425 mE	6428320 mN	8.	403485 mE	6428221 mN
2.	403452 mE	6428335 mN	9.	403457 mE	6428223 mN
3.	403486 mE	6428336 mN	10.	403430 mE	6428248 mN
4.	403506 mE	6428312 mN	11.	403416 mE	6428276 mN
5.	403519 mE	6428284 mN	12.	403420 mE	6428306 mN
6.	403521 mE	6428260 mN	13.	403472 mE	6428219 mN
7.	403511 mE	6428231 mN			

Test square B was located at:
403471 mE 6428273 mN

Mechanical Excavator trench K was located at:
403396 mE 6428307 mN

The probe holes were located at the following coordinates.

2PS70	403483 mE	6428210 mN
2PS60	403482 mE	6428220 mN
2PS30	403478 mE	6428249 mN
2PN60	403453 mE	6428335 mN

5.2.2 Location

MJ-02 is located in the southwest quarter of Lot 98 Bishop Road, Mundijong. It is approximately 190 m west of Taylor Road and 140 m north of Scott Road. Site MJ-04 is located 110 m to the northwest of MJ-02 on the same raised landform feature, whilst MJ-03 is located approximately 350 m to the west. See Figure 11.

5.2.3 Environment

The artefact scatter is located on a large, low white sand hill above low-lying plausiplain. The hill has an elevation of approximately 29 m above sea level. The area around the site has been previously cleared, with the exception of approximately a dozen large mature *Eucalyptus* sp. trees. The rise is relatively intact and the site has been subject to some minor disturbance by pastoral activities, grazing stock and burrowing fauna. The ground surface comprises fine white sand and visibility at the time of recording was approximately 80 % around the base of the tree and less than 10 % greater than 2 m out from the deflation around the tree base. See Plate 24 to Plate 32.

Manjedal Brook is located approximately 300 m to the north of the site and a minor ephemeral drainage line is located immediately to the south of the site. The surrounding low-lying plausiplain would have been inundated seasonally during the winter months.

5.2.4 Description

MJ-02 is a medium sized artefact scatter with subsurface deposit. MJ-02's surface exposure covers an area of 2 m by 1 m (2 sq m) and the site's subsurface extent is 117 m (north–south) by 103 m (east–west), totalling approximately 9,354 sq m. The site has a high artefact density and a medium level of raw material diversity.

Surface component

MJ-02 was originally located as a very small exposure of quartz artefacts located at the base of a large, mature Marri (*Corymbia calophylla*) tree approximately 20-30 m high on the southeast slope of a low rising, white Bassendean sand hill. It is likely that artefacts were exposed by livestock burrowing into the ground surface at the base of the tree.

The artefacts were visible over an area of 2 m by 1 m (2 sq m) around the base of the tree and all visible artefacts were recorded. The majority of the artefacts were located on the southwest side of the tree with one artefact located on the west side and one artefact on the north side of the tree. In total, 32 artefacts were located and recorded.

Based on the recorded artefacts, the average density is high (6.5/sq m). Artefact types recorded within the site comprised debris (n=19, 59.3%), flaked pieces (n=9, 28.1 %), flakes (n=3, 9.3%) and one retouched/utilised flaked piece (n=1, 3.1%). The majority of artefacts were manufactured from white quartz (n= 30, 93.7%) and a small proportion from crystal quartz (n=2, 6.2%). All artefacts were small in size, weighing between <0.1g and 1.3g with a median weight of 0.4 g. See Appendix 9.

Plate 24. Site MJ-02, view southwest



Plate 25. Site MJ-02, view southwest



Plate 26. Site MJ-02, view northeast, artefacts around base of tree



Plate 27. Site MJ-02, view of artefact bearing depression around base of tree



Plate 28. Site MJ-02, artefacts on southwest side of tree



Plate 29. Site MJ-02, artefacts on southwest side of tree



Plate 30. Site MJ-02, artefacts in depression on southwest side of tree



Plate 31.. MJ-02 retouched/utilised flaked piece, dorsal face



Plate 32. MJ-02 retouched/utilised flaked piece, ventral face



Subsurface extent

Four probe holes were dug across the site on a north–south orientation to determine the extent of subsurface artefacts, see Table 12. The probe hole tests indicated that subsurface artefacts extended across the southeast side of the sand hill over an area of 117 m (north–south) by 103 m (east–west), centred on the Marri tree under which the surface artefacts were originally identified. Additional probe holes were not dug due to time constraints. When the hand excavated test square was dug it was initially thought that MJ-02 and MJ-04 may have constituted a single site, however, it was subsequently determined through the probe holes dug at MJ-04 and results from Excavator trench K that these two sites are in fact separate discrete sites. See Figure 19.

The three probe holes located within the raised sand hill landform all displayed the sample stratigraphic profile, comprising light grey sand overlain by a thin humic brown layer. The probe hole dug below the raised landform within the alluvial soils consisted of compact clayey silt that was extremely hard to excavate.

Table 12. Probe hole data for MJ-02

Probe hole	Artefact present	Depth	Notes
2PS70	No	120mm	Dark orangey brown compact hard clayey silt
2PS60	Yes	560mm	Thin humic layer over white sand grading to orange
2PS30	Yes	540mm	Thin humic layer over white sand grading to orange
2PN60	Yes	570mm	Thin humic layer over white sand grading to orange

Plate 33. MJ-02 probe hole, with dark humic layer over light grey sand grading into orange with depth



Plate 34. MJ-02 probe hole 2PS70, compact clayey deposit found near the drainage channel at the bottom of the sandy rise



Subsurface deposit

One hand excavated test pit (Test square B) was dug within MJ-02 and one mechanically excavated trench (Excavator trench K) was dug adjacent to MJ-02, to determine the nature of subsurface deposit.

Test square B

Test Square B was dug on the 9 January 2013, by the whole excavation team. This test square was located close to the tree where the artefacts identify this site were originally found and was dug in 8 spits to a depth of 800 mm. The upper 200 mm consisted of a grey mottled humic sandy deposit with grass root activity. Between 200 mm and 700 mm depth the deposit consisted of yellow sand containing a number of larger tree roots. Below 700 mm the deposit graded into an orange-coloured sand. Artefacts were recovered from spits 1 to 3 and spits 5 and 6. Artefacts were therefore identified within Test square B above 600 mm in depth and only within the yellow sand. Test square B was abandoned at 800 mm depth due to the instability of the pit walls and the lack of artefacts within lowermost spits.

Plate 35. MJ-02 test square B, upper spits showing the darker humic layer above the pale yellow sand



Plate 36. MJ-02 test square B, western section showing the darker humic layer over the pale yellow sand and root activity throughout the pit



Excavator trench K

Excavator trench K was excavated on 23 January 2013. The trench was located at the centre of the sand hill between MJ-02 and MJ-04 (see Figure 21) and was dug to a depth of 2.1 metres. Artefacts were identified in spit 5 (410–520 mm depth), spit 12 (1200–1320 mm) and spit 13(1320–1460 mm). This was the only location within the project area where artefacts were identified within the orange-coloured sand deposits.

The stratigraphy evident within Excavator trench K was as follows:

- an upper humic layer of dark brown sandy deposit;
- an orange sand grading from light orange to dark orange at depth.

The stratigraphy identified in the excavator trench linked up with stratigraphy noted in both the MJ-02 and MJ-04 sites. Whilst the depths of the layers vary between the test squares and excavator trench, there appears to be two distinct layers of a brown, upper humic layer resulting from historic farming practices and a deeper sandy layer comprising the hill or dune formation

which grades from a light grey or orange sand to a darker orange colour at depth. As there was no noted clear break in the colour gradation, the sand is considered to be one deposit.

The pH levels within Excavator trench K were consistent at 6.5 (acidic). Comparison of soil samples against the Munsell (2009) soil colour chart indicated that the three upper spits displayed some colour variation whilst the lower ten spits were consistent in colour. Sands within Excavator trench K were also consistently medium-course to medium sand. See Table 13 for details.

Table 13. Summary of soil samples from Excavator trench K

Spit	pH	Munsell	Comments
1	6.5	10YR5/2	Medium-coarse sand
2	6.5	10YR7/3	Medium-coarse sand
3	6.5	10YR7/4	Medium-coarse sand
4	6.5	10YR6/6	Medium-coarse sand
5	6.5	10YR6/6	Medium-coarse sand
6	6.5	10YR6/6	Medium-coarse sand
7	6.5	10YR6/6	Medium-coarse sand
8	6.5	10YR6/6	Medium-coarse sand
9	6.5	10YR6/6	Medium sand
10	6.5	10YR6/6	Medium sand
11	6.5	10YR6/6	Medium sand
12	6.5	10YR6/6	Medium sand
13	6.5	10YR6/6	Medium sand
14	6.5	10YR6/6	Medium sand

Plate 37. Excavation of Excavator trench K



Plate 38. Excavator trench K, base of trench showing sand grading from orange to light yellow



Subsurface assemblage

Approximately 2.8 m^3 was excavated at MJ-02 and 55 artefacts were recovered from its subsurface deposit[14]. Twenty four artefacts were recovered from test square B, six from the probe holes, and 25 from Excavator trench K, see Appendix 9. Based on the density from the test square, it is estimated that the subsurface artefact density is approximately 20 artefacts per cubic meter.

In the test square artefacts were mainly concentrated in spits 1, 2 and 3 (0–300 mm depth), with single artefacts being located in spits 5 and 6 (between 400–600 mm depth). No artefacts were recovered from the test pit below 600 mm, however, artefacts were located in the excavator trench down to a depth of 1460 mm.

Artefact types recovered from the subsurface deposit comprised flaked pieces (n=23, 41.8%), debris (n=18, 32.7%), flakes (n=7, 12.7%), transversely broken flakes (n=5, 9%), a multiple platform core (n=1, 1.8%) and a retouched/utilised flaked piece (n=1, 1.8%). No formal tools were identified within the assemblage. Only two of the artefacts recovered from MJ-02 were observed to have cortex, indicating that the majority of the assemblage comprises tertiary or late stage reduction artefacts associated with trimming and resharpening tools or bifacial reduction activities.

Artefact lithologies were dominated by quartz and included white quartz (n=38, 69.1%), crystal quartz (n=16, 29.1%) and one piece of smokey quartz (n=1, 1.8%). The smokey quartz was located in Excavator trench K within spit 5 (410–520 mm depth). Both white quartz and crystal quartz appear at all depths throughout the subsurface deposit.

The majority of the subsurface artefacts from MJ-02 were small in size and light in weight. In total, 34 artefacts (61.8%) weighed <0.1g and 17 artefacts (30.9%) weighed between 0.1g and 0.3g. The heaviest artefact recovered was a core at 4.2g. The average weight of subsurface artefacts was 0.25g.

The length of subsurface artefacts at MJ-02 were all less than 20 mm, with the majority (n=41, 74.6%) measuring less than 10 mm. Due to the small sample size it is difficult to detect any

[14] Including from the test square, excavator trench and probe holes. Note that only a portion of the excavator trench and probe hole sediments were sieved, whilst all of the sediment from the test excavation was sieved.

trends in variation in artefact size over time and there appears to consistently be small artefacts at all depths, therefore indicating a lack of obvious size sorting between spits.

Comparison of surface and subsurface assemblages

Overall, the surface and subsurface assemblages from MJ-02 show a strong correlation with each other. The surface and subsurface assemblages were very similar in composition in terms of density, lithologies, artefact types and artefact weight, see Table 14 and Table 15.

The main points of difference between the surface and subsurface assemblages included the absence of smokey quartz within the surface assemblage, a higher percentage of debris in the surface assemblage whilst flaked pieces were more common subsurface and slightly higher diversity within the subsurface assemblage with regards to artefact type, platform and termination types, see Table 16.

Table 14. MJ-02, comparison of surface and subsurface artefact types and raw material types

Debris	59.3%	32.7%	White Quartz	93.7%	69.0%
Flaked Piece	28.1%	41.8%	Crystal Quartz	6.2%	29.0%
Flake	9.3%	12.7%	Smokey Quartz	0%	1.8%
Retouched Flaked Piece	3.1%	1.8%			
TBF	0.0%	9.0%			
Core	0.0%	1.8%			

Table 15. MJ-02, comparison of surface and subsurface artefact weight and length

0-5g	32	55	0-5mm	0	11
Total	32	55	5-10mm	19	30
			10-15mm	9	12
			15-20mm	3	2
			20-25mm	1	0
			Total	32	55

Table 16. MJ-02, comparison of surface and subsurface artefact platform and termination types

Faceted	1	4	Feather	3	4
Flaked	2	7	Stepped	0	3
Focalised	0	1	Total	3	7
Total	3	12			

5.2.5 Site interpretation

The majority of MJ-02 comprises subsurface deposit with only a small proportion of it being exposed on the surface around the base of a large tree. These artefacts have likely been exposed by burrowing around the base of the tree by stock such as sheep and cattle.

Based on the dominance of debris and flaked pieces in the site's assemblage, the absence of formal tools, artefact density, small size of the debitage and late stage reduction evident within the assemblage, it is likely that MJ-02 represents a short term camp site where activities such as core reduction and tool trimming and re-sharpening were undertaken. As residue analysis was not undertaken it is difficult to ascertain whether plant or faunal processing activities were also undertaken on the site. Plant and animal resources would have been readily available within the surrounding plausiplain wetland.

The low–moderate level of artefact diversity, low level of raw material diversity and MJ-02's proximity to an ephemeral rather than permanent water source suggest that the site would have been visited only occasionally and possibly for short periods of time, reflecting high residential mobility within the area. The presence of smokey quartz within the assemblage may point to some spatial and temporal connection between MJ-02 and other sites within the local region containing the material including MJ-01, MJ-06 and MJ-07.

No radiocarbon dating was undertaken at MJ-02, however, utilising a combination of Hallam (1987) and Schwede's (1990) relative dating scheme for the Swan Coastal Plain, MJ-02 can be classified as 'Late Phase' with an estimated date range of 0–3000 BP, due to its quartz rich assemblage and high proportion of waste flakes.

All of the quartz material at MJ-02 was procured elsewhere and brought onto site. It is likely that the various forms of quartz were obtained from veins within the Darling Scarp and/or Plateau, indicating that the people utilising MJ-02 would have ranged between the Darling Plateau and the Swan Coastal Plain. The relatively large amount of artefacts with complex platforms, indicating preparation of materials prior to flaking, also implies that raw materials were being conserved during the occupation of MJ-02.

5.2.6 Statement of archaeological significance

MJ-02 is a medium sized artefact scatter with subsurface deposit, situated on the southern slope of a Bassendean sand dune above an ephemeral water course. During the wet months the dune would have also been surrounded by inundated wetland. MJ-02 can be classified as 'Late Phase', according to Hallam (1987) and Schwede's (1990) relative dating scheme, with occupation dating between 0 and 3000 BP. MJ-02 represents a short term camp site, where people undertook core reduction and tool maintenance activities on an ephemeral basis. The site may have some spatial and temporal relation to other sites within the local region including MJ-01, MJ-06 and MJ-07.

MJ-02 is assessed as being of importance and significance due to its archaeological and scientific values. The site possesses archaeological research potential as the data that has been collected from this site can contribute to a significant proportion of the research questions identified above in section 3.1, including questions 1–12 and 14–16, however, the collected data does not necessarily provide substantially different information to the existing Swan Coastal Plain knowledge base. The site has relatively good integrity, some ability to be placed within a relative temporal context and whilst it is not a rare site type, it is a good representative example of a Pinjarra Plains Late Phase open artefact scatter with subsurface deposit.

It is the opinion of the authors that MJ-02 constitutes a site within the meaning of section 5a of the *Aboriginal Heritage Act 1972*.

5.2.7 MJ-02 recommendations

It is **recommended** that Peet and its contractors are:

- advised of the existence and location of archaeological site MJ-02; and
- informed that MJ-02 may meet the requirements of section 5 of the *Aboriginal Heritage Act 1972* and therefore it should not be impacted upon in any way.

Should at any stage Peet wish to disturb MJ-02 and an application is made for consent to use the land under section 18 of the *Aboriginal Heritage Act 1972*, it is **further recommended** that:

- no further physical archaeological investigation of MJ-02 is required; and
- Peet consults with the appropriate Nyungar Elders and Aboriginal Consultants about any proposed section 18 application, mitigation and salvage strategies and the management of excavated and salvaged materials.

Figure 17. Summary of artefacts recorded within MJ-02

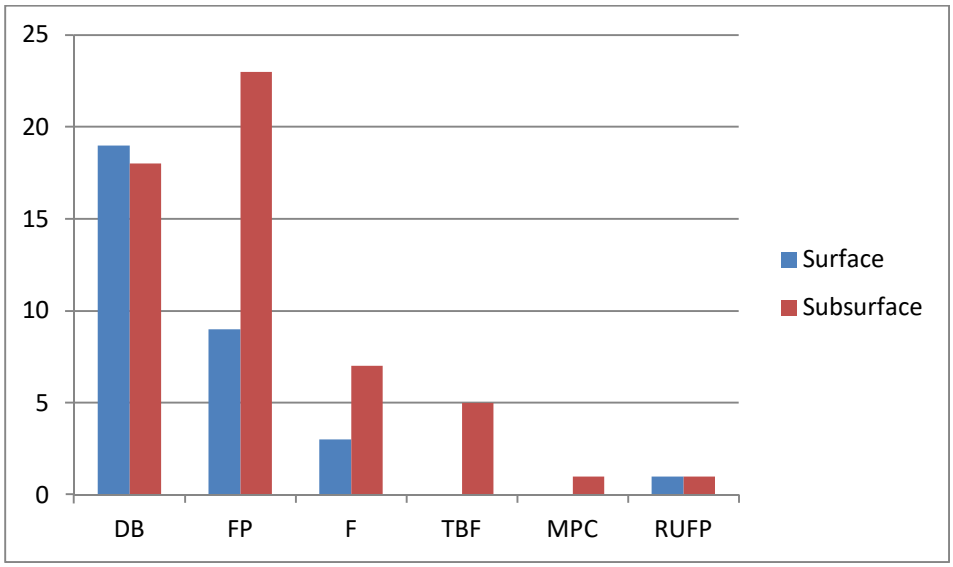
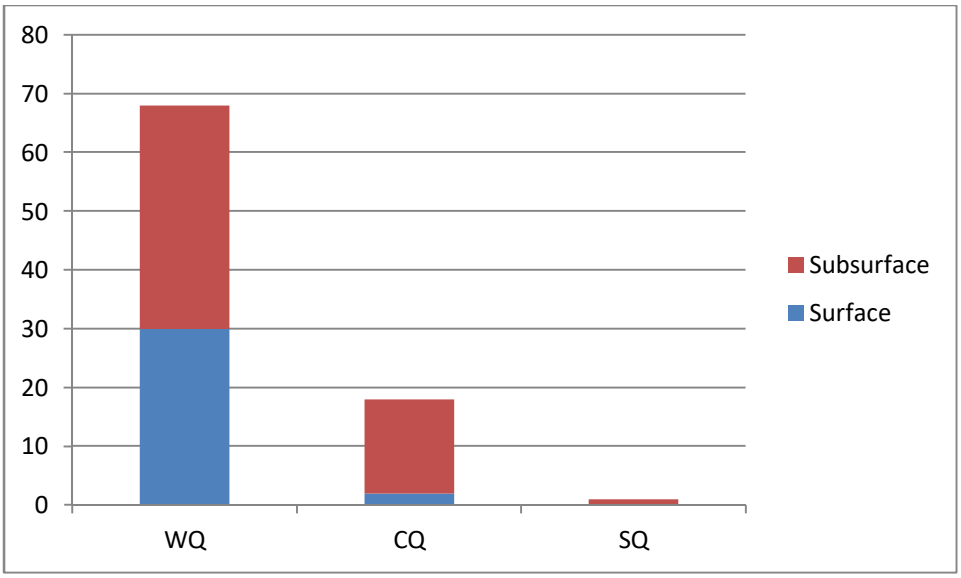


Figure 18. Summary of lithologies present within MJ-02 artefact sample



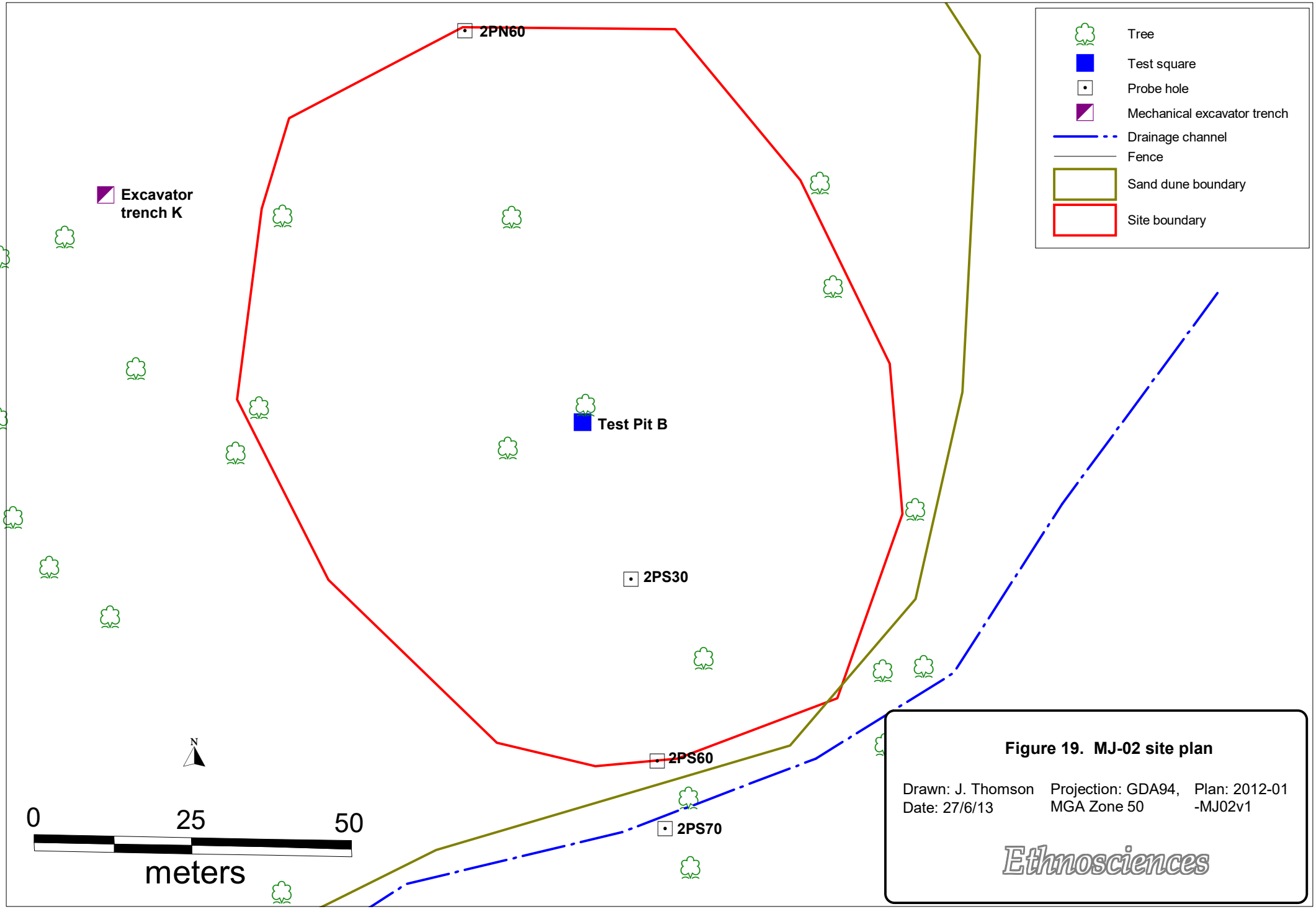


Figure 19. MJ-02 site plan

Drawn: J. Thomson
Date: 27/6/13

Projection: GDA94, MGA Zone 50

Plan: 2012-01 -MJ02v1

Ethnosciences

Figure 20. MJ-02 test square B section (drawn by D. Neuweger)

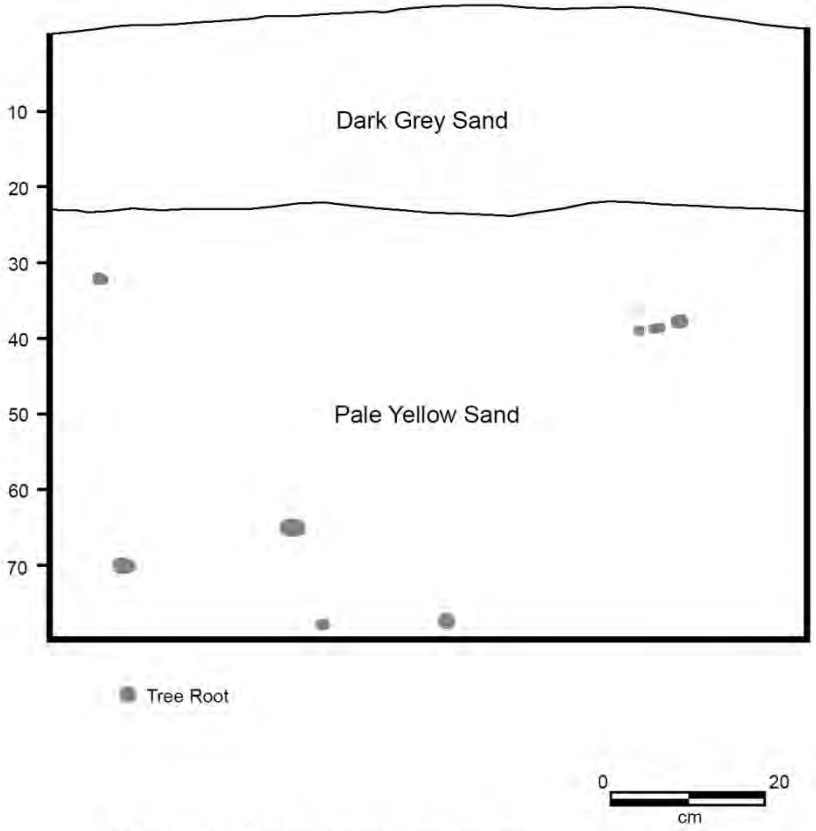




Figure 21. Sites MJ-04, MJ-02 and Excavator Trench K

Drawn: J. Thomson
Date: 27/06/13

Projection: GDA94, MGA Zone 50

Plan: 2012-01 -19v1

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5.3 MJ-03 – Artefact scatter with potential archaeological deposit

5.3.1 Grid References

The site's surface extent is bounded by the following coordinates.

1.	403050 mE	6428314 mN	5.	403032 mE	6428287 mN
2.	403066 mE	6428314 mN	6.	403028 mE	6428284 mN
3.	403064 mE	6428304 mN	7.	403027 mE	6428298 mN
4.	403053 mE	6428294 mN	8.	403035 mE	6428305 mN

5.3.2 Location

MJ-03 is located on the western border in the southwest quarter of Lot 98 Bishop Road, Mundijong. It is approximately 600 m west of Taylor Road and 160 m north of Scott Road. Site MJ-04 is located 240 m to the northeast, MJ-02 is located 350 m to the east and Aboriginal Site DAA Id 18187 Tonkin Highway – Mundijong Road Scatter #1 is located approximately 70 m to the south-southwest, within the same sandy rise. See Figure 11.

5.3.3 Environment

The artefact scatter is located on an elevated white sand lens above low-lying plausiplain. The rise has an elevation of approximately 26.5 m above sea level and the area around the site has been previously cleared, with a firebreak and pastoral fence having been constructed along the western boundary of the site. The ground surface comprises fine white sand and visibility at the time of recording ranged between 30-100%, with visibility being very high along the graded fire break track. See Plate 39 to Plate 46.

Manjedal Brook is located approximately 200 m to the north of the site. The surrounding low-lying plausiplain would have been inundated seasonally during the winter months.

5.3.4 Description

MJ-03 is a small stone artefact scatter with potential archaeological deposit. Only the surface component of the site has been recorded to date, the site's subsurface potential was not tested during the section 16 excavations due to time constraints and because the site is located within a service corridor outside the designated footprint for Peet's proposed residential development and hence will not be impacted by Peet's proposed activities. The following site description is based on the surface component only.

MJ-03 comprises a low density artefact scatter with a medium level of raw material diversity. Artefacts were identified over an area of 38 m (east–west) by 22 m (north–south), or 663 sq m, and have been exposed by the grading of a fire break or track and subsequent erosion. All visible surface artefacts were recorded and ten artefacts were recorded in total.

Based on the data collected from the site, the average artefact density is low (0.015/sq m). Artefact types recorded within the site comprised flaked pieces (n=6, 60 %) and flakes (n=4, 40%). All artefacts were manufactured from quartz, including white quartz (n= 7, 70%), crystal quartz (n=2, 20%) and pink quartz (n= 1, 10%). The majority of artefacts were small in size (less than 0.6g in weight and median length of 10.5 mm) and no retouch was noted. See Appendix 9 and Figure 22 to Figure 24.

Based on the nature of the landform unit within which MJ-03 is situated and the results of the section 16 subsurface excavation of other sites within the vicinity including MJ-02 and MJ-04, there is high potential for MJ-03 to contain subsurface deposit. Subsurface testing is required to

confirm the presence or absence and extent of any subsurface deposit, particularly outside the visible surface expression of artefacts as well as any potential association between MJ-03 and Aboriginal Site DAA Id 18187 Tonkin Highway – Mundijong Road Scatter #1 which is located within the same white Bassendean sand landform unit.

5.3.5 Site interpretation

Current site interpretation is based on the consideration of the surface component of MJ-03 only and it should be noted that subsurface excavation may reveal a more complex site occupation history.

Based on the low number of artefacts, the dominance of debitage within the assemblage, the absence of the absence of formal tools or retouched pieces and the low artefact density, MJ-03 is interpreted as representing either the by-products of task-specific activities or a short-term or relatively infrequently utilised occupation site, reflective of high residential mobility. The assemblage at this site reflects a technological process of on-site manufacture of cores and/or other artefacts prior to their removal and use in other parts of the landscape, leaving the discarded debitage component behind. Following Hallam's (1987) and Schwede's (1990) relative dating schemes, the site could be classified as a Late Phase site as it is comprised of a quartz rich assemblage with a high proportion of waste flakes.

5.3.6 Statement of archaeological significance

This statement of significance is based upon the consideration of the surface component of the site only. The significance of the site may change when due consideration is given to the potential subsurface deposit.

MJ-03 is a small stone artefact scatter with potential archaeological deposit situated on a Bassendean sand dune above seasonally inundated plausiplain wetlands. MJ-03 can be classified as 'Late Phase', according to Hallam (1987) and Schwede's (1990) relative dating scheme, with occupation dating between 0 and 3000 BP. MJ-03 represents a task-specific activity area, where people undertook core reduction and tool maintenance activities, or a short-term or relatively infrequently utilised occupation site.

MJ-03 is assessed as being of importance and significance at a local level due to its archaeological and scientific values. The site possesses archaeological research potential as the data that has been collected from this site can contribute to research questions identified above in section 3.1, including questions 1 – 9 and 11, however, the collected data does not necessarily provide substantially different information to the existing Swan Coastal Plain knowledge base. The site has reasonable integrity, some ability to be placed within a relative temporal context and whilst it is not a rare site type, it is a fair representative example of a Pinjarra Plains open artefact scatter with subsurface deposit.

It is the opinion of the authors that MJ-03 constitutes a site within the meaning of section 5a of the *Aboriginal Heritage Act 1972*.

5.3.7 MJ-03 recommendations

It is **recommended** that Peet and its contractors are:

- advised of the existence and location of archaeological site MJ-03; and
- informed that MJ-03 may meet the requirements of section 5 of the *Aboriginal Heritage Act 1972* and therefore it should not be impacted upon in any way.

Should at any stage Peet wish to disturb MJ-03 and an application is made for consent to use the land under section 18 of the *Aboriginal Heritage Act 1972*, it is **further recommended** that:

- the potential for, extent and nature of any subsurface archaeological deposit be assessed, and a new statement of significance be developed prior to submitting the section 18 notice; and
- Peet consults with the appropriate Nyungar Elders and Aboriginal Consultants about any proposed section 18 application, mitigation and salvage strategies and the management of any salvaged materials.

Figure 22. Summary of artefacts recorded within MJ-03

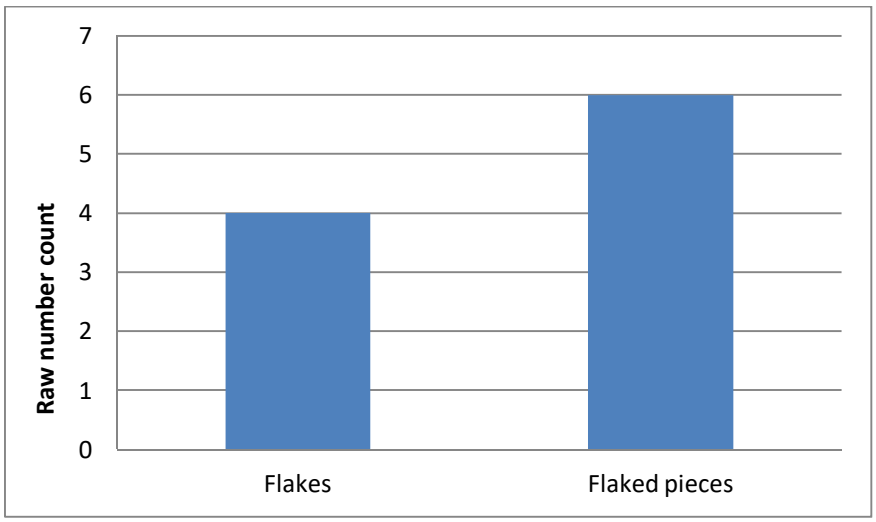


Figure 23. Summary of lithologies present within MJ-03 artefact sample

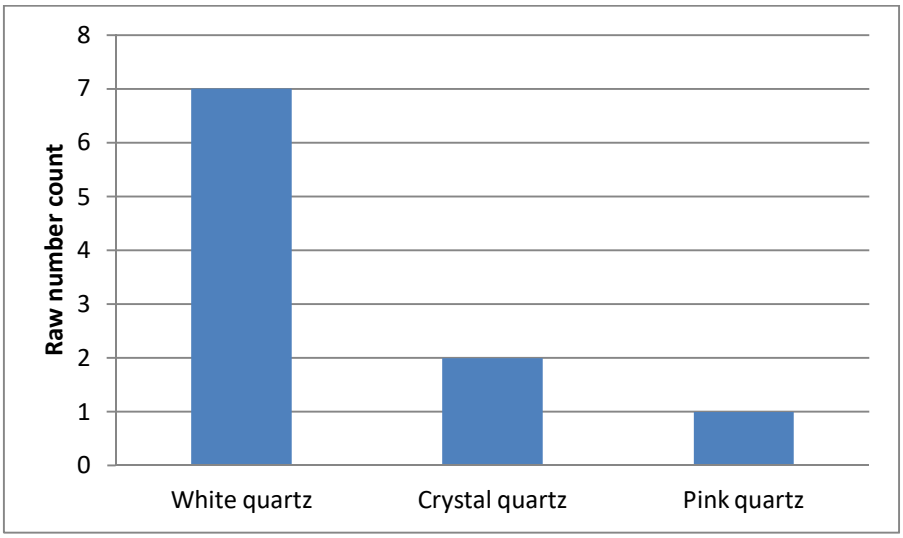


Figure 24. MJ-03 recorded artefact weights

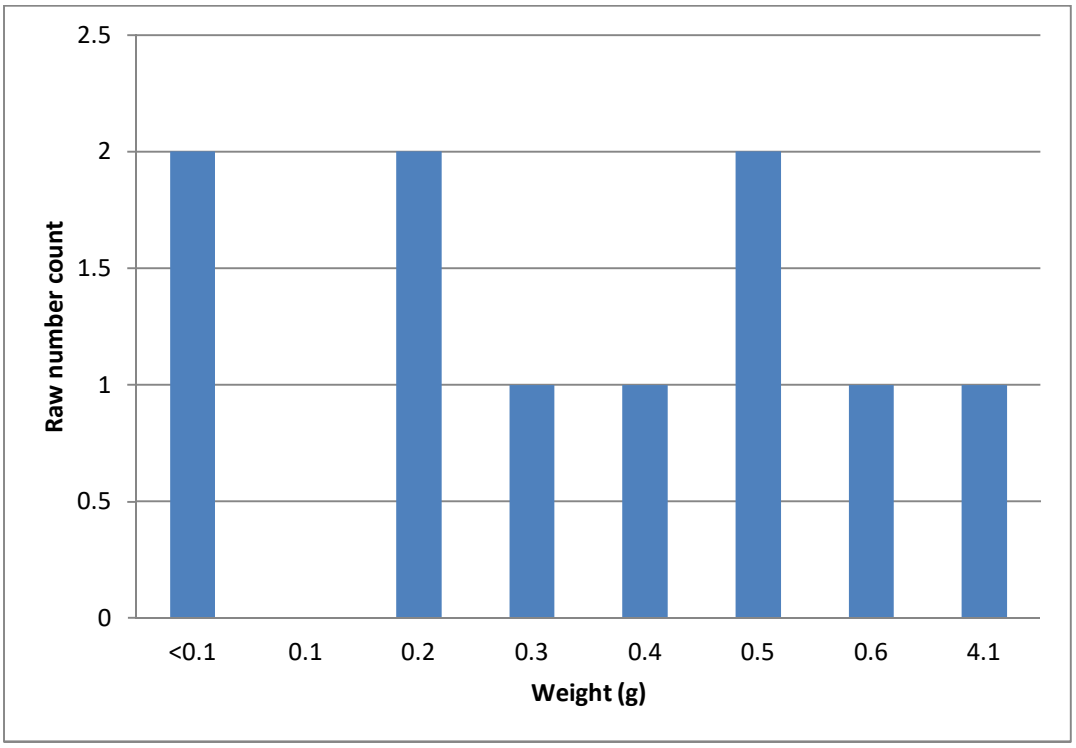


Plate 39. Site MJ-03 view northwest



Plate 40. Site MJ-03, view west



Plate 41. Site MJ-03, view west-southwest



Plate 42. Site MJ-03, view east



Plate 43. Site MJ-03, flaked quartz artefact

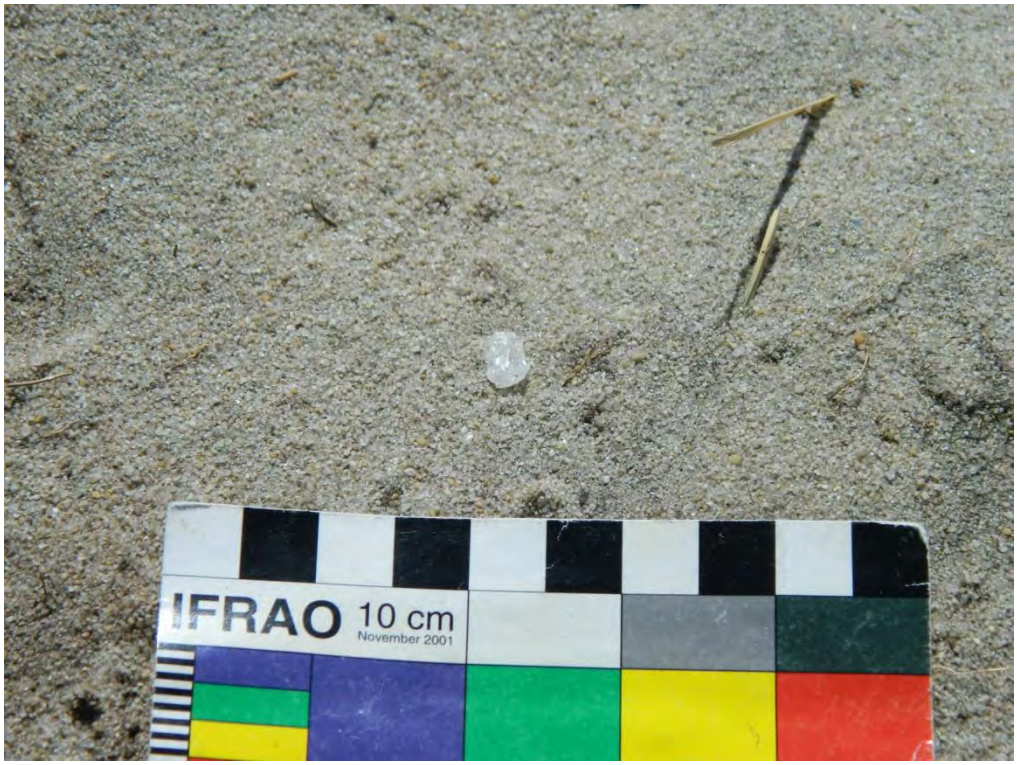


Plate 44. Site MJ-03, two quartz flakes



Plate 45. Site MJ-03, quartz flaked artefact



Plate 46. Site MJ-03, flaked quartz artefact



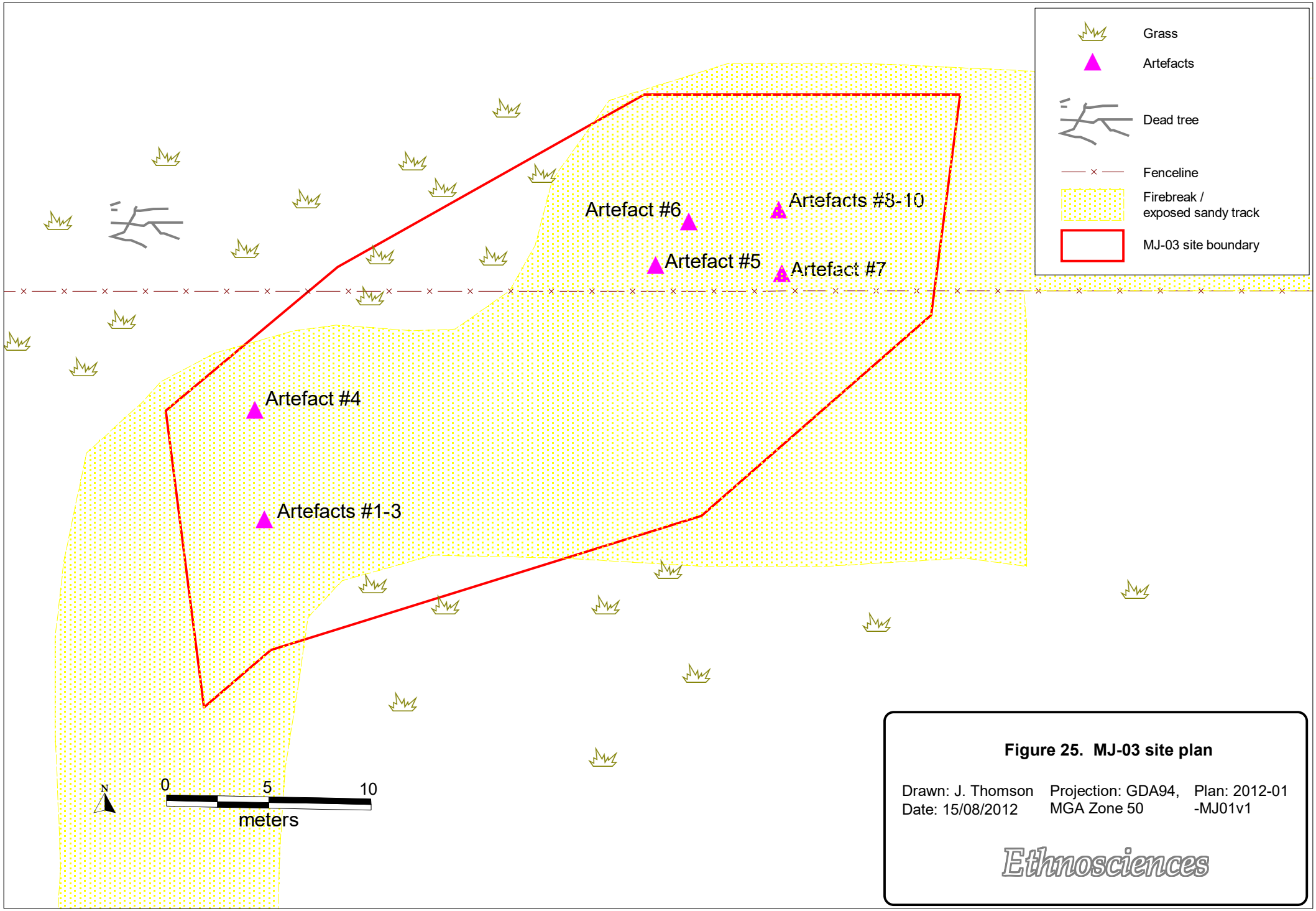


Figure 25. MJ-03 site plan

Drawn: J. Thomson
Date: 15/08/2012

Projection: GDA94, MGA Zone 50

Plan: 2012-01 -MJ01v1

Ethnosciences

5.4 MJ-04 – Artefact scatter with archaeological deposit

5.4.1 Grid References

The site extents are bounded by the following coordinates.

1.	403305 mE	6428395 mN	10.	403330 mE	6428375 mN
2.	403312 mE	6428398 mN	11.	403327 mE	6428360 mN
3.	403317 mE	6428398 mN	12.	403322 mE	6428350 mN
4.	403320 mE	6428393 mN	13.	403315 mE	6428350 mN
5.	403337 mE	6428395 mN	14.	403305 mE	6428358 mN
6.	403347 mE	6428395 mN	15.	403297 mE	6428373 mN
7.	403345 mE	6428388 mN	16.	403295 mE	6428385 mN
8.	403337 mE	6428385 mN	17.	403297 mE	6428388 mN
9.	403330 mE	6428383 mN			

Test square C was located at:
403314 mE 6428389 mN

The probe holes were located at the following coordinates.

4PW60	403263 mE	6428388 mN
4PW30	403289 mE	6428388 mN
4PW20	403297 mE	6428388 mN
4PN10	403313 mE	6428398 mN
4PE10	403324 mE	6428389 mN
4PE20	403335 mE	6428389 mN
4PE30	403345 mE	6428389 mN
4P340	403355 mE	6428390 mN
4PE50	403365 mE	6428390 mN
4PE60	403375 mE	6428391 mN
4PS40	403320 mE	6428352 mN
4PS60	403321 mE	6428330 mN

5.4.2 Location

MJ-04 is located in the centre of Lot 98 Bishop Road, Mundijong. It is approximately 340 m west of Taylor Road and 260 m north of Scott Road. Site MJ-02 is located within the same sandy rise, approximately 110 m to the southeast and MJ-03 is located 240 m to the southwest. See Figure 11.

5.4.3 Environment

The artefact scatter is located on the northern edge of a large, low, white sandy rise above low-lying plausiplain. The site has an elevation of approximately 28 m above sea level. The area around the site has been previously cleared, with a firebreak and pastoral fence having been constructed through the site. The ground surface comprises fine white sand and visibility at the time of recording ranged between 80-100%, with visibility being very high along the graded fire break track. See Plate 47 to Plate 54.

Manjedal Brook is located approximately 160 m to the north of the site. The surrounding low-lying plausiplain would have been inundated seasonally during the winter months.

5.4.4 Description

MJ-04 is a small sized artefact scatter with subsurface deposit. MJ-04's surface exposure covers an area of 36 m (east–west) by 13 m (north–south), or 303 sq m, and artefacts have been exposed by the grading of a fire break and subsequent erosion. The site's subsurface extent is 50 m (north–south) by 35 m (east–west), covering an area of approximately 1,342 sq m. The site has a low artefact density and a medium level of raw material diversity.

Surface component

MJ-04 was originally noted as a very small exposure of quartz artefacts located along a graded fire break adjacent to a paddock fence within Lot 98. The artefacts were visible over an area of 36 m (east–west) by 13 m (north–south) along the firebreak and five artefacts were recorded.

Based on the surface data collected from the site, the average surface artefact density is low (0.013/sq m). Artefact types recorded on the surface comprised flaked pieces (n=2, 40%), a flake (n=1, 20%), a transversely broken flake (n=1, 20%) and debris (n=1, 20%). All artefacts were manufactured from quartz, including white quartz (n= 3, 60%) and crystal quartz (n=2, 40%). The majority of artefacts were small in size (less than 0.7g in weight and median length of 9.8 mm) and no retouch was noted. See Appendix 9.

Plate 47. Site MJ-04, view northwest



Plate 48. Site MJ-04, view east

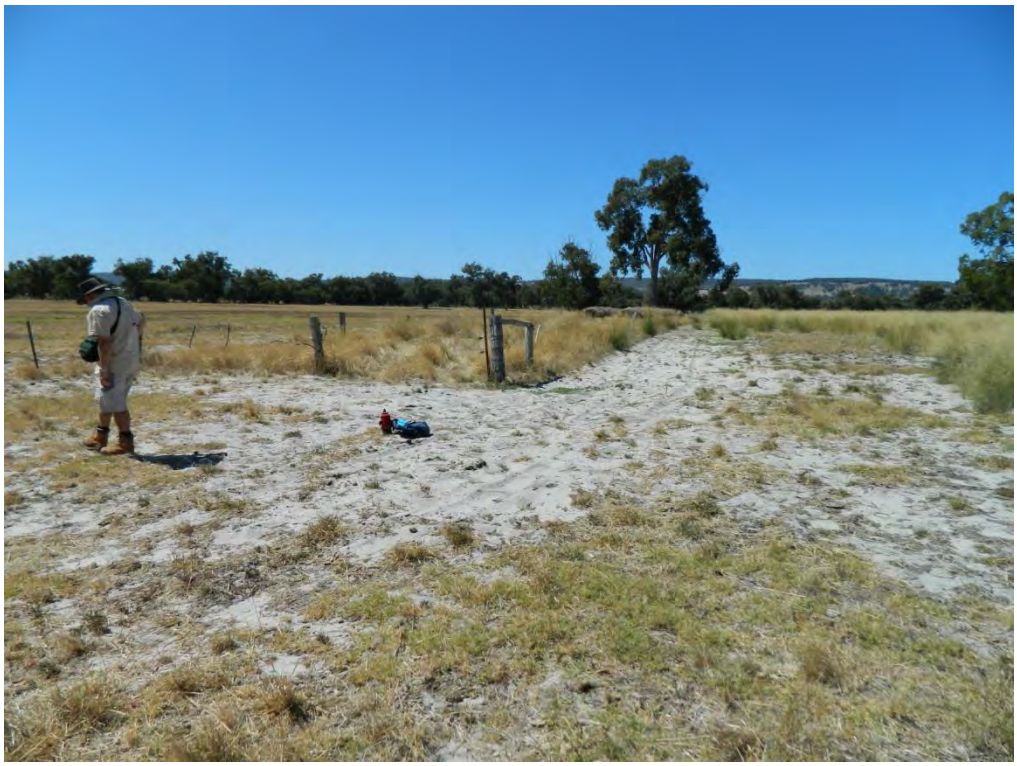


Plate 49. Site MJ-04, view west-northwest



Plate 50. Site MJ-04, view west



Plate 51. Site MJ-04, view north-northeast



Plate 52. Site MJ-04, quartz transversely broken flake



Plate 53. Site MJ-04, crystal quartz flaked piece



Plate 54. Site MJ-04, crystal quartz artefacts



Subsurface extent

Twelve probe holes were dug across the site on north–south and east–west orientations to determine the extent of subsurface artefacts, see Table 17. The results of the probe holes indicated that MJ-04 is a relatively small discrete site, extending over an area of approximately 50 m (north–south) by 35 m (east–west) on the northern flank of the sandy rise. At the time of excavation of the hand dug test squares it was originally thought that MJ-04 and MJ-02 may have constituted a single site, however, it was subsequently determined through the probe holes dug at MJ-04 and results from Excavator trench K that these two sites are in fact separate discrete sites. See Figure 19.

All of the probe holes contained the same stratigraphy, comprising a dark humic layer with grass roots overlying a white sand layer.

Table 17. Probe hole data for MJ-04

Probe hole	Artefact present	Depth	Notes
4PE60	No	710mm	Thin humic layer over white sand grading to an orange sand
4PE50	No	400mm	Thin humic layer over white sand grading to an orange sand
4PE40	No	440mm	Thin humic layer over white sand grading to an orange sand
4PE30	No	300mm	Thin humic layer over white sand grading to an orange sand
4PE20	No	410mm	Thin humic layer over white sand grading to an orange sand
4PE10	Yes	380mm	Thin humic layer over white sand grading to an orange sand
4PS60	No	-	Thin humic layer over white sand grading to an orange sand
4PS40	Yes	430mm	Thin humic layer over white sand grading to an orange sand
4PW30	No	380mm	Thin humic layer over white sand grading to an orange sand
4PW20	Yes	380mm	Thin humic layer over white sand grading to an orange sand
4PN10	No	370mm	Thin humic layer over white sand grading to an orange sand

Plate 55. MJ-04 probe hole, small humic layer overlying sand grading from grey into yellow



Subsurface deposit

One hand excavated test pit (Test square C) was dug within MJ-04 to determine the nature of subsurface deposit.

Test square C

Test square C was dug on the 10 January 2013, by the whole excavation team. The test square was located on the firebreak close to where the surface artefacts were originally identified and was dug in 8 spits to a depth of 800 mm. The upper 100 mm of deposit consisted of a loosely consolidated, grey and white-mottled humic sandy deposit with some vegetable matter present. From 200 mm to 700 mm depth the deposit consisted of damp yellow sand which dried to white in colour. Below 700 mm depth the deposit became orange-coloured sand. It was noted that the stratigraphy at MJ-04 is very similar to MJ-02. Artefacts were recovered from spits 1 to 5, and above 500 mm depth. Test square C was abandoned at 800 mm depth due to the instability of the pit walls and the lack of artefacts within lowermost spits.

Plate 56. MJ-04 test square C prior to excavation, located on unconsolidated sand along firebreak

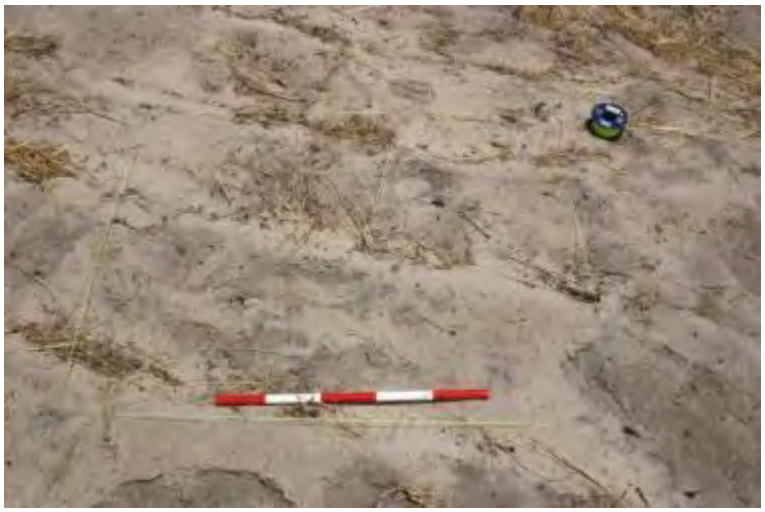


Plate 57. MJ-04 test square C, base of excavation, showing loose dark humic layer overlying light yellow–white sand



Subsurface assemblage

In total, approximately 2 m^3 was excavated at MJ-04 and 34 artefacts were recovered from its subsurface deposit. Twenty seven artefacts were recovered from test square C and seven artefacts were recovered from the probe holes, see Appendix 9. Based on the density from the test square, it is estimated that the subsurface artefact density is approximately 17 artefacts per cubic meter.

In the test square artefacts were distributed fairly evenly across spits 1 through to 5 (0–500 mm depth), with a slightly higher number of artefacts being located in spit 1. No artefacts were recovered from the test pit below 500 mm.

Artefact types recovered from the subsurface deposit comprised debris (n=17, 50%), flaked pieces (n=8, 23.5%), flakes (n=5, 14.7%), multiple platform cores (n=2, 5.9%), one transversely broken flake (n=1, 2.9%) and one manuport (n=1, 2.9). No formal tools were identified in the assemblage. Only one of the artefacts recovered from MJ-04 was observed to have any cortex, indicating that the remainder of the assemblage is comprised of tertiary or late stage reduction artefacts associated with trimming and resharpening tools or reduction activities.

Artefact lithologies were dominated by quartz and included white quartz (n=19, 55.9%), crystal quartz (n=13, 38.2%) and brown quartz (n=1, 2.9%). One dolerite manuport (n=1, 2.9%) was also

located from probe hole 4PE50. Both crystal quartz and white quartz occur continuously until spit 4 (depth of 400 mm) below which only white quartz was recovered. The one piece of brown quartz was recovered from spit 1, indicating it was used only in relatively recent times.

The majority of the subsurface artefacts from MJ-04 were small in size and light in weight. In total, 20 artefacts (60.6%) weighed <0.1g and nine artefacts (27.3%) weighed between 0.1g and 0.3g. The heaviest artefact recovered was a core at 8g, whilst the dolerite manuport (which was not included in the weight analysis) weighed 138.6g. The average weight of subsurface artefacts was 0.4g. The majority (n=32, 94.1%) of MJ-04's subsurface artefacts were less than 20 mm in length, with only two pieces (including the manuport) being of larger size. Due to the small sample size it is difficult to detect any trends in variation in artefact size over time and there appears to consistently be small artefacts at all depths, therefore indicating a lack of obvious size sorting between spits.

Comparison of surface and subsurface assemblages

Overall, the density of artefacts was higher within the subsurface component than within the surface exposure. The surface and subsurface assemblages were very similar in composition in terms of artefact types, raw material types and artefact size and weight, see Table 18.

The main points of difference between the assemblages were that there were a higher proportion of flaked pieces on the surface, there was a greater diversity of artefact types, lithologies, and platform and termination types subsurface and the subsurface assemblage contained heavier and longer artefacts. See Table 19 and Table 20.

Table 18. MJ-04, comparison of surface and subsurface raw material and artefact type

Artefact type	Surface	Subsurface	Raw material type	Surface	Subsurface
Flaked piece	40.0%	23.5%	White Quartz	60.0%	55.8%
Debris	20.0%	50.0%	Crystal Quartz	40.0%	38.2%
Flake	20.0%	14.7%	Brown Quartz	0%	2.9%
Transverse broken flake	20.0%	2.9%	Dolerite	0%	2.9%
Core	0%	5.8%			
Manuport	0%	2.9%			

Table 19. MJ-04, comparison of surface and subsurface artefact weight and length

Weight (g)	Surface	Subsurface	Length (mm)	Surface	Subsurface
0-5	5	32	0-5	1	11
5-10	0	1	5-10	2	11
135-140	0	1	10-15	1	8
Total	5	34	15-20	1	2
			30-35	0	1
			85-90	0	1
			Total	5	34

Table 20. MJ-04, comparison of surface and subsurface platform and termination types

Platform type	Surface	Subsurface	Termination type	Surface	Subsurface
Crushed	0	1	Feather	1	3
Faceted	1	0	Stepped	0	2
Flaked	1	3	Total	1	5
Focalised	0	2			
Total	2	6			

5.4.5 Site interpretation

Based on the dominance of debris and flaked pieces in the site's assemblage, the absence of formal tools, artefact density, small size of the debitage and late stage reduction evident within the assemblage, it is likely that MJ-04 represents an occupation site where activities such as core reduction and tool trimming and re-sharpening were undertaken. As residue analysis was not undertaken it is difficult to ascertain whether plant or faunal processing activities were also undertaken on the site. Plant and animal resources would have been readily available within the surrounding plausiplain wetland.

The low–moderate level of artefact diversity and low level of raw material diversity suggests that the site would have been visited only occasionally and possibly for short periods of time, reflecting high residential mobility within the area.

No radiocarbon dating was undertaken at MJ-04, however, utilising a combination of Hallam (1987) and Schwede's (1990) relative dating scheme for the Swan Coastal Plain, MJ-04 can be classified as 'Late Phase' with an estimated date range of 0–3000 BP, due to its quartz rich assemblage and high proportion of waste flakes.

All of the quartz material at MJ-04 was procured elsewhere and brought onto site. It is likely that the various forms of quartz were obtained from veins within the Darling Scarp and/or Plateau, indicating that the people utilising MJ-04 would have ranged between the Darling Plateau and the Swan Coastal Plain. The relatively large amount of artefacts with complex platforms, indicating preparation of materials prior to flaking, also implies that raw materials were being conserved during the occupation of MJ-04.

5.4.6 Statement of archaeological significance

MJ-04 is a small artefact scatter with subsurface deposit, situated on the southern slope of a Bassendean sand dune above an ephemeral water course. During the wet months the dune would have also been surrounded by inundated wetland. MJ-04 can be classified as 'Late Phase', according to Hallam (1987) and Schwede's (1990) relative dating scheme, with occupation dating between 0 and 3000 BP. MJ-04 represents a task-specific activity area, where people undertook core reduction and tool maintenance activities on an ephemeral basis.

MJ-04 is assessed as being of importance and significance at a local level due to its archaeological and scientific values. The site possesses archaeological research potential as the data that has been collected from this site can contribute to a significant proportion of the research questions identified above in section 3.1, including questions 1–12 and 14–16, however, the collected data does not necessarily provide substantially different information to the existing Swan Coastal Plain knowledge base. The site has moderate to good integrity, some ability to be placed within a relative temporal context and whilst it is not a rare site type, it is a representative example of a Pinjarra Plains Late Phase open artefact scatter with subsurface deposit.

It is the opinion of the authors that MJ-04 constitutes a site within the meaning of section 5a of the *Aboriginal Heritage Act 1972*.

5.4.7 MJ-04 recommendations

It is **recommended** that Peet and its contractors are:

- advised of the existence and location of archaeological site MJ-04; and
- informed that MJ-04 may meet the requirements of section 5 of the *Aboriginal Heritage Act 1972* and therefore it should not be impacted upon in any way.

Should at any stage Peet wish to disturb MJ-02 and an application is made for consent to use the land under section 18 of the *Aboriginal Heritage Act 1972*, it is **further recommended** that:

- no further physical archaeological investigation of MJ-04 is required; and
- Peet consults with the appropriate Nyungar Elders and Aboriginal Consultants about any proposed section 18 application, mitigation and salvage strategies and the management of excavated and salvaged materials.

Figure 26. Summary of artefacts recorded within MJ-04

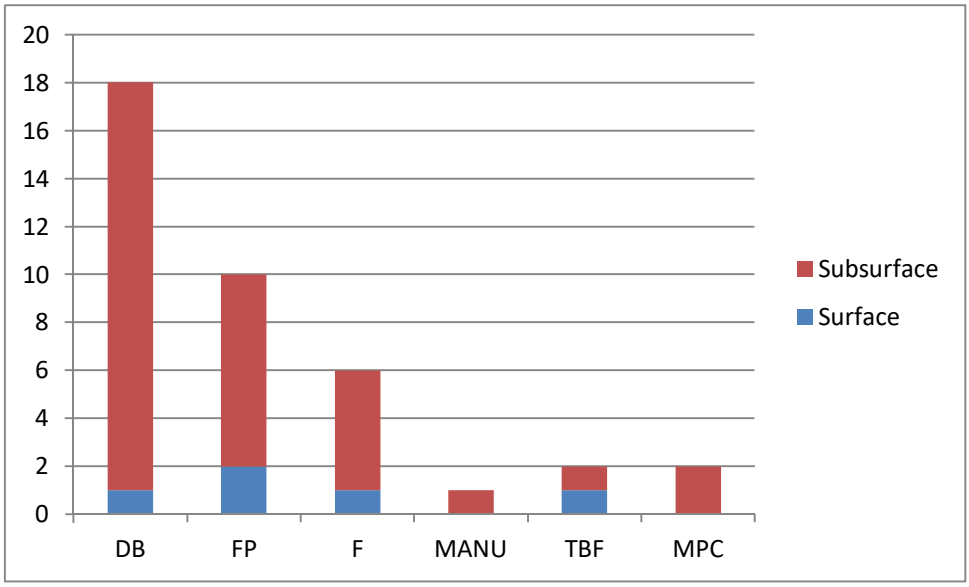
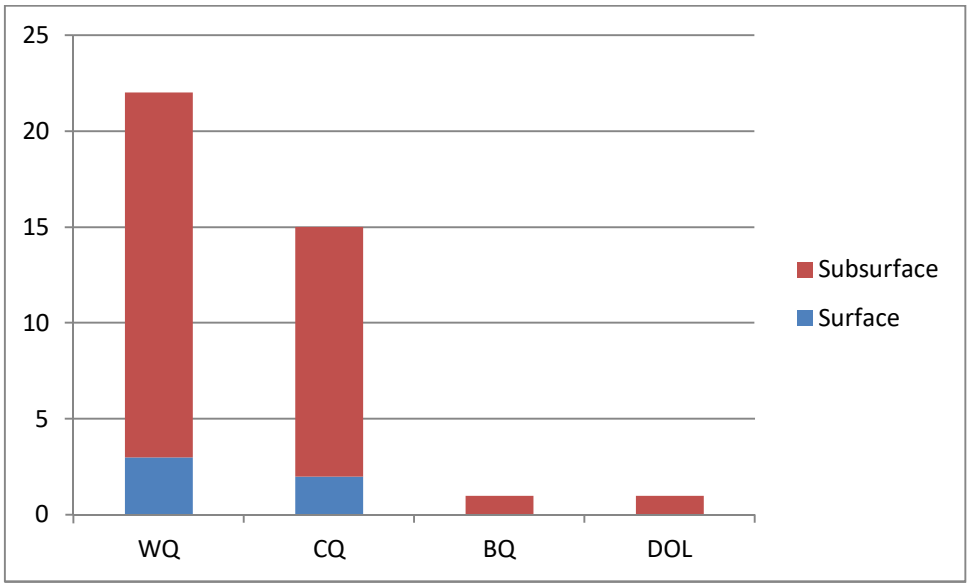


Figure 27. Summary of lithologies present within MJ-04



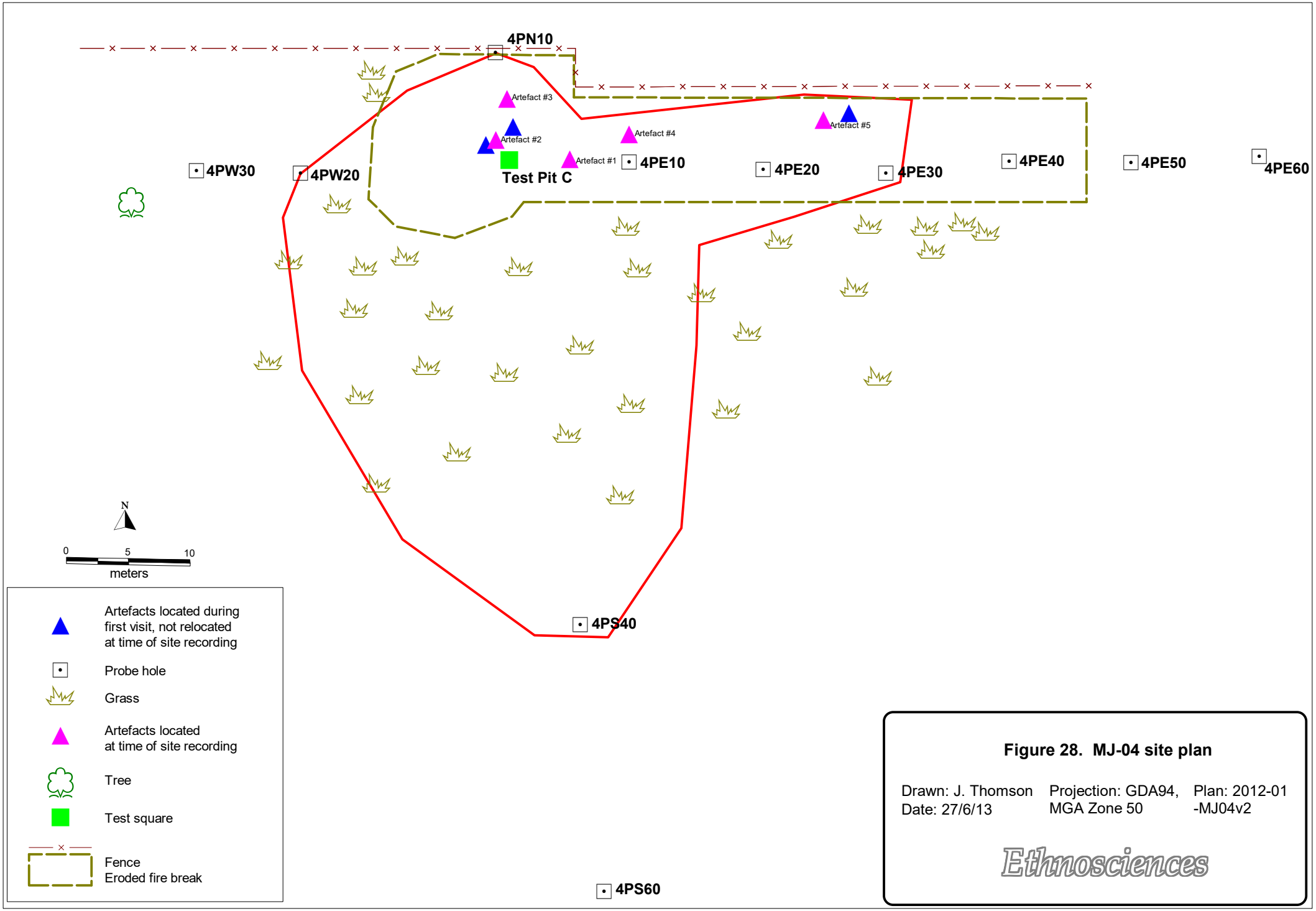


Figure 28. MJ-04 site plan

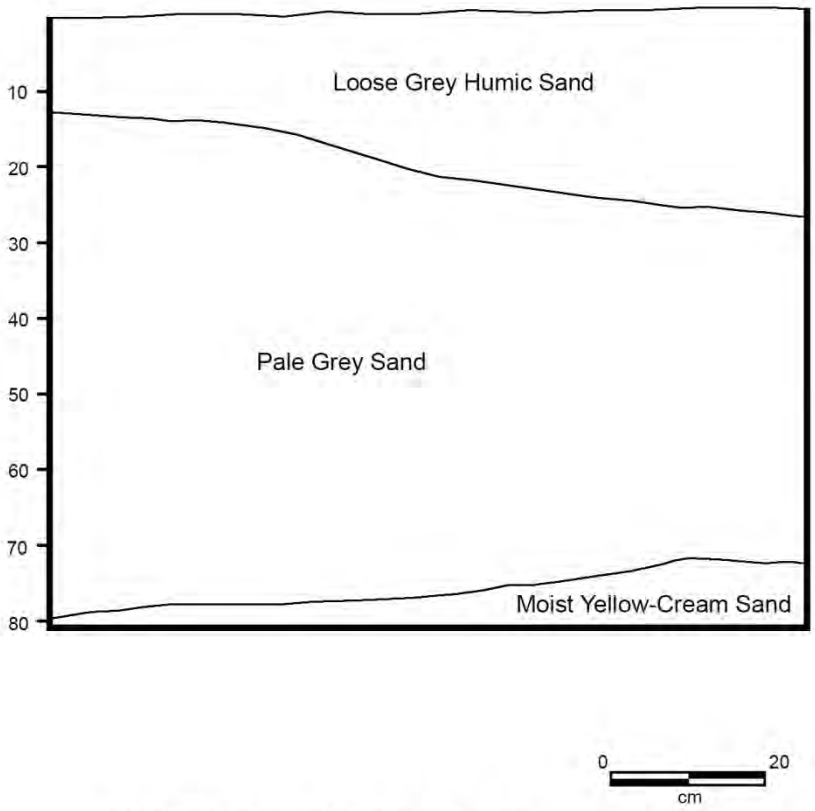
Drawn: J. Thomson
Date: 27/6/13

Projection: GDA94, MGA Zone 50

Plan: 2012-01 -MJ04v2

Ethnosciences

Figure 29. MJ-04 test square C section (drawn by D. Neuweger)



5.5 DAA Id 3648 Soldiers Road, Mundijong – Artefact scatter with archaeological deposit

This site description includes the newly identified extension to DAA Id 3648, previously referred to as **MJ-05** (see Thomson, 2012b, Thomson et al., 2012), as well as the previously recorded site DAA Id 3648 recorded by Hallam (1975) and Pearce (1979).

5.5.1 Grid References

The site extents are bounded by the following coordinates:

1.	404460 mE	6428688 mN	17.	404793 mE	6428305 mN
2.	404516 mE	6428690 mN	18.	404752 mE	6428299 mN
3.	404547 mE	6428659 mN	19.	404734 mE	6428302 mN
4.	404571 mE	6428624 mN	20.	404647 mE	6428380 mN
5.	404703 mE	6428619 mN	21.	404628 mE	6428400 mN
6.	404755 mE	6428628 mN	22.	404601 mE	6428434 mN
7.	404788 mE	6428629 mN	23.	404504 mE	6428412 mN
8.	404912 mE	6428621 mN	24.	404426 mE	6428380 mN
9.	404943 mE	6428621 mN	25.	404357 mE	6428384 mN
10.	404945 mE	6428617 mN	26.	404326 mE	6428397 mN
11.	404921 mE	6428549 mN	27.	404343 mE	6428417 mN
12.	404915 mE	6428398 mN	28.	404377 mE	6428440 mN
13.	404922 mE	6428278 mN	29.	404412 mE	6428475 mN
14.	404911 mE	6428267 mN	30.	404427 mE	6428519 mN
15.	404878 mE	6428277 mN	31.	404423 mE	6428590 mN
16.	404849 mE	6428301 mN	32.	404445 mE	6428635 mN

Test square D was located at:
404517 mE 6428584 mN

Mechanical Excavator trench G was located at:
404527 mE 6428601 mN

The probe holes were located at the following coordinates.

5PE60	404568 mE	6428589 mN
5PW60	404457 mE	6428588 mN
5PW90	404431 mE	6428588 mN
5PS150	404521 mE	6428375 mN
5PN90	404516 mE	6428674 mN
5PS90	404516 mE	6428498 mN

5.5.2 Location

DAA Id 3648 is located in the southeast corner of Lot 9000 Soldiers Road, immediately west of Soldiers Road, surrounding two freshwater lakes and north of Manjedal Brook. Site MJ-01 is located 110 m to the northwest and the two modified trees (MJ-08 and MJ-09) are located approximately 60 m and 170 m respectively to the south of DAA Id 3648, on the southern side of Manjedal Brook. See Figure 11.

The DAA AHIS location for this site appears to be in the wrong location, as it depicts DAA Id 3648 as being located to the south of Manjedal Brook, centred on the coordinate 404710 mE, 6428248 mN. This location was surveyed by systematic pedestrian transects and no artefactual material was located. However, the area to the **north** of Manjedal Brook, as defined by the grid references above, matches previous site descriptions by Hallam (1975) and Pearce (1979) contained in the DAA site file, in terms of both site location and site content.

5.5.3 Environment

DAA Id 3648 and its newly recorded extension (MJ-05) is located across several large, elevated white sand ridges and dunes that surround two freshwater lakes (including one remnant and one intact lake) to the west of Soldiers Road. Both lakes held water at the time of recording. Manjedal Brook is located less than 10 m south of the site and low-lying plausiplain is located to the north and west of the site. Prior to European landscape modification, the surrounding plausiplain would have been inundated seasonally during the winter months.

Hallam initially identified the site as being situated on the sand dune along the southern side of the lakes. This dune has an elevation of approximately 45 m above sea level. A second elevated sand ridge is located along the east side of the lakes, where the extension to the site (MJ-05) was located, and has an elevation of approximately 38.5 m above sea level.

The majority of the site has been previously cleared of vegetation and part of the southern sand dune has been previously bulldozed and pushed into the western remnant lake. Two notable artefact-bearing deflations occur within the southern and eastern dune formations. Several fence lines, vehicle tracks and cattle tracks dissect the site and the boundary fencing for Lot 9000 passes through the site's northern extension. Apart from the deflation and the disturbance caused by the fence lines and other pastoral activities, the eastern sand ridge is relatively intact.

The area surrounding the eastern lake was quite heavily vegetated by *Melaleuca* sp. and *Eucalyptus* sp. trees, shrubs and grasses at the time of inspection. The ground surface comprised fine white sand and visibility at the time of surface recording was good, ranging between 70–90%.

5.5.4 Previous site investigations

DAA Id 3648 was first recorded by Hallam in 1975. It is described as being located in a paddock between two small lakes, adjacent to the road with a winter creek to the south. At that time, the site comprised of white sandy soil that had been cleared for farming, and disturbed by ditch digging and cattle. Hallam estimates that the site contains approximately 30,000 artefacts, of which 95 % are made from quartz, with the remaining 5 % were manufactured from fossiliferous chert, mylonite, granite and other metamorphic rocks, most likely brought down the scarp from the Darling Plateau. Artefacts were located over an area measuring 50 by 30 metres.

Pearce (1979) undertook subsequent investigations at the site in 1975 as part of a Masters dissertation through the University of Western Australia. Pearce describes the site as being

located on a low sand bank lying between two small lakes, one and half kilometres north of Mundijong and on the west side of Soldier's Road. Pearce also noted that large trees, one of which had an oval scar, lined the banks of a small creek [Manjedal Brook] that flowed on the southern flank of the site, which was situated on a farming property. This tree was relocated during the current field work and is included as site MJ-08 below.

Pearce collected a total of 3133 surface artefacts from six 5 by 5 m sample squares. He commented that artefacts were densest in an eroded gully and on the side of a channel that had been dug to connect the two small lakes. Pearce also excavated a stepped 1 by 1 m trench, to a depth of 75 cm, from which he recovered a further 1781 artefacts. The artefacts were mainly comprised of quartz debris measuring less than 15 mm long. Eleven backed tools were found in the lower half of the trench. The density of artefacts was not uniform in the deposit with two peaks at 20 cm and 60 cm depth. Pearce attributed this to two potential reasons including changes in density of occupation or changes in the rates of erosion and accumulation of sand. Ochre was also located in the trench and one charcoal sample from the 10–20 cm spit returned a date of 1620 ± 105 BP (SUA 646).

5.5.5 Site description

The current status of DAA Id 3648, as defined in the field during the current fieldwork, generally concurs with the findings of Hallam and Pearce, however, the current size of the site is notably larger than that originally defined by Hallam. A large extension to the site was recorded during the current fieldwork to the east and north of the two lakes (previously referred to as MJ-05), see Figure 34. The discrepancy in site size may be due to subsequent erosion of the sand dunes over the last 30 years coupled with impacts by animals, variation in ground cover and vegetation, and different sampling methods.

In summary, DAA Id 3648 Soldiers Road Mundijong comprises an extensive open stone artefact scatter with grinding material and dated subsurface archaeological deposit. The site's total extent is 500 m (east – west) by 340 m (north – south) and approximately 149,900 sq m. The site has a low to medium artefact density and a medium level of raw material diversity. The site contained a range of formal tools including backed tools, scrapers, anvils, a stone axe and grinding material. A number of large tools and artefacts were previously collected by the landowner Mr Sam Lang and are currently stored at the Lang homestead in Mundijong, see below. Several radiocarbon dates have been gained from the site including Pearce's date of 1620 ± 105 BP (SUA 646) and two dates of 2000 +/- 30 BP (BETA-345001) and 5510 +/- 30 BP (BETA-345001) from the current excavations within the MJ-05 extension area, see Table 22.

Surface component

Artefacts are visible over an area of 550 m (east–west) by 325 m (north–south), or 82,030 sq m, both surrounding and in between the two freshwater lakes. A concentration of artefacts was also recorded within an east-facing deflation, approximately 385 sq m in size, located at 404527 mE, 6428607 mN on the sand dune to the west of the two lakes.

Surface artefacts within the deflation were recorded through the use of a sampling grid of 41, 1 by 1 m sample squares spaced 2 m apart. Outside the deflation artefacts were identified and recorded through a series of closely spaced (2-5 m) pedestrian transects walked across the site, totalling 1.3108 km in length, with all visible artefacts being recorded in detail. In the area to the south of the eastern lake, artefacts from three arbitrarily placed 5 by 5 m sample squares were recorded to site avoidance level. In total it is estimated that a 32 % sample of the site's surface

expression was examined and 191[15] artefacts were recorded, including 69 within the deflation. See Appendix 9.

Based on the current data collected from the site, the average artefact density ranged from low (0.013/sq m) to the north of the lakes to medium (0.3/sq m) to the south of the lakes adjacent to Manjedal Brook and medium (0.34/sq m) within the deflation. Using this density figure the total surface artefact population could number up to approximately 16,000 artefacts, however, Hallam estimated that this figure could be as high as 30,000.

Artefact types recorded within the site comprised debris (n=87, 45.5%), flaked pieces (n=57, 29.8%), flakes (n=32, 16.8%), transversely broken flakes (n=4, 2.1%), longitudinally broken flakes (n=4, 2.1%), single platform cores (n=2, 1%), retouched/utilised flaked piece (n=2, 1%), a multiple platform core (n=1, 0.5%), a broken flake (n=1, 0.5%) and a millstone fragment (n=1, 0.5%). See Figure 31.

Raw material diversity was medium with artefacts being manufactured from a variety of rock types including white quartz (n=148, 77.5%), crystal quartz (n=29, 15.2%), pink quartz (n=5, 2.6%), mylonite (n=5, 2.6%), dolerite (n=2, 1%), silcrete (n=1, 0.5%) and yellow quartz (n=1, 0.5%), see Figure 32.

The majority of the debitage recorded was small in size. Artefact lengths ranged from 3.4 mm to 33.9 mm with a median of 10.8 mm and artefact weights ranged from 0.1 g to 10.4 g with a median of 0.4 g, see Figure 33. Similarly, the cores were all small in size with a median length of 32.1 mm and median weight of 12.4 g. The majority of artefacts had very little cortex and no retouch was noted on any of the artefacts.

[15] Note that this figure includes artefacts from the south east corner of the site which were recorded to site avoidance level. These artefacts were not included in some of the artefact analyses as the relevant attribute e.g. weight, was not recorded, therefore figures presented in Table 26 may differ from those presented here.

Plate 58. DAA Id 3648, view east of sand dune along northern boundary of site



Plate 59. DAA Id 3648, view south of sand dune in northern section of site



Plate 60. DAA Id 3648, view north of eastern freshwater lake



Plate 61. DAA Id 3648, view northwest of artefacts on track in area south of lake and north of Manjedal Brook

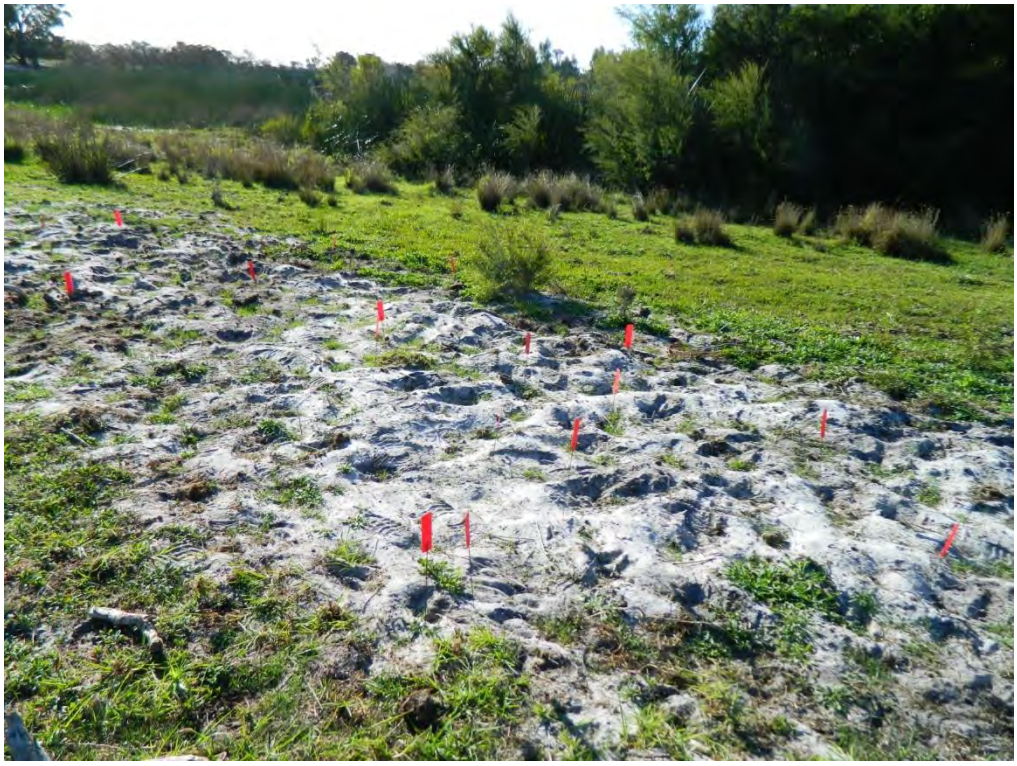


Plate 62. DAA Id 3648, view east of area between lakes and Manjedal Brook



Plate 63. DAA Id 3648, view southeast of area between lakes and Manjedal Brook



Plate 64. Site DAA Id 3648 (MJ-05 extension), view south along ridge towards Manjedal Brook in background



Plate 65. Site DAA Id 3648 (MJ-05), view east-southeast of deflation within the eastern sand ridge, towards adjacent freshwater lakes

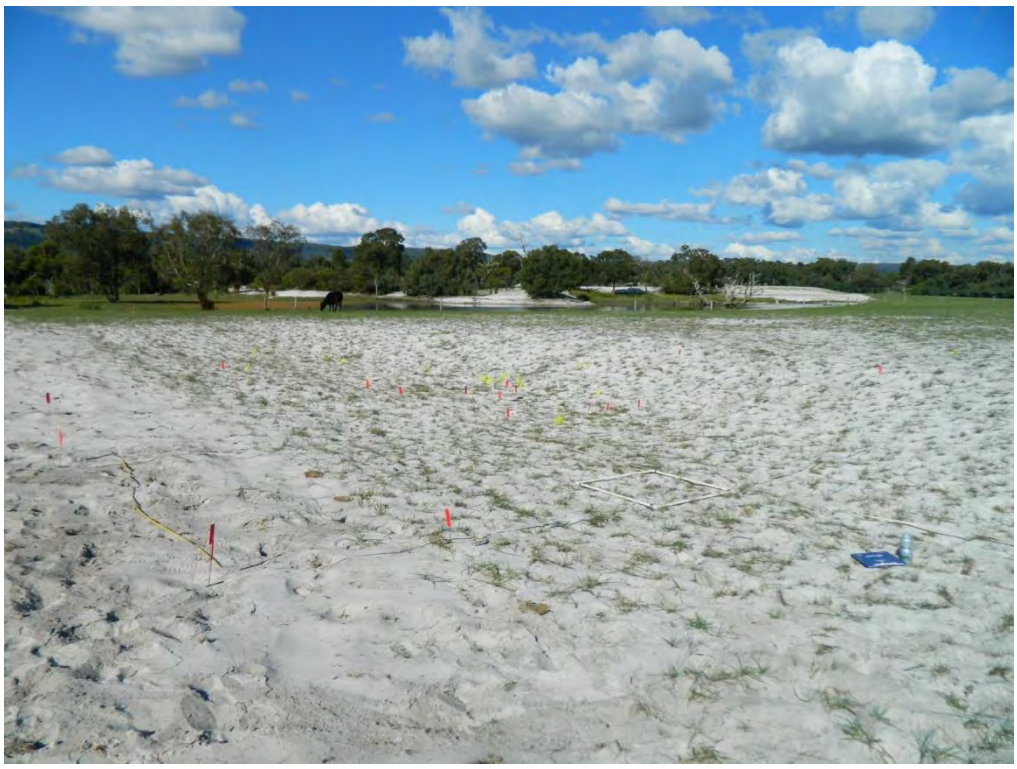


Plate 66. Site DAA Id 3648 (MJ-05), view southwest of deflation area within the eastern sand ridge



Plate 67. Site DAA Id 3648 (MJ-05), artefact #42



Plate 68. Site DAA Id 3648 (MJ-05), artefact #44



Plate 69. Site DAA Id 3648 (MJ-05), artefacts #45 and 46



Plate 70. Site DAA Id 3648 (MJ-05), artefact #47



Plate 71. DAA Id 3648 Soldiers Road Mundijong, artefacts #66, 67, 68



Plate 72. DAA Id 3648 Soldiers Road Mundijong, artefact #74



Plate 73. Site DAA Id 3648 (MJ-05), artefact #48, millstone fragment



Plate 74. Site DAA Id 3648 (MJ-05), artefacts from sample square N9

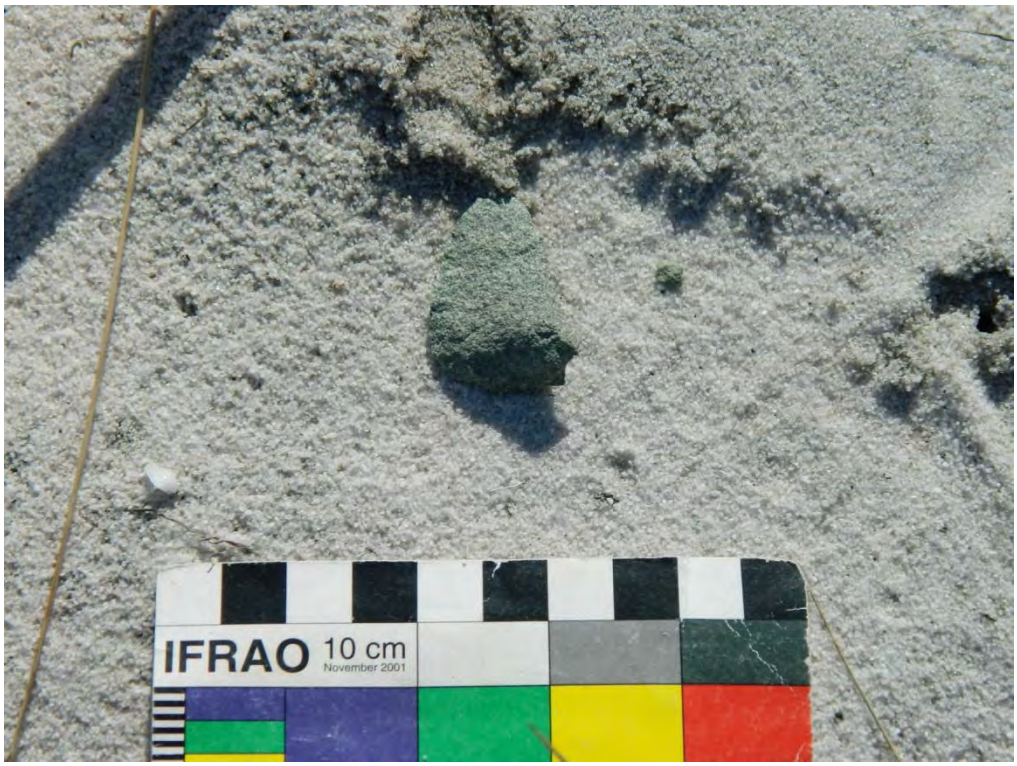


Plate 75. Site DAA Id 3648 (MJ-05), multiple platform core from sample square S9



Subsurface extent

Given that part of DAA Id 3648 is located within a wetland conservation zone and is earmarked for public open space within Peet's residential development, subsurface investigations of DAA ID 3648 were focused on the newly recorded extension of the site (MJ-05) on the sand ridge to the west of the two lakes.

Six probe holes were dug across the MJ-05 extension to determine the extent of subsurface artefacts, see Table 21. The probe hole tests indicated that subsurface artefacts extend across the entire raised dune area and that whilst a drain has been previously cut between the two lakes and the southern and eastern dunes, the sand ridge where the MJ-05 extension is located is part of the DAA Id 3648 site.

Soil across the majority of the MJ-05 extension comprised white sand overlain by a thin grey–brown humic layer. One probe hole was dug to the south of the sand ridge within the area subject to flooding by Manjedal Brook. This probe hole contained compact, orange-coloured sand with clay that was difficult to dig by hand.

Table 21. Probe hole data from DAA Id 3648 (MJ-05)

Probe hole	Artefact found	Depth	Notes
5PS90	Yes	550mm	Small humic layer under grass, then white sand
5PS150	No	600mm	Orange sand
5PN90	Yes	600mm	Small humic layer under grass, then white sand
5PE60	Yes	500mm	Small humic layer under grass, then white sand
5PW60	Yes	400mm	Small humic layer under grass, then white sand
5PW90	Yes	500mm	Small humic layer under grass, then white sand

Plate 76. DAA Id 3648 (MJ-05) probe hole 5PW60



Subsurface deposit

One hand excavated test pit (Test square D) and one mechanically excavated trench (Excavator trench G) were dug at DAA Id 3648 (MJ-05) to determine the nature of subsurface deposit within the newly recorded extension area.

Test square D

Test Square D was dug on 15 January 2013, by the whole excavation team. The test square was located close to highest point of the eastern sand dune, approximately 20 m south of the deflation. Test square D was excavated to a depth of 1000 mm in 10 spits and was abandoned at 1000 m due to the instability of the pit walls. Artefacts were recovered from each spit down to 1000 mm.

The spits above 300 mm depth contained darker grey sand and was discoloured by roots and vegetative matter contained within these layers. Between 300 mm and 1000 mm depth the sand was uniformly white–grey sand which dried to a whiter colour. The sand within the bottom two spits (800 mm to 1000 mm) was notably damper, however, no pooling of water was observed.

Two dates were obtained from charcoal samples recovered from test square D. Charcoal samples were obtained from spit 6 and spit 10, with the latter sample being *in situ*. The dates were in stratigraphic order with the spit 6 charcoal being dated to 2000 +/- 30 BP (BETA-345001) and the spit 10 charcoal dated at 5510 +/- 30 BP (BETA-345001), see Table 22.

Plate 77. DAA ID 3649 (MJ-05) test square D, completion of spit 1 (0-100mm)

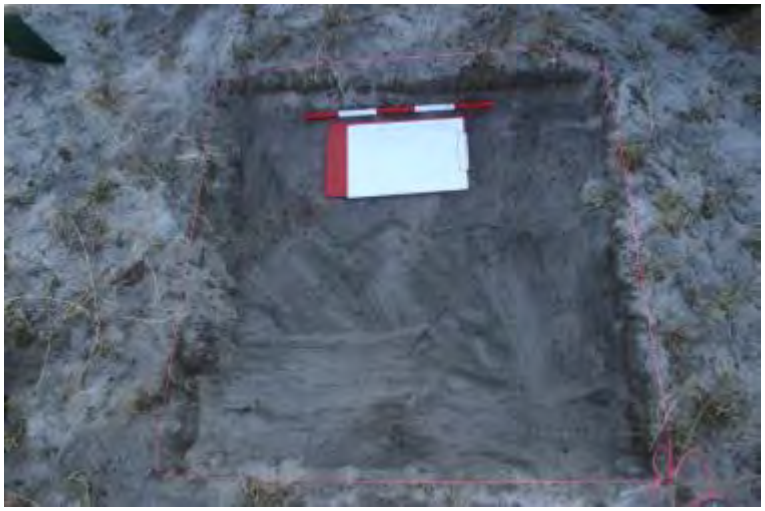


Plate 78. DAA Id 3648 (MJ-05) test square D, *in situ* artefact

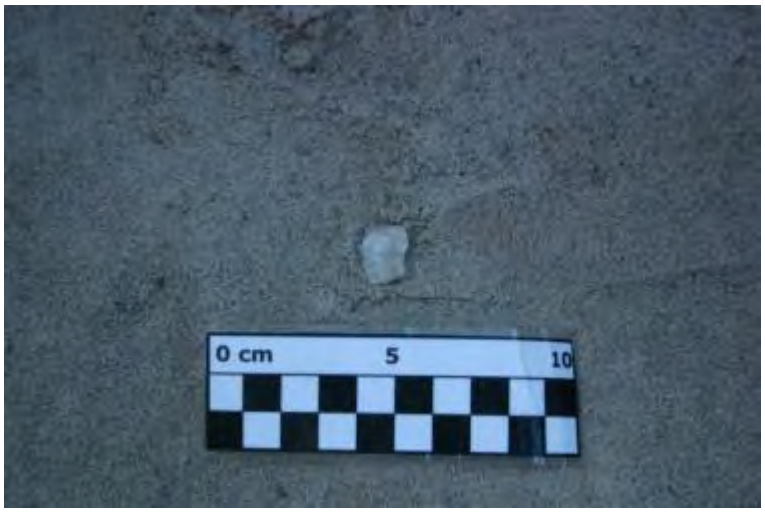


Plate 79. DAA Id 3648 (MJ-05), test square D, section where burning was identified

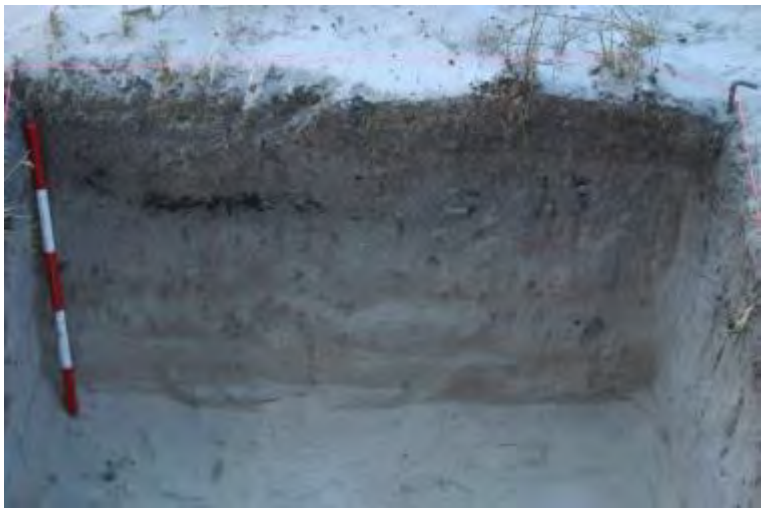


Table 22. Radiocarbon dates from DAA Id 3648 (MJ-05)

Sample	Site	Spit	Depth (mm)	Sample type	Measured date	Conventional age	2 Sigma Calibration
MJ05TPD6	DAA Id 3649 (MJ-05)	6	600	Loose charcoal collected from sieve	2000 +/- 30 BP	2000 +/- 30 BP	Cal BC 50 Cal AD 70 (Cal BP 2000 to 1880)
MJ05TPD10-A	DAA Id 3649 (MJ-05)	10	1000	*In situ* charcoal	5510 +/- 30 BP	5510 +/- 30 BP	Cal BC 4440 to 4420 (Cal BP 6390 to 6370)/ Cal BC 4370 to 4330 (Cal BP 6320 to 6280)

Excavator Trench G

Excavator trench G was excavated on 22 January 2013. The trench was located on the southern edge of the deflation within the eastern sand ridge, with the excavator cutting back and into the stable dune. Excavator trench G was dug to a depth of 2.3 metres. Artefacts were recovered down to a depth of 2.3 m, with artefacts being present within spits 1–5 (inclusive), spit 7, spits 9–10 (inclusive) and spits 14 – 24 (inclusive).

Stratigraphy evident within Excavator trench G matched that observed in test square D and comprised a thin upper humic layer of dark brown-grey sand overlying pale grey-white sand down to the base of the trench. Sand at the base of Excavator trench G was also notably wet.

The pH levels within the trench ranged between acidic to neutral (pH 6–7). The five upper spits displayed some variation in colour whilst the lower 22 spits all had the same colour sand. Overall the sand within the excavator trench was medium course to medium sand. See Table 23 for details.

Table 23. Summary of soil samples from Excavator Trench G

Spit	pH	Munsell	Comments
1	6.5	10YR6/1	Medium-coarse sand
2	6.5	10YR6/2	Medium-coarse sand
3	6	10YR5/1	Medium-coarse sand
4	7	10YR6/1	Medium sand
5	6.5	10YR6/1	Medium sand
6	6.5	10YR7/1	Medium sand
7	6.5	10YR7/1	Medium sand
8	7	10YR7/1	Medium sand
9	6.5	10YR7/1	Medium sand
10	6.5	10YR7/1	Medium sand
11	6.5	10YR7/1	Medium sand
12	7	10YR7/1	Medium sand
13	7	10YR7/1	Medium sand
14	7	10YR7/1	Medium sand
15	7	10YR7/1	Medium sand
16	7	10YR7/1	Medium sand
17	7	10YR7/1	Medium sand
18	7	10YR7/1	Medium sand
19	7	10YR7/1	Medium sand
20	6.5	10YR7/1	Medium sand
21	7	10YR7/1	Medium sand
22	7	10YR7/1	Medium sand
23	7	10YR7/1	Medium sand
24	7	10YR7/1	Medium sand
25	7	10YR7/1	Medium sand
26	7	10YR7/1	Medium sand
27	7	10YR7/1	Medium sand

Plate 80. DAA Id 3648 (MJ-05) Excavator trench G, base of trench with sand visibly damp



Plate 81. DAA Id 3648 (MJ-05) Excavator trench G, spits laid out separately on tarpaulins

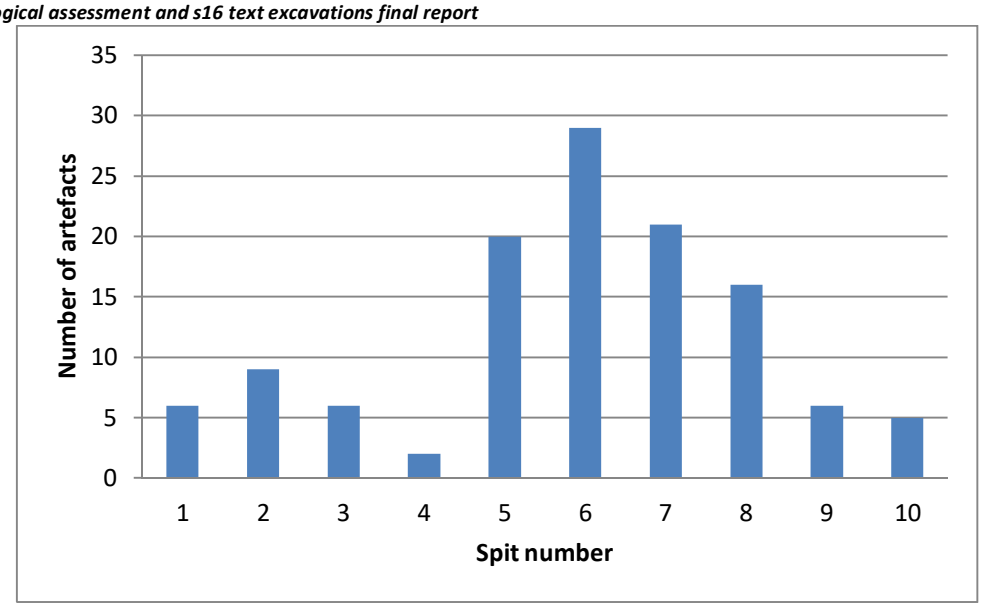


Subsurface assemblage

In total, approximately 3 m^3 was excavated at DAA Id 3648 (MJ-05) and 321 artefacts were recovered from its subsurface deposit. One hundred and thirty one artefacts were recovered from test square D, 32 artefacts from the probe holes and 158 from Excavator trench G, see Appendix 9. Based on the density from the test square, it is estimated that the subsurface artefact density is approximately 107 artefacts per cubic meter.

In the test square artefacts were of lower density within the top 400 mm with an increase in discard rates between spits 5 to 8 (400 – 800 mm depth). Artefacts were recovered to the base of the test square (1000 mm depth), see Figure 30. Within the excavator trench, artefacts were recovered almost continuously down to spit 24 (2200 – 2230 mm depth) with a gap in artefact occurrence between spits 11 to 13 (1000 – 1200 mm depth). No generalisations can be made about artefact discard rates based on the excavator trench as the entire excavated deposit was not sieved.

Figure 30. DAA Id 3648 (MJ-05) test square D artefact distribution per spit



Artefact types recovered from the subsurface deposit comprised debris (n=197, 61.4%), flaked pieces (n=79, 24.6%), multiple platform cores (n=12, 3.7%), flakes (n=9, 2.8%), single platform cores (n=7, 2.2%), longitudinally broken flakes (n=7, 2.2%), retouched/utilised flakes (n=4, 1.2%), transversely broken flakes (n=3, 0.9%), manuports (n=2, 0.6%) and one retouched/utilised flaked piece (n=1, 0.3%). One steep edged scraper was identified in the assemblage. Only one of the subsurface artefacts recovered from DAA 3648 (MJ-05) was observed to have any cortex, indicating that the remainder of the assemblage is comprised of tertiary or late stage reduction artefacts associated with trimming and resharpening tools or reduction activities.

Artefact lithologies were dominated by quartz and included white quartz (n=201, 62.6%), crystal quartz (n=95, 29.6%) and smokey quartz (n=4, 1.2%), plus minor amounts of fossiliferous chert (n=4, 1.2%), quartzite (n=4, 1.2%), pink quartz (n=3, 0.9%), brown quartzite (n=3, 0.9%), conglomerate (n=3, 0.9%), dolerite (n=3, 0.9%) and yellow quartz (n=1, 0.3%). Both white quartz and crystal quartz occur continuously throughout the deposit. Brown quartzite, fossiliferous chert and quartzite all occur below spit 15 (below 1300 mm depth) down to spit 20 (1800 – 1900 mm depth). Smokey quartz was only present above spit 7 (above 700 mm depth) indicating use in more recent times in comparison to the chert and quartzites.

The majority of the subsurface artefacts from DAA Id 3648 (MJ-05) were small in size and light in weight. In total, 315 artefacts (98.1%) weighed less than 5g, four artefacts (1.3%) weighed between 5g and 10g, one artefact weighed in the 25g to 30g weight range and one in the 40g to 45g category. The average weight of subsurface artefacts was 2.9g. The majority (n=315, 98.4%) of DAA Id 3648 (MJ-05)'s subsurface artefacts were less than 20 mm in length, with the remainder measuring up to 50 mm in length. There does not appear to be any detectable trends in variation in artefact size over time as there appears to be a range of sizes at all depths, therefore indicating a lack of obvious size sorting between spits.

Comparison of surface and subsurface assemblages

Overall, the surface and subsurface assemblages from DAA Id 3648 (MJ-05) show a strong correlation with each other. The surface and subsurface assemblages were very similar in composition in terms of artefact types, lithologies, artefact weight and size, see Table 24 to Table 26.

The main points of difference between the surface and subsurface assemblages included greater diversity within the subsurface assemblage in terms of lithologies, artefact weight and size ranges, whereas the surface assemblage showed greater diversity in terms of platform types and artefact terminations. Retouched artefacts were also only located within the subsurface assemblage.

Table 24. DAA Id 3648 (MJ-05), comparison of surface and subsurface artefact and raw material types

Artefact Type	Surface	Subsurface	Raw material type	Surface	Subsurface
Debris	45.5	61.4	White Quartz	77.5	62.6
Flaked piece	29.8	24.6	Crystal Quartz	15.2	29.6
Flake	16.8	2.8	Mylonite	2.6	0
Core	1.5	5.9	Pink Quartz	2.6	1.2
Transversely Broken Flake	2.1	0.9	Yellow Quartz	0.5	0.3
Longitudinally Broken Flake	2.1	2.2	Dolerite	1	0.9
Retouched Flake	0	1.2	Silcrete	0.5	0
Retouched Flaked Piece	1	0.3	Foss Chert	0	1.2
Longitudinally & Transversely Broken Flake	0.5	0	Quartzite	0	1.2
Manuport	0.5	0.6	Smokey Quartz	0	1.2
			Conglomerate	0	0.9
			Brown Quartzite	0	0.9

Table 25. DAA Id 3648 (MJ-05), comparison of surface and subsurface platform and termination types

Platform Type	Surface	Subsurface	Termination Type	Surface	Subsurface
Crushed	1	0	Feather	15	22
Faceted	3	8	Hinged	0	0
Flaked	19	16	Outré passé	1	0
Focalised	5	2	Stepped	8	2
Total	28	26	Total	24	24

Table 26. DAA Id 3648 (MJ-05), comparison of surface and subsurface artefact weight and length

Weight (g)	Surface	Subsurface	Length (mm)	Surface	Subsurface
0-5	155	315	0-5	10	315
5-10	7	4	5-10	65	4
10-15	3	0	10-15	57	0
15-20	0	0	15-20	16	0
20-25	0	0	20-25	9	0
25-30	0	1	25-30	2	1
40-45	0	1	30-35	5	0
65-70	0	0	35-40	1	1
100-105	0	0	40-45	0	0
135-140	1	0	45-50	0	0
245-250	0	0	50-55	0	0
Total	166	321	70-75	0	0
			75-80	1	0
			85-90	0	
			Total	166	321

5.5.6 Sam Lang Collection

Whilst conducting the excavations at DAA Id 3648 (MJ-05), the landowner Mr Sam Lang paid a courtesy visit to the survey team and informed us that over the years he had collected a number of large 'pieces' from the site to ensure their safekeeping. He invited the survey team to the Lang homestead to view the collection. Due to time constraints, the individual artefacts were each photographed and a short descriptive was recorded about them. The collection was in good condition and provides a rich additional source of data and information through which the site can be interpreted.

In summary, the collection consisted of 47 large artefacts of which a high proportion was ground. The artefacts included 11 manuports, 10 grindstones, 9 top grindstones (mullas), 5 multiple platform cores, 5 single platform cores, 3 anvils (the Winjan representatives indicated that these objects could also be firestones), 2 flakes and one axe and one axe blank, see Table 27. There was a wide variety of raw materials within the collection, many of which were metamorphic in origin and were most likely originally procured from the Darling Scarp or Plateau. The collection provides a good source for undertaking provenance studies to enhance knowledge of travel and trade routes within the region.

Table 27. DAA Id 3648 (MJ-05), summary of artefacts currently held by Mr Sam Lang

Artefact No.	Artefact type	Lithology	Artefact No.	Artefact type	Lithology
1	Multiple platform core	Basalt	25	Manuport	Grey metamorphic
2	Grindstone (mulla)	Yellow metamorphic	26	Flaked grindstone	Orange metamorphic
3	Partial grindstone	Yellow metamorphic	27	Possible core	Quartz
4	Grindstone (mulla)	Green-grey metamorphic	28	Core	White quartz
5	Grindstone (mulla)	Basalt	29	Ground anvil/firestone	Grey metamorphic
6	Ground single platform core with depression (?anvil)	Basalt	30	Flake	Basalt
7	Large flake blank	Basalt	31	Core	White quartz
8	Manuport	Granite	32	Ground cobble	Grey metamorphic
9	Grindstone	White metamorphic	33	Ground cobble	Grey metamorphic
10	Manuport	Pink quartzite	34	Manuport	White degraded metamorphic rock with iron staining
11	Ground anvil/firestone	-	35	Manuport	Pink and grey granite
12	Multiple platform core with possible core rejuvenation	Basalt	36	Manuport	Black basalt with white quartz veins
13	Ground flake	Basalt	37	Manuport	White quartz
14	Ground and flaked anvil/firestone	Basalt	38	Manuport	Basalt
15	Broken grindstone (mulla)	Grey metamorphic	39	Grindstone (mulla)	Black and orange metamorphic
16	Grindstone (mulla)	Grey metamorphic	40	Manuport	Black and orange metamorphic
17	Manuport	White vein quartz	41	Multiple platform core	Basalt
18	Grey metamorphic material	Basalt	42	Manuport	Pink quartz
19	Possible axe head	Grey metamorphic	43	Broken grindstone (mulla)	Grey metamorphic
20	Ground multiple platform core	Grey metamorphic	44	Grindstone	White metamorphic
21	Ground and flaked stone axe blank	Basalt	45	Grindstone	Black metamorphic
22	Grindstone	Grey-green metamorphic	46	Multiple platform core	Basalt
23	Grindstone	White-grey metamorphic	47	Grindstone (mulla)	Pink and grey metamorphic
24	Grindstone	White-grey metamorphic			

Plate 82. DAA Id 3648, top grindstone (mulla), Sam Lang collection



Plate 83. DAA Id 3648, anvil/firestone, Sam Lang collection



Plate 84. DAA Id 3648, anvil/firestone, Sam Lang collection



Plate 85. DAA Id 3648, stone axe, Sam Lang collection



Plate 86. DAA Id 3648, anvil/firestone, Sam Lang collection



5.5.7 Site interpretation

Based on the artefact density, artefact assemblage composition, grinding materials and tools located at the site, the diversity of artefacts and raw materials included in the assemblage, the close proximity of the site to the freshwater lakes, surrounding wetlands, Manjedal Brook and the Darling Scarp, DAA Id 3648 is interpreted as representing a long term base camp, frequently occupied for long periods of time to enable people to access the resources of the Swan Coastal Plain at certain times of the year. The adjacent lakes, wetland and brook would have comprised a resource-rich zone where flora and faunal resources could have been easily accessed and supported large groups of people for extended periods of time.

A wide variety of activities appear to have been undertaken at the site including the manufacturing and maintenance of tools and the processing and consumption of faunal and floral resources. The presence of grinding material within the site could also indicate the use of DAA ID 3648 by family groups including women and children. Further insights into specific activities could be gained through residue or use wear analysis of a sample of artefacts from DAA Id 3648.

All of the stone material on site was procured elsewhere and brought onto site. The fossiliferous chert would have been transported over 23 km from a now submerged deposit off the coast, whilst the quartz, metamorphic and igneous rocks would have been obtained from quarries within the Darling Scarp and/or Plateau, indicating that the people utilising DAA Id 3648 would have ranged over a relatively large area between the Darling Plateau and the coastline. The relatively large amount of artefacts with complex platforms, indicating preparation of materials prior to flaking, also implies that raw materials were being conserved during the occupation of DAA Id 3648.

The site also appears to have been used over a substantial depth of time. Although the earliest date currently obtained from the site is 5510 +/- 30 BP (BETA-345001), this date was gained from

1000 mm depth and the results of the Excavator trench G indicated that artefacts occurred throughout the deposit down to the watertable at a depth of 2230 mm. If the rate of sedimentation is assumed to have been constant over time then occupation of the site could date back to at least 10,000 years BP. Optically stimulated luminescence (OSL) dating could further enhance the dating and interpretation of the site.

5.5.8 Statement of archaeological significance

DAA Id 3648 Soldiers Road Mundijong (MJ-05) is an extensive artefact scatter with grinding material and subsurface deposit, situated around two remnant freshwater lakes, adjacent to Manjedal Brook and surrounded by seasonally inundated wetland. DAA Id 3648 can be classified as 'Early Phase' according to both Hallam (1987) and Schwede's (1990) relative dating schemes, occupation dating back to at least 5510 +/- 30 BP (BETA-345001). Based on the occurrence of artefacts down to the watertable, it is further estimated that occupation of the site dates back to approximately 10,000 BP. DAA Id 3648 (including the MJ-05 extension) represents a long term base camp, frequently occupied for long periods of time, where a wide variety of activities took place including the manufacturing and maintenance of tools and the processing and consumption of faunal and floral resources. The presence of grinding material within the site also points to the use of DAA Id 3648 (MJ-05) by family groups including women and children. The camp would have enabled people to access the local resource-rich zone surrounding the freshwater lakes as well as additional resources of the Swan Coastal Plain at particular times of year.

DAA Id 3648 Soldiers Road Mundijong (MJ-05) is assessed as being of very high importance and significance to the community as a whole due to its aesthetic, archaeological and scientific values. Its heritage values are further enhanced because of the rarity of a number of the site's features and its good interpretive capacity.

The site holds aesthetic value not only because of the picturesque setting of the site but also because the range of environmental contexts – freshwater lakes, adjacent Manjedal Brook, surrounding plausiplain and views of the Darling Scarp – provide a good interpretive context in which the public and wider community can connect with the past. The site also has an unusual range of aesthetically attractive and technologically advanced artefacts, such as the ground anvil/firestones, stone axe and backed artefacts, along with a range of raw materials of aesthetic interest.

DAA Id 3648 (MJ-05) has significant archaeological and scientific research potential. The data that has been collected from this site can contribute to all of the research questions identified above in section 3.1 as well as contributing substantially different information on a number of topics of research relevant to the Swan Coastal Plain and the broader South West Western Australia region. Specifically, DAA Id 3648 (MJ-05) has the potential to contribute to research relating to site formation in Bassendean sand dunes, South West social and trade networks through the provenancing of raw materials from the site, microlithic stone tool technologies in the South West and Swan Coastal Plain particularly over the period when small tool technology appears to have been introduced, occupation patterns and antiquity. The research value of the site is further enhanced by the good stratigraphic integrity of the site, its dateable deposit, its ability to be placed in a temporal context, moderate–high levels of internal complexity and its potential for further residue and use wear studies.

If the site were to be subjected to optically stimulated luminescence (OSL) dating, then DAA Id 3648 (MJ-05) would also have the potential to contribute to other scientific research including

the geomorphic development of the Pleistocene sand dunes of the eastern Swan Coastal Plain (cf. Kendrick et al., 1991).

The primary values associated with DAA ID 3648 are further enhanced by the rarity of a number of elements of the site and its interpretive capacity. DAA Id 3648 (MJ-05) is rare in that it is one of a small number of sites with relatively good integrity situated next to one of the few remaining freshwater lakes on the Swan Coastal Plain. It is also rare because it has good subsurface integrity and dateable deposit, which is reportedly not common within open sites situated within the Bassendean sands (Bowdler et al., 1991). It is also one of few absolutely dated sites on the Swan Coastal Plain. Further, it is also rare to find artefacts such as those within Sam Lang's collection (grinding stones, anvil/firestones, stone axes) in association with open sites on the Swan Coastal Plain which, in addition to the physical setting of the site, adds significantly to the interpretive capacity of the site.

These characteristics mean that DAA Id 3648 Soldiers Road has the potential to play a key role in the interpretation of Aboriginal prehistory of the Mundijong region and broader Swan Coastal Plain and therefore is a site of great importance and significance to the community as a whole. The Aboriginal representatives who worked on the current investigations also expressed their amazement at the diversity, complexity and intactness of the site and commented that they felt very few comparable sites currently remain.

It is the opinion of the authors that DAA Id 3648 Soldiers Road Mundijong (including the newly recorded MJ-05 extension) constitutes a site within the meaning of **section 5a and 5c** of the *Aboriginal Heritage Act 1972* and the preservation of this site would benefit current and future generations of Western Australians.

5.5.9 DAA Id 3648 Soldiers Road Mundijong recommendations

It is **recommended** that Peet and its contractors are:

- advised of the existence and location of DAA Id 3648 Soldiers Road Mundijong;
- advised of the newly recorded extension to DAA Id 3648 Soldiers Road Mundijong (formerly referred to as MJ-05) on the sand dune to the east of the two freshwater lakes; and
- informed that DAA Id 3648 (including the MJ-05 extension) may meet the requirements of section 5 of the *Aboriginal Heritage Act 1972* and therefore it should not be impacted upon in any way.

Should at any stage Peet wish to disturb DAA Id 3648 and an application is made for consent to use the land under section 18 of the *Aboriginal Heritage Act 1972*, it is **further recommended** that:

- Peet consults with the appropriate Nyungar Elders and Aboriginal Consultants about any proposed section 18 application, further research required, mitigation and salvage strategies and the management of any salvaged materials;
- the portion of the site located within the current conservation zone and proposed public open space be capped with geotextile fabric to ensure its long term conservation, prior to any landscaping being undertaken in this area; and
- Peet develop and implement a public interpretation plan for DAA Id 3648 Soldier's Road Mundijong (including MJ-05), to be incorporated into the proposed public open space surrounding the lakes.

It is **also recommended** to the Department of Aboriginal Affairs that:

- the boundary for DAA Id 3648 Soldier's Road Mundijong (including the MJ-05 extension) be updated to reflect the boundary included in the site description in section 5.5.1 above.

Figure 31. Summary of artefacts recorded within DAA Id 3648 (MJ-05)

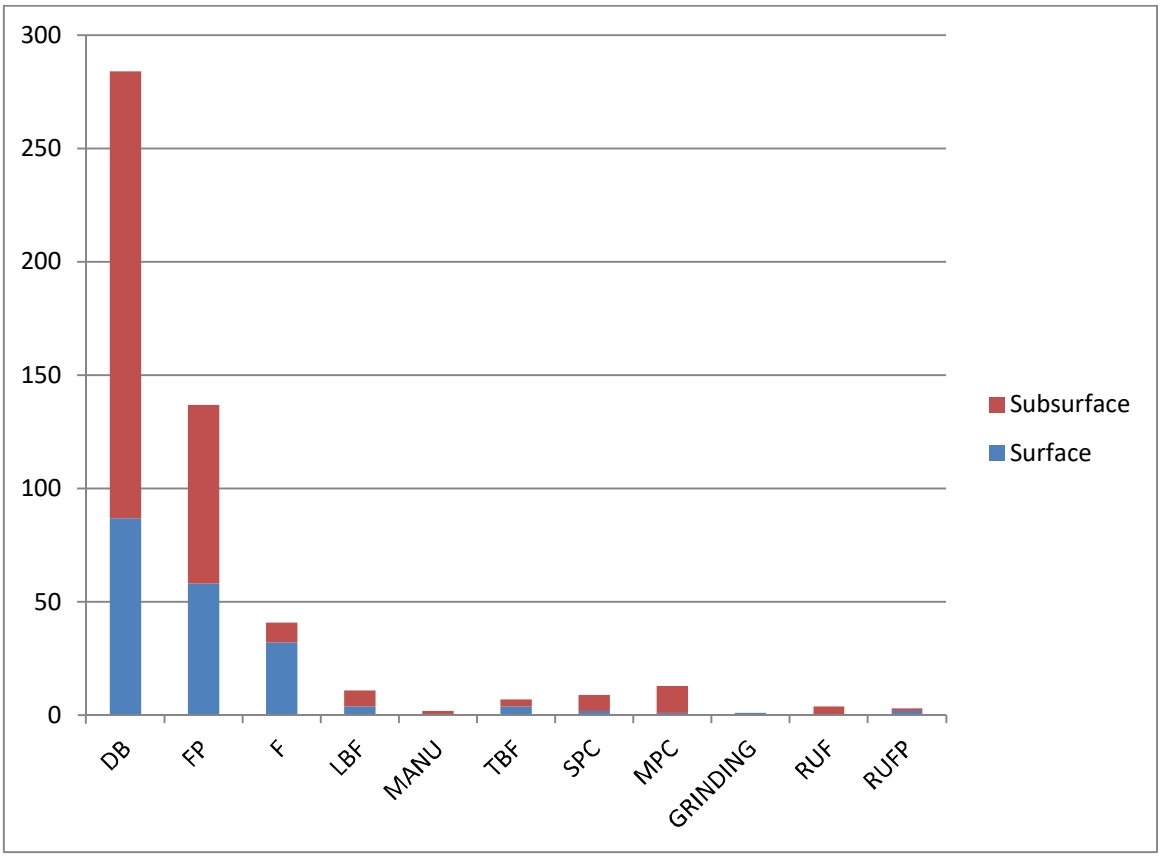


Figure 32. Summary of lithologies present within DAA Id 3648 (MJ-05) artefact sample

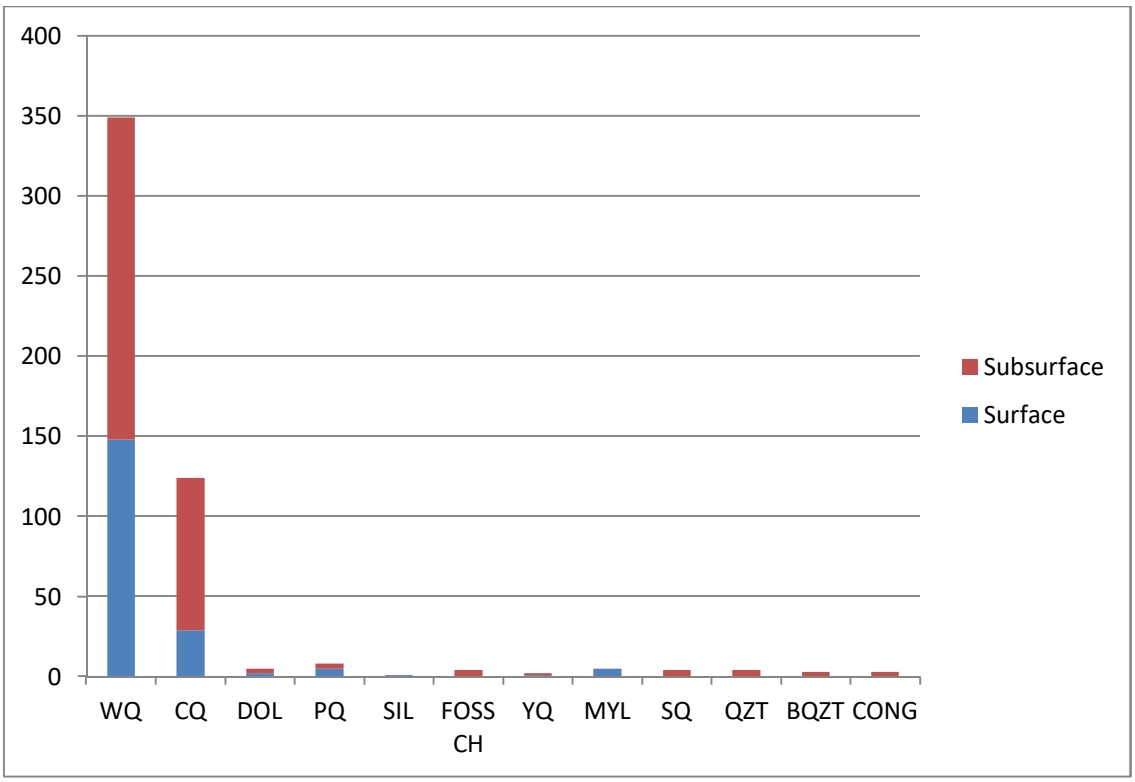
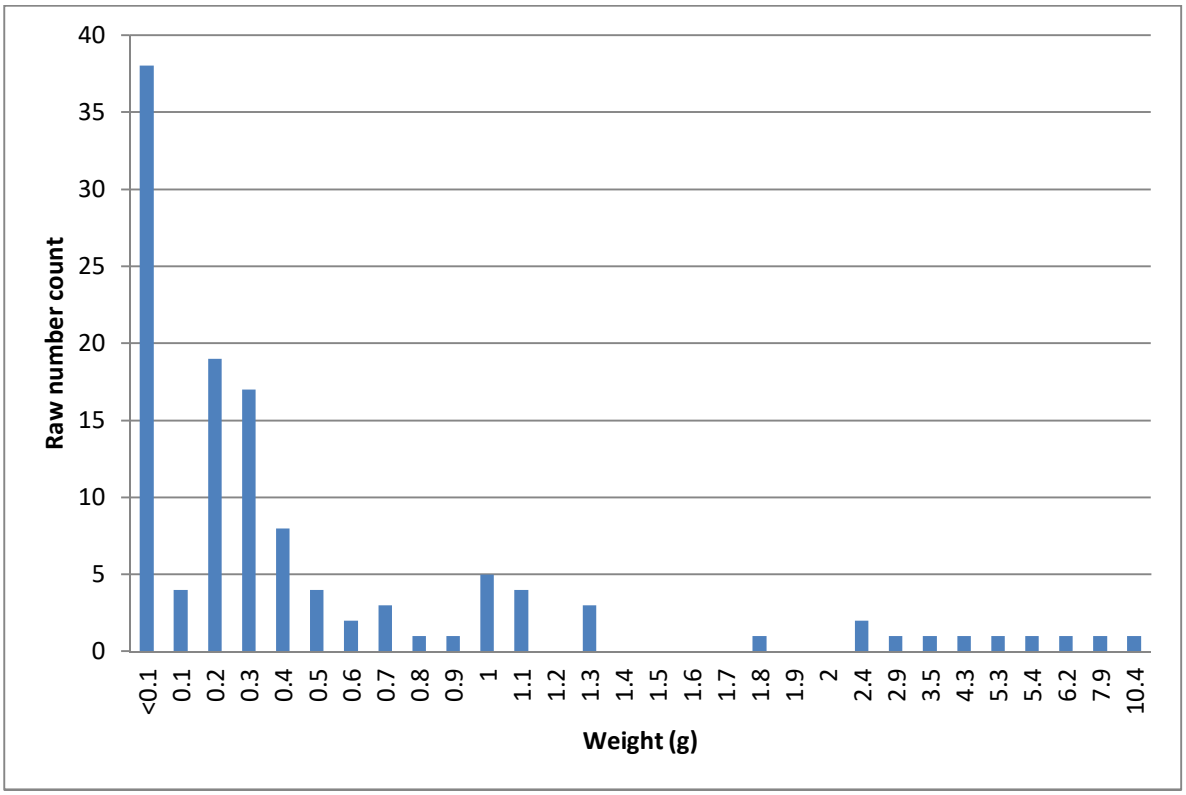


Figure 33. DAA Id 3648 (MJ-05) recorded artefact weights (surface assemblage)



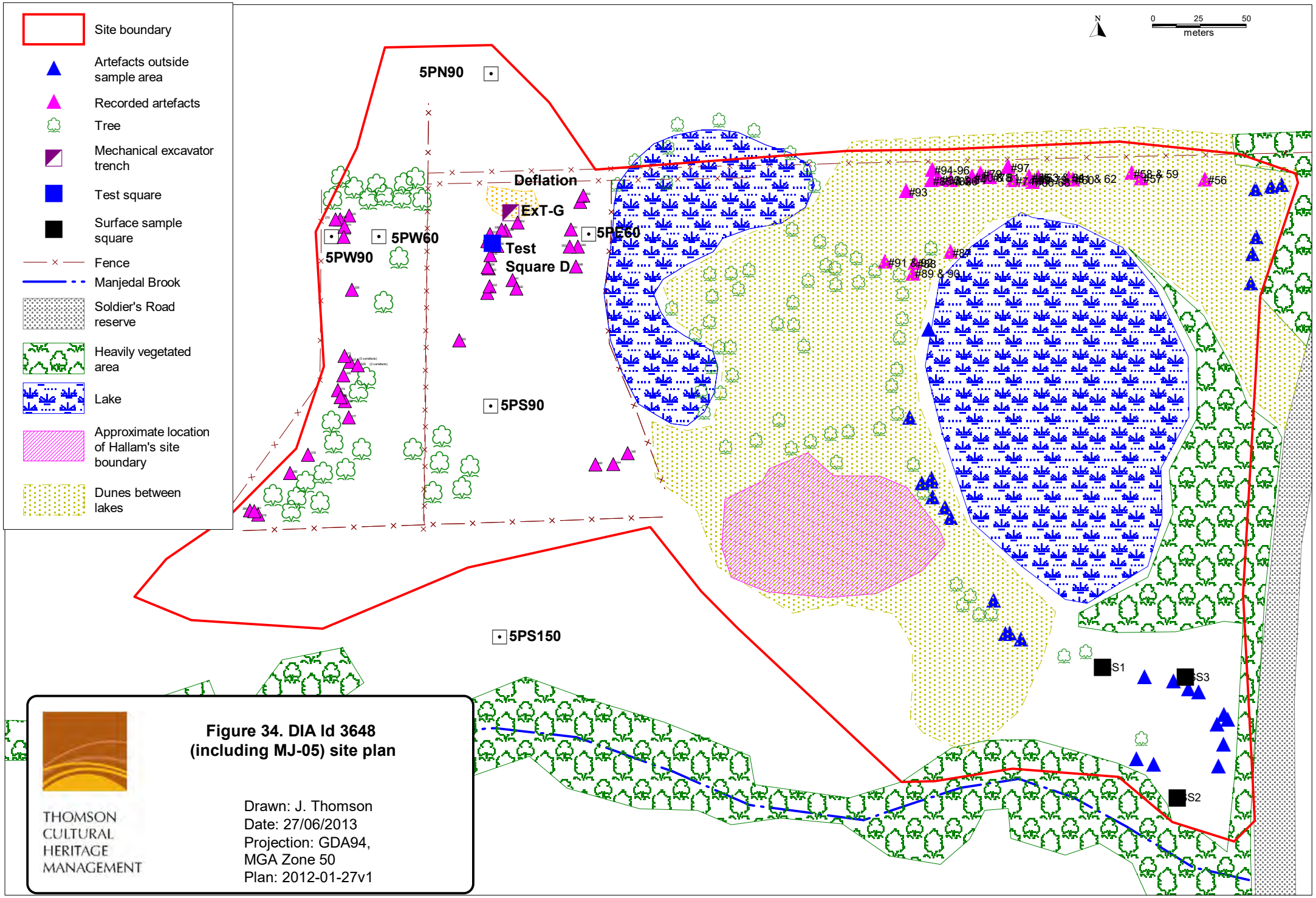


Figure 34. DIA Id 3648 (including MJ-05) site plan

Drawn: J. Thomson
Date: 27/06/2013
Projection: GDA94, MGA Zone 50
Plan: 2012-01-27v1

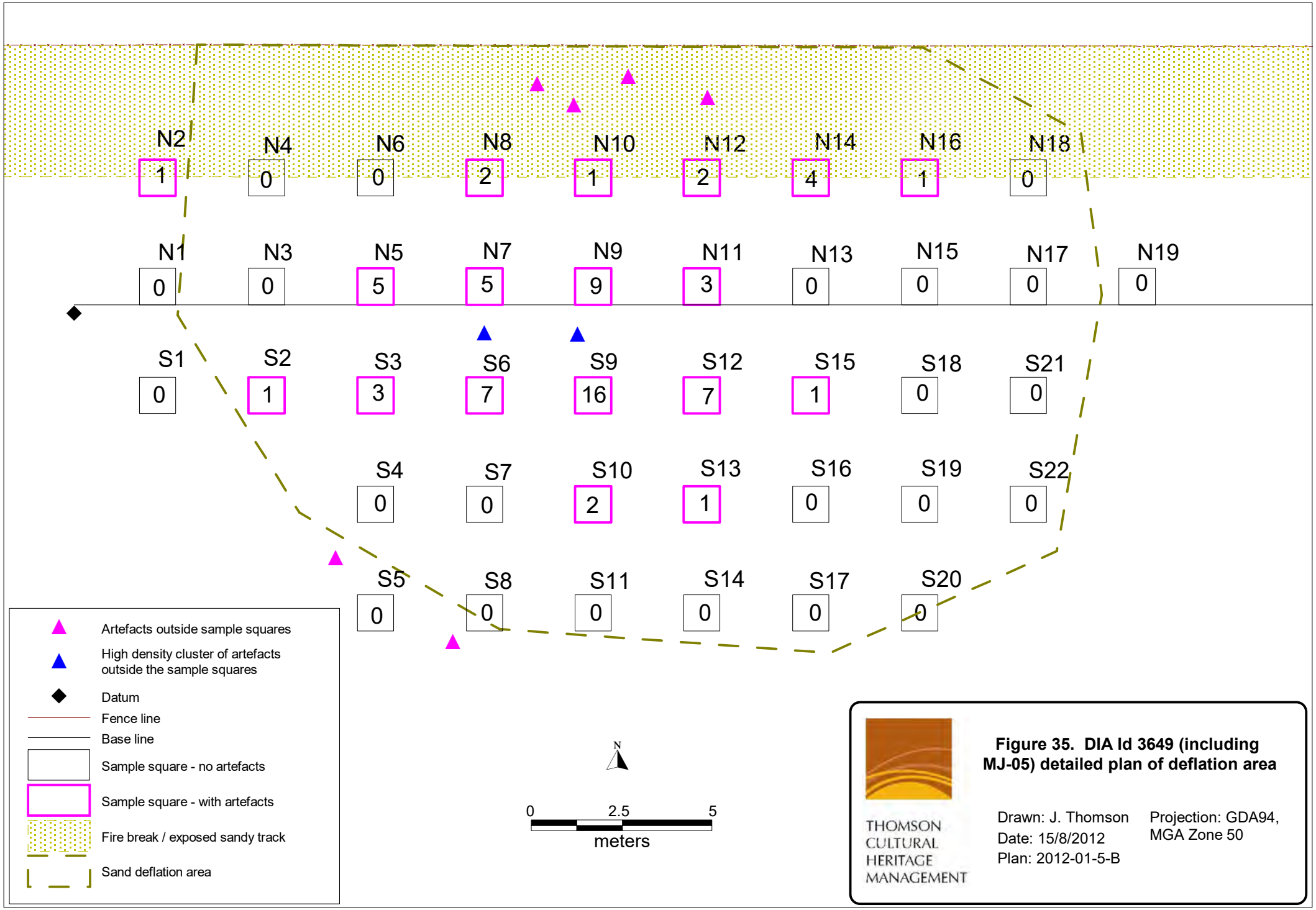
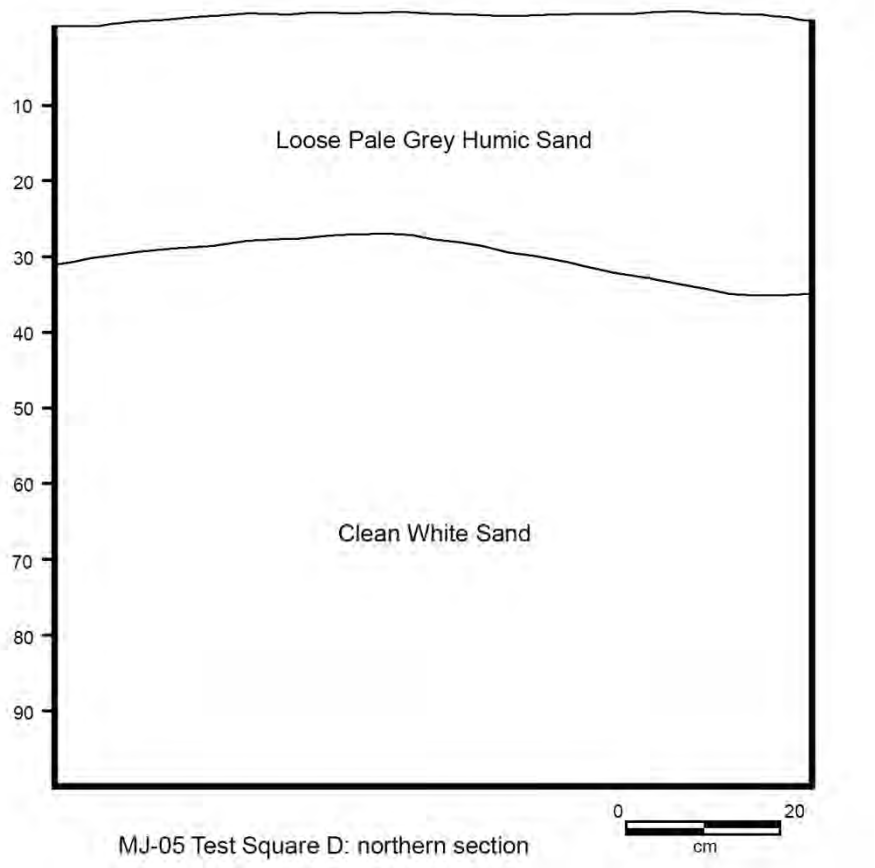

N2 1
N4 0
N6 0
N8 2
N10 1
N12 2
N14 4
N16 1
N18 0
N1 0
N3 0
N5 5
N7 5
N9 9
N11 3
N13 0
N15 0
N17 0
N19 0
S1 0
S2 1
S3 3
S6 7
S9 16
S12 7
S15 1
S18 0
S21 0
S4 0
S7 0
S10 2
S13 1
S16 0
S19 0
S22 0
S5 0
S8 0
S11 0
S14 0
S17 0
S20 0
Artefacts outside sample squares
High density cluster of artefacts outside the sample squares
Datum
Fence line
Base line
Sample square - no artefacts
Sample square - with artefacts
Fire break / exposed sandy track
Sand deflation area
N
0
2.5
5
meters
THOMSON CULTURAL HERITAGE MANAGEMENT
Figure 35. DIA Id 3649 (including MJ-05) detailed plan of deflation area
Drawn: J. Thomson
Date: 15/8/2012
Plan: 2012-01-5-B
Projection: GDA94, MGA Zone 50

Figure 36. DAA Id 3648 (MJ-05) test square D section (drawn by D. Neuweger)



5.6 MJ-08 – Modified tree

5.6.1 Grid references

The tree is located at the following coordinates:

1. 404725 mE 6428247 mN

A buffer of approximately 30 m should be applied around the tree.

5.6.2 Location

MJ-08 is located in the southeast corner of Lot 9000 Soldiers Road, approximately 190 m west of Soldiers Road and 20 m **south** of Manjedal Brook. DAA Id 3648 Soldiers Road Mundijong is located approximately 100 m north of the tree on the opposite side of Manjedal Brook. MJ-09 is located approximately 460 m due west. See Figure 11.

5.6.3 Environment

The tree is located in an open, mostly cleared paddock with a few large scattered Jarrah trees. Manjedal Brook is lined with large *Melaleuca* sp. trees. Ground cover comprised low grasses and weeds overlying a grey-white sand ground surface. Several pastoral fences dissected the paddock.

5.6.4 Description

MJ-08 is a modified *Eucalyptus marginata* (Jarrah) tree, approximately 10 m high with one main trunk that splits into three approximately 5 m above the ground. The girth of the tree had a diameter of 3.86 m. The tree appeared to be dead at the time of recording.

The bark has been removed from the lower section of the northern side of the trunk, creating a single ovoid shaped scar. The scar is approximately 1,880 mm long by 960 mm wide, with a regrowth depth of 140 mm. It is located approximately 560 mm above ground level.

Plate 87. MJ-08, modified tree, view south



Plate 88. MJ-08, view east, arrow indicating location of scar



Plate 89. MJ-08, close up of scar



Plate 90. MJ-08, detail of the scar regrowth



5.6.5 Site interpretation

This tree represents a single event of the procurement of bark for manufacturing artefacts such as a shield or container.

5.6.6 Statement of archaeological significance

MJ-08 is a modified *Eucalyptus marginata* (Jarrah) tree with a large ovoid-shaped scar on its northern side, most likely the result of a single event where the wood was procured for a shield or container.

MJ-08 is assessed as being of importance and significance due to its archaeological and scientific values. In terms of research potential, when considered individually modified trees have limited ability to provide information not available from other sites or contribute to regional research questions. However, as Rhoads (1992) points out, when considered in relation to other modified trees within the region they offer the means to investigate a specific time period (approximately the last 500 years), which many other artefactual-based sites do not. As Rhoads' study shows, groups of modified trees can be used to reveal information about how the modification of trees may have been organised at a regional scale and how they correlate with regional environmental contexts and water availability.

Modified trees are also rare in the local region, with only one other modified tree being recorded at Byford (DAA Id 23914 Byford Archaeological Survey 001). DAA Id 23914 differs from MJ-08 in that it is a modified Marri tree with two scars. DAA Id 23914 has also been reported felled and therefore may no longer exist. In contrast, whilst MJ-08 is located on a deceased tree, the scar is in good condition and has the potential to be conserved in the future. Further, MJ-08 has good interpretive capacity when considered in relation to local resource exploitation.

It is the opinion of the authors that MJ-08 constitutes a site within the meaning of section 5a of the *Aboriginal Heritage Act 1972*.

5.6.7 MJ-08 recommendations

It is **recommended** that Peet and its contractors are:

- advised of the existence and location of archaeological site MJ-08;
- informed that MJ-08 may meet the requirements of section 5 of the *Aboriginal Heritage Act 1972* and therefore it should not be impacted upon in any way; and
- advised to apply a 30 m buffer around the tree to prevent any inadvertent disturbance during groundwork activities.

Should at any stage Peet wish to disturb MJ-08 and an application is made for consent to use the land under section 18 of the *Aboriginal Heritage Act 1972*, it is **further recommended** that:

- Peet consults with the appropriate Nyungar Elders and Aboriginal Consultants about any proposed section 18 application, mitigation and salvage strategies and the management of any salvaged materials.

5.7 MJ-09 – Modified tree

5.7.1 Grid references

The tree is located at the following coordinates:

1. 404263 mE 6428244 mN

A buffer of approximately 30 m should be applied around the tree.

5.7.2 Location

MJ-09 is located along the central southern boundary of Lot 9000 Soldiers Road, approximately 66 m west of Soldiers Road and 50 m **south** of Manjedal Brook. DAA Id 3648 Soldiers Road Mundijong is located approximately 230 m northeast of the tree on the opposite side of Manjedal Brook. MJ-08 is located approximately 460 m due east. See Figure 11.

5.7.3 Environment

The tree is located in an open, mostly cleared paddock with a few large scattered Jarrah trees. Manjedal Brook is lined with large *Melaleuca* sp. trees. Ground cover comprised low grasses and weeds overlying a grey-white sand ground surface. Several pastoral fences dissected the paddock.

5.7.4 Description

MJ-08 is a modified *Eucalyptus marginata* (Jarrah) tree, approximately 20-25m high with one main trunk. The girth of the tree had a diameter of approximately 4 m. The tree was alive and growing at the time of recording and the Aboriginal Consultants present estimated based on the tree's size that the tree could be over 100 years old.

The bark has been removed from the middle section of the east-southeast side of the trunk, approximately 3.25 m above the ground. The single scar is roughly circular in shape, measuring approximately 1240 mm long by 2350 mm wide. Regrowth depth was not measured at the time of recording due to difficulty in accessing the scar.

5.7.5 Site interpretation

This tree represents a single event of the procurement of bark for manufacturing artefacts such as a shield or container.

5.7.6 Statement of archaeological significance

MJ-09 is a modified *Eucalyptus marginata* (Jarrah) tree with a large circular-shaped scar on its east-southeast side, most likely the result of a single event where the wood was procured for a shield or container.

MJ-09 is assessed as being of importance and significance due to its archaeological and scientific values. In terms of research potential, when considered individually modified trees have limited ability to provide information not available from other sites or contribute to regional research questions. However, as Rhoads (1992) points out, when considered in relation to other modified trees within the region they offer the means to investigate a specific time period (approximately the last 500 years), which many other artefactual-based sites do not. As Rhoads' study shows, groups of modified trees can be used to reveal information about how the modification of trees may have been organised at a regional scale and how they correlate with regional environmental contexts and water availability.

Modified trees are also rare in the local region, with only one other modified tree being recorded at Byford (DAA Id 23914 Byford Archaeological Survey 001). DAA Id 23914 differs from MJ-09 in that it is a modified Marri tree with two scars. DAA Id 23914 has also been reported felled and therefore may no longer exist. In contrast, whilst MJ-09 is located on a living tree, the scar is in good condition and has the potential to be conserved in the future. Further, MJ-09 has good interpretive capacity when considered in relation to local resource exploitation.

It is the opinion of the authors that MJ-09 constitutes a site within the meaning of section 5a of the *Aboriginal Heritage Act 1972*.

Plate 91. MJ-09, modified tree, view east



Plate 92. MJ-08, view west of scar



Plate 93. MJ-09, close up of scar



5.7.7 MJ-09 recommendations

It is **recommended** that Peet and its contractors are:

- advised of the existence and location of archaeological site MJ-09;
- informed that MJ-09 may meet the requirements of section 5 of the *Aboriginal Heritage Act 1972* and therefore it should not be impacted upon in any way; and
- advised to apply a 30 m buffer around the tree to prevent any inadvertent disturbance during groundwork activities.

Should at any stage Peet wish to disturb MJ-09 and an application is made for consent to use the land under section 18 of the *Aboriginal Heritage Act 1972*, it is **further recommended** that:

- Peet consults with the appropriate Nyungar Elders and Aboriginal Consultants about any proposed section 18 application, mitigation and salvage strategies and the management of any salvaged materials.

6.0 ANALYSIS

6.1 Artefact analysis

Analysis of the Mundijong lithic assemblages was undertaken in order to assess the content, complexity and spatial patterning of the sites. The specific research questions for this project are listed in section 3.1 above and focus on comparing:

- sites by density and raw material in relation to the location and size of site; and
- sites identified during this assessment with the previously studied and excavated portion of site DIA Id 3648 Soldiers Road, Mundijong.

It should be noted that the artefact analysis includes two additional sites, MJ-06 and MJ-07, which are newly recorded sites located at Lot 50 Cockram Street, Mundijong. These two sites are reported on in full under a separate cover (Thomson and Neuweger, 2014), however, the subsurface testing of these two sites was undertaken at the same time as MJ-01 to MJ-04 and DIA Id 3648 under the same section 16 permit. The results of the subsurface testing at MJ-06 and MJ-07 are therefore relevant to the research undertaken in this report and are included in the analysis and subsequent discussion below.

In this section the terms 'total collection', 'total assemblage' and 'total excavation assemblage' are used to refer to the combined artefact assemblages from all sites excavated during the section 16 excavation field work, unless otherwise noted. The complete artefact catalogue is included in Appendix 9 and the large data analysis tables are included in Appendix 10.

6.1.1 Subsurface excavation assemblage

This section examines the complete assemblage recovered during test excavations at MJ-01 to MJ-07 and DIA Id 3648 (MJ-05) and compares the sites to one another. The individual sites were further analysed for intra site variations, see section 6.1.2 below.

Discard Frequency

The total assemblage from the sub-surface excavations at the Mundijong sites consisted of 1471 pieces of artefactual stone, with a total weight of 1.2 kg. MJ-06 contained the largest number of artefacts with 916 pieces collected from the excavation at this site. This site also contained the highest artefact density at 216.7 artefacts per sq m. DIA Id 3648 (MJ-05) contained the next highest concentration of artefacts with 337 artefacts recovered from the test excavation, providing an artefact density of 112.3 artefacts per sq m. MJ-04 contained the smallest number of recovered artefacts at 34 and had the lowest density of 17 artefacts per square metre. See Table 28 for details.

Analysis of the relationship between the total number of artefacts to the total weight of the artefacts has shown that artefacts recovered from site DIA Id 3648 (MJ-05) are significantly heavier than other sites, indicating a higher level of primary and early stage artefact production at this site. Conversely, whilst MJ-06 contains 62.3% of the artefacts collected, the artefacts only comprise 19.8% of the total assemblage weight, indicating smaller artefact size and/or later stage reduction of artefacts. See Table 29 for further details.

Table 28. Excavation and artefact details

Site	Probe holes	Test squares	# of excavator trenches	Total excavated (sq m)	Artefact total	Artefacts per sq m	Total weight (g)
MJ-01	3	1	1	2.8	77	28.0	12.5
MJ-02	3	1	1	2.8	55	20.0	14.1
MJ-04	4	1	0	2.0	34	17.0	152.9
DIA Id 3648 (MJ-05)	4	1	1	3.0	337	112.3	971.7
MJ-06	6	1	1	3.5	916	261.7	286.7
MJ-07	0	1	0	1.0	52	52.0	11.6
Total					1471		1449.5

Table 29. Comparison of artefact and weight totals

Site	Artefact Total	% of total artefacts	Weight Total (grams)	% of total weight
MJ-01	77	5.2%	12.5	0.9%
MJ-02	55	3.7%	14.1	1.0%
MJ-04	34	2.3%	152.9	10.5%
DIA Id 3648 (MJ-05)	337	22.9%	971.7	67.0%
MJ-06	916	62.3%	286.7	19.8%
MJ-07	52	3.5%	11.6	0.8%
Total	1471		1449.5	

Artefact Types

The most common flaked stone artefact type occurring in the total assemblage was debris, followed by flaked pieces, see Table 48 in Appendix 10 and Figure 37. With the exception of MJ-02, all sites displayed a dominance of debris within their assemblages. At MJ-02 the most dominant artefact type was flaked pieces, followed by debris. MJ-07 was the only site that contained an equal number of flaked pieces and complete flakes and MJ-07 had the highest proportion of flakes of any of the sites tested. Longitudinally and transversely broken flakes were identified in all sites, however, transversely broken flakes were only identified at MJ-01, MJ-02, MJ-06 and MJ-07, whilst only longitudinally broken flakes were identified in MJ-01, DIA Id 3648 (MJ-05) and MJ-06. The highest number of cores was identified at DIA Id 3648 (MJ-05) and DIA Id 3648 (MJ-05) also contained the most manuports in number, but not in frequency.

The total assemblage contained 13 retouched pieces (0.9% of the entire collection). The location of the retouched pieces and the number of retouched margins per artefact are shown in Table 30. In summary, there were an equal number of artefacts with one and two retouched margins and only one artefact that had three retouched margins.

Seven formal tools were identified within the total excavation assemblage, comprising less than 1% of the collection. Steep edged scrapers were the most common tool type and no formal tools were identified at MJ-04 or MJ-07, see Table 48 in Appendix 10.

Figure 37. Artefact types by site

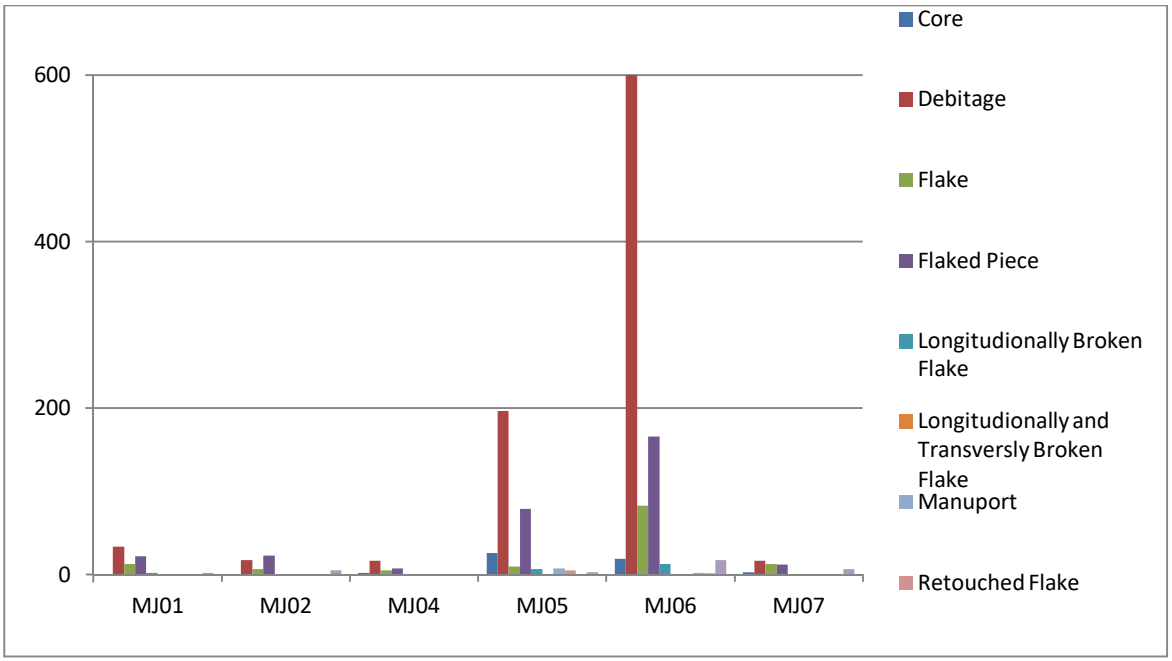


Table 30. Retouched artefacts by site

				DIA Id 3648 (MJ-05)			
1 Margin		1		4	1		6
2 Margins	2			1	3		6
3 Margins				1			1
Total	2	1	0	6	4	0	13

Raw Material

A total of fifteen raw material types were identified from the test excavations, with only two of these raw material types comprising 92.2% of the entire excavated collection. The most common lithic material identified was white quartz (55.9% of total artefacts), followed by crystal quartz (36.3% of total assemblage), see Table 49 in Appendix 10 and Figure 38.

With regards to raw material diversity, none of the sites contain all fifteen identified raw material types; however crystal quartz and white quartz were recovered from every site. DIA Id 3648 (MJ-05) had the greatest raw material diversity with twelve raw materials types identified within its sub-surface assemblage. MJ-06 contained eight raw materials types, MJ-01 contained five, MJ-04 and MJ-07 contained four raw material types and MJ-02 contained only three types of different raw materials. DIA Id 3648 (MJ-05) was the only site to contain brown quartzite, conglomerate, schist and yellow quartz. MJ-06 was the only site to contain granite and MJ-07 was the only site to contain mylonite, although mylonite was recorded at DIA Id 3648 Soldiers Road site by Pearce (1979). MJ-07 is also the only site that had smokey quartz (69.2%) as the most common raw material type.

Four of the seven formal tools identified within the total excavation assemblage were manufactured from crystal quartz, two were made from white quartz and one was made from smokey quartz, see Table 31.

Figure 38. Lithic material types by total artefacts recovered

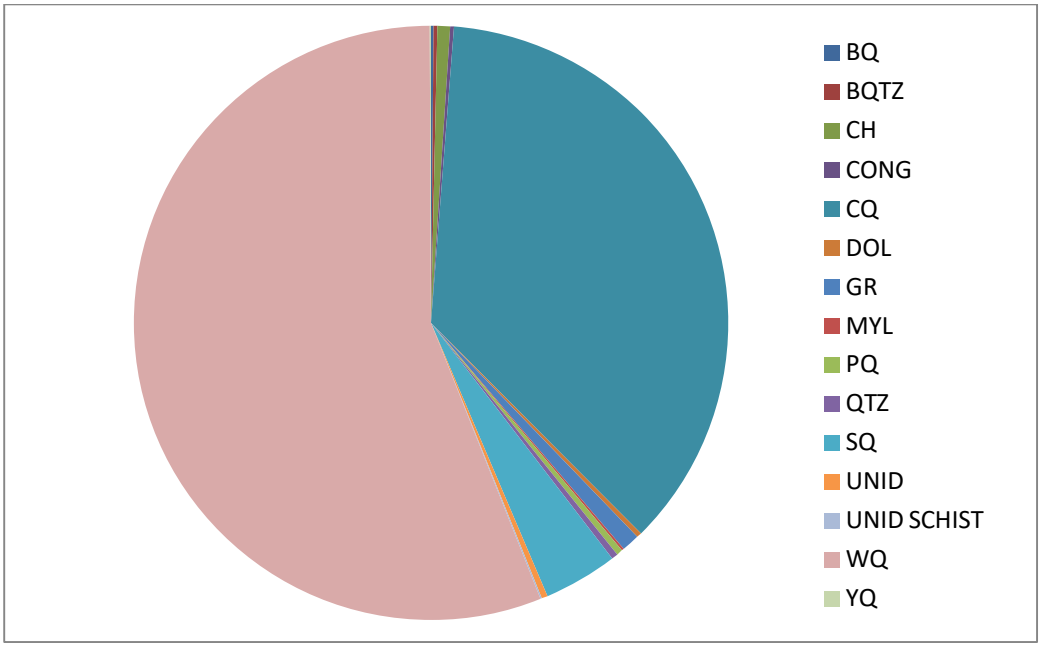


Table 31. Tool types and raw materials

Tool	MJ-01	MJ-02	DAA Id 3648 (MJ-05)	MJ-06
Bladelet	1 (SQ)			
Flat edged scraper	1 (CQ)	1 (CQ)		
Notched scraper			1 (CQ)	
Steep edge scraper			1 (WQ)	2 (CQ, WQ)

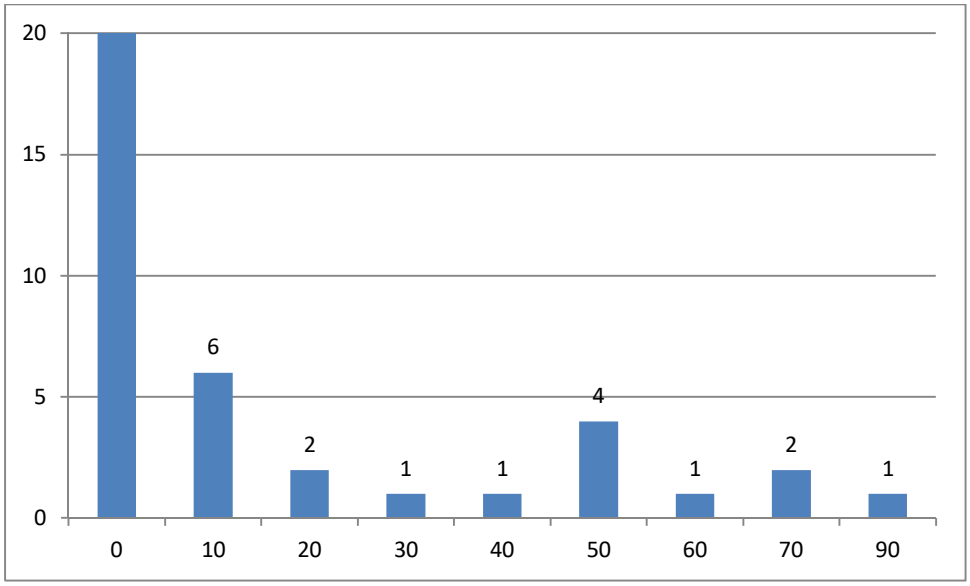
Manufacturing stages and reduction sequences

Cortex was noted on eighteen artefacts (1.2% of the total excavated assemblage), of which six (33.3%) had 10% cortex and four (22.2%) had 50% cortex. Artefacts with cortex were recovered primarily from MJ-06. The lack of flakes with cortex indicates that these sites are not being used as initial reduction places and that flakes and blanks from quarries, which are later used as cores, are being brought onto the sites. See Table 32 and Figure 39.

Table 32. Artefacts with cortex by site

Site	10% cortex	20% cortex	30% cortex	40% cortex	50% cortex	60% cortex	70% cortex	90% cortex	Total
MJ-01									0
MJ-02	1	1							2
MJ-04	1								1
DAA Id 3648 (MJ-05)								1	1
MJ-06	4	1	1	1	4		2		13
MJ-07						1			1
Total	6	2	1	1	4	1	2	1	18

Figure 39. Percentage of cortex identified on subsurface artefacts

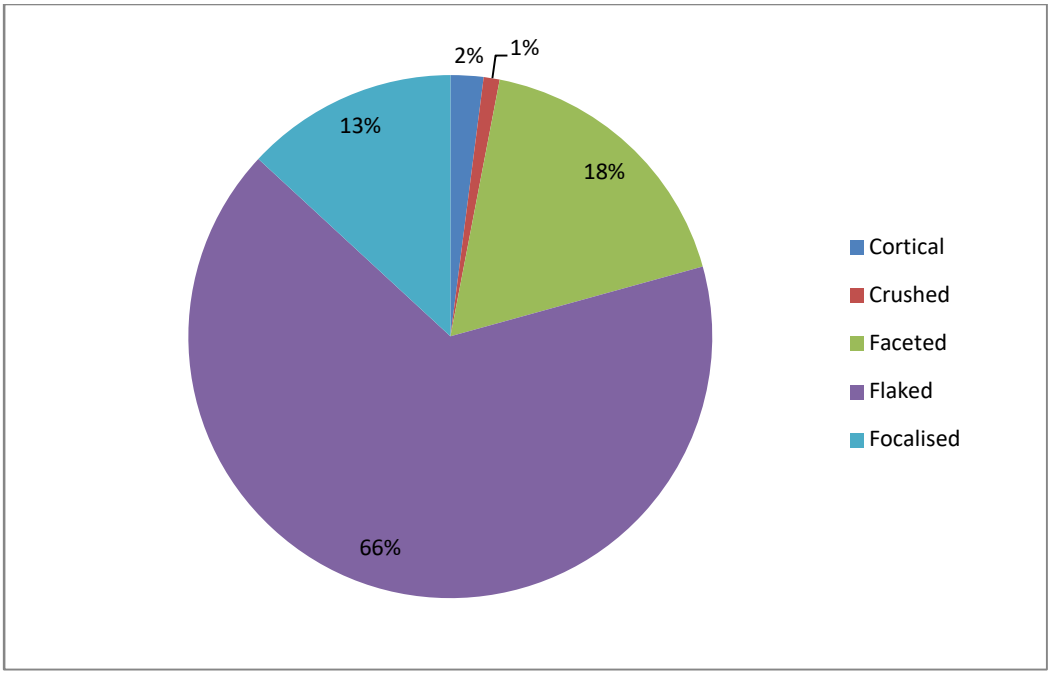


One hundred and ninety eight platforms were identified on artefacts within the total excavated assemblage. The most common type of platform was flaked (n=131, 66%). The majority of artefacts with identified platforms were recovered from MJ-06. Focalised platforms are most common in MJ-06 and cortical platforms are found only within MJ-06. See Table 33 and Figure 40.

Table 33. Platform types by site

Site	Cortical	Crushed	Faceted	Flaked	Focalised	Total
MJ-01			3	16		19
MJ-02			4	7	1	12
MJ-04		1		3	2	6
DAA Id 3648 (MJ-05)			8	16	2	26
MJ-06	4		15	77	19	115
MJ-07		1	5	12	2	20
Total	4	2	35	131	26	198

Figure 40. Platform types identified



Two hundred and three terminations were identified on artefacts within the total excavated assemblage, of which 41 were broken and could not be accurately identified. Of those that could be identified, the most common type was feather (n=126, 78%) and stepped (n=31, 19%) with the other types equalling less than 3% of the total, see Figure 41. MJ-06 contains the highest number of termination types and the only outré passé termination was identified at MJ-06, see Table 34 and Figure 41. Feather and step terminations were present in all sites.

Figure 41. Termination types identified

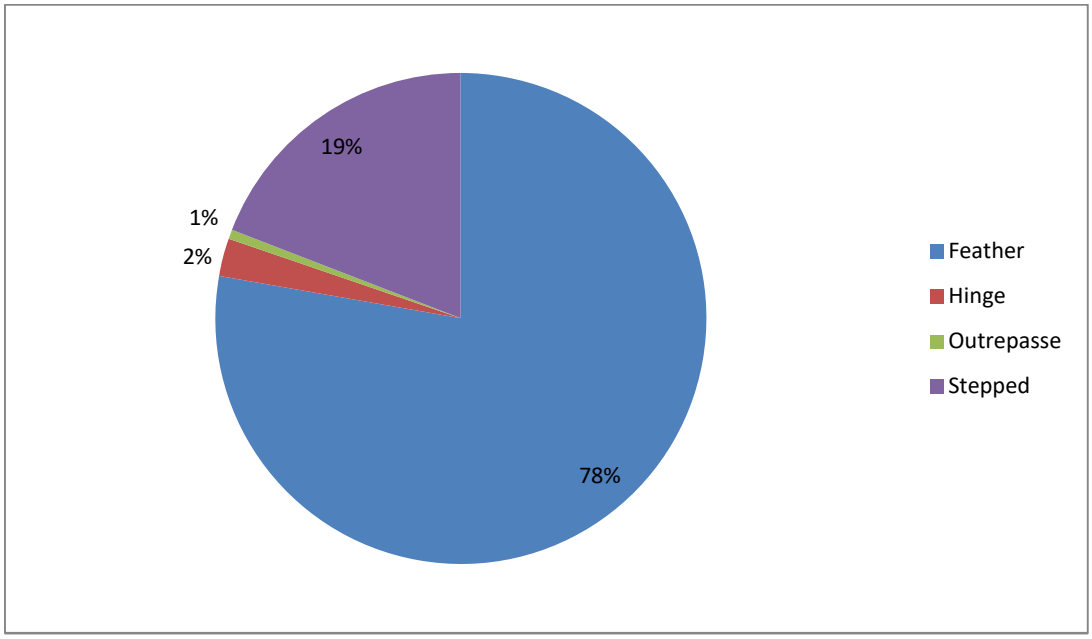


Table 34. Flake terminations by site

	Feather	Hinge	Outré passé	Stepped	Total
MJ-01	12	1		4	17
MJ-02	4			3	7
MJ-04	3			2	5
DAA Id 3648 (MJ-05)	22			2	24
MJ-06	76	3	1	17	97
MJ-07	9			3	12
Total	126	4	1	31	162

Artefact and Flake size

Overall the analysis showed that the artefacts recovered from the sites at Mundijong are all relatively small and light.

Artefacts were classified according to length categories (5 mm brackets), with the smallest observation being 1.2 mm and the largest 87.1 mm. The most common length category was 5–10 mm (48.4% of the total excavation assemblage). The next most common length category was 0–5 mm (30.8%). Overall, 92.2% of the collection had a maximum length of less than 15.1 mm, indicating that the artefacts collected from all the sites are relatively small objects, see Table 35**Error! Reference source not found.**.

MJ-01 and MJ-02 were noted as containing particularly small artefacts, with no artefact lengths being longer than 20.1 mm, whilst in contrast DIA Id 3648 (MJ-05) had artefacts in each size category up to 90 mm.

Table 35. Artefact lengths by site

Maximum length (mm)	MJ-01	MJ-02	MJ-04	DAA Id 3648 (MJ-05)	MJ-06	MJ-07	Total
0-5	27	11	11	90	304	10	453
5-10	36	30	11	159	448	28	712
10-15	11	12	8	41	108	11	191
15-20	3	2	2	18	32	2	59
20-25				8	14		22
25-30				9	9	1	19
30-35			1	3			4
35-40				1			1
40-45				2	1		3
45-50				2			2
50-55				2			2
70-75				1			1
85-90			1	1			2
Total	77	55	34	337	916	52	1471

When artefact types were considered in relation to the size categories, it was evident that the largest artefacts recorded were predominantly cores and manuports. The majority of cores ranged

between 15–30 mm in length. Debris is most commonly of a small size ranging in length from 0–10 mm. Flakes are slightly larger with a length most commonly between 5–15 mm. Retouched pieces and identified tools ranged between 5–25 mm. See Table 36.

Table 36. Artefact lengths by artefact type

Maximum length (mm)	C	DB	F	FP	LBF	LBF/TBF	MANU	RF	RFP	TBF	Total
0-5		394	10	37	4		1			7	453
5-10	1	454	72	153	9	2		2	2	17	712
10-15	5	37	40	88	6			3	1	11	191
15-20	15	7	4	24	3	1		2	2	1	59
20-25	13	1	1	5			1	1			22
25-30	12	1	4	2							19
30-35	3						1				4
35-40							1				1
40-45	2						1				3
45-50				1			1				2
50-55	1						1				2
70-75							1				1
85-90							2				2
Total	52	894	131	310	22	3	10	8	5	36	1471

With regards to weight, a significant proportion of the total collection falls within the 0–5 g category (n=1440, 97.9%), with sites MJ-01, MJ-02 and MJ-07 containing artefacts only from this size category. MJ-05 displays the greatest diversity of weight ranges, with artefacts in almost all weight categories. When classified according to artefact type, manuports and cores were the heaviest objects whilst all other artefacts, with the exception of one flake, weigh less than 10 g, see Table 37 and Table 38.

Table 37. Artefact weight by site

Weight (g)	MJ-01	MJ-02	MJ-04	MJ-05	MJ-06	MJ-07	Total
0-5	77	55	32	317	907	52	1440
5-10			1	9	6		16
10-15				1	2		3
15-20					1		1
20-25				1			1
25-30				1			1
40-45				3			3
65-70				2			2
100-105				1			1
135-140			1	1			2
245-250				1			1
Total	77	55	34	337	916	52	1471

Table 38. Artefact weight by artefact type

Weight (g)	C	DB	F	FP	LBF	LBF/TBF	MANU	RF	RFP	TBF	Total
0-5	36	893	128	309	22	3	1	7	5	36	1440
5-10	10	1	3				1	1			16
10-15	2						1				3
15-20							1				1
20-25	1										1
25-30	1										1
40-45	1			1			1				3
65-70							2				2
100-105	1										1
135-140							2				2
245-250							1				1
Total	52	894	131	310	22	3	10	8	5	36	1471

The length of flake platforms was also examined to analyse artefact size across the total excavated collection. Platform lengths ranged between 1.3 mm and 17.4 mm, with the majority of artefacts (81.8%) having platform length between 2 mm and 8 mm, and a high proportion of these measuring between 2–4 mm in length. The results of the flake platform length analysis concur with the artefact weight and length analyses, which indicate that the majority of artefacts recovered from the Mundijong sites are all small in size. See Table 39.

Table 39. Artefact platform length by site

Platform length (mm)	MJ-01	MJ-02	MJ-04	DAA Id 3648 (MJ-05)	MJ-06	MJ-07	Total
0-2	1			1	2	1	5
2-4	9	4	3	5	28	8	57
4-6	3	3		6	29	2	43
6-8	5	4		4	23	3	39
8-10				5	9	2	16
10-12	1			1	3		5
12-14				1	1	1	3
14-16					1		1
16-18				1			1
Total	19	11	3	24	96	17	170

6.1.2 Intra-site subsurface comparisons

The intra-site analysis examined each spit within each site in order to assess levels of bioturbation and sorting of artefacts within the sand dunes as a result of taphonomic processes, as well as examining any changes in artefact production over time.

Taphonomic analysis

The subsurface deposit observed within the Mundijong sites during the excavation displayed no strong evidence that the sand dunes were mobile at the time of artefact deposition, as there was no stratification nor obvious weight or size sorting of artefacts observed.

There did not appear to be any correlation between sites with regards to the depth of artefact bearing layers, see Table 40. Spit 11 (1000 – 1100 mm depth) was the only spit that did not contain artefacts within any of the sites. Overall spit 7 (600 – 700 mm depth) was the densest artefact-bearing layer across sites, however, this is likely skewed because of the large amount of artefacts recovered from spit 7 at MJ-06. MJ-06 appears to have two distinct concentrated layers of artefacts (spit 5 and 7); whereas artefacts at MJ-05 are more evenly distributed with almost all spits containing artefacts. MJ-04 contained artefacts only within the first five spits (down to a depth of 500 mm) and MJ-07 contains artefacts only in spit 7 (600 – 700 mm depth).

In summary, from the artefact depth analysis there does not appear to be any obvious patterns in artefact depth distribution that links each of the Mundijong sites together nor suggests that the sites were used at the same time or in the same way.

Table 40. Spit totals by site

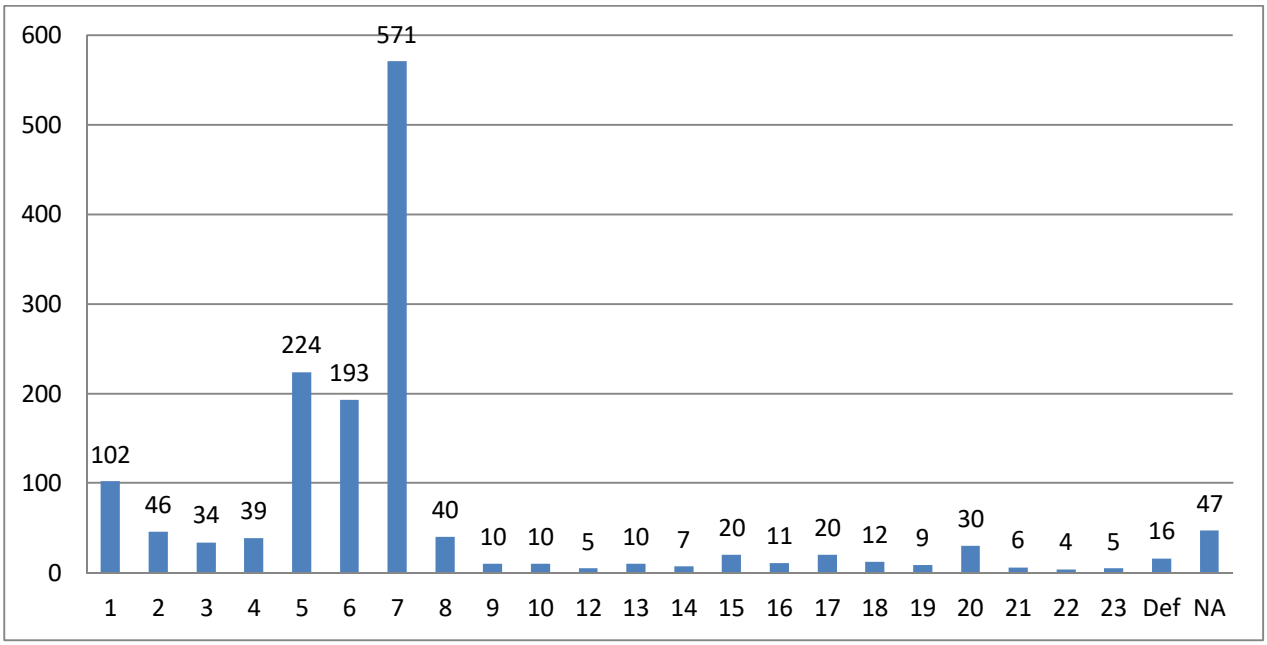
Spit	MJ-01	MJ-02	MJ-04	DAA Id 3648 (MJ-05)	MJ-06	MJ-07	Total
1	35	14	12	41			102
2	15	5	2	22	2		46
3	6	3	4	20	1		34
4	4		5	24	6		39
5	8	1	11	28	176		224
6	4	19		37	133		193
7	2			21	499	49	571
8	1			18	21		40
9				8	2		10
10				5	5		10
11							0
12	1				4		5
13				6	4		10
14		1		2	4		7
15	1	5		8	6		20
16				2	9		11
17				7	13		20
18				8	4		12
19				8	1		9
20				30			30
21				6			6
22				4			4
23				5			5
Deflation				16			16

NA		7		11	26	3	47
Total	77	55	34	337	916	52	1471

Further, when artefact depth distribution is considered in relation to artefact weight, it appears that light weight artefacts are present in all sites at both the top and bottom of the excavation units, see Table 50 in Appendix 10 and Figure 42. At DAA Id 3648 (MJ-05), the heaviest artefacts were located in the deflation area, potentially indicating that these heavier objects have been recently uncovered in the sand blow out. Similarly, examination of artefact length in relation to spit depth shows that the longest artefacts were found in the deflation at DAA Id 3648 (MJ-05), see Table 51 in Appendix 10 and Figure 43.

It is concluded that there is no obvious size sorting between spits and that artefacts are not moving downwards within the dunes.

Figure 42. Total artefact numbers per spit for complete excavated assemblage



Artefact types

Artefact types across each site were examined according to spit. Table 52 in Appendix 10 shows there was no clear correspondence or patterning of artefact types and depth between sites. For example, cores are found in DAA Id 3648 (MJ-05) both in the very upper layers as well as the lower layers, with a break between but conversely debris was found within all spits.

Raw material

Raw material was examined according to average weight and length, in order to determine the difference between the raw materials found in the Mundijong sites, and to determine whether there were any differences in the use of the various raw materials.

The seven heaviest raw materials types, brown quartz (n=2), conglomerate (n=3), dolerite (n=4), pink quartz (n=5), unidentified (n=5), schist (n=1) and yellow quartz (n=1) had on average the longest length and the lowest levels of occurrence within the total excavated assemblage. The more common raw materials were found in larger amounts across the sites and tended to be of average weight and length. See Figure 44 and Figure 45.

Figure 43. Total number of artefacts per spit by site

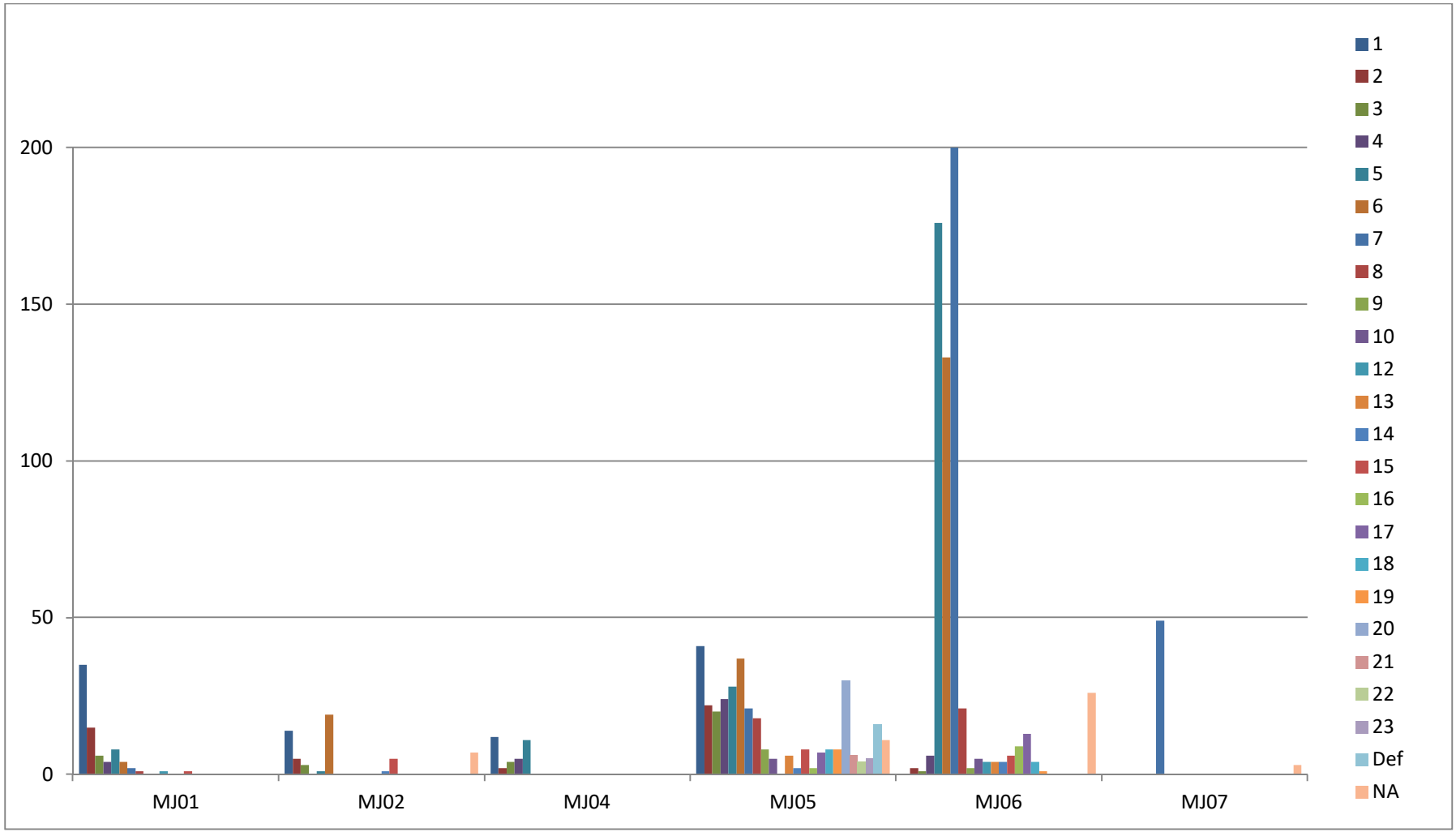


Figure 44. Average weight (g) of raw material types

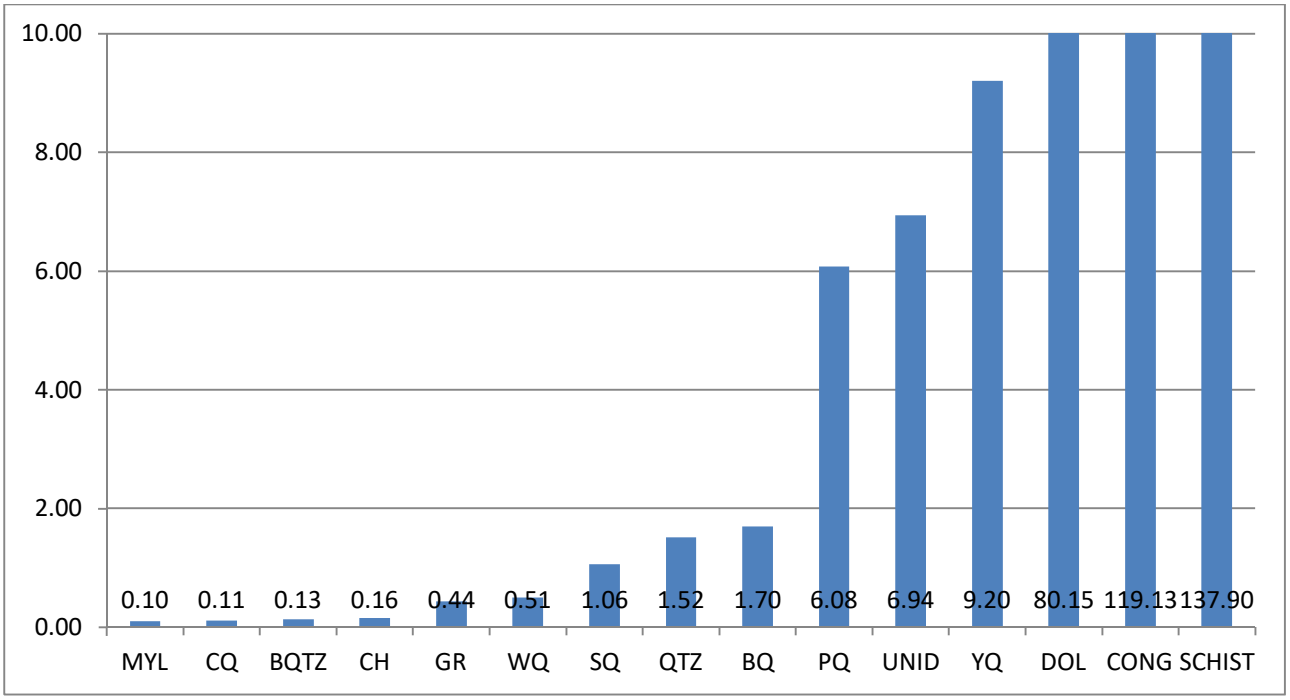
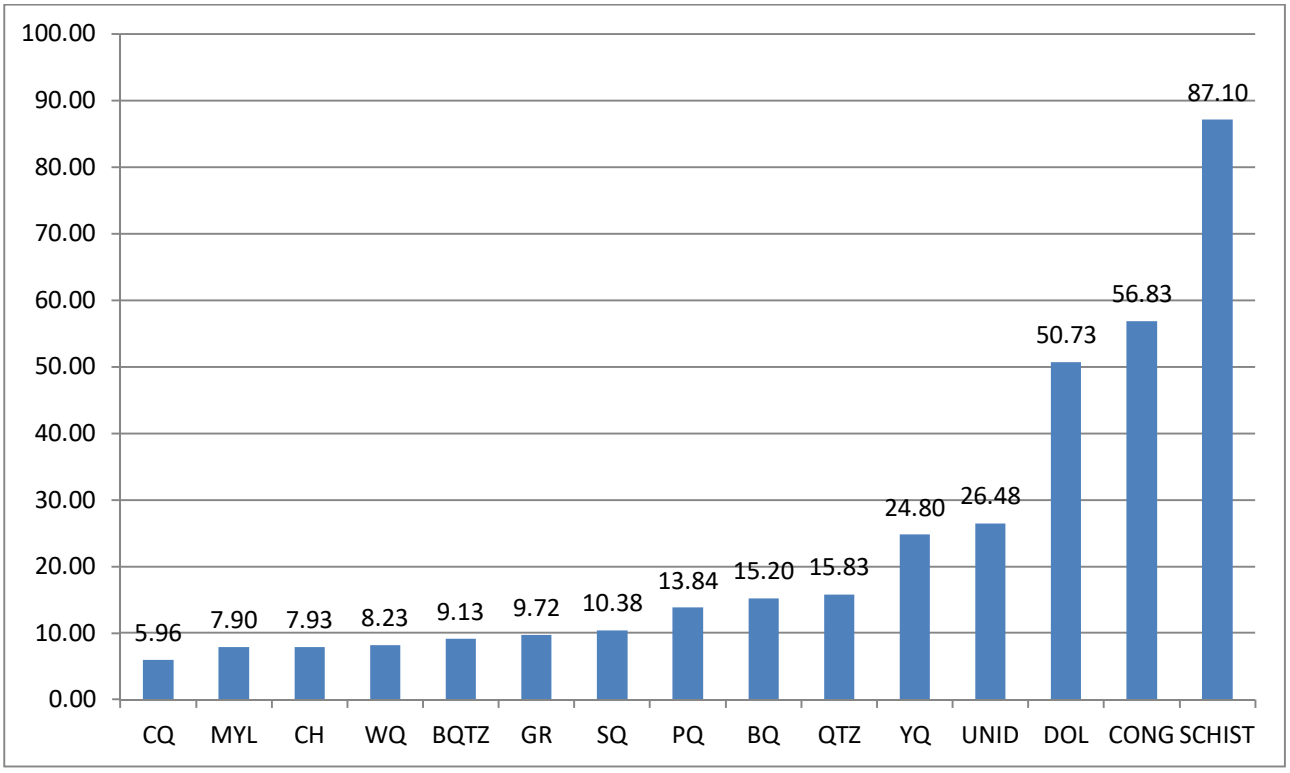


Figure 45. Average length (mm) of raw material



Examination of the distribution of raw material types across sites and spits revealed no clear patterns of association between raw material types and depth. White quartz was found in almost all spits and the remaining raw material types are generally spread throughout the spits, see Table 53 in Appendix 10.

Manufacturing stages and reduction sequences

An analysis of the location of artefacts with cortex and the various platform and termination types within the Mundijong sites was undertaken to determine if there were any changes over time in the use or the types of artefacts being manufactured.

Most artefacts with cortex were identified at MJ-06 and were concentrated in spit 7. Artefacts manufactured from white quartz were the most common to have cortex, whilst minor amounts of smoky quartz, brown quartz and crystal quartz were identified with cortex. See Table 41.

Table 41. Artefacts with cortex site and spit locations

Spit	1	5	6	7	9	14	Deflation	Total
MJ-02								
10			1 (SQ)					1
20	1 (WQ)							1
MJ-04								
10	1 (BQ)							1
DAA Id 3648 (MJ-05)								
90							1 (WQ)	1
MJ-06								
10		1 (WQ)		2 (CQ, WQ)	1 (WQ)			4
20				1 (WQ)				1
30			1 (WQ)					1
40				1 (CQ)				1
50				3 (WQ)		1 (WQ)		4
70			1 (WQ)	1 (WQ)				2
MJ-07								
60				1 (WQ)				1
Total	2	1	3	9	1	1	1	18

Analysis showed that there was no obvious patterning with regards to depth or site locations of the various platform types identified. Flaked platforms are identified in all sites and spread out among the spits. Faceted platforms are also common and are identified at all sites except MJ-04. They also appear to be distributed across all spits. See Table 42.

A review of the raw material types with regards to platform type identified that several raw material are used to make flakes. Interestingly, the two mylonite pieces identified at MJ-07 are both flakes with flaked platforms.

Table 42. Artefact platform type site and spit locations

Spit	1	2	3	4	5	6	7	8	13	14	15	16	17	19	20	DEF	NA	Total
MJ-01																		
Faceted	3																	3
Flaked	8	2	1		3	2												16
MJ-02																		
Faceted						2				1	1							4
Flaked	1	1	1			3					1							7
Focalised	1																	1
MJ-04																		
Crushed				1														1
Flaked	1			1	1													3
Focalised	1				1													2
DAA Id 3648 (MJ-05)																		
Faceted	1						2	1							2	1	1	8
Flaked	2	3		1		1	2	1			1			1	2	2		16
Focalised		2																2
MJ-06																		
Cortical					1	2							1					4
Faceted					1	5	8					1						15
Flaked					13	18	30	1	1		2	2	4				6	77
Focalised				1	6	5	4					1	1				1	19
MJ-07																		
Crushed							1											1
Faceted							5											5
Flaked							12											12
Focalised							2											2
Total	18	8	2	4	26	38	66	3	1	1	5	4	6	1	4	3	8	198

There is a similar pattern with regards to artefact terminations. Feather and stepped terminations are found at all sites. Hinge terminations are found at MJ-01 and MJ-06 and the one outré passé termination is present at MJ-06. There also appeared to be no significant clustering of termination types by spits. See Table 43.

Table 43. Artefact terminations site and spit locations

Spit	1	2	3	4	5	6	7	8	13	15	16	17	19	20	22	Deflation	NA	Total
MJ-01																		
Feather	8		1		1	2												12
Hinge		1																1
Stepped	3	1																4
MJ-02																		
Feather	1					1				2								4
Stepped		1				2												3
MJ-04																		
Feather				2	1													3
Stepped	2																	2
DAA Id 3648 (MJ-05)																		
Feather	3	4		1			3	2		1		1	1	2	1	2	1	22
Stepped							1							1				2
MJ-06																		
Feather					15	16	32			1	3	4					5	76
Hinge					1	2												3
Outré passé					1													1
Stepped					3	4	4		1		1	2					2	17
MJ-07																		
Feather							9											9
Stepped							3											3
Total	17	7	1	3	22	27	52	2	1	4	4	7	1	3	1	2	8	162

6.1.3 Summary

Overall there is no indication of bioturbation or sorting of the artefacts identified by site. This conclusion is based on the non correlation between depth, size and weight and the lack of evidence observed during excavation that the dunes have been mobile.

It is noted that none of the Mundijong sites contained any artefacts at spit 11. Sites MJ-01, MJ-02, DAA Id 3648 (MJ05) and MJ-06 contained artefacts below spit 11.

7.0 DISCUSSION

This section discusses the results of the archaeological assessment in relation to the research questions initially posed and the broader regional context. Several avenues for future archaeological inquiry are also identified.

7.1 Research questions

Sixteen research questions were posed in section 3.1 which guided the archaeological investigation at the Mundijong sites. Each research question is addressed below.

7.1.1 Surface component

1. *Is the hypothesis that sites are located on elevated Bassendean white sand dunes or rises, and/or adjacent to water sources supportable?*

The current survey and subsurface investigation has confirmed this hypothesis. All artefacts located during the investigation were located on and/or within white Bassendean sand rises. Within the Mundijong area these sandy rises are surrounded by low lying plausiplain which becomes inundated in the wetter months providing periodic sources of water and enriched resources. Site MJ-07 has further indicated that the sandy rises within the region can contain subsurface artefacts with no surface expression.

Subsurface testing of the plausiplain clays between the Bassendean sand dunes did not reveal any artefactual material and therefore it is concluded that artefactual material is confined only to the sand dunes, sand rises and sand lenses within the Pinjarra Plain alluvial unit.

The results of the investigation also confirmed that sites located closer to more permanent water sources, such as DAA Id 3648 (MJ-05), comprise larger, denser and more complex sites.

2. *Is Thomson's (2011) finding that artefacts within sites located on sandy rises and dunes are predominantly located on the top and eastern slopes correct?*

The distribution patterns of artefacts located on sandy rises within the Mundijong area did not exhibit any correlation in terms of location or elevation on the sand dune and therefore do not concur with Thomson's (2011) findings at Pinjarra. Within the Mundijong area the surface exposure of artefacts appeared to be more a factor of previous ground disturbance, such as mechanical excavation of sand pits associated with land clearance and pastoral activities, and subsequent weathering and erosion rather than a product of past behaviours or selective landscape use.

3. *Is there an association between dune aspect or erosion surface orientation and artefact types/densities?*

Artefact density was higher within deflations or erosion surfaces at all of the Mundijong sites. As outlined above, erosion surface orientation was mainly determined by previous ground disturbance associated with European occupation and therefore it is concluded that surface artefact density and distribution across the sandy rises and dunes was more a factor of land clearance and pastoral activities rather than a behavioural preference for occupation on a particular side of the sand dunes.

4. *Is there an association between dune altitude and artefact types and/or densities?*

There does not appear to be any significant association between dune altitude and artefact types. All of the Mundijong sites assemblages were dominated by debitage (debris, flaked pieces and

flakes) with no discernible variation between sites on dunes of different altitudes. Similarly, there were no obvious associations between dune height and either surface or subsurface density (see Table 44).

Table 44. Comparison of dune height, artefact types and artefact density

Site	Dune altitude	Artefact types	Surface density	Subsurface density
MJ-01	44.34	Predominantly DB, FP, F	high (1.48/sq m)	58/m3
MJ-02	29.68	Predominantly DB, FP, F	high (6.5/sq m)	20/m3
MJ-03	26.8	Predominantly FP, F	low (0.015/sq m)	-
MJ-04	31.6	Predominantly FP, F, TBF, DB	low (0.013/sq m)	17/m3
DAA Id 3648 (MJ-05)	40.5	Predominantly DB, FP, F	medium (0.3/sq m)	107/m3
MJ-06	34.5	Predominantly DB, FP, F, MPC, Retouch	medium	248/m3
MJ-07	30.16	Predominantly DB, FP, F, MPC	nil	26/m3

5. What is the variability between sites in terms of artefact type, lithology and size?

Considering only the surface component of the sites, it was identified that there was a higher diversity in artefact types and presence of formal tool types at large and extensive sized sites when compared to small sized sites. Similarly, raw material diversity was higher on the surface of large and extensive sites and conversely there was very low raw material diversity at small sites. It should be noted however that the surface assemblage is not necessarily representative of the complete assemblage of an artefact scatter within a Bassendean sand dune, see below for further discussion.

6. What activities can be identified at the site[s]?

A range of activities can be identified at the Mundijong sites. Site DAA Id 3648 (MJ-05) has been interpreted as being the main base camp within the local region, due to its extensive size, assemblage variability and complexity and its immediate proximity to permanent fresh water. At this site family groups likely gathered for extended periods of time to exploit the resources of the Swan Coastal Plain and the nearby Jarrah forest of the Darling Scarp, and identifiable activities included the manufacturing and maintenance of tools and the processing and consumption of faunal and floral resources. At smaller, more peripheral sites such as MJ-01, MJ-02, MJ-03, MJ-04 and MJ-06, shorter term occupation activities included core reduction, tool trimming and re-sharpening.

7. How does the high density of sites within the survey area compare with the regional context?

Site density within the Pinjarra Plains geomorphic unit was initially evaluated by Hallam (1986) as part of the SAAS. Hallam identified a site density of 1.63 sites per sq km for the Pinjarra Plain which was adjusted to 6.35 sites per sq km to account for 'fractional visibility' (Hallam, 1986:7). Subsequent surveys within the region recorded similar density levels, see Table 45.

Table 45. Regional site densities

Survey area	Report	Site density per sq km
Perth airport	Anderson (1983)	6.5
Tonkin highway	Edwards and McDonald (1999)	6.5
Forrestdale industrial area	McDonald Hales & Associates (2001b)	6.0
Byford	Tempus (2006)	3.8
Pinjarra Refinery	Thomson (2011)	4.4
Champion Lakes Recreational Park	McDonald Hales & Associates (2002)	5.7

The site density recorded for Lots 37, 98 and 9000 Bishop Road Mundijong was notably higher than the regional density figures, at 11.85 sites per sq km. When the survey results are considered in conjunction with the site density from Lot 50 Cockram Street, site density is only slightly lower at 10 sites per sq km. As noted by Tempus Archaeology (2006: 66), this difference may be partly a result of the local geomorphology and its influence on residential mobility patterns within the local region.

8. *What does the apparent site distribution indicate? To what degree is it skewed by concentrated urban development? (after Strawbridge 1987)*

Site distribution within the survey area indicates that the Mundijong area was well used during pre-European times. Local site distribution strongly correlates with distribution patterns observed on the Swan Coastal Plain by Hallam (1987), Anderson (1984) and Strawbridge (1987). All sites located within the Mundijong survey areas were located on and within elevated Bassendean sand dunes or rises above low-lying, seasonally inundated, plausiplain wetlands. No artefactual material was located on or within the clay of plausiplain areas. All recorded sites were located within 350 m of a water source with DAA Id 3648 (MJ-05), the most extensive site, being located immediately adjacent to a permanent fresh water lake, and all other sites being located adjacent to plausiplain wetland which would have held seasonal surface water.

Whilst the site distribution patterns at Mundijong indicate a preferential selection for occupation of elevated sand rises close to water, it appears that Early and Middle phase sites are located within closer proximity to the more permanent water supply provided by the fresh water lakes. During the Late phase there was an increase in smaller-sized, peripheral sites located away from the freshwater lakes, but adjacent to the more ephemeral water source provided by the plausiplain wetland. Notwithstanding the effects of erosion, sampling bias and vegetation cover, it could be argued that the change in site distribution patterns during the Late phase may indicate changes in population size or residential mobility during the period 3000 BP to 0 BP.

The Mundijong area has been subjected to European farming practices over recent times and whilst the survey results have shown that sites are more likely to be found in areas of vegetation clearance, disturbance and erosion, site MJ-07 also demonstrates that artefacts can still be present even where land has been cleared and there is no surface expression.

9. *Is the level of reduction of fossiliferous chert greater away from the coast (the predicted source location)?*

Only a very small sample of fossiliferous chert artefacts was recovered during the Mundijong investigations. One fossiliferous chert flaked piece was located at site MJ-01, and two pieces of debris, one flaked piece and one retouched/utilised flaked piece manufactured from fossiliferous chert were recovered from DAA Id 3648 (MJ-05). All the fossiliferous chert artefacts were small in size, had no cortex and appear to have been extensively reduced. Despite the small sample size, these results fit with the general pattern of higher levels of reduction away from the coast.

10. *Does the amount of fossiliferous chert within an assemblage decrease or increase with proximity to the coast (i.e. the proposed source), or proximity to other water sources?*

As noted above, the sample size of fossiliferous chert artefacts is too small to allow for an accurate evaluation of this hypothesis. In general, the Mundijong survey area which is located at the easternmost boundary of the Swan Coastal Plain has very little amounts of fossiliferous chert, with the lithology being absent in Late phase sites within this area.

11. *What is the level and character of variability between sites classified according to Hallam/Schwede's four phases?*

Of the sites excavated during the current investigations, only two sites (DAA Id 3648 (MJ-05) and MJ-06), were dated using absolute dating methods and can be securely allocated to Hallam's (1987) and Schwede's (1990) occupation phases. With a date of 5510 +/- 30 BP (BETA-345001), site DAA Id 3648 (MJ-05) has been identified as an Early phase site with continuous occupation through the Late and Final phases, according to both Hallam's (1987) and Schwede's (1990) occupation phases. Site MJ-06, with a lower date of 1750 +/- 30 BP (BETA-345001), was identified as a Middle Phase site according to Hallam (1987) and a Late Phase site according to Schwede (1990).

Given the small sample size it is difficult to identify variability between the sites particularly in reference to only the surface component of the sites. The similarities and differences of the two sites including both the surface and subsurface assemblages are discussed below in question15.

7.1.2 Subsurface investigations

12. *What is the archaeological significance and nature, and the spatial extent and distribution of the newly recorded sites MJ-01, MJ-02, MJ-03, MJ-04 and MJ-06? Specifically,*
    a. *Is the surface area of the deflations at the sites an accurate representation of the sites' size and artefact distribution?*
    b. *Is the artefact types identified on the surface representative of the subsurface artefacts?*
    c. *Is the lithic raw material identified on the surface representative of the subsurface raw materials identified?*
    d. *Is the density per metre of surface artefacts representative of the subsurface density?*

The nature of newly recorded sites MJ-01, MJ-02, MJ-04, MJ-06 and MJ-07 is that they all comprise flaked stone artefact scatters with subsurface deposits that are notably larger and more complex than their surface expressions. Site MJ-03's subsurface component is yet to be investigated, however it can be extrapolated from the results of investigations at the other sites that MJ-03 will also comprise a flaked stone artefact scatters with a subsurface deposit. The archaeological significance of each of the sites is outlined in the site descriptions in section 5.0 above.

The results of the investigations at sites MJ-01, MJ-02, MJ-04, MJ-06 and MJ-07 showed that the surface artefacts located during the survey were an indication of the presence of an archaeological site but only represented a small proportion of the total artefacts and diversity of artefact types, lithologies and densities of artefacts within a sand dune. Thus a surface assemblage on a sand dune can be used to determine the presence of a site but does not indicate the density or complexity of the entirety of the site.

The surface artefacts identified at all excavated sites comprised only a small proportion of the subsurface artefacts recovered during the archaeological excavations both in terms of number of artefacts and spatial extent, see Table 46. Where artefacts were located within a deflation or exposure on a sand dune it was found that subsurface artefacts were also present and in most cases they were present throughout the entirety of the dune formation. The only variation to this finding was at site MJ-04, which was located on the lower edge of a large sand dune in the transition zone to low-lying plausiplain. Further, site MJ-07 demonstrated that artefacts may be present within a sand dune and have no surface expression at all.

From the artefact analysis it was identified that the surface artefacts are not entirely representative of the subsurface assemblage as there was a much higher diversity in both artefact types and raw materials within subsurface assemblages when compared to their surface assemblages. MJ-06 provides a good example of this. Artefact density was also typically much higher in the subsurface assemblage than on the surface. See Table 46.

Table 46. Comparison of surface and subsurface expressions of each Mundijong site tested

Site	Estimated size from surface exposure (m^2)	Number of surface artefacts	Estimated surface density (# per m^2)	Total m^3 excavated	Number of excavated artefacts	Excavated artefact density (# per m^3)	Determined site extent (m^2)
MJ-01	383	83	1.5	2.8	77	27.5	16,280
MJ-02	2	32	6.5	2.8	55	19.6	9,272
MJ-04	13	5	0.01	2	34	17.0	11,020
DAA Id 3648 (MJ-05)	385	125	0.34	3	337	112.3	82,740
MJ-06	1877	15	0.15	3.5	916	261.7	66,330
MJ-07	0	0	0	1	52	52.0	36,370
Total					1471		

13. *What is the extent of the subsurface deposit at DAA 3648 Soldier's Road Mundijong (MJ-05)?*
    a. *Is the surface area of the deflations at the site an accurate representation of the site's size and artefact distribution?*
    b. *Is the artefact types identified on the surface representative of the subsurface artefacts?*
    c. *Is the lithic raw material identified on the surface representative of the subsurface raw materials identified?*
    d. *Is the density per metre of surface artefacts representative of the subsurface density?*

As for the newly recorded sites, DAA Id 3648 (MJ-05)'s surface artefact expression was not representative of the subsurface component of the site. The deflation where artefacts were identified at the western extension (MJ-05) to DAA Id 3648 Soldiers Road represented only a small proportion of the full extent of the site, as subsurface artefacts were located across the entirety of the sand dune formation to the west of the freshwater lakes. Similarly, the number of artefacts, the diversity in artefact types, lithologies and density were all much higher and more complex subsurface compared to the surface assemblage.

14. *Pearce's (1979) excavations at DAA Id 3648 Soldier's Road Mundijong suggested that two distinct stratigraphic units were present within the study area – an upper layer of 'loose sandy matrix' and a lower layer comprising a 'compact' matrix of sand, that were unique from one another. This issue was not addressed by Pearce and therefore allows for the formulation of the hypothesis that there are two distinct stratigraphic units in the area.*
    a. *Is this hypothesis correct?*
    b. *Are there any discernible stratigraphic differences within the sites?*
    c. *Do all artefact scatters contain the same stratigraphic layers?*
    d. *If there are no discernible stratigraphic layers is there any evidence of denser layers of artefactual material?*

e. Is there any evidence of taphonomic process sorting or moving the artefacts?

The results from the subsurface investigation identified that two distinct soil units were present at all excavated sites. These two units comprised an upper layer of loose sand containing humic material which overlayed a lower layer of clean, compact sand. It is the authors' opinion that these layers are not in fact two separate layers but are a variation of the same stratigraphic unit, where the upper part of the unit has been disturbed by European land clearance and agricultural activities. So whilst Pearce's hypothesis that there were two discernible layers is correct, we argue that there is nothing contained within these layers to indicate that they were laid down at distinctly separate times rather the unit has accumulated slowly over time and that it is historical activities that have resulted in a colour and matrix change within the unit. Other than this variation at the upper level, the dune at DAA Id 3648 (MJ-05) did not contain notable stratigraphic changes within the dune. The clean sand unit sat on top of a hard cemented layer of compact sand or laterite which in most cases was a deep red or orange colour. This layer was considered to be the top of the B1 horizon and the only significant stratigraphic change within the dunes excavated.

The spits excavated at MJ-05 showed that there was a detectable layering of artefacts within the dune, with some spits containing significantly more artefacts than other spits, but there was nothing noted in the soils observed during excavation to indicate differences between these layers as the sand was homogeneous across all spits.

The subsurface artefacts at MJ-05 did not appear to be size sorted within the dune and there were no obvious taphonomic changes observed. It is therefore hypothesised by the authors that the dunes tested have been stable within the last 10,000 years and that the sand present has been built up slowly over time. The artefacts which are larger than the sand grains have managed to stay close to where they were discarded in the undisturbed areas of the site and have been covered over time by the build up of sand. There is presently no indication as to the timing of sand deposition; however Optically Stimulated Luminescence (OSL) dating could provide much better information on the process of sand dune formation and subsequent site formation processes in the Mundijong area.

Comparing the findings of the current excavation to Pearce's 1979 thesis is a rather difficult task. Efforts were made to compare artefact form between the typology used by Pearce in 1979 and typologies used today. Table 47 shows that there were a number of similarities between the results of Pearce's excavations and the current investigations. Both excavations demonstrated that the surface artefact density was much less than the subsurface artefact density; however the subsurface artefact density in the western dune (MJ-05) was less than Pearce's excavations. The difference could be explained by the location of the two test pits, as Pearce's pit was located within 3 – 5 m of the lake's edge between the two lakes and the current test pit was placed at the top of a 60 m high sand dune approximately 60 m away from the western lake's edge.

Raw materials were similar between surface and subsurface assemblages in both excavations, with the exception of fossiliferous chert which was not identified on the surface during the current investigations. The percentage of quartz artefacts identified in the current subsurface assemblage was similar to the amount identified by Pearce. A number of additional raw material types were identified in the current excavation.

Artefact size was also similar between the two excavations with over 85 percent of both subsurface assemblages being comprised of artefacts less than 15mm in length.

When DAA Id 3648 Soldiers Road, as recorded by Hallam and Pearce, and the MJ-05 extension recorded during the current investigations are considered together, the two components would have during previous times constituted one large and complex site located on the same sand dune formation surrounding the two freshwater lakes prior to the channel being cut across the dune and fill being pushed into the western lake. When all artefact assemblages including the Lang collection are considered together, along with its antiquity, the good integrity of a large part of the site, and the rarity of finding such an intact large and complex site on the Swan Coastal Plain, it is obvious that DAA Id 3648 Soldiers Road (MJ-05) is key to the interpretation of Aboriginal prehistory both in the Mundijong region and the broader Swan Coastal Plain and therefore is a site of great importance and significance to the community as a whole. The Aboriginal representatives who worked on the current investigations also expressed their amazement at the diversity, complexity and intactness of the site and commented that they felt very few comparable sites currently remain.

Table 47. Comparison of Pearce and current excavations

	Pearce 1975	Current excavations
Surface artefact density	20.9 per m^2	0.34 per m^2
Surface raw materials	Quartz Silcrete Dolerite Mylonite Fossiliferous chert	Quartz (94.3%) Silcrete (0.8%) Dolerite (0.8%) Mylonite (4.0%)
Excavated density	445.3 per m^3	112.3 per m^3
Excavated raw materials	Quartz (98.3%) Silcrete (0.2%) Dolerite (3.3%)	Quartz (95.5%), Dolerite (0.9%), Fossiliferous Chert (1.2%) Conglomerate (0.9%) Schist (0.3%) Unidentified (1.2%)
Noted concentrations in excavated artefacts	200mm 600mm	0-100mm 500-600mm
Backed objects	11 (0.01%)	6 (1.8%)
Size of objects	85.5% less than 15mm	86.1% less than 15mm

15. How do sites MJ01, MJ-02, MJ-03, MJ-04 and MJ-06 compare with site DAA Id 3648 (MJ-05)?

- *a. Does the previously registered site, which has different raw materials in its surface expression, show a significant difference in artefact type and raw material type to the MJ01–MJ06 sites?*
- *b. Is there any indication that there are more complex processes or different activities occurring at the sites with multiple raw materials types?*
- *c. Is there a link between site size/density/complexity, as indicated from the two registered sites which are over 200m by 200m and DAA Id 3648 Soldier's Road Mundijong?*

DAA Id 3648 (MJ-05) was anticipated at the commencement of the subsurface testing to be the largest and most complex of the sites. Post excavation, site MJ-06 was in fact found to be the densest of the sites but smaller in size and younger in age than DAA Id 3648 (MJ-05). MJ-06 was interesting in that it consisted of a similar surface expression to sites MJ-01, MJ-02 and MJ-04 but its subsurface assemblage comprised a much greater number of artefacts and raw material types similar to that found at DAA Id 3648 (MJ-05).

Some minor variations were observed in artefact types and raw material types between DAA Id 3648 (MJ-05) and the other excavated sites. In general, artefact types were similar across all assemblages;

with formal tools were located within sites MJ-01, MJ-06 as well as DAA Id 3648 (MJ-05). DAA Id 3648 (MJ-05) was the only site with additional ground stone artefact material including grindstones, firestones and axe blanks as identified in the Sam Lang collection. DAA Id 3648 (MJ-05) and MJ-06 were also the only two sites to contain raw material types other than quartz in their surface expression, indicating a greater variation and complexity, which has been interpreted as representing a higher frequency of occupation and wider ranging of groups occupying the site in comparison to the other excavated sites.

The artefact analysis has also revealed similarities in activities undertaken at all of the excavated sites. The minor amount of formal tools identified at the sites combined with the small amounts of cortex on the artefacts and large amounts of very small sized debris indicates that none of the sites comprised primary manufacturing sites and that all material had been brought onto each site. It is likely that 'tooling up' activities, where artefacts were finished off, sharpened or repurposed then the final product was removed and used elsewhere in the landscape, occurred at each of the artefact scatters in the survey area. DAA Id 3648 (MJ-05) however also served as a more frequently used base camp where other activities such as grinding and processing of resources took place as indicated by its more complex artefact assemblage and the presence of ground stone artefacts.

Further artefact analysis, such as residue and use wear analysis will help to elucidate additional activities that may have occurred to the Mundijong sites.

The excavation also confirmed that there is a link between site size, density and complexity.

16. *Can the comparative analyses of the data from sites MJ-01, MJ-02, MJ-03, MJ-04, MJ-06 and DAA Id 3648 (MJ-05) provide a basis for the development of predictive modelling techniques that allow future heritage consultants working within the local region to a priori estimate:*
    a. *The location of archaeological sites and sites with archaeological deposit?*
        i. *Is there any artefactual material present in the areas identified as low potential?*
        ii. *Do the areas identified as moderate or high potential have distinct boundaries?*
        iii. *Is there any relationship between artefact location and density and the Bassendean Sand Dunes?*
    b. *The size/area/extent of a site from the quantity and distribution of artefacts present in the deflation zones?*
    c. *The potential for sub-surface deposits to be present at a site based upon the quantity and distribution of artefacts present in the deflation zones.*

The authors consider that the results of the Mundijong archaeological investigations can be used as a basis for further predictive modelling for archaeological work in the local region.

The investigations have shown that all artefact scatter sites within the project area occur on elevated Bassendean sand rises or dunes above plausiplain wetland. No artefactual material was identified within the low potential areas of low-lying, seasonally inundated, plausiplain wetland areas, either on the surface or below. All artefact scatters tested also contained subsurface deposit which extended across the entire landform or dune in all but one case (MJ-04). The testing also confirmed that the further away from a permanent water source, the less complex and less dense sites become.

Surface artefactual material was exposed within the project area through land surface disturbance, such as firebreaks or deflated areas, and the comparison of surface and subsurface assemblages

showed that size, extent and content of the deflation areas identified on the surface were not a clear indication of the subsurface component. This is likely due to the fact that every small dune in the region has its own unique history, and factors such as vegetation components, proximity to permanent water and to inundation water likely relate to complexity and size of the subsurface sites. Artefacts present within deflations can indicate that there is likely an archaeological site present and a high likelihood that additional artefactual material may be located within the sand dune on which the deflation is located.

One of the additional key findings relating to future predictive modelling was the discovery of site MJ-07. This site had no surface expression at all and the subsurface artefacts were located within the same landform type (an elevated Bassendean sand dune) as all the other artefact scatters in the local area. This demonstrated that despite an obvious occurrence of artefacts on the surface, archaeological material was present within all sand dunes and rises within the project area.

There were no distinct boundaries between areas of moderate and high archaeological potential. Site MJ-04 was identified within an area of moderate potential on the lower slope of a sand dune adjacent to an inundation zone. The results of the excavations at MJ-04 indicate that areas of moderate archaeological potential can also contain archaeological sites and material however these are likely to be much smaller, low density and less complex assemblages.

7.2 Regional context comments

Two general reflections on the results of the archaeological investigations within the context of regional Swan Coastal Plain archaeology are outlined below.

Overall, the results of the archaeological investigations have confirmed all of Strawbridge's (1987) defining principles for site distribution on the Swan Coastal Plain apply to the Mundijong region. Although the Mundijong project area is located within the Pinjarra Plain geomorphic unit, the site distribution patterns observed within the area reflect more closely patterns observed by Hallam (1986, 1987) for the Bassendean sands rather than for the alluvial plains along the major rivers of the Swan Coastal Plain, which are often deemed representative of the alluvial units of the Pinjarra Plain.

Based on the results of the excavations at Mundijong, the authors also disagree with Bowdler et al's (1991) assertion that sites in Bassendean sands are not worth excavating due to their lack of integrity resulting from continual deflation and reworking of the sand dunes over time and the ensuing mixing of artefacts on the same level. Despite the sites not containing distinct stratified deposit, the Mundijong excavations showed no detailed evidence within the sand dunes of continual erosion and reworking events, which would be evidenced by the presence of laminated stratigraphy (cf. Sullivan et al., 2012). Also, whilst there were levels where subsurface artefacts appeared to be more concentrated in some of the Mundijong sites (such as MJ-06) none of the sites contained size sorting of artefacts or a single artefact layer where artefacts have been mixed at the one level. In contrast, all of the excavated sites showed the continual occurrence of artefacts over multiple spits and carbon dates obtained at DAA Id 3648 (MJ-05) and MJ-06 showed no inversion, thus demonstrating that in general sites on Bassendean sand dunes within the Mundijong region do have subsurface integrity. This debate further highlights the need for much more detailed comprehension of dune formation processes.

7.3 Local region synthesis

Interpretation of the results of the Mundijong archaeological investigations within a regional context is presented here. Applying Hallam's (1986, 1987) and Anderson's (1984) land use models to the data gained from the current investigations, the following basic synthesis is proposed for the local Mundijong area.

The Mundijong region has been occupied by Aboriginal groups for over 5500 years and it is highly likely that the area surrounding the freshwater lakes and adjacent to Manjedal Brook (DAA Id 3648 Soldiers Road including the MJ-05 extension) has been utilised for over 10,000 years, and up to and during historic times. From the Early phase onwards, DAA Id 3648 Soldiers Road (MJ-05) would have been a key focus in the occupation of the Mundijong region during the summer and autumn months by Aboriginal groups, who appear to have frequently returned to and occupied DAA Id 3648 (MJ-05) for extended periods of time. The site would have been particularly attractive for occupation due to its proximity to the reliable, long term water supply from the two fresh water lakes and Manjedal Brook and related availability of a rich variety of plant and animal resources.

In the middle occupation phase the groups appear to have extended their occupation slightly further afield from the lakes to the sand dune at MJ-01 and potentially MJ-06. During the late phase, in addition to occupying the dunes at DAA Id 3648 (MJ-05) and MJ-01, Aboriginal groups appear to have camped on sand dunes located further away from the lakes and Manjedal Brook, such as those containing sites MJ-02, MJ-03, MJ-04, MJ-06 and MJ-07. These sites were occupied temporarily or infrequently by smaller and more mobile groups exploiting resources available in the plausiplain wetlands. During winter and spring, the groups would either disperse into the Jarrah forests and plateau areas as suggested by Anderson (1984), or may have continued living at the larger campsites such as DAA Id 3648 (MJ-05) or MJ-01 whilst accessing resources from the nearby Jarrah forests and inundated plausiplain wetlands (see Schwede, 1990).

The range of raw materials located at sites DAA Id 3648 (MJ-05), MJ-01 and MJ-07 all indicate that the Aboriginal groups who occupied the Mundijong area either had a large ranging area or extensive social and trade networks that extended beyond the Swan Coastal Plain and Yilgarn Block. Anderson (1984:25) notes that much of the lithic materials found at DAA Id 3648 (MJ-05) and MJ-01 apart from quartz and fossiliferous chert would have come from beyond the Yilgarn Block or from other distant areas. Similarly, Pearce (1979) suggests that the main source of mylonite, which was located at site MJ-07, was from an area along the Darling Scarp near Walyunga.

7.4 Future research directions

Further research on the following topics would be of benefit in developing the above synthesis of the archaeology of the Mundijong area.

- Dune and site formation processes could be further informed by the use of optically stimulated luminescence dating (OSL) of the Mundijong sites, in particular DAA Id 3648 (MJ-05).
- Provenancing study of raw materials from sites DAA Id 3648 (MJ-05),MJ-01 and MJ-07 may further elucidate ranging areas and extents of social and trade networks of the Aboriginal groups who resided within the Mundijong area.

- Residue and use wear studies of artefacts recovered from sites such as DAA Id 3648 (MJ-05) could provide more detailed information on the activities undertaken at and nature of the Mundijong sites.

8.0 RECOMMENDATIONS

Peet and its contractors are **advised** that:

- the archaeological assessment and test excavations at Lots 37, 98 and 9000 Bishop Road Mundijong are now complete;
- **six** newly recorded archaeological sites including four artefact scatters (MJ-01, MJ-02, MJ-03 and MJ-04) and two modified trees (MJ-08 and MJ-09) have been located and recorded in detail;
- an extension to previously identified Aboriginal Site DAA Id 3648 Soldier's Road Mundijong (MJ-05) has been located on a dune to the west of the freshwater lakes in Lot 9000. This extension has also been recorded in detail; and
- it has been confirmed that Aboriginal Site DAA Id 450 South-East Corridor 03 is located within Lot 37 Bishop Road, however, as the site is also located within the proposed Tonkin Highway extension reserve corridor and will not be impacted upon by Peet's proposed development, no further investigations were undertaken at the site.

Based on the results of the archaeological assessment and test excavations, it is **recommended** that:

- MJ-01, MJ-02, MJ-03, MJ-04, DAA Id 3648 (including the MJ-05 extension), MJ-08, MJ-09 and DAA Id 450 South-East Corridor 03 may meet the requirements of section 5 of the *Aboriginal Heritage Act 1972* and therefore should not be impacted upon in any way without Ministerial consent under section 18 of the AHA;
- a 30 m buffer be applied around sites MJ-08 and MJ-09 during construction;
- Peet develop and implement an Aboriginal Heritage Management Plan (AHMP); and
- Peet implement suitable controls to prevent any impacts on archaeological sites during earthworks, including adequate physical demarcation of site boundaries and effective management processes such as ground disturbance permits and operator inductions.

Should at any stage Peet wish to disturb MJ-01, MJ-02, MJ-03, MJ-04, DAA Id 3648 (including the MJ-05 extension), MJ-08 or MJ-09 and an application is made for consent to use the land under section 18 of the *Aboriginal Heritage Act 1972*, it is **further recommended** that Peet:

- consult with the appropriate Nyungar Elders and Aboriginal Consultants about any proposed section 18 application, mitigation and salvage strategies and the management of any excavated or salvaged materials;
- cap the portion of DAA Id 3648 (including MJ-05) located within the current conservation zone and proposed public open space with geotextile fabric to ensure its long term conservation, prior to any landscaping being undertaken in this area; and
- develop and implement a public interpretation plan for DAA Id 3648 Soldier's Road Mundijong (including MJ-05), to be incorporated into the proposed public open space surrounding the lakes.

It is also **recommended to the Department of Aboriginal Affairs** that the boundary for DAA Id 3648 Soldier's Road Mundijong (including the MJ-05 extension) be updated to reflect the boundary included in the site description included in this report.

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10.0 APPENDICES

Appendix 1 – Acronyms and definitions

AHA	Western Australian *Aboriginal Heritage Act 1972*
AHIS	Aboriginal Heritage Inquiry System
Artefact	Any moveable object that has been used, modified or manufactured by humans.
Camp	A place at which Aboriginal people have camped in association with traditional cultural life past or present.
Deposit	An accumulation of cultural material and sediment deposited over time.
DAA	Department of Aboriginal Affairs
GDA	Geodetic Datum of Australia
Lithology	The description of the characteristics of the rock(s) used to make stone artefacts, including colour, grain size and composition.
MGA	Map Grid of Australia
PAD	Potential Archaeological Deposit
Pedestrian transect	A survey technique that uses walked lines or corridors across a survey area. These may be straight lines between two points or sinuous lines following the contours of the ground.
TCHM	Thomson Cultural Heritage Management

See Appendix 5 for site type definitions.

Appendix 2 – Section 16 Permit

Government of Western Australia
Department of Indigenous Affairs

ENQUIRIES : Warren Mitchell– Ph (08) 6551 8136

OUR REF: 12/1294

YOUR REF:

Ms Jo Thomson
Principal Consultant
Thomson Cultural Heritage Management
PO Box 9052 Nicholson Road
SUBIACO WA 6008

Dear Jo

RE: ABORIGINAL HERITAGE ACT 1972 – SECTION 16 PERMIT – NORTH MUNDIJONG RESIDENTIAL PROPERTY DEVELOPMENT

Attached is the amended Section 16 Permit granting Diana Neuweger and yourself consent to conduct the excavations in North Mundijong.

Kind Regards

W Mitchell

Dr Warren Mitchell
Senior Heritage Officer

October 2012

Ground Floor, 151 Royal Street, East Perth, Western Australia, 6004
PO box 3153, East Perth, Western Australia, 6892
Telephone 1300 651 077 Facsimile (08) 6551 8088

Section 16 Permit

Aboriginal Heritage Act 1972

PERMIT No.:	527
RECIPIENT:	Ms Jo Thomson and Dr Diana Neuweger
OF:	Thomson Cultural Heritage Management.

is hereby permitted under Section 16 of the *Aboriginal Heritage Act 1972* to:

SECTION 16 TYPE:	*E. Undertake an excavation of any of the site(s) described hereunder for the purposes of evaluating the archaeological potential of the site(s).*	*F. Management of the cultural material collected/located.*

for the following location(s)

SITE(S)/AREA:	DIA 3648 (Soldiers Road, Mundijong) and six recently recorded places of Aboriginal archaeological interest in four residential development lots owned by PEET Pty Ltd in North Mundijong (Lot 50 Mundijong Road and Lots 37, 98 and 9000 Bishop Road, North Mundijong).

for the period of:

PERIOD:	22nd October 2012	22nd October 2013
	Commences	*Expires*

FINAL REPORT DUE:	22nd October 2014

This licence is issued subject to the provisions of the above Act, its regulations and conditions (please see overleaf).

Dated this 22nd day of October 2012

Signed: _____

Registrar of Aboriginal Sites

CONDITIONS FOR PERMIT HOLDER

The holder must:

1. Adhere to the provisions of the *Aboriginal Heritage Act 1972* and its Regulations.

2. Consult with and, where appropriate, involve members of the relevant Aboriginal communities in all aspects of the project (e.g. prior to submitting application, during activity, providing copies of the results and report). The researcher is accountable to the relevant Aboriginal people and communities during the research and the archaeological method and procedures must be explained to them, and approved by them. An appropriate protocol should be established with the relevant Aboriginal people and any representative organisations in regard to community reporting procedures.

3. All activities undertaken as part of this permit must be consistent with the methods and procedures contained in the Section 16 application submitted 28th May 2012 and accompanying documentation. Sufficient excavation, research and analysis should be undertaken to answer the specified research questions outlined in the application and the excavation should only cease when either: a) bedrock has been reached; or b) culturally sterile deposit has been excavated to a minimum depth of 40cm.

4. Submit site documentation on appropriate forms to be accessioned with the Department of Indigenous Affairs, and a report on the results, after consultation with and agreement from the relevant Aboriginal people.

5. Where human skeletal material is discovered at any site, cease any activity at the site, inform the relevant Aboriginal people and the Registrar immediately and await instructions.

6. Where any site is sampled, site plans should be included in the documentation provided to the Department of Indigenous Affairs (see 4 and 8).

7. Provide the Department of Indigenous Affairs and the relevant Ahoriginal communities/ people with:
   i) Interim reports of the project at the end of each calendar year; and
   ii) A final report within 12 months of the expiration of the permit.

8. Also provide the Department with any subsequent documentation and published reports (e.g. theses, carbon dates, journal articles).

9. In the case of a general area permit the relevant Aboriginal people make the final decision as to whether any archaeological investigations proceed.

Appendix 3 – DAA section 5 threshold test guidelines

Government of **Western Australia**
Department of **Aboriginal Affairs**

SECTION 5 OF THE ABORIGINAL HERITAGE ACT 1972

The *Aboriginal Heritage Act 1972* (Act) makes provision for 'the preservation on behalf of the community of places and objects customarily used by or traditional to the original inhabitants of Australia or their descendants, or associated therewith, and for other purposes incidental thereto'. The Act should be read in conjunction with the *Aboriginal Heritage Regulations 1974.*

A place may be assessed as an Aboriginal Site under one or more of the paragraphs of section 5 of the Act. The following is designed to assist in the interpretation of the Act. Note that although the meaning of 'importance' and 'significance' are ordinarily interchangeable, where it is necessary to distinguish between them, for the purpose of interpreting the Act, 'importance' is taken to involve an estimate of worth and 'significance' is concerned more with the meaning of the thing.

SECTION 5(a)

Any place of importance and significance where persons of Aboriginal descent have, or appear to have, left any object, natural or artificial, used for, or made or adapted for use for, any purpose connected with the traditional cultural life of the Aboriginal people, past or present.

The threshold test is whether Aboriginal persons appear to have left an Object (whether one referred to in section 15 or other Object under section 6).

It is the place that must be 'of importance and significance' and to the community as a whole.

Additional to the criteria in section 39 of the Act, the following will be taken into account when determining whether the object at that place is worthy of preservation:

- The intactness and condition of the place and object;
- The temporal context of the place and object;
- The complexity or diversity of the object;
- The relationship between the objects and the place;
- The rarity and uniqueness of the place and object;
- The context and relationship of the place to other places;
- The contribution to research to the understanding of Aboriginal people past and present.

SECTION 5(b)

Any sacred, ritual or ceremonial site which is of importance and special significance to persons of Aboriginal descent.

The threshold test is whether the place is a 'sacred, ritual or ceremonial site'. If so, the place is a Site if 'of importance and special significance to persons of Aboriginal descent'.

Additional to the criteria in section 39 of the Act, the following will be taken be into account when determining whether a place is a sacred, ritual or ceremonial site:

Sacred Site

- The meaning of "site" is narrower than 'place';
- For a place to be a sacred site requires that it is devoted to a religious use rather than a place subject to mythological story, song or belief;
- For sacred sites associated with Travelling Ancestors:
  - There are stories and songs that celebrate the activities of ancestral figure(s);
  - Either there are events which occurred to the ancestral figure at the place; or
  - The ancestral figure left some mark or thing that has form eg a spring or rock formation;
- For sacred sites associated with figures or powers, the place is associated with a figure or a power which belongs to the country or was always there.

Ceremonial Site

- There is an established ceremonial site;
- Initiation and higher religious ceremonies are carried out at the place;
- Respect is paid to the place as a result of past ceremonial use;
- The place is retained for future ceremonial use.

Ritual Site

- An identified form of ritual is carried out at the place eg for an increase or regeneration of a species or phenomena.

Note: This is the only paragraph of section 5 where the place must be 'of importance and special significance' and to 'Aboriginal people only'.

SECTION 5(c)

Any place which, in the opinion of the Committee, is or was associated with the Aboriginal people and which is of historical, anthropological, archaeological or ethnographical interest and should be preserved because of its importance and significance to the cultural heritage of the State.

The threshold tests are whether the place 'is or was associated with the Aboriginal people' and is also 'of historical, anthropological, archaeological or ethnographic interest'.

If so, the place is a Site if it should be preserved because of its 'importance and significance to the cultural heritage of the State'.

Additional to the criteria in section 39 of the Act, the following will be taken into account when determining whether a place is a site:

- It marks important events, changes or patterns of Aboriginal prehistory or history;
- It possesses uncommon, rare or endangered features of Aboriginal prehistory or history;
- It has the potential to yield important information that will make a substantial contribution to an understanding Aboriginal prehistory or history;
- It demonstrates the principal characteristics of Aboriginal prehistoric and historic places or environments;
- It exhibits particular aesthetic characteristics valued by the community;
- It demonstrates the creative or technical achievement of a particular period of Aboriginal prehistory or history; or
- It has special association with the life or works of an Aboriginal person or persons of historical importance;

and the preservation of the place would benefit current and future generations of Western Australians.

SECTION 5(d)

Any place where objects to which this Act applies are traditionally stored, or to which, under the provisions of this Act, such objects have been taken or removed.

A traditional storage place has that status and function under Aboriginal traditions and customs (even if no Objects are currently stored there). A traditional burial ground is accepted as a storage place.

There is no assistance in the Act as to who may designate the place or on what conditions. The acceptance of a place as a designated storage place will be limited to places where by dint of an arrangement sanctioned by the Minister, Objects are now stored by way of preservation.

Appendix 4 – DAA AHIS search results

Search Criteria

14 surveys in a search box. The box is formed by these diagonally opposed corner points:

MGA Zone 50	
Northing	Easting
6434378	397460
6421013	409908

Disclaimer

Heritage Surveys have been mapped using information from the reports and / or other relevant data sources. Heritage Surveys consisting of small discrete areas may not be visible except at large scales. Reports shown may not be held at DIA. Please consult report holder for more information. Refer to www.dia.wa.gov.au/heritage for information on requesting reports held by DIA.

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Legend

Access

Some reports are restricted. The type of restriction is shown as a code in brackets following the catalogue number. No code indicates an unrestricted report.

[CLOSED]	Closed
[OWE]	Open with exception
[TBD]	To be determined
[RESTRICTED PENDING]	Restricted pending

Survey 2848

Project	Tonkin Highway Extension, Albany Highway to South Western Highway, Mundijong.
Start Date	31 Jul 2001
Proponents	Main Roads Western Australia Western Infrastructure
Consultants	Australian Interaction Consultants
Survey Types	Ethnographic
Aboriginal People Consulted?	Yes

Related Reports

Report ID	Catalogue Number	Title	Recorders	Held At
105723	HSR MW 2001 PAR	Consultation for a Section 18 Application under the Aboriginal Heritage Act (1972) of the Proposed route of the Tonkin Highway Extension Albany Highway/Mills Road West, Martin, to South Western Highway, Mundijong	Ronald T. Parker	DIA

Survey 2784

Project	Tonkin Highway Extension, Mills Road West, Martin to South Western Highway, Mundijong.
Start Date	28 Jan 1999
Proponents	Main Roads Western Australia
Consultants	BSD Consultants
Survey Types	Ethnographic
Aboriginal People Consulted?	Yes

Related Reports

Report ID	Catalogue Number	Title	Recorders	Held At
19122	HSR MW 2001 BSD [OWE]	Summary report section 18 notice to disturb Aboriginal Sites : Tonkin Highway extension Mills Road West, Martin to South Western Highway, Mundijong	BSD Consultants	DIA

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Survey 2682

Project	Tonkin Highway Extension and Mundijong Road Realignment.
Start Date	03 Dec 1998
Proponents	BSD Consultants Main Roads Western Australia
Consultants	McDonald, Hales and Associates Pty Ltd
Survey Types	Archaeological and Ethnographic
Aboriginal People Consulted?	Yes

Related Reports

Report ID	Catalogue Number	Title	Recorders	Held At
19121	HSR MW 1999 EDW [OWE]	Report of an Aboriginal Heritage Survey : proposed Tonkin Highway extension and Mundijong Road Realignment Project	Adele Millard C. Coomer E. McDonald K. Edwards Andrea Staub E. Pollard Guida Coventry	DIA

Survey 2646

Project	Byford Village.
Start Date	24 Jun 1998
Proponents	McDonald, Hales and Associates Pty Ltd
Consultants	Collard & Collard Consultants
Survey Types	Ethnographic
Aboriginal People Consulted?	Yes

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Survey 2646 (continued)

Related Reports

Report ID	Catalogue Number	Title	Recorders	Held At
103327	HSR MW 1998 COL [OWE]	Aboriginal Heritage Survey Consultation : Byford Village Project	Fred Collard	DIA

Survey 2624

Project	Byford Village, Byford.
Start Date	22 Jun 1998
Proponents	Mitchell Goff
Consultants	McDonald, Hales and Associates Pty Ltd
Survey Types	Archaeological and Ethnographic
Aboriginal People Consulted?	Yes

Related Reports

Report ID	Catalogue Number	Title	Recorders	Held At
103328	HSR MW 1998 BUR	Aboriginal Heritage : Report on Additional Ethnographic Consultation, Mitigative Recording, and Newly Identified Archaeological Material, Byford Village, Byford	A. Gardoz Fred Collard S.F. Burke A. Murphy K. Edwards	DIA

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Survey 2576

Project	Roadworks, Mundijong Road
Start Date	01 Oct 1996
Proponents	Halpern Glick Maunsell Pty Ltd Main Roads Western Australia
Consultants	R. O'Connor
Survey Types	Ethnographic
Aboriginal People Consulted?	Yes

Related Reports

Report ID	Catalogue Number	Title	Recorders	Held At
104184	HSR MW 1996 OCO	Report on an Ethnographic Survey of an Area of Proposed Roadworks at Mundijong Road. October 1996.	Rory O'Connor	DIA

Survey 2540

Project	Roadworks, Mundijong Road.
Start Date	01 Oct 1996
Proponents	Halpern Glick Maunsell Pty Ltd Main Roads Western Australia
Consultants	Quartermaine Consultants
Survey Types	Archaeological
Aboriginal People Consulted?	No

Related Reports

Report ID	Catalogue Number	Title	Recorders	Held At
103259	HSR MW 1996 QUA	Report on an Archaeological Investigation for Aboriginal Sites Proposed Roadworks at Mundijong Road. October 1996.	Gary Quartermaine Caroline Heine	DIA

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Survey 2545

Project	Byford Village, Byford.
Start Date	03 Apr 1996
Proponents	Mitchell Goff
Consultants	McDonald, Hales and Associates Pty Ltd
Survey Types	Archaeological and Ethnographic
Aboriginal People Consulted?	Yes

Related Reports

Report ID	Catalogue Number	Title	Recorders	Held At
103490	HSR MW 1996 PRI	Report of an Aboriginal heritage survey, Byford Village, Byford	C. Prince J. Lewington Patrick J. Wyburn R. A. Hovingh T. Lamond	DIA

Survey 2563

Project	South-East Corridor Structure Plan.
Start Date	21 Jun 1995
Proponents	Ministry for Planning
Consultants	McDonald, Hales and Associates Pty Ltd
Survey Types	Archaeological and Ethnographic
Aboriginal People Consulted?	Yes

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Survey 2563 (continued)

Related Reports

Report ID	Catalogue Number	Title	Recorders	Held At
102051	HSR MW 1996 BLO	Revised Report of an Aboriginal Heritage Survey South-East Corridor Structure Plan. March. 1996.	A. Murphy Clint Hammond E. Blockley E. McDonald K. Edwards Paul Greenfeld	DIA
17927	HSR SW 1995 BLO [CLOSED]	List of Informants (For Report 95/139). Oct. 1995.	McDonald, Hales and Associates Pty Ltd	

Survey 3641

Project	South-East Corridor Structure Plan.
Start Date	21 Jun 1995
Proponents	Minister for Planning and Infrastructure
Consultants	McDonald, Hales and Associates Pty Ltd
Survey Types	Archaeological and Ethnographic
Aboriginal People Consulted?	Yes

Related Reports

Report ID	Catalogue Number	Title	Recorders	Held At
101972	HSR SW 1995 BLO [OWE]	Report of an Aboriginal Heritage Survey, South-East Corridor Structure Plan. Oct.1995	Clint Hammond E. Blockley Paul Greenfeld	DIA

Survey 3737

Project	Ballaruk, (Traditional Owners of Whadjuk territory) Site Recording Project
Start Date	01 Jan 1994
Proponents	Heritage Council of Western Australia
Consultants	Tamora Pty Ltd
Survey Types	Ethnographic
Aboriginal People Consulted?	Yes

Related Reports

Report ID	Catalogue Number	Title	Recorders	Held At
21817	HSR MW 1994 MAC	Ballaruk (traditional owners) Aboriginal site recording project	Barrie Machin	Department of Indigenous Affairs
21818	HSR MW 1995 MAC	Ballaruk (traditional owners of Whadjuk territorial boundaries the lands of the Ballaruk Peoples) Aboriginal site recording project : additional material	Barrie Machin	

Survey 1794

Project	Proposed Byford-Collie and Ongerup-Jerramungup sections of the Perth to Adelaide optic fibre cable route
Start Date	01 Dec 1989
Proponents	Telecom Australia
Consultants	Gary Quartermaine R. O'Connor
Survey Types	Archaeological and Ethnographic
Aboriginal People Consulted?	Yes

Survey 1794 (continued)

Related Reports

Report ID	Catalogue Number	Title	Recorders	Held At
104275	HSR SW 1989 OCO [OWE]	Report on a Survey for Aboriginal Sites on the Proposed Byford-Collie and Ongerup-Jerramungup Sections of the Perth to Adelaide Optic Fibre Cable Route. December 1989.	Gary Quartermaine Rory O'Connor Caroline Heine K. Shaw William Douglas	DIA

Survey 875

Project	Carnarvon Gas Pipeline Lateral
Start Date	10 Sep 1986
Proponents	State Energy Commission
Consultants	Dames & Moore Pty Ltd Gary Quartermaine
Survey Types	Archaeological and Ethnographic
Aboriginal People Consulted?	Yes

Related Reports

Report ID	Catalogue Number	Title	Recorders	Held At
103014	HSR P 1986 QUA	Addendum to Aboriginal site survey of Dampier to Perth natural gas pipeline - gas lateral facilities Carnarvon lateral	Gary Quartermaine	DIA

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Survey 2274

Project	The Perth Area.
Start Date	01 Apr 1970
Proponents	University of Western Australia
Consultants	University of Western Australia
Survey Types	Archaeological and Archaeological and Ethnographic
Aboriginal People Consulted?	No

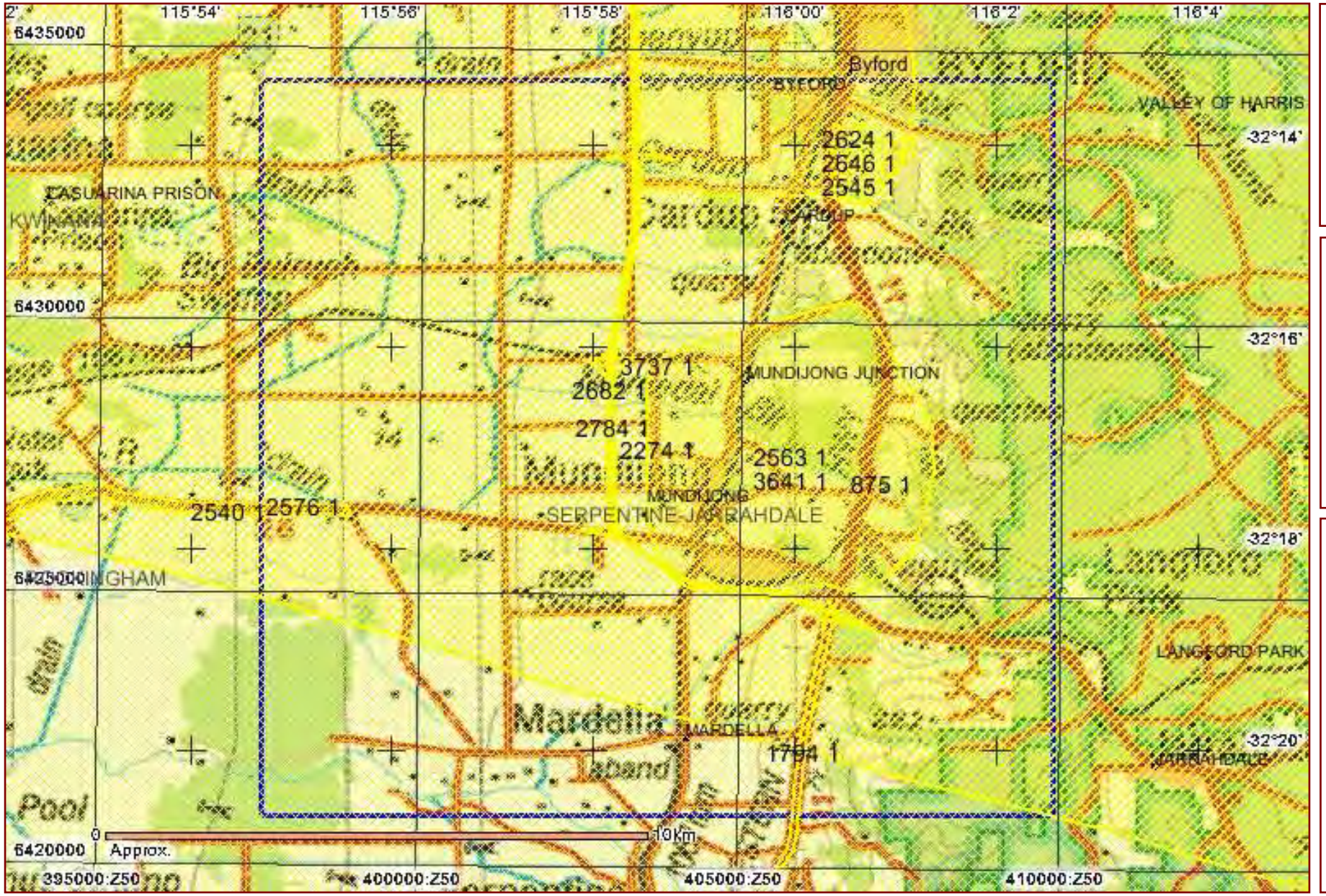
Related Reports

Report ID	Catalogue Number	Title	Recorders	Held At
103564	HSR MW 1972 UWA	An Archaeological Survey Project: The Perth Area, Western Australia. Apr 1972.	University of Western Australia H. Polach	DIA
104023	Not in Catalogue	An Archaeological Survey Project. The Perth Arch. Area. Western Australia Report no.4 April 1971.	University of Western Australia H. Polach	DIA

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Aboriginal Heritage Inquiry System

Heritage Survey Database





Legend

Selected Heritage Surveys

- Heritage Survey
- Town
- Map Area
- Search Area

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Search Criteria

28 Other Heritage Places in Coordinates search area (2); 397460mE, 6434378mN (zone 50) : 409908mE, 6421013mN (zone 50)

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Coordinate Accuracy

Accuracy is shown as a code in brackets following the site coordinates.

Reliable The spatial information recorded in the site file is deemed to be reliable, due to methods of capture.

Unreliable The spatial information recorded in the site file is deemed to be unreliable due to errors of spatial data capture and/or quality of spatial information recorded.

Status

Lodged	**ACMC Decision Made**
Information lodged, awaiting assessment	**Registered Site** **Insufficient Information Stored Data**

Spatial Accuracy

Index coordinates are indicative locations and may not necessarily represent the centre of the sites, especially for sites with an access code "closed" or "vulnerable". Map coordinates (Lat/Long) and (Easting/Northing) are based on the GDA 94 datum. The Easting/Northing map grid can be across one or more zones. The zone is indicated for each Easting on the map, i.e. '5000000:Z50' means Easting=5000000, Zone=50.

Sites Shown on Maps

Site boundaries may not appear on maps at low zoom levels.

List of Other Heritage Places with Map

ID	Status	Access	Restriction	Place Name	Type	Additional Info	Informants	Coordinates	Place No.
3310	Stored Data	Open	No Gender Restrictions	CARDUP.	Artefacts / Scatter	Camp		404190mE 6432718mN Zone 50 [Unreliable]	S00206
3313	Insufficient Information	Open	No Gender Restrictions	MUNDIJONG.	Artefacts / Scatter	Camp		406065mE 6426234mN Zone 50 [Unreliable]	S00209
3590	Insufficient Information	Open	No Gender Restrictions	WHITBY	Artefacts / Scatter			407195mE 6427120mN Zone 50 [Unreliable]	S02416
3591	Insufficient Information	Open	No Gender Restrictions	YARRABAH	Artefacts / Scatter			406870mE 6425980mN Zone 50 [Unreliable]	S02417
16108	Stored Data	Open	No Gender Restrictions	CARDUP BROOK	Mythological			407530mE 6431805mN Zone 50 [Reliable]	
17923	Stored Data	Open	No Gender Restrictions	IF #2	Artefacts / Scatter			403038mE 6427638mN Zone 50 [Reliable]	
18189	Stored Data	Open	No Gender Restrictions	Tonkin highway - mundijong road scatter # 13	Artefacts / Scatter			403043mE 6427990mN Zone 50 [Reliable]	
18190	Stored Data	Open	No Gender Restrictions	Tonkin Highway - Mundijong Road Scatter # 14	Artefacts / Scatter			404475mE 6425300mN Zone 50 [Reliable]	
18192	Stored Data	Open	No Gender Restrictions	Tonkin highway - mundijong road scatter # 16	Artefacts / Scatter			407050mE 6424150mN Zone 50 [Reliable]	
21305	Stored Data	Open	No Gender Restrictions	Byford Village Isolated Finds	Artefacts / Scatter	[Other: Multiple Isolated Finds]		406780mE 6433772mN Zone 50 [Unreliable]	
23914	Stored Data	Open	No Gender Restrictions	Byford Archaeological Survey 001	Modified Tree, Artefacts / Scatter			405373mE 6432652mN Zone 50 [Reliable]	
23915	Stored Data	Open	No Gender Restrictions	Byford Archaeological Survey 002	Artefacts / Scatter			404363mE 6432537mN Zone 50 [Reliable]	

Aboriginal Heritage Inquiry System

Aboriginal Sites Database

ID	Status	Access	Restriction	Place Name	Type	Additional Info	Informants	Coordinates	Place No.
23916	Stored Data	Open	No Gender Restrictions	Byford Archaeological Survey 003	Artefacts / Scatter			403847mE 6432559mN Zone 50 [Reliable]	
23918	Stored Data	Open	No Gender Restrictions	Byford Archaeological Survey 005	Artefacts / Scatter			404185mE 6433441mN Zone 50 [Reliable]	
23919	Insufficient Information	Open	No Gender Restrictions	Byford Archaeological Survey 006	Artefacts / Scatter			403254mE 6433533mN Zone 50 [Reliable]	
23920	Stored Data	Open	No Gender Restrictions	BAS/ISO - 001	Artefacts / Scatter			404022mE 6432479mN Zone 50 [Reliable]	
23921	Stored Data	Open	No Gender Restrictions	BAS/ISO - 002	Artefacts / Scatter			404809mE 6432444mN Zone 50 [Reliable]	
23922	Stored Data	Open	No Gender Restrictions	BAS/ISO - 003	Artefacts / Scatter			404364mE 6434301mN Zone 50 [Reliable]	
23923	Stored Data	Open	No Gender Restrictions	BAS/ISO - 004				404343mE 6434232mN Zone 50 [Reliable]	
23924	Stored Data	Open	No Gender Restrictions	BAS/ISO - 005	Artefacts / Scatter			404386mE 6434106mN Zone 50 [Reliable]	
23925	Stored Data	Open	No Gender Restrictions	BAS/ISO - 006	Artefacts / Scatter			404377mE 6434111mN Zone 50 [Reliable]	
24979	Stored Data	Open	No Gender Restrictions	Nettleton Road 19-09-07/001	Artefacts / Scatter		*Registered Informant names available from DIA	406625mE 6434289mN Zone 50 [Reliable]	
24980	Stored Data	Open	No Gender Restrictions	Nettleton Road 19-09-07/002	Artefacts / Scatter		*Registered Informant names available from DIA	406896mE 6433922mN Zone 50 [Reliable]	
24981	Stored Data	Open	No Gender Restrictions	Nettleton Road 19-09-07/003	Artefacts / Scatter		*Registered Informant names available from DIA	406992mE 6434247mN Zone 50 [Reliable]	

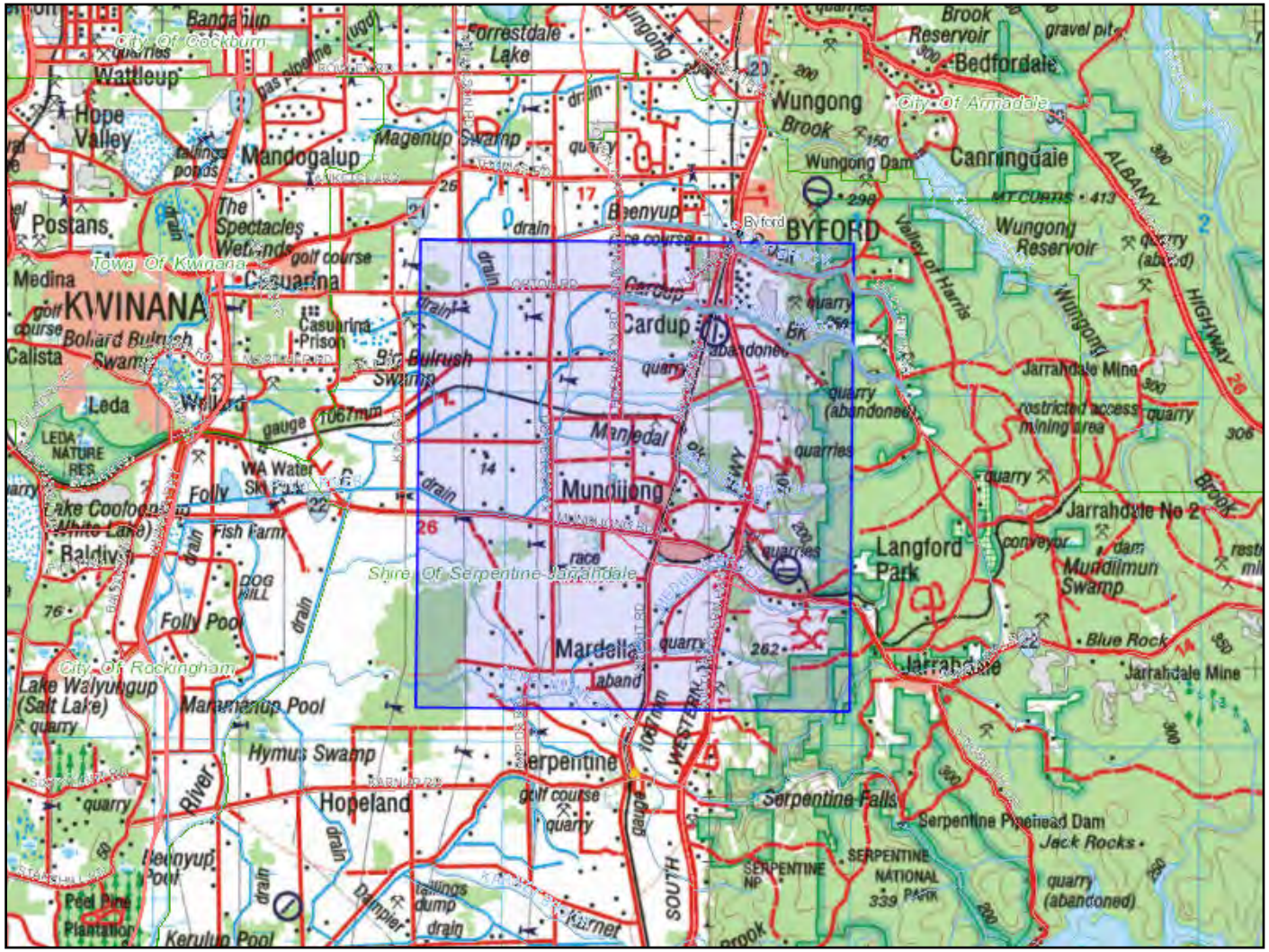
Aboriginal Heritage Inquiry System

Aboriginal Sites Database

ID	Status	Access	Restriction	Place Name	Type	Additional Info	Informants	Coordinates	Place No.
24982	Stored Data	Open	No Gender Restrictions	Nettleton Road Isolated Finds	Artefacts / Scatter		*Registered Informant names available from DIA	406980mE 6434342mN Zone 50 [Reliable]	
24983	Stored Data	Open	No Gender Restrictions	Nettleton Road 1-06	Artefacts / Scatter		*Registered Informant names available from DIA	406895mE 6434284mN Zone 50 [Reliable]	
24984	Stored Data	Open	No Gender Restrictions	Nettleton Road 2-06	Artefacts / Scatter		*Registered Informant names available from DIA	407280mE 6434370mN Zone 50 [Reliable]	
24991	Stored Data	Open	No Gender Restrictions	Beenyup Brook	Mythological	Natural Feature	*Registered Informant names available from DIA	407501mE 6433928mN Zone 50 [Reliable]	

Aboriginal Heritage Inquiry System

Aboriginal Sites Database



Legend

Selected Heritage Places

- Other Heritage Places
- Aboriginal Community Occupied
- Aboriginal Community Unoccupied
- Town
- Search Area

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Search Criteria

29 Registered Aboriginal Sites in Coordinates search area (3); 397460mE, 6434378mN (zone 50) : 409908mE, 6421013mN (zone 50)

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Coordinate Accuracy

Accuracy is shown as a code in brackets following the site coordinates.

Reliable The spatial information recorded in the site file is deemed to be reliable, due to methods of capture.

Unreliable The spatial information recorded in the site file is deemed to be unreliable due to errors of spatial data capture and/or quality of spatial information recorded.

Status

Lodged	**ACMC Decision Made**
Information lodged, awaiting assessment	**Registered Site** **Insufficient Information Stored Data**

Spatial Accuracy

Index coordinates are indicative locations and may not necessarily represent the centre of the sites, especially for sites with an access code "closed" or "vulnerable". Map coordinates (Lat/Long) and (Easting/Northing) are based on the GDA 94 datum. The Easting/Northing map grid can be across one or more zones. The zone is indicated for each Easting on the map, i.e. '5000000:Z50' means Easting=5000000, Zone=50.

Sites Shown on Maps

Site boundaries may not appear on maps at low zoom levels.

List of Registered Aboriginal Sites with Map

Site ID	Status	Access	Restriction	Site Name	Site Type	Additional Info	Informants	Coordinates	Site No.
396	Registered Site	Open	No Gender Restrictions	SOUTH-EAST CORRIDOR 07 / CARDUP SIDING	Artefacts / Scatter			403514mE 6432467mN Zone 50 [Reliable]	S02959
448	Registered Site	Open	No Gender Restrictions	SOUTH-EAST CORRIDOR 01	Artefacts / Scatter			403350mE 6431996mN Zone 50 [Reliable]	S02953
449	Registered Site	Open	No Gender Restrictions	SOUTH-EAST CORRIDOR 02	Artefacts / Scatter			403039mE 6429389mN Zone 50 [Reliable]	S02954
450	Registered Site	Open	No Gender Restrictions	SOUTH-EAST CORRIDOR 03	Artefacts / Scatter			402915mE 6428941mN Zone 50 [Reliable]	S02955
3582	Registered Site	Closed	No Gender Restrictions	SERPENTINE RIVER	Ceremonial, Mythological		*Registered Informant names available from DIA	Not available for closed Sites	S02407
3648	Registered Site	Open	No Gender Restrictions	SOLDIERS ROAD,MUNDIJONG.	Artefacts / Scatter	Archeological Deposit, [BP Dating: 1620BP]		404714mE 6428249mN Zone 50 [Reliable]	S02329
16089	Registered Site	Open	No Gender Restrictions	BYFORD 01	Artefacts / Scatter			407178mE 6433329mN Zone 50 [Unreliable]	
16090	Registered Site	Open	No Gender Restrictions	BYFORD 02	Artefacts / Scatter		*Registered Informant names available from DIA	407169mE 6433099mN Zone 50 [Unreliable]	
16091	Registered Site	Open	No Gender Restrictions	BYFORD 03	Artefacts / Scatter		*Registered Informant names available from DIA	407119mE 6432899mN Zone 50 [Unreliable]	

Aboriginal Heritage Inquiry System

Aboriginal Sites Database

Site ID	Status	Access	Restriction	Site Name	Site Type	Additional Info	Informants	Coordinates	Site No.
16092	Registered Site	Open	No Gender Restrictions	BYFORD 04	Artefacts / Scatter		*Registered Informant names available from DIA	407049mE 6432879mN Zone 50 [Unreliable]	
16093	Registered Site	Open	No Gender Restrictions	BYFORD 05	Artefacts / Scatter		*Registered Informant names available from DIA	406899mE 6432879mN Zone 50 [Unreliable]	
16094	Registered Site	Open	No Gender Restrictions	BYFORD 06	Artefacts / Scatter		*Registered Informant names available from DIA	406479mE 6433489mN Zone 50 [Unreliable]	
16095	Registered Site	Open	No Gender Restrictions	BYFORD 07	Artefacts / Scatter		*Registered Informant names available from DIA	406579mE 6433489mN Zone 50 [Unreliable]	
16096	Registered Site	Open	No Gender Restrictions	BYFORD 08	Artefacts / Scatter		*Registered Informant names available from DIA	406429mE 6432829mN Zone 50 [Unreliable]	
16097	Registered Site	Open	No Gender Restrictions	BYFORD 09	Artefacts / Scatter	Shell	*Registered Informant names available from DIA	406539mE 6433359mN Zone 50 [Unreliable]	
16098	Registered Site	Open	No Gender Restrictions	BYFORD 10	Artefacts / Scatter		*Registered Informant names available from DIA	406729mE 6433489mN Zone 50 [Unreliable]	
16099	Registered Site	Open	No Gender Restrictions	BYFORD 11	Artefacts / Scatter		*Registered Informant names available from DIA	406599mE 6433399mN Zone 50 [Unreliable]	
16100	Registered Site	Open	No Gender Restrictions	BYFORD 12	Artefacts / Scatter			407153mE 6432454mN Zone 50 [Unreliable]	
16101	Registered Site	Open	No Gender Restrictions	BYFORD 13	Artefacts / Scatter			407100mE 6432337mN Zone 50 [Unreliable]	

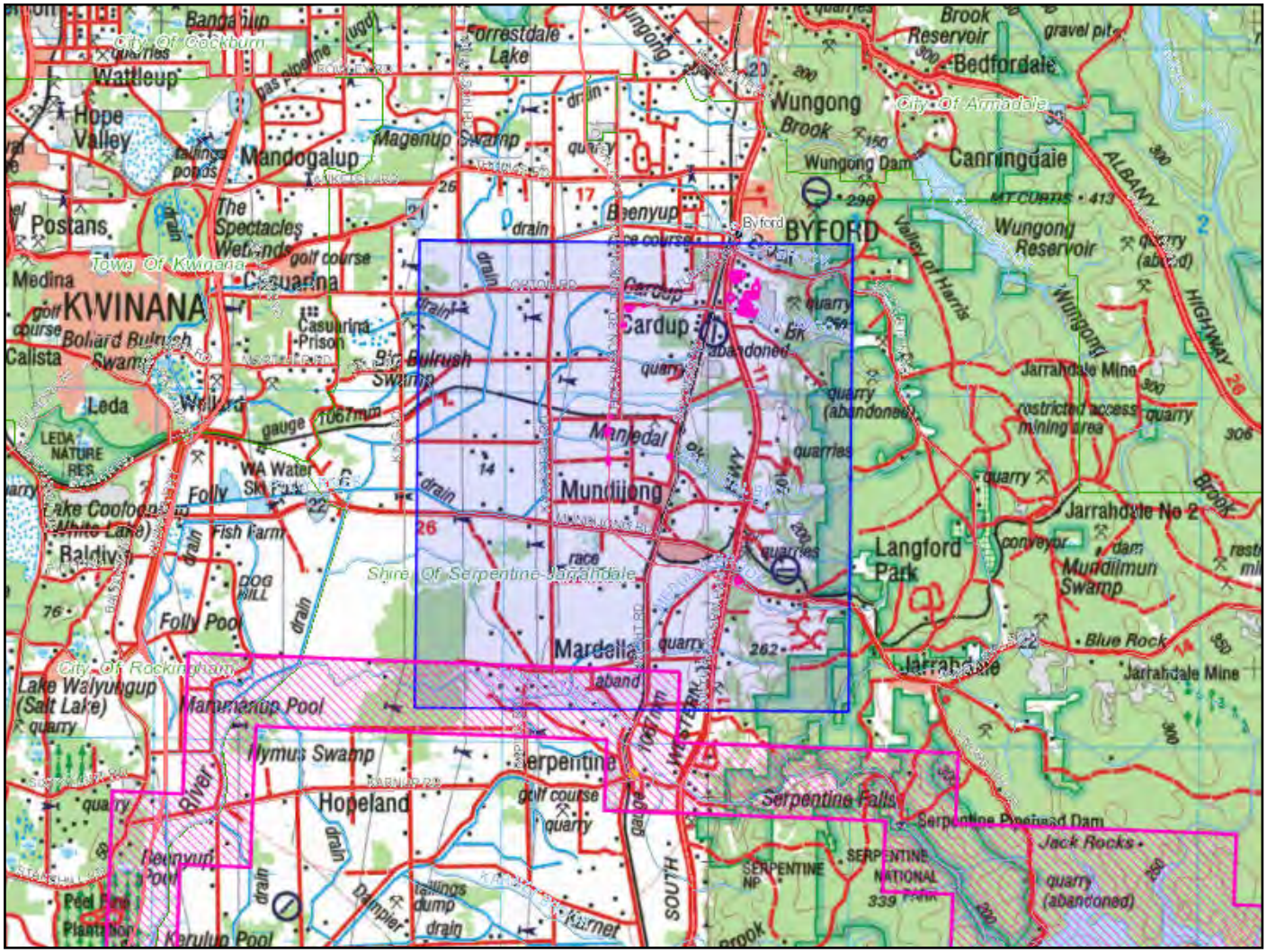
Aboriginal Heritage Inquiry System

Aboriginal Sites Database

Site ID	Status	Access	Restriction	Site Name	Site Type	Additional Info	Informants	Coordinates	Site No.
16102	Registered Site	Open	No Gender Restrictions	BYFORD 14	Artefacts / Scatter		*Registered Informant names available from DIA	406919mE 6432399mN Zone 50 [Unreliable]	
16103	Registered Site	Open	No Gender Restrictions	BYFORD 15	Artefacts / Scatter		*Registered Informant names available from DIA	406819mE 6432419mN Zone 50 [Unreliable]	
16104	Registered Site	Open	No Gender Restrictions	BYFORD 16	Artefacts / Scatter		*Registered Informant names available from DIA	406729mE 6432419mN Zone 50 [Unreliable]	
16105	Registered Site	Open	No Gender Restrictions	BYFORD 17	Artefacts / Scatter		*Registered Informant names available from DIA	406789mE 6432669mN Zone 50 [Unreliable]	
16106	Registered Site	Open	No Gender Restrictions	BYFORD 18	Artefacts / Scatter		*Registered Informant names available from DIA	406879mE 6432649mN Zone 50 [Unreliable]	
16107	Registered Site	Open	No Gender Restrictions	BYFORD 19	Artefacts / Scatter		*Registered Informant names available from DIA	406929mE 6432549mN Zone 50 [Unreliable]	
18187	Registered Site	Open	No Gender Restrictions	Tonkin highway - mundijong road scatter # 11	Artefacts / Scatter			402958mE 6428173mN Zone 50 [Reliable]	
18188	Registered Site	Open	No Gender Restrictions	Tonkin highway - mundijong road scatter # 12	Artefacts / Scatter			402961mE 6428042mN Zone 50 [Reliable]	
18191	Registered Site	Open	No Gender Restrictions	Tonkin highway - mundijong road scatter # 15	Artefacts / Scatter			406725mE 6424750mN Zone 50 [Reliable]	
23917	Registered Site	Open	No Gender Restrictions	Byford Archaeological Survey 004	Artefacts / Scatter			403917mE 6432563mN Zone 50 [Reliable]	

Aboriginal Heritage Inquiry System

Aboriginal Sites Database



Legend

Selected Heritage Sites

- Registered Sites
- Aboriginal Community Occupied
- Aboriginal Community Unoccupied
- Town
- Search Area

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Appendix 5 – Site type definitions

Artefact scatter

An artefact scatter is a place where human activity is identifiable by the presence of portable object(s) (e.g., stone, glass, bone, shell) utilised or modified by Aboriginal people in relation to traditional cultural life past or present.

Background scatter

The number of isolated artefacts (see definition below) recorded in a given area is used to calculate the density of the background scatter.

To calculate the estimated density of the background scatter, the following formula is used:

B = N/A1

B: estimated background scatter density (expressed as number of artefacts/km² and m²)

N: number of artefacts observed

A1: is estimated area viewed (see below).

A variety of factors can affect the survey intensity including visibility of the ground surface, limit of peripheral vision, width of transects etc. To account for these factors, the following formula is commonly used to determine the estimate the of area actually viewed (also known as survey intensity). (After Hiscock 1988: 73-79).

A1 = LxWxV

A1: estimated area viewed

L: length of the survey area

W: width of the area inspected (such as the width of the transect)

V: percentage of ground surface visible

Burial

(skeletal material)

A place where Aboriginal skeletal material is buried and/or where mortuary practices occurred. DAA require at least one of the following pieces of evidence to establish that the reported place is of Aboriginal origin:

- Aboriginal skeletal material is visible;
- Aboriginal mortuary/burial markers and or ethnographic evidence about the burial/skeletal material.

Engraving

A motif (either figurative or non-figurative) on a rock surface produced by percussion or abrasion. Engravings are also often referred to as petroglyphs.

Gnamma hole

A natural or artificial rock cavity which holds water after rain or is linked to the water table. May or may not include a cap stone.

Grinding material

Grinding patches or grooves are smoothed areas or grooves on rock surfaces (non-portable) that have been created by grinding activity associated with food production such as seed milling, preparation of pigments, tool manufacture and/or maintenance and ritual.

Historical A place that has historical associations with Aboriginal people and may or may not contain physical evidence of those associations.

Isolated artefact Artefact(s) that are not of sufficient density or number to be determined a site.

Midden A place where there is an accumulation of shell refuse that is derived from exploitation of a mollusc resource by Aboriginal people. Such sites may also contain artefacts, fireplaces, burnt shell and bones. Natural events (e.g. storms) may result in the formation of "midden like" features. Such features are distinguishable from middens by their lack of artefactual material, burnt shell or their composition being of non-edible mollusc species. Therefore, DAA require at least two of the following pieces of evidence to establish that the accumulation of shells is of Aboriginal origin:

- presence of charcoal, burnt wood, blackened shells, hearths;
- presence of bones of other edible species;
- presence of artefactual material;
- presence of layers indicating cultural rather than natural deposition;
- evidence that the shell fish have been exploited by human beings, e.g., broken open backs, edible size;
- demonstrable selection of edible, mature, shell fish species;
- ethnographic and/or historical evidence related to the accumulated shell refuse.

Modified tree One or more tree(s), living or dead, which has been modified by Aboriginal people by removing the bark or wood resulting in the formation of a scar. This sort of modification was and is frequently done for the making of implements, tools or other materials that were used in traditional cultural practices. DAA require at least two of the following pieces of evidence to establish that a scar is of Aboriginal origin:

- the scarred tree is an indigenous species and a mature individual;
- the scar base normally begins above ground level;
- the scar is roughly parallel-sided and fairly symmetrical in its overall shape;
- the bark regrowth is generally regular;
- the scar terminations are either squared off or pointed as a result of bark regrowth;
- axe marks are present;
- suspected toe holes are arranged in a usable pattern.

PAD (Potential archaeological deposit) An accumulation of cultural material and sediment deposited over time.

Painting Places where Aboriginal people have painted on surfaces. Paintings (including daubings, drawings, stencils, prints) can be figurative or non-figurative markings or motifs on surfaces such as rocks, rock walls and trees at fixed locations that are produced by adding pigments and or mediums, such as ochre, blood, beeswax, animal fats, vegetable dyes, tree saps.

Quarry Places where there is evidence for the extraction of stone or ochre. DAA

require at least two of the following pieces of evidence to establish that a natural occurrence of raw material has been used as a quarry:

- evidence for the removal of material/modified surfaces in the form of negative scarring, crushing, areas of excavation etc;
- presence of implements used during extraction (e.g. hammer stones, fire-hardened sticks) at the source;
- evidence of flaking and reduction of the stone material at the source.
- presence of partially-worked material at the source;
- ethnographic evidence relating to the extraction of raw material at the source.

Reduction area Reduction area refers to a cluster of stone artefacts which represent the remains of the flaking of a core. Artefacts within a reduction area can usually be conjoined back together.

Repository/cache A place where cultural or utilitarian objects are/were taken or stored by Aboriginal people, either past or present.

Rock shelter A place recognisable as a cave or overhang that may have been utilised by Aboriginal people.

Structure The placement or arrangement by Aboriginal people of stone, wood or other material made into a structure for ceremonial or utilitarian purposes.

Water source A source of water, (e.g., gnamma holes, soaks, springs, rock holes), with ethnographic evidence of its use or modification for use by Aboriginal people in connection with traditional cultural life past or present.

Appendix 6 – Artefact identification and recording

Flaked artefact identification

Flaked stone is identified on the basis of the presence of one or more of the following features (see Plate 94 and Plate 95):

- a positive or negative ring crack;
- a distinct negative or positive bulb of percussion or force;
- a definite eraillure scar beneath a striking platform;
- definite remnants of flake scars (e.g. dorsal scars and ridges);
- fracture termination.

Stone not exhibiting these features is regarded as not artefactual.

Plate 94. Features of the ventral surface of a flake produced through conchoidal fracture (Holdaway and Stern 2004:1.3.1)

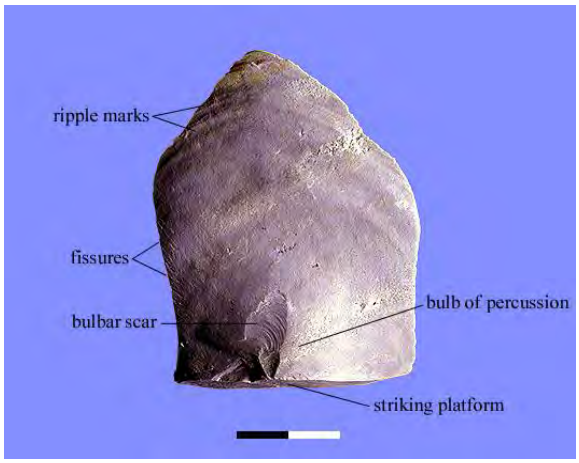


Plate 95. Features of the dorsal surface of a flake produced through conchoidal fracture (Holdaway and Stern 2004:1.3.1)



Flaked stone artefacts are classified into four types:

- flakes – exhibiting one positive ventral surface or part thereof;
- retouched flakes – containing negative flake scars created after the formation of the ventral surface;
- cores – contains one or more negative flake scars and no positive flake surfaces; and
- flaked pieces – items that cannot be placed unambiguously into one of the three above categories.

Flakes are characterised into four subcategories including complete flakes, longitudinally broken, transversely broken and flake fragments.

Artefact recording

The artefact analysis consisted of a full metrical recording of artefacts located. All artefacts located comprised material that appeared to be flaked, whilst no examples of ground stone were recorded. The following attributes were recorded for each artefact located.

Flakes

- Raw material
- colour
- completeness
- length
- width
- technological type (core, retouched flake, flake and parts thereof)
- Cross section (for debris)
- thickness
- termination type
- platform type
- platform width
- platform thickness
- number of scars present on the dorsal surface
- presence of retouch
- number of retouch scars
- length and invasiveness of retouch
- use wear presence/absence and location
- presence/absence of platform preparation (faceting, overhang removal)
- Weight (g)

Cores

- Raw material
- colour
- type (based on number of platforms),
- quantification of flake scars and platform characteristics

Artefact Metric Measurements

Flakes

Length Distance along the percussion axis from the ring crack to the distal margin.

Width Distance between the lateral margins measured at right angles to the percussion axis half way between the ring crack and distal margin.

Thickness Maximum distance between the ventral and dorsal surface of the flake half way between the ring crack and the distal margin.

Platform Width Distance along the striking platform from one lateral margin to the other.

Platform Thickness Distance across the striking platform from the centre of the ring crack to the dorsal surface.

Platform Type Type of platform may be one of the following:

- Flat – platform where it is not possible to determine whether it has a partial single flake scar, or if it has been heat fractured
- Flaked – striking platform formed by one flake scar
- Faceted – striking platform has a number of flake scars resulting from rotation of the core
- Cortical – unmodified platform consisting entirely of the outer surface of the parent rock
- Crushed – the proximal end of the flake is constituted by a sharp edge lacking a distinct platform

 # Dorsal Flake Scars Number of flakes taken off the dorsal side during production.

Cortex% The amount of cortex (chemical or mechanical weathered surface on rocks) on the dorsal side of a flake.

Overhang Removal Presence/absence of overhand removal, small flakes are removed from the edge of the platform.

Retouch/Utilisation Presence/absence of edge modification by the removal of small flakes. Both the length of retouch and location on the artefact is recorded.

Termination types The type of termination may be one of the following:

	• Feather – straight to the bottom of the flake with no deviation • Hinge – closing bend towards nearest free surface • Step – angled change of direction towards nearest free surface • Outré passé – plunging backwards towards the other side of the core
Weight	• Weight in grams to nearest 0.1g

Cores

Length	Size recorded along maximum dimensions.
Width	Size perpendicular to length.
Thickness	Size measured at 90° to both the width and the length.
# Platforms	Count number of platforms on the core.
Flake Scars	Total number, length and width of flake scars present on the core.
% Cortex	The amount of cortex (chemical or mechanical weathered surface on rocks) on the core.
Retouch/utilisation	Presence/absence of edge modification by the removal of small flakes.
Weight	Weight in grams to nearest 0.1g

Artefact recording acronyms

The following acronyms are used for recording artefact type and lithology.

F	Complete flake
FF	Flake fragment
LBF	Longitudinally broken flake
TBF	Transversely broken flake
RUF	Retouched/utilised flake
RUP	Retouch/utilised piece
BL	Blade
DB	Debris
GS	Grindstone
SPC	Single platform core
MPC	Multiplatform core
MANU	Manuport
CH	Chert
BIF	Banded Ironstone Formation
DOL	Dolorite
BAS	Basalt
CL	Chalcedony
SIL	Silcrete
WQ	White quartz
QZT	Quartzite
CQ	Crystal quartz
PQ	Pink quartz
BQ	Brown quartz

YQ	Yellow quartz
SQ	Smokey quartz
LAT	Laterite
SCH	Schist
GR	Granite

Ground stone artefacts

Ground stone artefacts can be classified into four categories including mullers, millstones, pestles and mortars. Full descriptions of these artefact types are included in Appendix 5.

The following attributes are generally recorded for ground material.

Length	Size recorded along maximum dimensions.
Width	Size perpendicular to length.
Thickness	Size measured at 90° to both the width and the length.
# Ground surfaces	Number of surfaces with ground patches.
Dimensions of ground surfaces	Length and width of all ground surfaces/patches.
Presence and type of any modification	E.g. pitting or hammer dressing to shape the artefact.
Weight	Weight to nearest 0.1g, as appropriate.

Other stone artefacts

Other stone artefacts include manuports, anvils and hammer stones. Manuports are natural objects that have been transported but not necessarily flaked or modified. Anvils comprise blocks or slabs of rock that have been used to support hammering of other objects and will exhibit pitting or indentations from these objects being struck. Hammer stones are usually round or ovoid rocks used to strike flakes off a core. Hammer stones usually have pitting on one or more surfaces from the percussion of other rock.

The following attributes are generally recorded for manuports, anvils, shell or hammer stones.

Length	Size recorded along maximum dimensions.
Width	Size perpendicular to length.
Thickness	Size measured at 90° to both the width and the length.
Modifications	Description of any modifications, e.g. pitting, indentations, or hammer dressing to shape artefact, plus the location and extent of each modification.
Weight	Weight to nearest 0.1g.

Modified trees

Modified trees are trees that have been scarred by people through the removal of bark. Scars made by people tend to be regular in shape, located above ground level and will often show evidence of axe marks (Burke and Smith 2004:226–27).

The following attributes are generally recorded for modified trees.

Type of tree	Tree species

Height of tree	Used to calculate the extent of the root system and therefore the boundary of the site.
Girth of tree	How wide the tree is around the middle.
# scars/modifications	Number of scars in the tree.
Type of scar	E.g. containers, canoes, access to honey.
General location of scar	General location of scar or modification on the tree
Height of scar	Height from base of tree.
Scar orientation and aspect	Direction of longest axis of each scar and compass bearing/direction scar is facing.
Scar shape	E.g. round, elongated, oval, irregular.
Degree of scar	How much bark has been removed
Scar dimensions	• length – maximum vertical dimension of scar • width – maximum horizontal dimension of scar • depth – distance between inner exposed wood and outer bark
Regrowth	Extent and depth of regrowth.
Implement	Type of implement used to create the scar or modification, e.g. evidence of stone axe or metal axe, where determinable.
Carvings	Presence and description of any carvings.

Appendix 7 – Beta Analytic AMS dating method

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Introduction to Radiocarbon Determination by the Accelerator Mass Spectrometry Method

AMS Counting

There are three principal isotopes of carbon which occur naturally - ^{12}C, ^{13}C (both stable) and ^{14}C (unstable or radioactive). These isotopes are present in the following amounts ^{12}C - 98.89%, ^{13}C - 1.11%, and ^{14}C - 0.00000000010%. Thus, one carbon-14 atom exists in nature for every 1,000,000,000,000 or (1 in a trillion) carbon-12 atoms in living material. The radiocarbon method is based on the rate of decay of the radioactive or unstable carbon isotope 14 (^{14}C), which is formed in the upper atmosphere through the effect of cosmic ray neutrons upon nitrogen-14.

The reaction is:

$$^{14}N + n \Rightarrow {}^{14}C + p$$

(Where n is a neutron and p is a proton)

The ^{14}C formed is rapidly oxidized to $^{14}CO2$ and enters the earth's plant and animal life ways through photosynthesis and the food chain. The rapidity of the dispersal of ^{14}C into the atmosphere has been demonstrated by measurements of radioactive carbon produced from thermonuclear bomb testing. ^{14}C also enters the earth's oceans in an atmospheric exchange and as dissolved carbonate [the entire ^{14}C inventory is termed the carbon exchange reservoir (Aitken, 1990)]. Plants and animals which utilize carbon in biological food chains take up ^{14}C during their lifetimes. They exist in equilibrium with the ^{14}C concentration of the atmosphere; that is, the number of ^{14}C atoms and non-radioactive carbon atoms stays approximately the same over time. As soon as a plant or animal dies, they cease the metabolic function of carbon uptake; there is no replenishment of radioactive carbon, only decay.

Libby, Anderson and Arnold (1949) were the first to measure the rate of this decay. They found that after 5568 years, half the ^{14}C in the original sample will have decayed and after another 5568 years, half of that remaining material will have decayed, and so on (see figure 1 below). The half-life (*t* 1/2) is the name given to this value which Libby measured at 5568±30 years. This became known as the Libby half-life. After 10 half-lives, there is a very small amount of

radioactive carbon present in a sample. At about 50,000-60 000 years, then, the limit of the technique is reached (beyond this time, other radiometric techniques must be used for dating). By measuring the ^{14}C concentration or residual radioactivity of a sample whose age is not known, it is possible to obtain the count rate or number of decay events per gram of Carbon. By comparing this with modern levels of activity (1890 wood corrected for decay to 1950 AD) and using the measured half-life, it becomes possible to calculate a date for the death of the sample.

As ^{14}C decays it emits a weak beta particle (*b*), or electron, which possesses an average energy of 160keV. The decay can be shown:

$$^{14}C \Rightarrow {}^{14}N + b$$

Thus, the ^{14}C decays back to ^{14}N. There is a quantitative relationship between the decay of ^{14}C and the production of a beta particle. The decay is constant but spontaneous. That is, the probability of decay for an atom of ^{14}C in a discrete sample is constant, thereby requiring the application of statistical methods for the analysis of counting data.

It follows from this that any material which is composed of carbon may be dated. Herein lies the true advantage of the radiocarbon method – it is able to be uniformly applied throughout the world on any material that contains residual carbon.

Because of this, laboratories from around the world are producing radiocarbon assays for the scientific community. The ^{14}C technique has been and continues to be applied and used in many different fields including hydrology, atmospheric science, oceanography, geology, palaeoclimatology, archaeology, biomedicine and materials science.

The Accelerator Mass Spectrometry method of direct ^{14}C isotope counting was first performed in 1977 by scientific research teams at Rochester and Toronto, the General Ionex Corporation, and soon after additional measurements were carried out at Simon Fraser and McMaster Universities (Gove, 1994).

Radiocarbon dating using Accelerator Mass Spectrometry (AMS) differs from the decay counting methods in that the amount of ^{14}C in the sample is measured directly, rather than by waiting for the individual radioactive decay events to occur. This makes the technique 1,000 to 10,000 times more sensitive than decay counting. The enhanced sensitivity is achieved by accelerating sample atoms as ions to high energies using a particle accelerator and using nuclear particle detection techniques. Additionally because of the increased sensitivity, counting times are greatly reduced (minutes to hours, instead of days) and sub-milligram sample sizes can be routinely measured. Because of this, a greatly

increased range of sample types and sizes can now be measured that previously gas-proportional or LSC counting techniques could not.

In the ^{14}C AMS technique, the element of interest (sample carbon) is chemically separated from the original sample, converted to graphite, pressed into a cathode (sample target holder) where it forms a solid graphite plug or layer, and is then placed into a sputter ion source of an accelerator.

This methodology outlines the general graphite sample preparation (chemistry) and AMS counting procedures at Beta Analytic Inc. for organic and carbonate samples. Through this process, the CO2 produced from carbonaceous raw materials is cryogenically purified (separated from non-combustible gases) and reduced to solid graphite for measurement in an AMS.

Conversion of Sample Carbon to Graphite

Sample Pretreatment

Each sample must first be pretreated or the material of interest isolated to ensure that only the primary carbon of interest will be analyzed. As many different types of carbon-containing compounds are present, different pretreatment regimes have been developed to concentrate and isolate the particular carbon fraction of interest prior to dating *(See Pretreatment Glossary – Standard Pretreatment Protocols at Beta Analytic*).

CO_2 Generation

The pretreated sample carbon is first oxidized to CO_2 either by combustion in an Oxygen stream or through direct reaction with reduced Cupric Oxide (metal wire / powder) for organics or through acid hydrolysis for carbonates.

Combustion OR Acid Hydrolysis

Organic + O2 + ΔH => CO2 Carbonate + HCl => CO2

(Sample) (900°C) (Sample)

Organic + CuO + ΔH => CO2

(Sample) (900°C)

The CO_2 generated is then cryogenically purified by removing water vapor and any non-combustible/condensable gases by passing through a series of dry-ice / Methanol water traps (~ -78°C) and depending on the sample type a series of liquid Nitrogen / Pentane slush traps (~129°C).

Conversion of CO_2 to Graphite (Graphitization reaction)

To produce the small amounts of elemental carbon from CO_2 for measurement in an AMS, we use the Bosch reaction (Manning and Reid, 1977) that is a chemical reaction between carbon dioxide and hydrogen that produces elemental carbon (graphite), water and heat.

The reaction takes place as two successive reductions; first to carbon monoxide and then to carbon, which permeates and adheres to the surface of the Cobalt powder (catalyst). More details on graphitization techniques and catalysts can be found in Vogel et al, 1984.

The overall reaction is as follows:

(550 to 650°C)
CO2 (g) + 2 H2 (g) → C(s) + 2 H2O (l)
(Co Catalyst)

However, the above reaction is actually the result of two separate reactions. The first reaction - the water-gas shift reaction is a fast one:

$$CO_2 + H_2 \rightarrow CO + H_2O$$

The second reaction controls the overall reaction rate:

$$CO + H_2 \rightarrow C + H_2O$$

During the graphitization procedure, cryogenically cleaned, dry CO_2 produced from the combustion or acid hydrolysis is transferred cryogenically (with Liquid Nitrogen @ -196°C)* to a specially designed graphitization cell under vacuum that is composed of Vycor glass, Pyrex glass and Stainless Steel (modified design after Lloyd et al, 1991).

** NOTE: Prior to the introduction of the CO_2 over the cobalt catalyst in the graphitization cell, the cobalt is pre-conditioned to remove any carbon contaminants by being evacuated then purged with Hydrogen multiple times and finally reduced over ¾ atmosphere of hydrogen for 1-2 hours at 550°C to 650°C.*

The pre-conditioned graphitization cell contains either a 4.5 mg or 3.5 mg aliquot of Cobalt metal powder (a mixture of 85% Alfa Aesar -400 mesh, and 15% Alfa Aesar Puratronic -22 mesh) that is specific to the size of the sample being graphitized.

Based on the amount of CO_2 generated during the combustion, the CO_2 is cryogenically transferred to a graphitization cell containing and amount of Cobalt

that is 3x greater in weight than the amount of carbon (3:1 ratio), then an aliquot of Ultra-Pure Research Grade Hydrogen is added such that the amount of Hydrogen is 3x greater in volume as the sample CO_2 (3:1 ratio). The graphitization cell is then placed into a 550°C to 650°C oven for a period of 10-12 hours while the water produced during the graphitization is continuously removed, via a cold finger that is part of the graphitization cell, by a dry-ice Methanol slush (-78°C*).*

After 10-12 hours have passed, the pressure in the graphitization cell is inspected to ensure that the reaction has gone to completion (that the CO_2 has been converted to graphite with a minimum yield falling in the range of 80-100%). If the reaction has not reached completion, the graphitization cell is returned to the oven, and reacted again for a period of 4-10 hrs. If the reaction does not reach an 80-100% completion following the second graphitization attempt, the sample is analyzed again starting from combustion.

If the graphitization has gone to completion, the graphitization cell is placed under a vacuum and allowed to warm to room temperature causing all water vapor formed during the graphitization reaction to be pumped away, leaving the graphite dry. The graphite is then purged 1x with ultra-pure (99.999) Argon which has passed through an ascarite molecular sieve to remove any CO2 and a silicone drying agent to remove any water vapor. This is then followed by pumping to a vacuum and then purged again with ultra-pure (99.999) Argon to equalize with atmospheric pressure. The graphitization tube is then removed from the graphitization cell and capped with an Al-foil cover and placed in a test tube rack ready to be loaded into a cathode for AMS counting.

AMS Cathode (Target) Loading

The prepared graphite sample is placed into an AMS cathode (target) by pouring the graphite directly from the graphitization tube into the cathode. The graphite powder is then compressed to a minimum of 150 psi (gauge reading) in an Arbor press or by hammering with a press-pin.

The surface of the graphite (target face) is optically inspected to ensure that the graphite appears to be smooth and homogenous (i.e. the graphite does not appear uneven or mottled in coloration). The cathode (target) is then placed into a cathode wheel and placed into the AMS along with the necessary Modern Standards (OXI and/or OXII, organic and carbonate blanks, TIRI known age standards (organic and or carbonate) and sufficient blind QA samples (samples previously measured by LSC and/or AMS) for C14/13 and C14/12 detection.

AMS Counting

As is common with other kinds of mass spectrometry, AMS counting is performed by converting the atoms in the sample (graphite) into a beam of fast moving ions

(charged atoms). The mass of these ions is then separated by the application of magnetic and electric fields and measured by nuclear particle detection techniques. The measurement of radiocarbon by mass spectrometry is very difficult because its concentration is less than one atom in 1,000,000,000,000 (one-trillion) atoms. Thus the accelerator is used to help remove ions that might be confused with radiocarbon before the final detection.

The sample is put into the ion source (as graphite) and is ionized by bombarding it with Cesium ions and then focused into a fast-moving beam. The ions produced are negative which prevents the confusion of ^{14}C with ^{14}N since nitrogen does not form a negative ion. The first bending magnet is used in the same way as the magnet in an ordinary mass spectrometer to select ions of mass 14 (this will include large number of $^{12}CH^{2-}$ and $^{13}CH^{-}$ ions and a very few $^{14}C^{-}$ ions). The ions then enter the accelerator. As they travel to the terminal detector they are accelerated sufficiently such that when they collide with the gas molecules in the stripper, all of the molecular ions (such as $^{12}CH_2$ and ^{13}CH) are broken up allowing most of the Carbon ions to pass through to a second bending magnet which further separates the ions with the mass and momentum expected of ^{14}C, ^{13}C, and ^{12}C.

Finally the filtered ^{14}C ions enter the detector where their velocity and energy are checked so that the number of ^{14}C ions in the sample can be counted. Not all of the radiocarbon atoms put into the ion source end up reaching the detector and so the stable isotopes, ^{12}C and ^{13}C are measured as well in order to monitor the detection efficiency. For each sample, a ratio of $^{14}C/^{13}C$ is calculated and compared to measurements made on standards with known ratios.

Uncertainties in AMS

Soon after the first AMS spectrometers were developed, the quality of AMS measurements was demonstrated through comparisons of the error in the mean of a series of n AMS measurements for a sample (external error) to the counting statistics of the measured total counts, N, in that series of measurements (internal error). If μ is the mean of a group of individual measurements, each with variance σ2 (here assumed equivalent for all measurements), the fractional precisions were shown to be equivalent:

$$\sigma^2_{ext} = \sigma^2 / n\,(n-1)\mu^2 = \sigma^2 \text{int} = 1/N_{total}$$

Indeed, equivalence of the standard error in the mean of AMS measurements to the precision expected from counting statistics demonstrated the degree to which

the spectrometer and its operation are free of systematic error. (Wölfli, et al., 1983; Donahue, Jull, & Zabel, 1984; Farwell, et al., 1984; Suter, et al., 1984).

The development of a uniform sample material for ^{14}C AMS, filamentous or fullerene graphite (Vogel et al, 1984), provided intense ion beams for all samples and standards, bringing the internal and external uncertainties into routine equivalence for precise ($\sigma \leq 1\%$) AMS quantification. (Bonani, et al., 1987; Vogel, at al., 1987).

Sample Isotopic Fractionation (Stable Isotope Ratios 13/12C)

In order to provide radiocarbon determinations that are both accurate and precise, it is necessary to measure the stable isotopes of ^{13}C and ^{12}C and their ratio. This is performed by extracting a small amount of the CO_2 generated during the combustion or acid hydrolysis and measuring the 13/12C ratio relative to the PDB mass-spectrometry standard. This ratio is later used in the calculation of the radiocarbon age and error to correct for isotopic fractionation in nature.

Fractionation during the geochemical transfer of carbon in nature produces variation in the equilibrium distribution of the isotopes of carbon (^{12}C, ^{13}C and ^{14}C). Craig (1953) first identified that certain biochemical processes alter the equilibrium between the carbon isotopes. Some processes, such as photosynthesis for instance, favors one isotope over another, so after photosynthesis, the isotope ^{13}C is depleted by 1.8% in comparison to its natural ratios in the atmosphere (Harkness, 1979). Conversely the inorganic carbon dissolved in the oceans is generally 0.7% enriched in ^{13}C relative to atmospheric carbon dioxide.

The extent of isotopic fractionation on the $^{14}C/^{12}C$ ratio, which must be measured accurately, is approximately double that for the measured $^{13}C/^{12}C$ ratio. If isotopic fractionation occurs in natural processes, a correction can be made by measuring the ratio of the isotope ^{13}C to the isotope ^{12}C in the sample being dated. The ratio is measured using an ordinary mass spectrometer. The isotopic composition of the sample being measured is expressed as delta13C which represents the parts per thousand difference (per mille) between the sample carbon-13 content and the content of the international PDB standard carbonate (Keith et al., 1964; Aitken, 1990). A d13C value, then, represents the per mille (part per thousand) deviation from the PDB standard. PDB refers to the Cretaceous belemnite formation at Peedee in South Carolina, USA. This nomenclature has recently been changed to VPDB (Coplen, 1994).

In summary, isotopic fractionation refers to the fluctuation in the carbon isotope ratios as a result of natural biochemical processes as a function of their atomic mass (Taylor, 1987). Variations as such are unrelated to time and natural radioactive decay. It is common practice in radiocarbon laboratories to correct radiocarbon activities for sample fractionation. The resultant ages are termed

"normalized", meaning the measured activity is modified with respect to -25 per mille wrt VPBD. The correction factor must be added or subtracted from the conventional radiocarbon age.

The deltaC13 value for a sample can yield important information regarding the environment from which the sample comes or the mixtures of materials used to produce it because the isotope value of the sample reflects the isotopic composition of the immediate environment. In the case of shellfish, for example, marine shells typically possess a dC13 value of between -1 and +4 per mille, whereas river shells possess a value of between -8 and -12 per mille. Therefore, in a case where the precise environment of the shell is not known, it is possible to determine the most likely by analysis of the dC13 result.

Fractionation also describes variations in the isotopic ratios of carbon brought about by non-natural causes. For example, samples may be fractionated in the laboratory through a variety of means. Usually, this is due to lack of attention to detail and incomplete conversion of the sample from one stage to another or from one part of the laboratory to another. In Liquid Scintillation Counting, for example, incomplete synthesis of acetylene during lithium carbide preparation may result in a low yield and concurrent fractionation. Similarly, the transfer of gases in a vacuum system may involve fractionation error if the sample gas is not allowed to equilibrate throughout the total volume. Atoms of larger or smaller mass may be favored in such a situation. If, however, the entire sample is converted completely from one form to another (e.g. solid to gas, acetylene to benzene) then no fractionation will occur.

Radiocarbon Age and Error Calculation

Much of the information presented in this section is based upon the paper Stuiver, M. and Polach, H.A. 1977. Discussion: Reporting of ^{14}C data. *Radiocarbon* 19; 355-63.

The radiocarbon age of a sample is obtained by measurement of the residual radioactivity. This is calculated through careful measurement of the residual activity (per gram C) remaining in a sample whose age is unknown, compared with the activity present in Modern and Background samples.

Modern Standard

The principal modern radiocarbon standard is N.I.S.T (National Institute of Standards and Technology; Gaithersburg, Maryland, USA) Oxalic Acid I (C2H2O4). *Oxalic acid I* is N.I.S.T designation SRM 4990 B and is termed HOx1. This is the International Radiocarbon Dating Standard. Ninety-five percent of the activity of Oxalic Acid from the year 1950 is equal to the measured activity of the *absolute radiocarbon standard* which is 1890 wood. The 1890 wood was chosen

as the radiocarbon standard because it was growing prior to the fossil fuel effects of the industrial revolution.

The activity of 1890 wood is corrected for radioactive decay to 1950. Thus 1950, is year 0 BP by convention in radiocarbon dating and is deemed to be the 'present'. The year 1950 was chosen for no particular reason other than to honor the publication of the first radiocarbon dates calculated in December 1949 (Taylor, 1987;97).

The Oxalic acid standard was made from a crop of 1955 sugar beet. There were 1000 lbs made. The isotopic ratio of HOx I is -19.3 per mille with respect to (wrt) the PBD standard belemnite (Mann, 1983). The Oxalic acid standard which was developed is no longer commercially available. Another standard, *Oxalic Acid II* was prepared when stocks of HOx 1 began to dwindle. The Oxalic acid II standard (HOx 2; N.I.S.T designation SRM 4990 C) was made from a crop of 1977 French beet molasses. In the early 1980s, a group of 12 laboratories measured the ratios of the two standards. The ratio of the activity of Oxalic acid II to 1 is 1.2933±0.001 (the weighted mean) (Mann, 1983). The isotopic ratio of HOx II is -17.8 per mille.

According to Stuiver and Polach (1977), all laboratories should report their results either directly related to NBS Oxalic acid or indirectly using a sub-standard which is related to it.

Background Detection

It is vital for a radiocarbon laboratory to know the contribution to routine sample activity of non-sample radioactivity. Obviously, this activity is additional and must be removed from calculations. In order to make allowances for background counts and to evaluate the limits of detection, materials which radiocarbon specialists can be fairly sure contain no activity are measured under identical counting conditions as normal samples.

Background samples usually consist of geological samples of infinite age such as coal, lignite, limestone, ancient carbonate, anthracite, marble or swamp wood. By measuring the activity of a background sample, the normal radioactivity present while a sample of unknown age is being measured can be accounted for and deducted.

Conventional radiocarbon ages (BP)

A radiocarbon measurement termed a conventional radiocarbon age (or CRA) is obtained using a set of parameters outlined by Stuiver and Polach (1977), in the journal *Radiocarbon*. A time-independent level of ^{14}C activity for the past is assumed in the measurement of a CRA. The activity of this hypothetical level of ^{14}C activity is equal to the activity of the absolute international radiocarbon

standard. The Conventional Radiocarbon Age BP is calculated using the radiocarbon decay equation:

t = -8033 ln (Asn/Aon)

Where -8033 represents the mean lifetime of ^{14}C (Stuiver and Polach, 1977). Aon is the activity in counts per minute of the modern standard. Asn is the equivalent cpm for the sample. 'ln' represents the natural logarithm.

A CRA embraces the following recommended conventions:

• a half-life of 5568 years;
• the use of Oxalic acid I or II as the modern radiocarbon standard;
• correction for sample isotopic fractionation (deltaC13) to a normalized or base value of -25.0 per mille relative to the ratio of $^{12}C/^{13}C$ in the carbonate standard VPDB (more on fractionation and deltaC13);
• the use of 1950 AD as 0 BP, ie all ^{14}C ages head back in time from 1950;
• the assumption that all ^{14}C reservoirs have remained constant through time.

Additional terms are sometimes requested to be or reported with, or in lieu of the standard Conventional Radiocarbon Age BP result from which all others are mathematically derived. These are the “Measured Radiocarbon Age BP”, Percent Modern Carbon (pMC), Mean Biobased Result (expressed in %), Percent Mean Biogenic Carbon Content, Percent Biomass CO2, Fraction Modern Carbon (fmdn or fMC) as well as d14C, D14C, delta 14C, Δ14C and delta 13/12C (all of which are expressed in per mille notation (%) rather than per cent notation.)

d14C represents the per mille depletion in sample carbon 14 prior to isotopic fractionation correction and is measured by;

d14C=((Asn/Aon) - 1)1000 per mille

D14C represents the 'normalized' value of d14C. 'Normalized' means that the activity is scaled in relation to fractionation of the sample, or its deltaC13 value. All D14C values are normalized to the base value of - 25.0 per mille with respect to the standard carbonate (VPDB). D14C is calculated using:

D14C=d14C - 2(dC13 + 25)(1 + d14C/1000) per mille

This value can then be used to calculate the CRA using the equation given above.

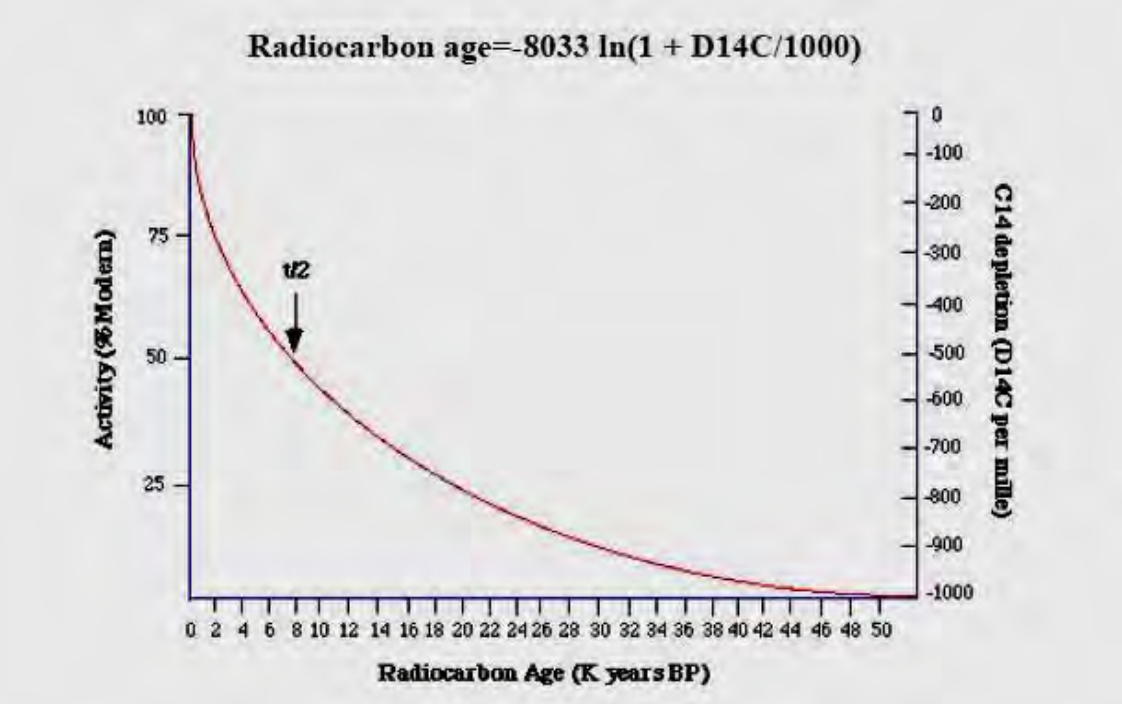


Figure 1 - Decay curve for ^{12}C showing the activity at one half-life (t/2). The terms "%Modern" or "pMC" and D14C are shown related in this diagram along with the Radiocarbon age in years BP (Before 1950 AD).

Age reporting

If the reservoir corrected conventional radiocarbon age calculated is within the past 200 years, it should by convention be termed 'Modern' (Stuiver and Polach, 1977; 362). If a sample age falls after 1950, it is termed greater than Modern, or >Modern. Absolute percent modern (%M or pMC - 'percent modern carbon') is calculated using:

%M=100 x Asn/Aabs

or

Asn/Aon(1/8267(y-1950)) x 100 percent

Where Aabs is the absolute international standard activity, 1/8267 is the lifetime based on the new half life (5730 yr), Y = the year of measurement of the appropriate standard. This is an expression of the ratio of the net modern activity against the residual normalized activity of the sample, expressed as a percentage and it represents the proportion of radiocarbon atoms in the sample compared to that present in the year 1950 AD. Thus, %Modern becomes a useful term in describing radiocarbon measurements for the past 45 years when, due to

the influx of artificial radiocarbon into the atmosphere as a result of nuclear bomb testing, the 'age' calculation becomes a 'future' calculation.

If the sample approaches D14C = -1000 per mille within 2 standard deviations, it is considered to be indistinguishable from the laboratory background, i.e., not able to be separated with confidence from the laboratory count-rates which result from a sample which contains no radionuclide. In this instance, a Greater-Than Age is calculated. An example of a Greater-Than Age is >55, 000 yr or >50, 000 yr (Gupta and Polach, 1985).

Samples whose age falls between modern and background and are given finite ages. Standard errors released with each radiocarbon assay are usually rounded by convention (Stuiver and Polach, 1977). Again, not all laboratories subscribe to these conventions, some do not round up ages.

Standard Error and Sources of Error

Statistical analysis is necessary in radiocarbon dating because the decay of ^{14}C although constant, is spontaneous. It is not possible to measure the entire radioactivity in a given sample, hence the need for some kind of statistical analysis of counted data. The distribution of counted ^{14}C decay events will, over time, yield a pattern. The pattern is termed a "normal distribution curve".

A normal or "Gaussian" distribution describes the symmetrical bell shaped cluster of events around the average or mean of the data. In a normal distribution, 2 out of 3, or 68% of the values or counts observed will fall within one standard deviation of the average of the data. At two standard deviations, 95% of the observed counts will fall within the range and at three standard deviations, 99% of the counts which comprise the normal distribution will fall within this region.

Each radiocarbon date is released as a conventional radiocarbon age with 'standard error'. This is the '±' value and by convention is ± 1 sigma. The standard error is based principally upon counting statistics, however other sources of error are possible and their effects are listed below:

Summary; The accuracy of radiocarbon dates (modified from Polach, H.A. 1976). Sources of Error	**Effect upon Age Determination**	**Measures to minimize the error incurred**
1. Precision of age determination	Statistical; Typically ±1%Modern or less	Big samples, longer count times, repeat sample assays
2. Inherent a. ^{14}C half-life	Libby half life 3% too low	Multiply CRA's by 1.03 if necessary
b. $^{12}C/^{13}C$ fractionation	Variable, up to	Stable isotope analyses

	450 yr for shell.	using Mass Spec.
c. ^{14}C Modern standard	Variable > 80 yr	International crosscheck of secondary standards.
d. Variation in past ^{14}C production rates	0-800 yr, beyond *ca*12 ka not determined	Tree ring calibration; otherwise interpret results in radiometric timescale.
e. Distribution of ^{14}C in nature	Surface ocean latitudinal dependence -400 to -750 yr. Deep ocean -1800 yr.	Interpretation of results.
f. Changes of ^{14}C concentration in the atmosphere.	Industrial effect *ca* -2.5% and atom bomb effect +160% in atmosphere	Interpretation of results
3. Contamination	Nil to 300 yr up to 15 ka; >20 ka possible beyond 25 ka.	Interpretation of results, analysis and dating of extracted pretreated fractions.
4. Biological age of material	<10 yr to>1000 yr	Identification of species of material in the case of wood and charcoal to short lived samples only.
5. Association of sample and event	Intermediate	Interpretation of results
6. Human	Intermediate	Care in field and laboratory
7. Interpretation of results	Intermediate	Care in interpretation, interdisciplinary approach and collaboration

Accuracy and Precision in Radiocarbon Dating

It is important to note the meaning of "accuracy" and "precision" in radiocarbon dating. Accuracy refers to the date being a 'true' estimate of the age of a sample within the range of the statistical limits or ± value of the date. Thus, for the sake of argument, if we were radiocarbon dating a sample of human bones from an individual who we knew died in 1066 AD and obtained a date of 1040±40 AD, we would have dated the event of his death accurately. If however the date obtained were 1000±15 AD, we would be inaccurate.

In terms of precision, however, the former is imprecise in comparison to the latter because of the larger stated error value. As such it can be seen that the date of 1000±15 AD while being highly precise is, in this instance, inaccurate.

Reservoir Effects

A Conventional Radiocarbon Age or CRA does not take into account specific differences between the activity of different carbon reservoirs. A CRA is derived using an age calculation based upon the decay corrected activity of the absolute radiocarbon standard (1890 AD wood) which is in equilibrium with atmospheric radiocarbon levels (as mentioned previously, 1890 wood is no longer used as the primary radiocarbon standard, instead Oxalic Acid standards I and II were correlated with the activity of the original standard). In order to ascertain the ages of samples which were formed in equilibrium with different reservoirs to these materials, it is necessary to provide an age correction. Implicit in the Conventional Radiocarbon Age BP is the fact that it is not adjusted for this correction.

Radiocarbon samples which obtain their carbon from a different source (or reservoir) than atmospheric carbon may yield what is termed apparent ages. A shellfish alive today in a lake within a limestone catchment, for instance, will yield a radiocarbon date which is excessively old. The reason for this anomaly is that the limestone, which is weathered and dissolved into bicarbonate, has no radioactive carbon. Thus, it dilutes the activity of the lake meaning that the radioactivity is depleted in comparison to 14C activity elsewhere. The lake, in this case, has a different radiocarbon reservoir than that of the majority of the radiocarbon in the biosphere and therefore an accurate radiocarbon age requires that a correction be made to account for it.

One of the most commonly referenced reservoir effects concerns the ocean. The average difference between a radiocarbon date of a terrestrial sample such as a tree, and a shell from the marine environment is about 400 radiocarbon years (see Stuiver and Braziunas, 1993). This apparent age of oceanic water is caused both by the delay in exchange rates between atmospheric CO_2 and ocean bicarbonate, and the dilution effect caused by the mixing of surface waters with upwelled deep waters which are very old (Mangerud 1972). A reservoir correction must therefore be made to any conventional shell dates to account for this difference. Human bone may be a problematic medium for dating in some instances due to human consumption of fish, whose ^{14}C label will reflect the ocean reservoir. In such a case, it is very difficult to ascertain the precise reservoir difference and hence apply a correction to the measured radiocarbon age.

Spurious radiocarbon dates caused by volcanic emanations of radiocarbon-depleted CO_2 probably also come under the category of reservoir corrections. Plants which grow in the vicinity of active volcanic fumaroles will yield a

radiocarbon age which is too old. Bruns *et al.* (1980) measured the radioactivity of modern plants growing near hot springs heated by volcanic rocks in western Germany and demonstrated a deficiency in radiocarbon of up to 1500 years through comparison with modern atmospheric radiocarbon levels. Similarly, this effect has been noted for plants in the bay of Palaea Kameni near the prehistoric site of Akrotiri, which was buried by the eruption of the Thera volcano over 3500 years ago (see Weninger, 1989). The effect has been suggested as providing dates in error for the eruption of Thera which has been linked to the demise of the Minoan civilization in the Aegean. One modern plant growing near the emanations had an apparent age of 1390 yr. The volcanic effect has a limited distance however. Bruns *et al.* (1980) found that at 200 m away from the source, plants yielded an age in agreement with that expected. They suggested that the influence of depleted CO_2 declined rapidly with increasing distance from the source. Radiocarbon discrepancies due to volcanic CO_2 emissions are a popular source of ammunition for fundamentalist viewpoints keen to present evidence to show that the radiocarbon method is somehow fundamentally flawed.

Suess or Industrial Effect

Since about 1890, the use of industrial and fossil fuels has resulted in large amounts of CO_2 being emitted into the atmosphere. Because the source of the industrial fuels has been predominantly material of infinite geological age (*e.g.* coal, petroleum), whose radiocarbon content is nil, the radiocarbon activity of the atmosphere has been lowered in the early part of the 20th century up until the 1950s. The atmospheric radiocarbon signal has, in effect, been diluted by about 2%. Hans Suess (1955) discovered the industrial effect (also called after him) in the 1950s. A number of researchers found that the activity they expected from material growing since 1890 AD was lower. The logical conclusion from this was that in order to obtain a modern radiocarbon reference standard, representing the radiocarbon activity of the 'present day', one could not very well use wood which grew in the 1900s since it was affected by this industrial effect. Thus it was that 1890 wood was used as the modern radiocarbon standard, extrapolated for decay to 1950 AD.

Atom Bomb Effect

Since about 1955, thermonuclear tests have added considerably to the ^{14}C atmospheric reservoir. This ^{14}C is 'artificial' or 'bomb' ^{14}C, produced because nuclear bombs produce a huge thermal neutron flux. The effect of this has been to almost double the amount of ^{14}C activity in terrestrial carbon bearing materials (Taylor, 1987).

De Vries (1958) was the first person to identify this 'Atom Bomb' effect. In the northern hemisphere the amount of artificial carbon in the atmosphere reached a peak in 1963 (in the southern hemisphere around 1965) at about 100% above normal levels. Since that time the amount has declined owing to exchange and

dispersal of ^{14}C into the earth's carbon cycle system. The presence of bomb carbon in the earth's biosphere has enabled it to be used as a tracer to investigate the mechanics of carbon mixing and exchange processes.

Appendix 8 – Significance assessment

Cultural heritage significance in the Australian context

Heritage significance is the degree to which a place, object or activity possesses a certain valued attribute. Current definitions of significance acknowledge that value is not inherent in objects or places but rather people attribute value to these entities (Thomson, 2012a: 10). Further, cultural heritage will often have multiple values which can be contested (Truscott, 1992, Tunbridge and Ashworth, 1996, Greer and Henry, 1996, Harrington, 2004).

In Australian cultural heritage management practice, the *Australia ICOMOS Burra Charter* (2013) is the primary model adopted for significance assessments of heritage places. This model divides significance into five types including aesthetic, historical, scientific, social and spiritual. Although none of these categories are mutually exclusive, the scope of this report requires primarily the assessment of the scientific significance of any archaeological sites located. The Burra Charter states that 'the scientific or research value of a place will depend upon the importance of the data involved, on its rarity, quality or representativeness, and on the degree to which the place may contribute further substantive information' (Byrne et al., 2003).

In Western Australia, the Aboriginal Cultural Material Committee (ACMC) determines whether the AHA 'applies to a place by operation of one or more paragraphs in Section 5' (DIA, 2012). The ACMC is directed by section 39(2) of the AHA to have regard to the following in evaluating the importance of places and objects:

> (a) any existing use or significance attributed under relevant Aboriginal custom;
>
> (b) any former or reputed use or significance which may be attributed upon the basis of tradition, historical association, or Aboriginal sentiment;
>
> (c) any potential anthropological, archaeological or ethnographical interest; and
>
> (d) aesthetic values.

Section 39(3) also states that 'Associated sacred beliefs, and ritual or ceremonial usage, in so far as such matters can be ascertained, shall be regarded as the primary considerations to be taken into account in the evaluation if any place or object for the purposes of the Act'.

The DAA have recently developed a threshold test guideline which states that in addition to the criteria set out in section 39, the following will be taken into account when considering whether section 5a and 5c apply to a place or object:

Section 5a:

- Intactness and condition of the place and object;
- The temporal context of the place and object;
- The complexity or diversity of the object;
- The relationship between the objects and the place;
- The rarity and uniqueness of the place and object;
- The context and relationship of the place to other places;
- The contribution to research to the understanding of Aboriginal people past and present.

Section 5c:

- It marks important events, changes or patterns of Aboriginal prehistory or history;
- It possessed uncommon, rare or endangered features of Aboriginal prehistory or history;
- It has the potential to yield important information that will make a substantial contribution to an understanding of Aboriginal prehistory or history;
- It demonstrates the principal characteristics of Aboriginal prehistoric or historic environments;
- It exhibits particular aesthetic characteristics valued by the community;
- It demonstrates the creative or technical achievement of a particular period of Aboriginal prehistory or history; or
- It has special association with the life or works of an Aboriginal person or persons of historical importance;

and the preservation of the place would benefit current and future generations of Western Australians.

Archaeological significance

When providing recommendations with regards to the **archaeological** significance of a place, the DAA (2010) requires the following attributes to be considered and articulated in archaeological reports:

- Research potential – the potential of an Aboriginal site to contribute to timely and specific research questions. This depends on a number of factors including its state of preservation and the range of past human activities reflected at that site.
- Representativeness – the extent to which the archaeology of a particular Aboriginal site is represented at other localities within the region. Unusual or unique sites are normally accorded a higher archaeological significance than sites that are very common.

These requirements are based on Bowdler's framework for significance assessment which recommends that '...the significance of archaeological resources should be assessed according to 'timely and specific research questions' on the one hand, and representativeness on the other. The latter takes care of the argument that we cannot predict next year's or next century's research capabilities and interests, but itself requires research'(Bowdler, 1981: 129). Bowdler further highlights that archaeological significance 'is a mutable, even transformational, quality, which changes as the subject changes' (Bowdler 1984: 7).

Bickford and Bowdler (in Bowdler, 1984b: 1-2, Bickford and Sullivan, 1984a: 23-24, Sullivan, 1983) developed the following set of questions to aid with the assessment of research potential:

1. Can this site contribute knowledge which no other site can?
2. Can this site contribute knowledge which no other resource, such as documents or oral history or previous research can?
3. Is this knowledge relevant to specific or general questions about human history or behaviour or some other substantive topic?

It should be noted, however, that the two concepts of research value and representativeness are not unproblematic (see Thomson 2012). The use of research questions or agendas has been criticised, amongst other things, for their inherent biases and failure to predict or cater for unanticipated or

future research questions (Bruier & Mathers 1997; Smith 2004; Dixon 1977; Dunnell 1984; Raab & Klinger 1979). The concept of representativeness was conceived as a solution to these problems, however, as Smith (1994: 27-28, 2004: 119-120) has demonstrated, every site is unique in some respect and every site in a group of sites will be different hence defining representativeness actually depends on the research questions asked and the criteria used to assess the resource.

Smith's (1991) research on defining a site type profile for artefact scatters determined that any move towards a representative sample must include sites from different time periods, different environmental units, different cultural and land management units and that the sample should also include different size sites (based on artefact numbers and densities), sites containing different percentages of raw materials and artefact types, and that such variations should be considered for each time period, environmental, cultural and land management unit (Smith, 1994: 28). Smith highlights the practical issue of how viable, in a logistical sense, are representative samples and questions whether any of these attributes have any meaning in the context of archaeological theory and research (Smith, 1994: 28, Thomson, 2012a: 12-13, Thomson, 2012d). Smith (1994: 28-29) also emphasizes Bowdler's point that the archaeological 'resource' and archaeological values are highly dynamic and change over time.

Further, it should also be noted that there are significant issues with the data available to inform assessments of representativeness. As McDonald Hales and Associates (2001a: 34-35) note, the process of assessing representativeness is predicated on the availability of high quality and up-to-date information. The main source of data is the DAA's AHIS which has several issues including very broadly defined site types which do not facilitate identification of sub-classes of sites, for example different types of artefact scatters or shell scatters. Secondly, data on what sites have been destroyed in a region either, through official sanction or illegally, is not available. This lack of information can dramatically skew determinations of representativeness in a region. Thirdly, as some Traditional Owners, land owners and consultants choose not to submit consultancy reports to the DAA, for a variety of reasons, the AHIS does not contain a complete record of surveys and site information in some regions. There is also significant variability in the quality and detail of information submitted to DAA as a result of the varying skills and experience of the site assessor, variation in technical, methodological or definitional differences between consultants and differences in the timing, location and intensity of archaeological research (McDonald Hales and Associates, 2001a: 34-35, see also Mathers et al., 2005). This variability can result in the incomparability of data and lead to a limited number of factors, such as site type, that can be compared in the assessment of representativeness (Thomson, 2012a: 28, Thomson, 2012d).

Appendix 9 – Artefact data

MJ-01 surface artefact data

Sample square	Artefact #	Artefact Type	Lithology	Cross-section	Artefact Dimensions			Platform Type	Platform Dimensions		Termination	# Dorsal flake scars	Cortex %	Parallel Arrises	Retouch/ Utilisation?	R/U Location	R/U Length	Weight (g)
					Length	Width	Depth		Length	Width								
N4	1	DB	WQ	L	4.4	3.3	1.2	-	-	-	-	1	0	0	-	-	-	<0.1
N4	2	FP	WQ	L	6.5	4.9	0.7	-	-	-	F	1	0	0	-	-	-	<0.1
N4	3	LBF	CQ	W	6.9	3.3	0.7	FA	2.2	1.2	F	1	0	0	-	-	-	<0.1
N4	4	DB	WQ	TB	3.9	3.1	0.9	-	-	-	-	0	0	0	-	-	-	<0.1
N4	5	DB	WQ	I	5.8	3	0.8	-	-	-	-	0	0	0	-	-	-	<0.1
N4	6	DB	WQ	L	6.4	3.8	0.6	-	-	-	-	0	0	0	-	-	-	<0.1
N4	7	F	CQ	L	4.4	1.8	0.7	I	2.5	1.4	F	1	0	0	-	-	-	<0.1
N5	1	FP	WQ	L	6.3	1.9	1.5	-	-	-		0	0	0	-	-	-	<0.1
N5	2	F	CQ	L	4.6	2	1.1	FK	3.1	1	F	2	0	0	-	-	-	<0.1
N5	3	DB	WQ	I	5.6	3.3	1	FO	-	-	HT	2	0	0	-	-	-	<0.1
N5	4	LBF	WQ	TB	5.1	2.7	0.9	-	-	-	-	0	0	0	-	-	-	<0.1
N5	5	FP	CQ	W	4.7	3.5	1.2	FL	3.3	1.5	F	0	0	0	-	-	-	<0.1
N5	6	F	CQ	L	5.5	5.7	0.9	-	-	-	F	2	0	1	-	-	-	<0.1
N8	1	DB	WQ	W	4.8	3.9	1	FA	3.5	1.7	F	1	0	0	-	-	-	<0.1
N8	2	F	WQ	I	3.4	3.5	1.4	-	-	-	-	0	0	0	-	-	-	<0.1
N8	3	FP	CQ	W	9	4	1.7	FL	4.5	2.1	CR	3	0	0	-	-	-	0.2
N8	4	FP	CQ	L	7.7	5.6	0.7	-	-	-	-	0	0	0	-	-	-	<0.1
N8	5	DB	WQ	I	5.9	5	0.8	-	-	-	-	1	0	0	-	-	-	<0.1
N8	6	F	CQ	L	4.9	2.1	0.7	-	-	-	-	0	0	0	-	-	-	<0.1
N9	1	FP	WQ	L	7	4.7	1.2	FO	-	-	F	1	0	0	-	-	-	<0.1
N9	2	FP	CQ	L	8.9	3.5	1.5	-	-	-	-	1	0	0	-	-	-	<0.1
N9	3	DB	WQ	W	4.6	3.4	1.3	-	-	-	-	0	0	0	-	-	-	<0.1
N9	4	DB	BAS	I	11.1	8.5	2	-	-	-	-	0	0	0	-	-	-	0.2
N9	5	DB	CQ	I	4.3	3.5	0.8	-	-	-	-	0	0	0	-	-	-	<0.1
N9	6	FP	WQ	I	12.7	6.5	1.8	-	-	-	-	1	0	0	-	-	-	<0.1
N9	7	FP	WQ	TB	8.8	7.3	1.1	-	-	-	-	2	0	0	-	-	-	<0.1
S5	1	FP	WQ	W	9.3	3.5	1.4	-	-	-	-	1	0	0	-	-	-	<0.1
S5	2	DB	WQ	I	4.5	4.2	2.1	-	-	-	-	0	0	0	-	-	-	<0.1
N11	1	MANU	WQ	-	29.5	12.9	12.3	-	-	-	-	0	100	0	-	-	-	5.5
N11	2	F	WQ	TB	9	2	0.9	FO	-	-	S	2	0	1	-	-	-	<0.1

Sample square	Artefact #	Artefact Type	Lithology	Cross-section	Artefact Dimensions			Platform Type	Platform Dimensions		Termination	# Dorsal flake scars	Cortex %	Parallel Arrises	Retouch/ Utilisation?	R/U Location	R/U Length	Weight (g)
					Length	Width	Depth		Length	Width								
N11	3	F	CQ	I	5.4	2.1	0.8	FK	2.2	1.1	S	1	0	1	-	-	-	<0.1
N12	1	F	CQ	L	7.4	6.6	1	FO	-	-	F	1	0	0	-	-	-	<0.1
N12	2	FP	WQ	W	7.9	2.4	2.4	-	-	-	-	1	0	0	-	-	-	<0.1
N12	3	DB	CQ	I	8.2	4.6	2.7	-	-	-	-	0	0	0	-	-	-	<0.1
S7	1	F	WQ	TB	8.9	6	1.3	FO	-	-	S	1	0	0	-	-	-	<0.1
N15	1	FP	WQ	I	11.1	7.6	2.9	-	-	-	-	1	0	0	-	-	-	0.3
N16	1	FP	WQ	I	10.1	10.8	4	-	-	-	-	2	0	0	-	-	-	0.6
N16	2	DB	BAS	L	5.4	5.3	1.9	-	-	-	-	0	0	0	-	-	-	<0.1
N16	3	F	WQ	L	7.5	7.5	1.9	FA	4.1	1.8	F	1	0	0	-	-	-	0.1
N16	4	FP	CQ	I	12.2	8.6	3.4	-	-	-	-	1	0	0	-	-	-	0.4
N16	5	F	WQ	I	37.8	28.2	8.3	FK	5.8	2.4	F	4	0	0	-	-	-	5.5
N16	6	FP	WQ	TB	10.6	6.6	2.2	-	-	-	-	2	2	0	-	-	-	0.2
N16	7	DB	WQ	T	7.9	5.9	4.5	-	-	-	-	0	0	0	-	-	-	0.3
N16	8	DB	WQ	TB	5.4	3.6	2.6	-	-	-	-	0	0	0	-	-	-	<0.1
N16	9	FP	WQ	I	8.1	7.5	2	-	-	-	-	1	0	0	-	-	-	0.2
N17	1	F	WQ	W	16.9	13	3.2	CR	8.8	1.1	S	1	0	0	-	-	-	0.9
N17	2	FP	WQ	I	26.8	13	5.6	-	-	-	-	2	0	0	-	-	-	1.4
N17	3	DB	WQ	W	11.8	6.9	2.6	-	-	-	-	0	0	0	-	-	-	0.2
N17	4	DB	WQ	I	11.5	8.6	2.9	-	-	-	-	0	0	0	-	-	-	0.3
N17	5	DB	WQ	I	4.7	3.5	1.4	-	-	-	-	0	0	0	-	-	-	<0.1
N18	1	DB	WQ	L	2.2	5.2	2.6	-	-	-	-	0	0	0	-	-	-	<0.1
S9	1	F	PQ	W	12.5	9.1	4.6	FA	7.6	3.4	F	0	100	0	-	-	-	1.7
N19	1	F	WQ	TB	15.2	11.9	2.4	FK	4.1	3.8	S	1	0	0	-	-	-	0.4
N19	2	DB	WQ	T	12.3	4.2	4.2	-	-	-	-	0	0	0	-	-	-	0.2
N19	3	DB	WQ	T	6.6	4.2	3.7	-	-	-	-	0	0	0	-	-	-	0.1
N20	1	FP	WQ	W	9	4.7	3.1	-	-	-	-	2	0	0	-	-	-	0.2
N20	2	DB	WQ	I	10.6	8.4	2.8	-	-	-	-	0	0	0	-	-	-	0.4
N20	3	F	CQ	I	12.7	7.4	3.4	FA	6	1.8	F	2	0	0	-	-	-	0.3
N20	4	DB	WQ	TB	5.2	1.9	2.2	-	-	-	-	0	0	0	-	-	-	<0.1
N20	5	FP	WQ	W	6.9	5.7	1.5	-	-	-	-	1	0	0	-	-	-	<0.1
N20	6	DB	WQ	I	8.5	7.2	2.9	-	-	-	-	1	0	0	-	-	-	0.1

Sample square	Artefact #	Artefact Type	Lithology	Cross-section	Artefact Dimensions			Platform Type	Platform Dimensions		Termination	# Dorsal flake scars	Cortex %	Parallel Arrises	Retouch/ Utilisation?	R/U Location	R/U Length	Weight (g)
					Length	Width	Depth		Length	Width								
N20	7	FP	WQ	I	11.7	7.2	3.8	-	-	-	-	1	0	0	-	-	-	0.3
N20	8	FP	WQ	I	11.8	7.2	3.8	-	-	-	-	2	0	0	-	-	-	0.5
N21	1	FP	WQ	W	3.8	4.8	1.7	-	-	-	-	1	0	0	-	-	-	0.2
N21	2	FP	WQ	I	21.4	15.4	11.4	-	-	-	-	3	0	0	-	-	-	4.7
N21	3	F	CQ	TB	6.2	4.6	1.4	FA	4.4	1.1	S	1	0	0	-	-	-	<0.1
N21	4	F	CQ	L	8.4	5.2	1.7	FA	5.4	1.8	F	2	0	0	-	-	-	<0.1
N21	5	FP	WQ	I	18.1	12	7.4	-	-	-	-	2	0	0	-	-	-	1.6
N21	6	TBF	WQ	W	19.7	16.1	5.9	FK	14.8	4.2	BK	1	0	0	-	-	-	2
N21	7	DB	WQ	W	7.9	5.1	3.3	-	-	-	-	0	0	0	-	-	-	<0.1
N21	8	DB	WQ	I	9	5.6	5.3	-	-	-	-	0	0	0	-	-	-	0.4
N21	9	DB	WQ	I	10.7	9.6	7.3	-	-	-	-	0	0	0	-	-	-	0.47
N24	1	FP	WQ	W	6.2	5.6	2.2	-	-	-	-	1	20	0	-	-	-	<0.1
N24	2	LBF	WQ	I	12.8	4.1	2.4	FA	2.2	1.6	F	1	0	0	-	-	-	0.2
N24	3	LBF	WQ	L	16.5	7.1	3.9	FO	-	-	L	1	0	0	-	-	-	0.3
N25	1	DB	WQ	I	8.4	5.9	3.5	-	-	-	-	0	0	0	-	-	-	0.3
N25	2	DB	WQ	W	8.3	5.9	3.3	-	-	-	-	0	50	0	-	-	-	0.2
N25	3	F	WQ	I	14.9	11.9	4.8	FK	11.9	3.4	F	1	50	0	-	-	-	1.3
N25	4	DB	CQ	TB	5.5	3.8	1.4	-	-	-	-	0	0	0	-	-	-	<0.1
N25	5	MANU	WQ	TB	30	29.1	17.6	-	-	-	-	0	100	0	-	-	-	29.6
S13	1	DB	WQ	TB	5.2	7	5.3	-	-	-	-	0	0	0	-	-	-	0.3
S13	2	DB	WQ	W	9	4.7	2.9	-	-	-	-	0	0	0	-	-	-	0.2
S19	1	LBF	WQ	I	21	10.1	4.3	FA	3.6	1.4	F	2	0	0	-	-	-	0.8

MJ-02 surface artefact data

Artefact #	Artefact Type	Lithology	Cross-section	Artefact Dimensions			Platform Type	Platform Dimensions		Termination	# Dorsal flake scars	Cortex %	Parallel Arrises	Retouch/ Utilisation?	R/U Location	R/U Length	R/U Width	Weight (g)
				Length	Width	Depth		Length	Width									
1	F	CQ	L	9	6.1	1.7	FK	5.9	1.4	F	2	0	0	N	-	-	-	<0.1
2	DB	WQ	I	7.8	3.5	3.3	-	-	-	-	0	30	0	N	-	-	-	0.2
3	FP	WQ	W	6.5	4.5	1.4	-	-	-		1	0	0	N	-	-	-	<0.1
4	DB	WQ	L	6.1	2.9	1.3	-	-	-	-	0	0	0	N	-	-	-	<0.1
5	RUP	WQ	L	18.7	10.6	5.3	-	-	-	-	1	70	0	AM	RLM	15.1	3.7	1.2
															DM	11.9	3.7	
															LLM	13.5	2.2	
6	DB	WQ	L	6.5	4.9	1.5	-	-	-	-	0	0	0	N	-	-	-	<0.1
7	F	WQ	TB	11.1	9.5	3.6	FA	10	3	F	3	0	1	N	-	-	-	0.5
8	FP	WQ	I	17.2	7.3	3.4	-	-	-	-	2	0	0	N	-	-	-	0.5
9	DB	WQ	I	14.9	8.4	5.5	-	-	-	-	0	100	0	N	-	-	-	0.8
10	FP	WQ	L	15.7	9.1	2.9	-	-	-	-	4	30	0	N	-	-	-	0.4
11	DB	WQ	I	7.3	4.8	3	-	-	-	-	0	20	0	N	-	-	-	<0.1
12	DB	WQ	I	5.5	2.2	1.6	-	-	-	-	0	0	0	N	-	-	-	<0.1
13	DB	WQ	L	5.9	4	1.1	-	-	-	-	0	0	0	N	-	-	-	<0.1
14	DB	WQ	L	6.6	3	1.2	-	-	-	-	0	0	0	N	-	-	-	<0.1
15	DB	WQ	I	6.6	4.1	2.4	-	-	-	-	0	0	0	N	-	-	-	<0.1
16	FP	WQ	I	8.9	4.7	2.1	-	-	-	-	0	100	0	N	-	-	-	<0.1
17	FP	WQ	TB	10.7	9.9	2.2	-	-	-	-	2	0	0	N	-	-	-	0.4
18	DB	WQ	TG	8.9	4.6	1.6	-	-	-	-	0	0	0	N	-	-	-	<0.1
19	DB	WQ	I	9.3	6.4	6.4	-	-	-	-	0	0	0	N	-	-	-	0.3
20	DB	WQ	TB	6	2.9	2.4	-	-	-	-	0	0	0	N	-	-	-	<0.1
21	FP	WQ	I	11.3	6	6.6	-	-	-	-	3	0	0	N	-	-	-	0.6
22	DB	WQ	L	10	4.8	1.8	-	-	-	-	0	0	0	N	-	-	-	0.1
23	DB	WQ	I	8.6	4.6	1.3	-	-	-	-	0	0	0	N	-	-	-	<0.1
24	DB	WQ	TG	10.2	5.3	2.5	-	-	-	-	0	0	0	N	-	-	-	0.2
25	DB	WQ	W	10.9	4.5	2.5	-	-	-	-	0	0	0	N	-	-	-	0.2
26	DB	WQ	I	9.3	4.3	4.2	-	-	-	-	0	0	0	N	-	-	-	0.3
27	F	CQ	L	6.7	4.6	1.9	FK	4.8	2	F	1	0	0	N	-	-	-	<0.1
28	DB	WQ	TB	14.2	7.1	4.5	-	-	-	-	0	0	0	N	-	-	-	0.8

Artefact #	Artefact Type	Lithology	Cross-section	Artefact Dimensions			Platform Type	Platform Dimensions		Termination	# Dorsal flake scars	Cortex %	Parallel Arrises	Retouch/ Utilisation?	R/U Location	R/U Length	R/U Width	Weight (g)
				Length	Width	Depth		Length	Width									
29	FP	WQ	I	13	11	7.4	-	-	-	-	3	0	0	N	-	-	-	1.3
30	FP	WQ	W	20.8	9.2	6.7	-	-	-	-	2	0	0	N	-	-	-	1.2
31	DB	WQ	DB	5.9	2.9	0.6	-	-	-	-	0	0	0	N	-	-	-	<0.1
32	FP	WQ	FP	7.4	7.6	1.9	-	-	-	-	1	0	0	N	-	-	-	0.2

MJ-03 surface artefact data

Artefact #	Way point	Artefact Type	Lithology	Cross-section	Artefact Dimensions			Platform Type	Platform Dimensions		Termination	# Dorsal flake scars	Cortex %	Parallel Arrises	Retouch/ Utilisation?	R/U Location	R/U Length	R/U Width	Weight (g)
					Length	Width	Depth		Length	Width									
1	289	F	CQ	-	9.6	6.8	1.3	FO	-	-	-	1	0	2	N	-	-	-	<0.1
2	289	FP	WQ	-	12.3	8.8	3.3	-	-	-	-	2	0	0	N	-	-	-	0.6
3	289	FP	WQ	-	11.1	12.2	4.1	-	-	-	-	3	0	0	N	-	-	-	0.5
4	290	FP	CQ	-	7.1	11.1	2.4	-	-	-	-	2	0	0	N	-	-	-	0.2
5	299	F	WQ	I	10.7	11.1	3.3	FK	7	2.8	F	5	30	0	N	-	-	-	0.5
6	300	FP	WQ	L	9.2	6.7	1.8	-	-	-	-	1	0	0	N	-	-	-	0.2
7	301	F	PQ	L	25.2	14.3	8	FA	16	8.1	F	3	0	0	N	-	-	-	4.1
8	302	F	WQ	L	5	5.2	1.3	FK	2.7	1.6	S	1	0	0	N	-	-	-	<0.1
9	302	FP	WQ	I	10.4	11	4	-	-	-	-	0	0	0	N	-	-	-	0.4
10	302	FP	WQ	L	12.4	8.9	2.7	-	-	-	F	1	0	0	N	-	-	-	0.3

MJ-04 surface artefact data

Artefact #	Way point	Artefact Type	Lithology	Cross-section	Artefact Dimensions			Platform Type	Platform Dimensions		Termination	# Dorsal flake scars	Cortex %	Parallel Arrises	Retouch/ Utilisation?	R/U Location	R/U Length	R/U Width	Weight (g)
					Length	Width	Depth		Length	Width									
1	304	F	CQ	L	9.8	9.7	1.7	FA	3.9	1.2	F	2	0	0	N	-	-	-	<0.1
2	305	TBF	WQ	L	9.4	4.8	1.2	FK	2.6	1.3	BK	2	0	0	N	-	-	-	<0.1
3	307	DB	CQ	I	2.7	2.7	0.7	-	-	-	-	0	0	0	N	-	-	-	<0.1
4	308	FP	WQ	L	18	8.5	3.6	-	-	-	-	1	0	0	N	-	-	-	0.6
5	309	FP	WQ	L	11.7	5.9	1.7	-	-	-	-	3	0	1	N	-	-	-	0.7

DAA Id 3648 Soldiers Road (including MJ-05) surface artefact data

MJ-05 extension surface artefact data from outside deflation

Artefact #	Way point	Artefact Type	Lithology	Cross-section	Artefact Dimensions			Platform Type	Platform Dimensions		Termination	# Dorsal flake scars	Cortex %	Parallel Arrises	Retouch/ Utilisation?	R/U Location	R/U Length	R/U Width	Weight (g)
					Length	Width	Depth		Length	Width									
1	325	F	WQ	W	19.6	10.4	6.2	FK	9.4	8.6	S	1	30	0	N	-	-	-	1.1
2	326	FP	WQ	I	15.7	13.6	4.3	-	-	-	-	1	0	0	N	-	-	-	1
3	327	FP	WQ	W	13.7	8	2.2	-	-	-	-	1	0	1	N	-	-	-	0.3
4	327	F	WQ	L	8	10.9	2.2	FK	7.6	2.4	S	1	0	0	N	-	-	-	0.2
5	327	DB	WQ	L	8.1	5.4	1	-	-	-	-	-	0	0	N	-	-	-	0.1
6	327	DB	WQ	T	11.7	7.3	3.3	-	-	-	-	-	0	0	N	-	-	-	0.2
7	327	DB	WQ	I	5.6	5	1.6	-	-	-	-	-	0	0	N	-	-	-	<0.1
8	328	DB	WQ	L	7	5.4	1.3	-	-	-	-	-	0	0	N	-	-	-	<0.1
9	329	DB	WQ	W	25.1	16.2	8.4	-	-	-	-	-	0	0	N	-	-	-	3.5
10	329	FP	WQ	L	10.3	6.3	2.2	-	-	-	-	-	0	0	N	-	-	-	1.1
11	330	DB	WQ	L	17	5.9	3.6	-	-	-	-	-	0	0	N	-	-	-	0.5
12	331	FP	WQ	L	21.8	14.1	4	-	-	-	-	1	0	0	N	-	-	-	1.8
13	332	DB	WQ	L	8.1	3	1.2	-	-	-	-	-	0	0	N	-	-	-	0.4
14	333	DB	WQ	L	9.5	7.7	2.9	-	-	-	-	-	0	0	N	-	-	-	0.3
15	333	DB	WQ	T	5.4	4.3	2.6	-	-	-	-	-	0	0	N	-	-	-	<0.1
16	334	FP	WQ	I	31.7	15.6	11.2	-	-	-	-	1	40	0	N	-	-	-	7.9
17	334	FP	WQ	L	8.6	6.8	1.5	-	-	-	-	1	0	0	N	-	-	-	<0.1
18	335	F	WQ	I	22.1	12.9	7.5	FK	8.8	2	F	4	0	0	N	-	-	-	2.4
19	336	FP	WQ	I	15.9	12	4.4	-	-	-	-	1	0	0	N	-	-	-	0.7
20	336	DB	WQ	L	8.5	6.6	1.5	-	-	-	-	-	0	0	N	-	-	-	<0.1
21	337	DB	WQ	L	5.6	2.2	1.3	-	-	-	-	-	0	0	N	-	-	-	<0.1
22	338	F	CQ	L	11.5	9.5	2.3	FA	7.2	1.4	F	3	0	0	N	-	-	-	0.2
23	339	DB	WQ	I	13.8	10.1	3.3	-	-	-	-	-	0	0	N	-	-	-	0.4
24	340	DB	WQ	TB	9.3	2.8	1.4	-	-	-	-	-	0	0	N	-	-	-	<0.1
25	340	DB	WQ	I	7	5.8	4.1	-	-	-	-	-	0	0	N	-	-	-	0.2
26	341	TBF (P)	WQ	-	8.6	11.7	2.8	FK	9.3	2.2	F	3	0	0	N	-	-	-	0.4
27	342	DB	WQ	L	6.8	5.1	1.3	-	-	-	-	-	0	0	N	-	-	-	<0.1
28	342	DB	WQ	T	8.8	6.3	2.7	-	-	-	-	-	0	0	N	-	-	-	0.2
29	343	F	CQ	W	4.3	8.6	3.5	FO	-	-	F	1	0	0	N	-	-	-	0.4

Artefact #	Way point	Artefact Type	Lithology	Cross-section	Artefact Dimensions			Platform Type	Platform Dimensions		Termination	# Dorsal flake scars	Cortex %	Parallel Arrises	Retouch/ Utilisation?	R/U Location	R/U Length	R/U Width	Weight (g)
					Length	Width	Depth		Length	Width									
30	343	DB	CQ	L	5.8	4.4	1.2	-	-	-	-	-	0	0	N	-	-	-	<0.1
31	343	DB	WQ	I	5.6	4.5	1	-	-	-	-	-	0	0	N	-	-	-	<0.1
32	344	FP	WQ	I	7.7	5.1	2.1	-	-	-	-	2	0	0	N	-	-	-	0.1
33	345	DB	WQ	L	5.4	3.5	0.9	-	-	-	-	-	0	0	N	-	-	-	<0.1
34	348	DB	CQ	L	6.5	3.6	0.8	-	-	-	-	-	0	0	N	-	-	-	<0.1
35	349	FP	PQ	I	16.2	8.1	5.1	-	-	-	-	2	0	0	N	-	-	-	0.7
36	350	DB	WQ	I	11	6.7	5	-	-	-	-	-	50	0	N	-	-	-	0.4
37	351	F	WQ	I	12.2	7.9	3.4	FK	7.3	2.3	S	1	0	0	N	-	-	-	0.3
38	352	DB	WQ	I	5.4	4.1	1	-	-	-	-	-	0	0	N	-	-	-	<0.1
39	353	DB	WQ	L	6	3.3	1.2	-	-	-	-	-	0	0	N	-	-	-	<0.1
40	354	FP	WQ	W	10.4	9.3	4.2	-	-	-	-	-	0	0	N	-	-	-	0.3
41	369	DB	WQ	TB	21.5	19.9	9.9	-	-	-	-	-	0	0	N	-	-	-	4.3
42	370	TBF (P)	WQ	L	5.5	3.9	1	FK	3.4	1.9	F	1	0	0	N	-	-	-	<0.1
43	371	F	WQ	I	14.3	12.1	3.7	FK	4.6	4.6	F	1	0	0	N	-	-	-	0.8
44	372	DB	WQ	I	16.5	13.9	4.9	-	-	-	-	-	0	0	N	-	-	-	1
45	373	LBF	WQ	TB	3.5	5.8	1.4	FK	4.7	1.4	-	-	0	0	N	-	-	-	<0.1
46	SEE CORES TABLE																		
47	374	F	WQ	TB	14.2	10	3.2	CR	-	-	ST	2	0	0	N	-	-	-	0.7
48	SEE GRINDING MATERIAL TABLE																		
49	377	FP	WQ	I	17.2	12	5.6	-	-	-	-	2	0	0	N	-	-	-	1.3
50	378	FP	WQ	I	15	10.2	3.2	-	-	-	-	1	0	0	N	-	-	-	0.5
51	382	LBF	WQ	L	19.1	10.8	5.1	FA	5.1	5.9	BROKEN	-	0	0	N	-	-	-	1.1
52	382	TBF	CQ	L	10.7	3.7	1.9	FK	2.9	1.1	-	1	0	0	N	-	-	-	0.2
53	379	F	WQ	L	12.8	8.2	2.3	FO	-	-	F	2	0	1	N	-	-	-	0.2
54	380	F	WQ	W	6.7	8.6	1.5	FK	4.7	1.6	F	1	0	0	N	-	-	-	0.1
55	381	FP	WQ	L	7.7	4.8	0.5	-	-	-	-	-	0	0	N	-	-	-	<0.1

MJ-05 extension surface artefact data from outside deflation (cores)

Artefact #	Wpt	Core type	Lithology	Artefact Dimensions			Number of platforms	Number of flake scars	Flake scar dimensions		Cortex %	Weight (g)
				Length	Width	Depth			Length	Width		
46	373	SPC	WQ	32.1	25	10.2	1	2	5.7	6.4	0	12.4
									5.9	8.3		

MJ-05 extension surface artefact data from outside deflation (grinding material)

Artefact #	Way point	Artefact Type	Lithology	Cross-section	Artefact Dimensions			# Ground surfaces	Ground surface dimensions		Cortex %	Weight (g)
					Length	Width	Depth		Length	Width		
48	376	MS FRAG	GMET	W	76.9	47.3	27.9	2	39.4	18.3	-	137.7
									23.7	8.2		

MJ-05 extension surface artefact data from within the deflation

Sample square	Artefact #	Artefact Type	Lithology	Cross-section	Artefact Dimensions			Platform Type	Platform Dimensions		Termination	# Dorsal flake scars	Cortex %	Parallel Arrises	Retouch/ Utilisation?	R/U Location	R/U Length	R/U Width	Weight (g)
					Length	Width	Depth		Length	Width									
N2	1	F	WQ	L	3.4	1.2	55	FK	5.1	1.4	F	1	0	0	N	-	-	-	<0.1
S2	1	F	SIL	L	3.9	7.8	1.1	FL	3.9	1	F	-	0	0	N	-	-	-	<0.1
N5	1	F	PQ	I	15.8	25.1	11.8	FA	19.5	9.2	ST	1	0	0	N	-	-	-	5.4
N5	2	DB	WQ	I	6.9	5.8	2.6	-	-	-	-	-	0	0	N	-	-	-	<0.1
N5	3	FP	WQ	L	4.9	5.4	1.8	-	-	-	-	-	0	0	N	-	-	-	<0.1
S3	1	DB	CQ	I	3.5	3.7	2.7	-	-	-	-	1	0	0	N	-	-	-	<0.1
S3	2	DB	WQ	L	6.8	6.3	1.4	-	-	-	-	-	0	0	N	-	-	-	<0.1
S3	3	DB	WQ	L	6.5	3.3	0.8	-	-	-	-	-	0	0	N	-	-	-	<0.1
N7	1	DB	WQ	TB	8.8	5.9	2.9	-	-	-	-	1	0	0	N	-	-	-	0.2
N7	2	DB	WQ	W	10.9	5.4	5.2	-	-	-	-	-	0	0	N	-	-	-	0.3
N7	3	F	WQ	L	12.4	4.5	1.6	FO	-	-	-	1	0	0	N	-	-	-	<0.1
N7	4	DB	WQ	W	6	3.3	1.8	-	-	-	-	-	0	0	N	-	-	-	<0.1
N7	5	DB	WQ	TG	3.6	2.7	2	-	-	-	-	-	0	0	N	-	-	-	<0.1
N8	1	DB	CQ	W	12.8	6.1	2.3	-	-	-	-	1	0	0	N	-	-	-	0.3
N8	2	DB	WQ	W	10.8	6.6	3.3	-	-	-	-	-	0	0	N	-	-	-	0.2
N9	1	F	MY	W	23	30.1	9.4	FL	15.5	4.6	F	3	0	2	N	-	-	-	6.2
N9	2	DB	MY	I	3.8	4.4	1.6	-	-	-	-	-	0	0	N	-	-	-	<0.1
N9	3	FP	CQ	W	8.6	6.3	2.8	-	-	-	-	2	0	1	N	-	-	-	0.1
N9	4	DB	WQ	W	13	11.9	4.8	-	-	-	-	-	0	0	N	-	-	-	1
N9	5	FP	WQ	L	11.1	4.7	1.4	-	-	-	-	-	0	0	N	-	-	-	<0.1
N9	6	DB	WQ	I	13.3	9	5	-	-	-	-	-	0	0	N	-	-	-	0.6
N9	7	DB	WQ	L	9.9	3.6	1.9	-	-	-	-	-	0	0	N	-	-	-	0.2
N9	8	DB	WQ	I	11.6	6	3	-	-	-	-	-	0	0	N	-	-	-	0.3
N9	9	DB	WQ	I	6	3.9	2	-	-	-	-	-	0	0	N	-	-	-	<0.1
N10	1	FP	CQ	W	10.1	6.5	2.7	-	-	-	-	1	0	0	N	-	-	-	0.2
S9	1	FP	WQ	I	16.4	9.2	11.7	-	-	-	-	1	0	0	N	-	-	-	1.3
S9	2	FP	WQ	I	21.7	13	6.3	-	-	-	-	1	0	0	N	-	-	-	2.9
S9	3	DB	CQ	TG	11.2	10.2	2.6	-	-	-	-	-	0	0	N	-	-	-	0.2
S9	4	DB	WQ	I	12.9	8.3	3.1	-	-	-	-	-	0	0	N	-	-	-	0.3
S9	5	DB	WQ	I	8.8	6.9	4.7	-	-	-	-	-	0	0	N	-	-	-	0.3

Sample square	Artefact #	Artefact Type	Lithology	Cross-section	Artefact Dimensions			Platform Type	Platform Dimensions		Termination	# Dorsal flake scars	Cortex %	Parallel Arrises	Retouch/ Utilisation?	R/U Location	R/U Length	R/U Width	Weight (g)
					Length	Width	Depth		Length	Width									
S9	6	FP	CQ	L	11.2	7.1	2.7	-	-	-	-	2	0	0	N	-	-	-	0.3
S9	7	DB	WQ	W	11.3	4.7	3.6	-	-	-	-	-	5	0	N	-	-	-	0.2
S9	8	F	CQ	L	5.5	5.7	1.2	FL	3.4	1	ST	1	0	0	N	-	-	-	<0.1
S9	9	DB	WQ	TB	10.3	4.4	1.5	-	-	-	-	-	0	0	N	-	-	-	0.2
S9	10	DB	WQ	I	10.2	7	2.5	-	-	-	-	-	20	0	N	-	-	-	0.2
S9	11	DB	CQ	I	6.9	3	2.2	-	-	-	-	-	0	0	N	-	-	-	<0.1
S9	12	FP	WQ	L	11.4	4.2	2.8	-	-	-	-	2	0	0	N	-	-	-	0.2
S9	13	DB	WQ	TB	7.3	5.6	2.4	-	-	-	-	-	0	0	N	-	-	-	<0.1
S9	14	F	MY	L	11.9	7.6	2.6	FL	5.9	2.7	ST	1	0	0	N	-	-	-	0.3
S9	15	DB	MY	I	16.9	7.4	3.4	-	-	-	-	-	0	0	N	-	-	-	0.4
S9	16	SEE CORE TABLE																	
S10	1	DB	CQ	I	11.6	7.7	4.2	-	-	-	-	-	0	0	N	-	-	-	0.5
S10	2	DB	WQ	L	8.5	6.5	1.4	-	-	-	-	-	0	0	N	-	-	-	0.2
S6	1	FP	WQ	I	21.2	11.6	7.9	-	-	-	-	-	0	0	N	-	-	-	2.4
S6	2	FP	WQ	I	22.7	25.7	6.8	-	-	-	-	-	0	0	N	-	-	-	5.3
S6	3	FP	PQ	I	15.2	11.9	7.4	-	-	-	-	-	0	0	N	-	-	-	1.1
S6	4	DB	WQ	I	13.3	8.4	3.6	-	-	-	-	-	0	0	N	-	-	-	0.3
S6	5	DB	WQ	I	8.5	8	3.4	-	-	-	-	-	0	0	N	-	-	-	0.3
S6	6	DB	WQ	TB	14.1	7	4	-	-	-	-	-	0	0	N	-	-	-	0.4
S6	7	LBF	CQ	L	8.8	4.5	1.1	FK	3.3	1.6	F	1	0	0	N	-	-	-	<0.1
N11	1	F	MY	L	11.1	17	4.3	FL	8.5	3.6	E	1	0	0	N	-	-	-	1
N11	2	FP	WQ	I	15.5	17.5	6.6	-	-	-	-	1	0	0	N	-	-	-	1.3
N11	3	F	WQ	I	11.7	10.6	6.1	FL	9.9	7.4	ST	3	0	1	N	-	-	-	0.9
N12	1	F	WQ	I	11.1	7.3	2.7	FO	-	-	F	4	0	0	N	-	-	-	0.3
N12	2	DB	WQ	I	11.4	5.5	3.2	-	-	-	-	-	0	0	N	-	-	-	0.3
S12	1	DB	WQ	TG	33.9	23.4	16.3	-	-	-	-	-	10	0	N	-	-	-	10.4
S12	2	FP	WQ	I	13.5	11.2	10	-	-	-	-	2	0	0	N	-	-	-	1
S12	3	F	WQ	TB	11.8	13.5	2.3	FK	8.4	2.4	F	1	0	0	N	-	-	-	0.4
S12	4	DB	CQ	TB	11	7.4	3.7	-	-	-	-	-	0	0	N	-	-	-	0.3
S12	5	DB	CQ	TG	9.6	11.2	5.8	-	-	-	-	-	0	0	N	-	-	-	0.3
S12	6	DB	CQ	TB	5.7	3.6	2.6	-	-	-	-	-	0	0	N	-	-	-	<0.1

Sample square	Artefact #	Artefact Type	Lithology	Cross-section	Artefact Dimensions			Platform Type	Platform Dimensions		Termination	# Dorsal flake scars	Cortex %	Parallel Arrises	Retouch/ Utilisation?	R/U Location	R/U Length	R/U Width	Weight (g)
					Length	Width	Depth		Length	Width									
S12	7	FP	WQ	L	9.1	2.7	1.2	-	-	-	-	1	0	1	N	-	-	-	<0.1
S13	1	FP	Y	W	14.7	10.7	4.9	-	-	-	F	-	30	0	N	-	-	-	0.5
N14	1	FP	WQ	L	9.6	6.2	1.8	-	-	-	-	1	0	0	N	-	-	-	0.2
N14	2	DB	WQ	TG	12.4	6.5	2.5	-	-	-	-	-	0	0	N	-	-	-	0.2
N14	3	SEE CORE SHEET						-	-	-	-	-	0	0	N	-	-	-	
N14	4	DB	WQ	L	9.2	5.6	0.9	-	-	-	-	1	0	0	N	-	-	-	<0.1
S15	1	FP	WQ	W	13.8	6.8	6.2	-	-	-	-	2	0	0	N	-	-	-	0.6
N16	1	F	WQ	L	10.8	7.9	1.6	FO	-	-	-	1	0	0	N	-	-	-	<0.1

MJ-05 extension surface artefact data from within the deflation (cores)

Artefact #	Wpt	Core type	Lithology	Artefact Dimensions			Number of platforms	Number of flake scars	Flake scar dimensions		Cortex %	Weight (g)
				Length	Width	Depth			Length	Width		
16	SS-S9	MPC	WQ	35.1	20.4	18.8	2	3	13.6	22.7	0	14.2
									8.7	15.1		
									6.4	12.9		
3	SS-N14	SPC	WQ	31.3	23.1	11.8	1	3	12.1	16.6	0	9
									7.6	9.6		
									9	6.6		

DAA Id 3648 surface artefact data

Artefact #	Way point	Artefact Type	Lithology	Cross-section	Artefact Dimensions			Platform Type	Platform Dimensions		Termi-nation	# Dorsal flake scars	Cortex %	Parallel Arrises	Retouch/ Utilisation?	R/U Location	R/U Length	R/U Width	Weight (g)
					Length	Width	Depth		Length	Width									
56	412	FP	WQ	TB	16.4	16.5	3.8	-	-	-	-	2	0	0	N	-	-	-	1.1
57	413	DB	WQ	L	6.1	4.8	1.5	-	-	-	-	-	0	0	N	-	-	-	0.2
58	414	F	WQ	L	5.5	4.1	0.7	FA	2.4	0.8	F	-	0	0	N	-	-	-	<0.1
59	414	FP	WQ	L	4	4.9	1.2	-	-	-	-	1	0	0	N	-	-	-	<0.1
60	415	LBF	WQ	L	11.9	7.6	1.5	FK	5	0.9	ST	1	0	0	N	-	-	-	0.2
61	416	FP	CQ	I	5.9	3.8	1.9	-	-	-	-	1	0	0	N	-	-	-	<0.1
62	416	DB	WQ	I	6.6	4.4	2.8	-	-	-	-	-	0	0	N	-	-	-	0.2
63	417	DB	WQ	I	13.4	7.5	5.2	-	-	-	-	-	0	0	N	-	-	-	0.5
64	417	DB	WQ	TB	10	6.9	2.9	-	-	-	-	-	0	0	N	-	-	-	0.3
65	418	F	WQ	L	11.9	9	2.1	FK	3.3	1.9	F	2	0	1	N	-	-	-	0.2
66	419	RUFP	WQ	I	39.9	11.8	9.1	-	-	-	-	-	0	0	Y	2	21.7	6.3	5.7
																MARGINS	23.8	5.9	
67	419	F	WQ	I	20.8	10.5	4.6	FK	6.2	3	BK	3	0	1	N	-	-	-	0.9
68	419	DB	CQ	I	5.3	4.4	1.7	-	-	-	-	-	0	0	N	-	-	-	<0.1
69	420	FP	PQ	I	28.4	20.3	7.8	-	-	-	-	2	0	0	N	-	-	-	3.8
70	420	FP	WQ	TG	11.2	9.4	8.6	-	-	-	-	1	0	0	N	-	-	-	1.2
71	420	DB	WQ	TG	7.4	6.6	4.3	-	-	-	-	-	0	0	N	-	-	-	0.1
72	420	DB	WQ	I	6.9	4.2	1.8	-	-	-	-	-	0	0	N	-	-	-	<0.1
73	420	DB	CQ	L	5.5	5.3	1.4	-	-	-	-	-	0	0	N	-	-	-	<0.1
74	421	F	GIG	I	16.5	11.5	4.9	FL	9.5	4.7	ST	4	0	1	OHR	-	-	-	1.6
75	421	F	WQ	L	5.3	2.8	0.8	FO	-	-	-	-	0	0	N	-	-	-	<0.1
76	421	DB	WQ	I	7.5	5.1	3.2	-	-	-	-	-	0	0	N	-	-	-	0.2
77	421	FP	WQ	L	12	4.7	3.1	-	-	-	-	2	0	0	N	-	-	-	0.2
78	422	DB	WQ	TB	11.3	9.7	3	-	-	-	-	-	0	0	N	-	-	-	0.3
79	423	DB	WQ	I	6.8	5.8	3.4	-	-	-	-	-	0	0	N	-	-	-	0.2
80	424	PBF	WQ	L	6.2	7.3	2.2	FK	5.4	1.2	BK	2	0	0	N	-	-	-	<0.1
81	424	FP	WQ	L	11.7	9.8	2.3	-	-	-	-	1	0	0	N	-	-	-	0.3

Artefact #	Way point	Artefact Type	Lithology	Cross-section	Artefact Dimensions			Platform Type	Platform Dimensions		Termi-nation	# Dorsal flake scars	Cortex %	Parallel Arrises	Retouch/ Utilisation?	R/U Location	R/U Length	R/U Width	Weight (g)
					Length	Width	Depth		Length	Width									
82	425	DB	WQ	W	23.8	20.2	12.4	-	-	-	-	-	0	0	N	-	-	-	6.3
83	426	FP	WQ	TG	11.6	6.9	4.7	-	-	-	-	1	0	0	N	-	-	-	0.4
84	426	FP	WQ	I	15.8	10	7.4	-	-	-	-	2	0	0	N	-	-	-	2.4
85	427	FP	WQ	TB	9.2	6.6	2.7	-	-	-	-	2	0	0	N	-	-	-	0.2
86	427	DB	WQ	I	12.1	6.1	5.9	-	-	-	-	1	0	0	N	-	-	-	0.5
87	428	FP	WQ	W	6.5	6.8	2.1	-	-	-	-	1	0	0	N	-	-	-	0.3
88	429	FP	WQ	I	5.7	9.6	5.3	-	-	-	-	2	0	0	N	-	-	-	0.9
89	430	DB	WQ	I	14.9	12.9	6.2	-	-	-	-	-	0	0	N	-	-	-	1.5
90	430	FP	CQ	L	9	4.6	1.1	FK	2.6	1.6	F	2	0	0	N	-	-	-	<0.1
91	431	DB	WQ	I	10	3.6	1.6	-	-	-	-	-	0	0	N	-	-	-	<0.1
92	431	FP	WQ	L	13.1	6.3	2.6	FK	3.3	2.1	F	3	0	0	N	-	-	-	0.2
93	432	FP	WQ	I	8	4.1	2.9	-	-	-	-	1	0	0	N	-	-	-	0.2
94	433	DB	WQ	I	6.9	4.4	4	-	-	-	-	-	0	0	N	-	-	-	0.1
95	433	FP	WQ	L	8.7	5.8	2	-	-	-	-	1	0	0	N	-	-	-	0.1
96	433	FP	WQ	L	13.8	9.4	3.8	-	-	-	-	2	0	0	N	-	-	-	0.4
97	434	DB	WQ	I	7.2	7.3	3.1	-	-	-	-	-	0	0	N	-	-	-	0.1

DAA Id 3648 surface artefact data (avoidance level recording)

Sample square	Artefact #	Artefact Type	Lithology
SS1 (5 x 5m) wpt 437	1	FP	WQ
	2	DB	WQ
	3	F	WQ
	4	FP	WQ
	5	FP	WQ
	6	TBF	WQ
	7	F	CQ
	8	DB	CQ
	9	FP	PQ
	10	RUP	WQ
	11	DB	WQ
	12	F	WQ
	13	FP	WQ
SS2 (5 x 5m) wpt438	1	F	CQ
	2	DB	CQ
	3	DB	CQ
SS3 (5 x 5m) wpt 439	1	FP	WQ
	2	FP	WQ
	3	DFF	WQ
	4	DB	WQ
	5	F	CQ
	6	DB	CQ
	7	FP	WQ
	8	DB	WQ
	9	FP	WQ

Isolated artefact data

Artefact #	Way point	Artefact Type	Lithology	Cross-section	Artefact Dimensions			Platform Type	Platform Dimensions		Termination	# Dorsal flake scars	Cortex %	Parallel Arrises	Retouch/ Utilisation?	R/U Location	R/U Length	R/U Width	Weight (g)
					Length	Width	Depth		Length	Width									
1	284	MPC	CQ	-	6	9.3	6	2	-	-	-	5	0	0	N	-	-	-	0.7
2	284	F	CQ	-	4.5	4.9	2.2	FK	2.7	1.3	-	2	0	0	N	-	-	-	<0.1
3	285	TBF	WQ	-	11.8	13	6.6	CO	12.9	3.6	-	0	100	0	N	-	-	-	1.5
4	286	DB	WQ	-	5.9	2.2	2.5	-	-	-	-	0	0	0	N	-	-	-	<0.1
5	287	DB	WQ	-	8.3	5.6	1.3	-	-	-	-	0	0	0	N	-	-	-	<0.1
6	288	FP	WQ	-	9.9	5.8	1.8	-	-	-	-	0	0	0	N	-	-	-	<0.1
7	292	DB	WQ	-	9	3.4	1.8	-	-	-	-	2	0	0	N	-	-	-	<0.1
8	306	F	WQ	L	8.1	4.7	0.9	FA	4	1.8	F	1	0	0	N	-	-	-	<0.1
9	362	FP	WQ	I	34.5	16.4	6.6	-	-	-	-	1	0	0	N	-	-	-	5.1
10	364	FP	PQ	W	15.5	15.6	6.1	-	-	-	-	1	0	0	N	-	-	-	2
11	363	FP	WQ	I	15.9	8.8	9.4	-	-	-	-	2	0	0	N	-	-	-	1.5
12	365	FP	WQ	TB	13.5	10.7	7.9	-	-	-	-	1	15	0	N	-	-	-	2.3
13	366	FP	WQ	I	8.4	5.2	4.7	-	-	-	-	1	0	0	N	-	-	-	0.2
14	436	FP	WQ	I	19.5	9	6	-	-	-	-	1	0	0	N	-	-	-	1.3

Excavation artefact data (all sites)

Artefact #	Site	Pit	Spit	Depth	Artefact Type	Pearce Artefact Type	Lithology	Pearce Lithology	Cross-section	Artefact Dimensions			Platform Type	Platform Dimensions		Termination	# Dorsal flake scars	Cortex %	Parallel Arrises	Retouch / Utilisation?	R/U Location	R/U Length	R/U Width	Weight (g)
										Length	Width	Depth		Length	Width									
15	MJ01	1PE60	NA	450	DB	FRAGS	WQ	QU	L	5.48	2.34	1.88	NA	-	-	-	0	0	0	N	-	-	-	<0.1
16	MJ01	1PS60	NA	470	DB	FRAGS	CQ	QU	L	12.69	3.36	2.20	NA	-	-	-	0	0	0	N	-	-	-	<0.1
17	MJ01	1PW60	NA	470	TBF/LBF	CHIP	WQ	QU	TG	6.84	4.24	2.00	Flaked	3.7	2	Broken	0	0	0	N	-	-	-	<0.1
18	MJ01	TPE	1	0-100	F	CHIP	SQ	QU	-	9.54	7.31	2.60	Flaked	6.72	2.25	Feather	2	0	1	N	-	-	-	0.2
19	MJ01	TPE	1	0-100	FP	CHIP	SQ	QU	-	1.22	4.33	2.14	-	-	-	-	1	0	0	N	-	-	-	0.1
20	MJ01	TPE	1	0-100	F	CHIP	SQ	QU	-	10.92	9.98	2.14	Flaked	4.56	0.88	Feather	0	0	0	N	-	-	-	0.2
21	MJ01	TPE	1	0-100	RUF	FES	SQ	QU	-	9.78	9.79	3.02	Flaked	7.66	3.42	-	1	0	0	Y	RLM, DM	7.25, 9.2	1.79, 1.64	0.6
22	MJ01	TPE	1	0-100	FP	CHIP	CQ	QU	-	11.17	7.58	1.43	-	-	-	Feather	1	0	0	N	-	-	-	<0.1

Artefact #	Site	Pit	Spit	Depth	Artefact Type	Pearce Artefact Type	Lithology	Pearce Lithology	Cross-section	Artefact Dimensions			Platform Type	Platform Dimensions		Termination	# Dorsal flake scars	Cortex %	Parallel Arrises	Retouch / Utilisation?	R/U Location	R/U Length	R/U Width	Weight (g)
										Length	Width	Depth		Length	Width									
23	MJ01	TPE	1	0-100	SPC	UNF	WQ	QU		See Core page														
24	MJ01	TPE	1	0-100	F	CHIP	SQ	QU	-	6.86	6.49	1.96	Flaked	6.86	1.93	Feather	1	0	0	N	-	-	-	0.1
25	MJ01	TPE	1	0-100	F	CHIP	WQ	QU	-	14.10	11.50	2.81	Faceted	3.94	2.22	Feather	0	0	0	N	-	-	-	0.3
26	MJ01	TPE	1	0-100	LBF	CHIP	WQ	QU	-	13.03	10.44	6.34	Flaked	6.6	4.32	Broken	2	0	0	N	-	-	-	0.9
27	MJ01	TPE	1	0-100	FP	CHIP	WQ	QU	-	12.08	6.64	2.69	-	-	-	-	0	0	0	N	-	-	-	0.3
28	MJ01	TPE	1	0-100	F	CHIP	WQ	QU	-	10.80	6.79	2.34	Flaked	6.24	3.48	Feather	3	0	0	N	-	-	-	0.2
29	MJ01	TPE	1	0-100	FP	CHIP	SQ	QU	-	9.21	5.75	2.13	-	-	-	-	0	0	0	N	-	-	-	0.1
30	MJ01	TPE	1	0-100	DB	FRAGS	CQ	QU	I	6.77	2.82	1.30	-	-	-	-	0	0	0	N	-	-	-	<0.1
31	MJ01	TPE	1	0-100	TBF	CHIP	CQ	QU	-	8.90	9.74	1.99	Faceted	4.53	1.45	Broken	2	0	0	N	-	-	-	0.2
32	MJ01	TPE	1	0-100	F	CHIP	WQ	QU	-	9.63	6.96	3.42	Faceted	3.35	2.13	Feather	0	0	0	N	-	-	-	0.2
33	MJ01	TPE	1	0-100	FP	CHIP	WQ	QU	-	10.05	5.18	4.52	-	-	-	-	0	0	0	N	-	-	-	0.3
34	MJ01	TPE	1	0-100	FP	CHIP	WQ	QU	-	8.07	8.10	2.81	-	-	-	-	0	0	0	N	-	-	-	0.2
35	MJ01	TPE	1	0-100	LBF	CHIP	CQ	QU	-	10.97	5.26	3.28	Flaked	2.8	2.3	Stepped	0	0	0	N	-	-	-	0.2
36	MJ01	TPE	1	0-100	FP	CHIP	CQ	QU	TB	7.12	6.80	1.39	-	-	-	Stepped	0	0	0	N	-	-	-	<0.1
37	MJ01	TPE	1	0-100	FP	CHIP	WQ	QU	-	5.60	5.12	1.97	-	-	-	-	0	0	0	N	-	-	-	<0.1
38	MJ01	TPE	1	0-100	F	CHIP	WQ	QU	-	5.42	4.56	1.86	Flaked	3.42	1.92	Stepped	1	0	0	N	-	-	-	<0.1
39	MJ01	TPE	1	0-100	DB	FRAGS	SQ	QU	TB	7.15	3.73	1.88	-	-	-	-	0	0	0	N	-	-	-	<0.1
40	MJ01	TPE	1	0-100	DB	FRAGS	WQ	QU	TB	4.82	3.31	1.53	-	-	-	-	0	0	0	N	-	-	-	<0.1
41	MJ01	TPE	1	0-100	DB	FRAGS	WQ	QU	I	6.15	2.16	2.49	-	-	-	-	0	0	0	N	-	-	-	<0.1
42	MJ01	TPE	1	0-100	DB	FRAGS	WQ	QU	I	5.01	2.62	1.92	-	-	-	-	0	0	0	N	-	-	-	<0.1
43	MJ01	TPE	1	0-100	FP	CHIP	WQ	QU	-	6.58	2.84	1.20	-	-	-	Feather	0	0	1	N	-	-	-	<0.1
44	MJ01	TPE	1	0-100	FP	CHIP	SQ	QU	-	4.80	3.72	1.88	-	-	-	-	0	0	1	N	-	-	-	<0.1
45	MJ01	TPE	1	0-100	DB	FRAGS	WQ	QU	L	5.89	4.02	2.61	-	-	-	-	0	0	0	N	-	-	-	0.1
46	MJ01	TPE	1	0-100	FP	CHIP	CQ	QU	-	4.56	3.98	1.58	-	-	-	-	1	0	0	N	-	-	-	<0.1
47	MJ01	TPE	1	0-100	DB	FRAGS	CQ	QU	TB	5.75	4.28	1.66	-	-	-	-	0	0	0	N	-	-	-	<0.1
48	MJ01	TPE	1	0-100	DB	FRAGS	CQ	QU	TB	4.93	5.00	1.35	-	-	-	-	0	0	0	N	-	-	-	<0.1
49	MJ01	TPE	1	0-100	DB	FRAGS	CQ	QU	TB	5.83	3.80	1.45	-	-	-	-	0	0	0	N	-	-	-	<0.1

Artefact #	Site	Pit	Spit	Depth	Artefact Type	Pearce Artefact Type	Lithology	Pearce Lithology	Cross-section	Artefact Dimensions			Platform Type	Platform Dimensions		Termination	# Dorsal flake scars	Cortex %	Parallel Arrises	Retouch / Utilisation?	R/U Location	R/U Length	R/U Width	Weight (g)
										Length	Width	Depth		Length	Width									
50	MJ01	TPE	1	0-100	DB	FRAGS	CQ	QU	I	3.52	2.52	2.48	-	-	-	-	0	0	0	N	-	-	-	<0.1
51	MJ01	TPE	1	0-100	DB	FRAGS	CQ	QU	L	3.82	3.32	0.88	-	-	-	-	0	0	0	N	-	-	-	<0.1
52	MJ01	TPE	1	0-100	DB	FRAGS	CQ	QU	L	4.61	3.12	1.22	-	-	-	-	0	0	0	N	-	-	-	<0.1
53	MJ01	TPE	2	100-300	F	CHIP	QTZ	QTZ	-	12.55	12.08	4.28	Flaked	10.84	4.52	Stepped	0	0	0	N	-	-	-	0.5
54	MJ01	TPE	2	100-300	F	CHIP	WQ	QU	-	6.04	11.71	2.36	Flaked	3.73	0.88	Hinge	0	0	0	N	-	-	-	0.1
55	MJ01	TPE	2	100-300	FP	CHIP	WQ	QU	TB	11.45	9.74	2.55	-	-	-	-	0	0	0	N	-	-	-	0.3
56	MJ01	TPE	2	100-300	FP	CHIP	CQ	QU	TB	8.00	6.03	1.74	-	-	-	-	1	0	0	N	-	-	-	0.1
57	MJ01	TPE	2	100-300	FP	CHIP	WQ	QU	-	9.57	4.91	1.99	-	-	-	-	0	0	1	N	-	-	-	0.1
58	MJ01	TPE	2	100-300	DB	FRAGS	SQ	QU	TB	9.04	2.98	2.02	-	-	-	-	0	0	0	N	-	-	-	0.1
59	MJ01	TPE	2	100-300	DB	FRAGS	CQ	QU	I	7.33	6.65	2.51	-	-	-	-	0	0	0	N	-	-	-	<0.1
60	MJ01	TPE	2	100-300	DB	FRAGS	CQ	QU	L	5.34	2.10	1.62	-	-	-	-	0	0	0	N	-	-	-	<0.1
61	MJ01	TPE	2	100-300	DB	FRAGS	WQ	QU	TB	4.14	3.25	1.44	-	-	-	-	0	0	0	N	-	-	-	<0.1
62	MJ01	TPE	2	100-300	DB	FRAGS	WQ	QU	TB	4.22	2.67	0.82	-	-	-	-	0	0	0	N	-	-	-	<0.1
63	MJ01	TPE	1&2 Cleaning	0-200	RUFP	Bladelet	CQ	QU	TG	15.39	4.93	3.06	-	-	-	-	0	0	1	Y	LLM, RLM	0.94, 13.6	1.49, 1.7	<0.1
64	MJ01	TPE	1&2 Cleaning	0-200	DB	FRAGS	SQ	QU	TB	7.18	3.23	2.63	-	-	-	-	0	0	0	N	-	-	-	<0.1
65	MJ01	TPE	1&2 Cleaning	0-200	FP	CHIP	WQ	QU	I	6.57	4.88	2.83	-	-	-	-	0	0	0	N	-	-	-	<0.1
66	MJ01	TPE	1&2 Cleaning	0-200	DB	FRAGS	WQ	QU	L	7.91	2.01	1.50	-	-	-	-	0	0	0	N	-	-	-	<0.1
67	MJ01	TPE	4	300-400	DB	FRAGS	WQ	QU	TB	6.76	6.12	2.08	-	-	-	-	0	0	0	N	-	-	-	0.1
68	MJ01	TPE	5	400-500	PTBF	FP	WQ	QU	-	15.48	7.68	2.90	Flaked	2.37	1.25	Broken	0	0	0	N	-	-	-	0.3
69	MJ01	TPE	6	500-600	F	CHIP	WQ	QU	-	5.43	4.14	1.77	Flaked	2.34	1.08	Feather	0	0	0	N	-	-	-	<0.1
70	MJ01	EXF	1	0-200	FP	CHIP	CQ	QU	L	4.10	4.80	0.80	-	-	-	-	0	0	0	N	-	-	-	<0.1

Artefact #	Site	Pit	Spit	Depth	Artefact Type	Pearce Artefact Type	Lithology	Pearce Lithology	Cross-section	Artefact Dimensions			Platform Type	Platform Dimensions		Termination	# Dorsal flake scars	Cortex %	Parallel Arrises	Retouch / Utilisation?	R/U Location	R/U Length	R/U Width	Weight (g)
										Length	Width	Depth		Length	Width									
71	MJ01	EXF	2	200-300	F	CHIP	WQ	QU	-	7.10	2.00	1.50	Flaked	1.6	0.5	Feather	1	0	0	N	-	-	-	<0.1
72	MJ01	EXF	2	200-300	DB	FRAGS	WQ	QU	TG	2.70	2.20	0.90	-	-	-	-	0	0	0	N	-	-	-	<0.1
73	MJ01	EXF	2	200-300	FP	CHIP	WQ	QU	TG	3.40	3.30	0.80	-	-	-	-	1	0	0	N	-	-	-	<0.1
74	MJ01	EXF	2	200-300	DB	FRAGS	WQ	QU	TG	4.20	1.80	1.50	-	-	-	-	0	0	0	N	-	-	-	<0.1
75	MJ01	EXF	2	200-300	DB	FRAGS	WQ	QU	TG	2.80	2.30	1.60	-	-	-	-	0	0	0	N	-	-	-	<0.1
76	MJ01	EXF	2	200-300	DB	FRAGS	WQ	QU	I	2.90	1.60	1.80	-	-	-	-	0	0	0	N	-	-	-	<0.1
77	MJ01	EXF	3	300-400	DB	FRAGS	WQ	QU	L	4.10	4.30	1.20	-	-	-	-	0	0	0	N	-	-	-	<0.1
78	MJ01	EXF	3	300-400	DB	FRAGS	WQ	QU	I	2.70	1.80	1.20	-	-	-	-	0	0	0	N	-	-	-	<0.1
79	MJ01	EXF	3	300-400	DB	FRAGS	WQ	QU	I	2.60	1.30	1.30	-	-	-	-	0	0	0	N	-	-	-	<0.1
80	MJ01	EXF	4	400-500	FP	CHIP	CQ	QU	L	7.20	5.00	0.60	-	-	-	-	0	0	0	N	-	-	-	<0.1
81	MJ01	EXF	4	400-500	F	CHIP	WQ	QU	-	7.20	2.20	7.00	Flaked	2.5	0.8	Feather	2	0	1	N	-	-	-	<0.1
82	MJ01	EXF	4	400-500	DB	FRAGS	WQ	QU	I	4.00	2.10	2.10	-	-	-	-	0	0	0	N	-	-	-	<0.1
83	MJ01	EXF	4	400-500	DB	FRAGS	WQ	QU	TG	3.60	2.40	1.20	-	-	-	-	0	0	0	N	-	-	-	<0.1
84	MJ01	EXF	5	500-600	F	CHIP	WQ	QU	-	4.30	5.70	0.90	Flaked	4.3	0.8	Feather	1	0	0	N	-	-	-	<0.1
85	MJ01	EXF	5	500-600	FP	CHIP	CQ	QU	I	3.90	3.10	1.10	-	-	-	-	0	0	0	N	-	-	-	<0.1
86	MJ01	EXF	5	500-600	DB	FRAGS	WQ	QU	TG	3.20	2.70	1.30	-	-	-	-	0	0	0	N	-	-	-	<0.1
87	MJ01	EXF	6	600-700	FP	CHIP	CQ	QU	TB	5.60	2.20	1.30	-	-	-	-	0	0	0	N	-	-	-	<0.1
88	MJ01	EXF	6	600-700	FP	CHIP	CH	CH	TG	5.30	3.70	1.70	-	-	-	-	1	0	0	N	-	-	-	<0.1
89	MJ01	EXF	7	700-800	DB	FRAGS	WQ	QU	L	3.40	2.20	1.00	-	-	-	-	0	0	0	N	-	-	-	<0.1
90	MJ01	EXF	11	1100-1200	DB	FRAGS	WQ	QU	L	3.70	2.40	0.90	-	-	-	-	0	0	0	N	-	-	-	<0.1
91	MJ01	EXF	14	1400-1500	FP	CHIP	WQ	QU	L	3.30	2.60	0.80	-	-	-	-	1	0	0	N	-	-	-	<0.1
92	MJ02	TPB	1	0-100	TBF	CHIP	WQ	QU	-	10.90	6.00	1.70	Focalised	-	-	Broken	1	20	0	N	-	-	-	0.2
93	MJ02	TPB	1	0-100	FP	CHIP	WQ	QU	TG	8.70	6.10	2.40	-	-	-	-	1	0	0	N	-	-	-	0.2
94	MJ02	TPB	1	0-100	DB	FRAGS	WQ	QU	I	6.90	4.30	2.60	-	-	-	-	0	0	0	N	-	-	-	<0.1

Artefact #	Site	Pit	Spit	Depth	Artefact Type	Pearce Artefact Type	Lithology	Pearce Lithology	Cross-section	Artefact Dimensions			Platform Type	Platform Dimensions		Termination	# Dorsal flake scars	Cortex %	Parallel Arrises	Retouch / Utilisation?	R/U Location	R/U Length	R/U Width	Weight (g)
										Length	Width	Depth		Length	Width									
95	MJ02	TPB	1	0-100	F	CHIP	CQ	QU	-	9.80	4.90	1.00	Flaked	2	1.2	Feather	1	0	0	N	-	-	-	<0.1
96	MJ02	TPB	1	0-100	FP	FRAGS	WQ	QU	TG	9.40	6.80	2.90	-	-	-	-	0	0	0	N	-	-	-	0.2
97	MJ02	TPB	1	0-100	FP	FRAGS	WQ	QU	L	5.00	3.00	0.30	-	-	-	-	0	0	0	N	-	-	-	<0.1
98	MJ02	TPB	1	0-100	DB	FRAGS	WQ	QU	I	7.50	6.50	3.90	-	-	-	-	0	0	0	N	-	-	-	0.3
99	MJ02	TPB	1	0-100	FP	CHIP	WQ	QU	I	7.70	5.20	1.30	-	-	-	-	1	0	0	N	-	-	-	<0.1
100	MJ02	TPB	1	0-100	FP	CHIP	WQ	QU	TB	5.80	4.30	1.10	-	-	-	-	1	0	0	N	-	-	-	<0.1
101	MJ02	TPB	1	0-100	FP	CHIP	WQ	QU	TG	5.30	5.00	2.00	-	-	-	-	0	0	0	N	-	-	-	<0.1
102	MJ02	TPB	1	0-100	DB	FRAGS	WQ	QU	L	4.70	1.50	1.20	-	-	-	-	0	0	0	N	-	-	-	<0.1
103	MJ02	TPB	1	0-100	DB	FRAGS	WQ	QU	TG	4.70	1.90	1.00	-	-	-	-	0	0	0	N	-	-	-	<0.1
104	MJ02	TPB	1	0-100	DB	FRAGS	WQ	QU	I	4.90	2.70	1.10	-	-	-	-	0	0	0	N	-	-	-	<0.1
105	MJ02	TPB	1	0-100	DB	FRAGS	WQ	QU	I	3.90	2.60	2.80	-	-	-	-	0	0	0	N	-	-	-	<0.1
106	MJ02	TPB	2	100-200	MPC	UNF	WQ	QU		See Core page														
107	MJ02	TPB	2	100-200	F	CHIP	WQ	QU	-	11.20	8.30	3.20	Flaked	7.2	3.1	Stepped	1	0	0	N	-	-	-	0.3
108	MJ02	TPB	2	100-200	DB	FRAGS	WQ	QU	I	6.20	3.60	1.90	-	-	-	-	0	0	0	N	-	-	-	<0.1
109	MJ02	TPB	2	100-200	FP	CHIP	CQ	QU	L	5.70	4.20	1.10	-	-	-	-	0	0	0	N	-	-	-	<0.1
110	MJ02	TPB	2	100-200	DB	FRAGS	WQ	QU	I	5.70	2.50	2.00	-	-	-	-	0	0	0	N	-	-	-	<0.1
111	MJ02	TPB	3	200-300	PTBF	CHIP	WQ	QU	-	3.50	2.60	0.90	Flaked	2.2	0.8	Broken	0	0	0	N	-	-	-	<0.1
112	MJ02	TPB	3	200-300	FP	CHIP	WQ	QU	L	4.80	4.50	0.70	-	-	-	-	1	0	0	N	-	-	-	<0.1
113	MJ02	TPB	3	200-300	FP	CHIP	WQ	QU	L	5.80	2.80	0.90	-	-	-	-	1	0	0	N	-	-	-	<0.1
114	MJ02	TPB	5	400-500	FP	CHIP	CQ	QU	I	6.30	6.90	2.80	-	-	-	-	1	0	0	N	-	-	-	0.1
115	MJ02	TPB	6	500-600	RUFP	UNF	CQ	QU	L	14.80	8.10	2.40	-	-	-	-	1	0	0	Y	1M	7.30	2.50	0.3
116	MJ02	2PN60	NA	570	F	CHIP	WQ	QU	-	10.90	5.40	3.70	Faceted	5.1	3	Feather	2	0	0	N	-	-	-	0.3
117	MJ02	2PN60	NA	570	DB	FRAGS	WQ	QU	I	6.30	3.00	2.00	-	-	-	-	0	0	0	N	-	-	-	<0.1
118	MJ02	2PN60	NA	570	DB	FRAGS	CQ	QU	I	4.30	2.60	2.20	-	-	-	-	0	0	0	N	-	-	-	<0.1
119	MJ02	2PN60	NA	570	FP	CHIP	WQ	QU	I	6.50	3.80	1.60	-	-	-	-	0	0	0	N	-	-	-	<0.1
120	MJ02	2PS30	NA	540	DB	FRAGS	CQ	QU	L	6.00	2.40	1.20	-	-	-	-	0	0	0	N	-	-	-	<0.1

Artefact #	Site	Pit	Spit	Depth	Artefact Type	Pearce Artefact Type	Lithology	Pearce Lithology	Cross-section	Artefact Dimensions			Platform Type	Platform Dimensions		Termination	# Dorsal flake scars	Cortex %	Parallel Arrises	Retouch / Utilisation?	R/U Location	R/U Length	R/U Width	Weight (g)
										Length	Width	Depth		Length	Width									
121	MJ02	2PS60	NA	560	PTBF	CHIP	CQ	QU	-	4.40	4.70	1.40	Flaked	4.7	1.2	Broken	2	0	1	N	-	-	-	<0.1
122	MJ02	EXK	5	410-520	F	CHIP	WQ	QU	-	13.30	11.30	3.60	Flaked	6.3	3.1	Stepped	2	0	0	N	-	-	-	0.6
123	MJ02	EXK	5	410-520	F	CHIP	WQ	QU	-	14.50	9.50	3.20	Flaked	5.5	3.3	Stepped	3	0	0	N	-	-	-	0.5
124	MJ02	EXK	5	410-520	FP	FP	SQ	QU	I	17.70	10.40	5.60	-	-	-	-	2	10	0	N	-	-	-	1.7
125	MJ02	EXK	5	410-520	FP	CHIP	CQ	QU	TG	10.40	10.90	2.10	-	-	-	-	2	0	0	N	-	-	-	0.2
126	MJ02	EXK	5	410-520	DB	FRAGS	WQ	QU	I	9.20	5.20	2.00	-	-	-	-	0	0	0	N	-	-	-	<0.1
127	MJ02	EXK	5	410-520	PTBF	CHIP	CQ	QU	-	6.60	10.50	3.00	Faceted	6.8	2.9	Broken	2	0	0	N	-	-	-	0.3
128	MJ02	EXK	5	410-520	FP	CHIP	CQ	QU	L	11.20	5.20	1.40	-	-	-	-	1	0	0	N	-	-	-	0.1
129	MJ02	EXK	5	410-520	FP	CHIP	WQ	QU	TG	10.10	8.30	2.70	-	-	-	-	1	0	0	N	-	-	-	0.2
130	MJ02	EXK	5	410-520	FP	CHIP	CQ	QU	I	9.00	6.60	1.60	-	-	-	-	1	0	0	N	-	-	-	<0.1
131	MJ02	EXK	5	410-520	DB	FRAGS	WQ	QU	I	6.50	4.80	3.10	-	-	-	-	0	0	0	N	-	-	-	<0.1
132	MJ02	EXK	5	410-520	DB	FRAGS	WQ	QU	TG	6.80	3.40	3.20	-	-	-	-	0	0	0	N	-	-	-	<0.1
133	MJ02	EXK	5	410-520	DB	FRAGS	WQ	QU	I	5.70	4.10	2.80	-	-	-	-	0	0	0	N	-	-	-	<0.1
134	MJ02	EXK	12	1200-1320	TBF	CHIP	WQ	QU	-	10.60	6.00	1.10	Faceted	3.2	1.3	Broken	1	0	0	N	-	-	-	<0.1
135	MJ02	EXK	13	1320-1460	FP	CHIP	WQ	QU	L	12.40	5.80	1.70	-	-	-	-	1	0	0	N	-	-	-	0.2
136	MJ02	EXK	13	1320-1460	F	CHIP	WQ	QU	-	6.90	3.20	0.80	Flaked	2	0.9	Feather	2	0	0	N	-	-	-	<0.1
137	MJ02	EXK	13	1320-1460	DB	FRAGS	WQ	QU	TG	3.30	2.40	1.70	-	-	-	-	0	0	0	N	-	-	-	<0.1
138	MJ02	EXK	13	1320-1460	DB	FRAGS	WQ	QU	I	4.20	3.00	1.60	-	-	-	-	0	0	0	N	-	-	-	<0.1
139	MJ02	EXK	13	1320-1460	F	CHIP	WQ	QU	-	8.60	10.80	3.60	Faceted	7.2	3.6	Feather	1	0	0	N	-	-	-	0.3
140	MJ02	EXK	BULK	NA	FP	CHIP	CQ	QU	TB	10.40	8.10	2.20	-	-	-	-	0	0	0	N	-	-	-	0.3
141	MJ02	EXK	BULK	NA	FP	CHIP	CQ	QU	I	9.80	5.30	2.30	-	-	-	-	1	0	0	N	-	-	-	0.1
142	MJ02	EXK	BULK	NA	FP	CHIP	WQ	QU	TB	7.30	6.80	2.00	-	-	-	-	1	0	0	N	-	-	-	0.1
143	MJ02	EXK	BULK	NA	FP	CHIP	CQ	QU	L	7.20	4.40	1.20	-	-	-	-	0	0	0	N	-	-	-	<0.1
144	MJ02	EXK	BULK	NA	DB	FRAGS	WQ	QU	I	4.10	1.40	1.40	-	-	-	-	0	0	0	N	-	-	-	<0.1
145	MJ02	EXK	BULK	NA	FP	CHIP	CQ	QU	L	5.60	4.20	0.80	-	-	-	-	1	0	0	N	-	-	-	<0.1
146	MJ02	EXK	BULK	NA	FP	CHIP	CQ	QU	L	7.40	3.20	0.70	-	-	-	-	0	0	0	N	-	-	-	<0.1

Artefact #	Site	Pit	Spit	Depth	Artefact Type	Pearce Artefact Type	Lithology	Pearce Lithology	Cross-section	Artefact Dimensions			Platform Type	Platform Dimensions		Termination	# Dorsal flake scars	Cortex %	Parallel Arrises	Retouch / Utilisation?	R/U Location	R/U Length	R/U Width	Weight (g)
										Length	Width	Depth		Length	Width									
147	MJ04	TPC	1	0-100	FP	FP	WQ	QU	I	16.60	14.10	3.00	-	-	-	-	2	0	0	N	-	-	-	0.7
148	MJ04	TPC	1	0-100	DB	FRAGS	BQ	QU	TB	11.30	4.20	1.90	-	-	-	-	0	10	0	N	-	-	-	0.1
149	MJ04	TPC	1	0-100	F	CHIP	CQ	QU	-	11.30	4.40	1.40	Flaked	3	0.9	Stepped	2	0	0	N	-	-	-	<0.1
150	MJ04	TPC	1	0-100	MPC	UNF	WQ	QU		See Core page														
151	MJ04	TPC	1	0-100	DB	FRAGS	CQ	QU	TG	8.70	5.30	7.00	-	-	-	-	0	0	0	N	-	-	-	0.3
152	MJ04	TPC	1	0-100	DB	FRAGS	CQ	QU	I	8.00	2.30	1.80	-	-	-	-	0	0	0	N	-	-	-	<0.1
153	MJ04	TPC	1	0-100	FP	CHIP	CQ	QU	L	6.20	3.10	1.10	-	-	-	-	0	0	0	N	-	-	-	<0.1
154	MJ04	TPC	1	0-100	DB	FRAGS	CQ	QU	L	4.90	2.30	0.60	-	-	-	-	0	0	0	N	-	-	-	<0.1
155	MJ04	TPC	1	0-100	DB	FRAGS	CQ	QU	I	3.80	2.10	0.80	-	-	-	-	0	0	0	N	-	-	-	<0.1
156	MJ04	TPC	1	0-100	DB	FRAGS	CQ	QU	L	6.00	3.20	1.00	-	-	-	-	0	0	0	N	-	-	-	<0.1
157	MJ04	TPC	1	0-100	DB	FRAGS	WQ	QU	I	8.50	5.70	3.50	-	-	-	-	0	0	0	N	-	-	-	0.2
158	MJ04	TPC	1	0-100	F	CHIP	WQ	QU	-	10.30	4.30	2.20	Focalised			Stepped	0	0	0	N	-	-	-	0.1
159	MJ04	TPC	2	100-200	DB	FRAGS	CQ	QU	L	4.00	3.80	1.00	-	-	-	-	0	0	0	N	-	-	-	<0.1
160	MJ04	TPC	2	100-200	DB	FRAGS	WQ	QU	TG	3.70	3.90	1.80	-	-	-	-	0	0	0	N	-	-	-	<0.1
161	MJ04	TPC	3	200-300	DB	FRAGS	WQ	QU	TG	7.40	2.80	2.70	-	-	-	-	0	0	0	N	-	-	-	<0.1
162	MJ04	TPC	3	200-300	DB	FRAGS	CQ	QU	L	4.40	4.40	1.10	-	-	-	-	0	0	0	N	-	-	-	<0.1
163	MJ04	TPC	3	200-300	DB	FRAGS	WQ	QU	I	4.40	2.40	1.90	-	-	-	-	0	0	0	N	-	-	-	<0.1
164	MJ04	TPC	3	200-300	DB	FRAGS	WQ	QU	TB	4.70	2.80	2.30	-	-	-	-	0	0	0	N	-	-	-	<0.1
165	MJ04	TPC	4	300-400	MPC	UNF	WQ	QU		See Core page														
166	MJ04	TPC	4	300-400	DB	FRAGS	CQ	QU	L	3.60	2.80	0.60	-	-	-	-	0	0	0	N	-	-	-	<0.1
167	MJ04	TPC	4	300-400	F	CHIP	WQ	QU	-	13.50	8.50	2.70	Crushed			Feather	1	0	0	N	-	-	-	0.3
168	MJ04	TPC	4	300-400	F	CHIP	CQ	QU	-	10.10	5.90	1.90	Flaked	3.5	2.2	Feather	1	0	0	N	-	-	-	0.1
169	MJ04	TPC	4	300-400	FP	CHIP	WQ	QU	L	8.70	6.90	1.20	-	-	-	-	0	0	0	N	-	-	-	<0.1
170	MJ04	TPC	5	400-500	FP	CHIP	WQ	QU	L	5.50	4.10	0.80	-	-	-	-	0	0	0	N	-	-	-	<0.1

Artefact #	Site	Pit	Spit	Depth	Artefact Type	Pearce Artefact Type	Lithology	Pearce Lithology	Cross-section	Artefact Dimensions			Platform Type	Platform Dimensions		Termination	# Dorsal flake scars	Cortex %	Parallel Arrises	Retouch / Utilisation?	R/U Location	R/U Length	R/U Width	Weight (g)
										Length	Width	Depth		Length	Width									
171	MJ04	TPC	5	400-500	DB	FRAGS	WQ	QU	L	3.30	2.60	1.00	-	-	-	-	0	0	0	N	-	-	-	<0.1
172	MJ04	TPC	5	400-500	DB	FRAGS	WQ	QU	L	2.90	2.10	0.60	-	-	-	-	0	0	0	N	-	-	-	<0.1
173	MJ04	TPC	5	400-500	FP	CHIP	WQ	QU	I	8.70	6.10	6.60	-	-	-	-	2	0	0	N	-	-	-	0.3
174	MJ04	4PE40	NA	440	F	CHIP	WQ	QU	-	5.00	3.60	1.40	Flaked	3.2	1.7	Feather	0	0	0	N	-	-	-	<0.1
175	MJ04	4PW10	NA	440	PTBF	CHIP	WQ	QU	-	12.40	11.20	4.70	Focalised	-	-	Broken	1	0	1	N	-	-	-	0.5
176	MJ04	4PW10	NA	440	DB	FRAGS	CQ	QU	I	6.60	6.90	3.80	-	-	-	-	0	0	0	N	-	-	-	0.3
177	MJ04	4PW10	NA	440	FP	CHIP	WQ	QU	L	10.10	3.80	1.20	-	-	-	-	1	0	0	N	-	-	-	<0.1
178	MJ04	4PS40	NA	440	FP	CHIP	CQ	QU	L	4.90	5.40	1.00	-	-	-	-	0	0	0	N	-	-	-	<0.1
179	MJ04	4PS40	NA	440	FP	CHIP	WQ	QU	TG	10.70	10.10	4.30	-	-	-	-	2	0	0	N	-	-	-	0.3
180	MJ04	4PE50	NA	440	MANU	LUMP	DOL	DOL	-	85.00	27.90	34.40	-	-	-	-	0	0	0	N	-	-	-	138.6
181	MJ06	EXJ	BULK	NA	FP	CHIP	WQ	QU	TG	14.00	11.00	4.40	-	-	-	-	1	0	0	N	-	-	-	0.5
182	MJ06	EXJ	BULK	NA	DB	FRAGS	WQ	QU	I	18.60	16.00	10.00	-	-	-	-	0	0	0	N	-	-	-	3.5
183	MJ06	EXJ	BULK	NA	F	CHIP	CQ	QU	-	6.50	3.40	0.90	Flaked	2.3	0.8	Feather	1	0	0	N	-	-	-	<0.1
184	MJ06	EXJ	BULK	NA	DB	FRAGS	WQ	QU	TB	7.80	3.70	2.00	-	-	-	-	0	0	0	N	-	-	-	<0.1
185	MJ06	EXJ	BULK	NA	DB	FRAGS	WQ	QU	L	3.70	2.40	0.80	-	-	-	-	0	0	0	N	-	-	-	<0.1
186	MJ06	EXJ	BULK	NA	DB	FRAGS	CQ	QU	TG	3.80	3.80	2.10	-	-	-	-	0	0	0	N	-	-	-	<0.1
187	MJ06	EXJ	BULK	NA	DB	FRAGS	CQ	QU	L	5.10	3.20	1.00	-	-	-	-	0	0	0	N	-	-	-	<0.1
188	MJ06	EXJ	BULK	NA	LBF	CHIP	CQ	QU	-	3.90	4.70	1.80	Flaked	3.1	1.3	Feather	1	0	0	N	-	-	-	<0.1
189	MJ06	EXJ	BULK	NA	DB	FRAGS	WQ	QU	TB	6.50	3.50	1.00	-	-	-	-	0	0	0	N	-	-	-	<0.1
190	MJ06	EXJ	BULK	NA	DB	FRAGS	CQ	QU	L	3.40	3.70	0.60	-	-	-	-	0	0	0	N	-	-	-	<0.1
191	MJ06	EXJ	BULK	NA	DB	FRAGS	WQ	QU	I	4.30	3.90	2.00	-	-	-	-	0	0	0	N	-	-	-	<0.1
192	MJ06	EXJ	BULK	NA	F	CHIP	WQ	QU	-	3.60	3.50	1.60	Flaked	3	1.2	Feather	0	0	0	N	-	-	-	<0.1
193	MJ06	EXJ	BULK	NA	FP	CHIP	GR	OTHER	E	12.40	5.30	3.20	-	-	-	-	1	0	0	N	-	-	-	0.2
194	MJ06	EXJ	BULK	NA	DB	FRAGS	GR	OTHER	TB	4.80	2.90	1.40	-	-	-	-	0	0	0	N	-	-	-	<0.1
195	MJ06	EXJ	BULK	NA	DB	FRAGS	GR	OTHER	I	7.30	6.80	4.60	-	-	-	-	0	0	0	N	-	-	-	0.3
196	MJ06	EXJ	BULK	NA	DB	FRAGS	GR	OTHER	I	6.00	4.90	3.00	-	-	-	-	0	0	0	N	-	-	-	0.1
197	MJ06	EXJ	1	0-200	DB	FRAGS	GR	OTHER	I	6.50	3.50	3.30	-	-	-	-	0	0	0	N	-	-	-	<0.1
198	MJ06	EXJ	1	0-200	FP	CHIP	GR	OTHER	I	11.20	9.10	4.10	-	-	-	-	1	0	0	N	-	-	-	0.5

Artefact #	Site	Pit	Spit	Depth	Artefact Type	Pearce Artefact Type	Lithology	Pearce Lithology	Cross-section	Artefact Dimensions			Platform Type	Platform Dimensions		Termination	# Dorsal flake scars	Cortex %	Parallel Arrises	Retouch / Utilisation?	R/U Location	R/U Length	R/U Width	Weight (g)
										Length	Width	Depth		Length	Width									
199	MJ06	EXJ	2	200-300	FP	CHIP	GR	OTHER	I	9.90	6.10	4.60	-	-	-	-	1	0	0	N	-	-	-	0.3
200	MJ06	EXJ	3	300-400	DB	FRAGS	WQ	QU	I	3.20	2.70	1.90	-	-	-	-	0	0	0	N	-	-	-	<0.1
201	MJ06	EXJ	3	300-400	DB	FRAGS	WQ	QU	TB	5.60	3.60	1.20	-	-	-	-	0	0	0	N	-	-	-	<0.1
202	MJ06	EXJ	3	300-400	FP	FP	WQ	QU	I	15.50	8.20	5.20	-	-	-	-	1	0	0	N	-	-	-	0.7
203	MJ06	EXJ	4	400-500	FP	CHIP	WQ	QU	I	12.20	12.20	8.30	-	-	-	-	1	0	0	N	-	-	-	1.5
204	MJ06	EXJ	4	400-500	FP	CHIP	WQ	QU	L	7.20	4.90	1.20	-	-	-	-	1	0	0	N	-	-	-	<0.1
205	MJ06	EXJ	4	400-500	FP	CHIP	WQ	QU	I	6.40	5.40	2.10	-	-	-	-	0	0	0	N	-	-	-	<0.1
206	MJ06	EXJ	4	400-500	DB	FRAGS	WQ	QU	I	6.30	5.20	3.10	-	-	-	-	0	0	0	N	-	-	-	<0.1
207	MJ06	EXJ	4	400-500	DB	FRAGS	WQ	QU	I	3.80	5.10	4.10	-	-	-	-	0	0	0	N	-	-	-	0.2
208	MJ06	EXJ	5	500-600	FP	FP	WQ	QU	E	15.50	7.20	4.30	-	-	-	-	1	0	0	N	-	-	-	0.7
209	MJ06	EXJ	6	600-700	FP	FP	WQ	QU	I	17.30	12.30	5.20	-	-	-	-	2	0	0	N	-	-	-	1
210	MJ06	EXJ	6	600-700	DB	FRAGS	WQ	QU	I	10.50	3.90	3.50	-	-	-	-	0	0	0	N	-	-	-	0.2
211	MJ06	EXJ	9	900-1000	MPC	UNF	WQ	QU		See Core page														
212	MJ06	EXJ	9	900-1000	FP	CHIP	WQ	QU	L	4.80	4.20	1.20	-	-	-	-	0	0	0	N	-	-	-	<0.1
213	MJ06	EXJ	9	900-1000	DB	FRAGS	WQ	QU	I	6.30	5.70	1.10	-	-	-	-	0	0	0	N	-	-	-	<0.1
214	MJ06	EXJ	9	900-1000	DB	FRAGS	WQ	QU	L	3.70	3.00	0.40	-	-	-	-	0	0	0	N	-	-	-	<0.1
215	MJ06	EXJ	9	900-1000	DB	FRAGS	WQ	QU	I	5.70	2.20	2.40	-	-	-	-	0	0	0	N	-	-	-	<0.1
216	MJ06	EXJ	11	1100-1200	FP	CHIP	CH	CH	I	6.80	5.80	2.60	-	-	-	-	0	0	0	N	-	-	-	<0.1
217	MJ06	EXJ	11	1100-1200	DB	FRAGS	WQ	QU	TB	4.20	2.40	1.30	-	-	-	-	0	0	0	N	-	-	-	<0.1
218	MJ06	EXJ	11	1100-1200	FP	CHIP	CQ	QU	I	3.60	3.10	1.30	-	-	-	-	0	0	0	N	-	-	-	<0.1
219	MJ06	EXJ	11	1100-1200	FP	CHIP	WQ	QU	L	5.50	3.80	1.50	-	-	-	-	0	0	0	N	-	-	-	<0.1
220	MJ06	EXJ	12	1200-1300	F	FLAKE	GR	OTHER	-	15.70	12.90	5.00	Flaked	8.2	4.7	Stepped	0	0	0	N	-	-	-	1.2
221	MJ06	EXJ	12	1200-1300	FP	CHIP	WQ	QU	L	8.90	4.60	2.10	-	-	-	-	1	0	0	N	-	-	-	0.2

Artefact #	Site	Pit	Spit	Depth	Artefact Type	Pearce Artefact Type	Lithology	Pearce Lithology	Cross-section	Artefact Dimensions			Platform Type	Platform Dimensions		Termination	# Dorsal flake scars	Cortex %	Parallel Arrises	Retouch / Utilisation?	R/U Location	R/U Length	R/U Width	Weight (g)
										Length	Width	Depth		Length	Width									
222	MJ06	EXJ	12	1200-1300	DB	FRAGS	WQ	QU	L	6.60	5.90	1.40	-	-	-	-	0	0	0	N	-	-	-	<0.1
223	MJ06	EXJ	12	1200-1300	FP	CHIP	WQ	QU	TB	9.80	5.80	2.50	-	-	-	-	0	0	0	N	-	-	-	0.2
224	MJ06	EXJ	13	1300-1400	TBF	CHIP	CH	CH	-	4.7	3.20	1.90	-	-	-	-	2	0	1	N	-	-	-	<0.1
225	MJ06	EXJ	13	1300-1400	DB	FRAGS	WQ	QU	L	2.60	0.70	2.30	-	-	-	-	0	0	0	N	-	-	-	<0.1
226	MJ06	EXJ	13	1300-1400	DB	FRAGS	CH	CH	TG	3.30	2.10	1.30	-	-	-	-	0	0	0	N	-	-	-	<0.1
227	MJ06	EXJ	13	1300-1400	RUFP	SES	WQ	QU	TG	8.00	6.20	3.40	-	-	-	-	2	50	1	Y	LLM, RLM	3.4,2.6	4.3,2.4	0.2
228	MJ06	EXJ	14	1400-1500	F	CHIP	CH	CH	-	9.90	7.10	1.20	Flat	2.4	1.1	Broken	1	0	0	N	-	-	-	<0.1
229	MJ06	EXJ	14	1400-1500	DB	FRAGS	CQ	QU	E	2.70	2.80	1.10	-	-	-	-	0	0	0	N	-	-	-	<0.1
230	MJ06	EXJ	14	1400-1500	DB	FRAGS	WQ	QU	E	7.30	2.80	2.20	-	-	-	-	0	0	0	N	-	-	-	<0.1
231	MJ06	EXJ	14	1400-1500	DB	FRAGS	WQ	QU	TB	5.20	1.80	1.40	-	-	-	-	0	0	0	N	-	-	-	<0.1
232	MJ06	EXJ	14	1400-1500	DB	FRAGS	WQ	QU	I	3.10	3.60	2.10	-	-	-	-	0	0	0	N	-	-	-	<0.1
233	MJ06	EXJ	14	1400-1500	LBF	CHIP	CQ	QU	-	3.70	3.80	1.10	Flaked	2.8	1.6	Feather	1	0	0	N	-	-	-	<0.1
234	MJ06	EXJ	15	1500-1600	FP	CHIP	CQ	QU	L	3.90	3.60	0.60	-	-	-	-	0	0	0	N	-	-	-	<0.1
235	MJ06	EXJ	15	1500-1600	F	CHIP	CQ	QU	-	6.30	3.70	0.70	Flaked	3.6	0.5	Feather	0	0	0	N	-	-	-	<0.1
236	MJ06	EXJ	15	1500-1600	F	CHIP	WQ	QU	-	7.40	10.00	0.90	Flaked	6.1	0.3	Feather	1	0	0	N	-	-	-	<0.1
237	MJ06	EXJ	15	1500-1600	DB	FRAGS	WQ	QU	I	2.20	3.80	1.80	-	-	-	-	0	0	0	N	-	-	-	<0.1
238	MJ06	EXJ	15	1500-1600	FP	CHIP	CQ	QU	I	8.70	4.90	2.00	-	-	-	-	0	0	0	N	-	-	-	0.1
239	MJ06	EXJ	15	1500-1600	DB	FRAGS	WQ	QU	I	3.40	3.10	0.90	-	-	-	-	0	0	0	N	-	-	-	<0.1
240	MJ06	EXJ	15	1500-1600	F	CHIP	WQ	QU	-	7.10	4.80	2.30	Focalised	-	-	Feather	1	0	0	N	-	-	-	<0.1
241	MJ06	EXJ	15	1500-1600	F	CHIP	WQ	QU	-	6.00	3.50	1.90	Faceted	2.7	2.1	Stepped	1	0	0	N	-	-	-	<0.1
242	MJ06	EXJ	15	1500-1600	FP	CHIP	WQ	QU	TB	7.50	7.70	2.00	-	-	-	-	1	0	0	N	-	-	-	0.2
243	MJ06	EXJ	16	1600-1700	F	CHIP	CQ	QU	-	6.10	5.90	1.00	Flaked	3.5	0.8	Feather	0	0	0	N	-	-	-	<0.1

Artefact #	Site	Pit	Spit	Depth	Artefact Type	Pearce Artefact Type	Lithology	Pearce Lithology	Cross-section	Artefact Dimensions			Platform Type	Platform Dimensions		Termination	# Dorsal flake scars	Cortex %	Parallel Arrises	Retouch / Utilisation?	R/U Location	R/U Length	R/U Width	Weight (g)
										Length	Width	Depth		Length	Width									
244	MJ06	EXJ	16	1600-1700	SPC	UNF	WQ	QU		See Core page														
245	MJ06	EXJ	16	1600-1700	F	CHIP	WQ	QU	-	6.30	10.40	2.80	Flaked	5.3	2.7	Feather	1	0	0	N	-	-	-	0.2
246	MJ06	EXJ	16	1600-1700	DB	FRAGS	WQ	QU	L	5.30	2.90	1.00	-	-	-	-	0	0	0	N	-	-	-	<0.1
247	MJ06	EXJ	16	1600-1700	FP	CHIP	WQ	QU	TG	6.70	5.70	1.40	-	-	-	-	2	0	1	N	-	-	-	<0.1
248	MJ06	EXJ	16	1600-1700	DB	FRAGS	WQ	QU	TG	5.50	5.00	2.30	-	-	-	-	1	0	0	N	-	-	-	<0.1
249	MJ06	EXJ	16	1600-1700	F	CHIP	WQ	QU	-	5.00	5.20	1.70	Flaked	3.3	1	Feather	0	0	0	N	-	-	-	<0.1
250	MJ06	EXJ	16	1600-1700	F	CHIP	CQ	QU	-	5.80	3.00	1.20	Flaked	3	0.8	Stepped	1	0	1	N	-	-	-	<0.1
251	MJ06	EXJ	16	1600-1700	DB	FRAGS	PQ	QU	I	4.60	2.10	1.10	-	-	-	-	0	0	0	N	-	-	-	<0.1
252	MJ06	EXJ	16	1600-1700	MPC	UNF	WQ	QU		See Core page														
253	MJ06	EXJ	16	1600-1700	F	FLAKE	WQ	QU	-	28.80	21.70	10.00	Focalised	-	-	Feather	0	0	0	N	-	-	-	5.1
254	MJ06	EXJ	16	1600-1700	F	FLAKE	WQ	QU	-	25.10	17.80	7.70	Cortical	7.7	5.8	Stepped	2	0	0	N	-	-	-	3.3
255	MJ06	EXJ	16	1600-1700	MPC	UNF	SQ	QU		See Core page														
256	MJ06	EXJ	17	1700-1800	DB	FRAGS	WQ	QU	I	5.50	5.70	1.40	-	-	-	-	0	0	0	N	-	-	-	<0.1
257	MJ06	EXJ	17	1700-1800	DB	FRAGS	WQ	QU	L	2.80	3.90	0.70	-	-	-	-	0	0	0	N	-	-	-	<0.1
258	MJ06	EXJ	17	1700-1800	DB	FRAGS	WQ	QU	I	3.70	1.60	1.30	-	-	-	-	0	0	0	N	-	-	-	<0.1
259	MJ06	EXJ	17	1700-1800	DB	FRAGS	WQ	QU	L	4.40	2.90	0.80	-	-	-	-	1	0	0	N	-	-	-	<0.1
260	MJ06	EXJ	18	1800-1900	DB	FRAGS	WQ	QU	I	4.40	2.20	1.70	-	-	-	-	0	0	0	N	-	-	-	<0.1
261	MJ07	EXH	4	550-700	F	CHIP	CH	CH	-	7.40	7.90	1.10	Flaked	7.1	1.3	Feather	1	0	0	N	-	-	-	<0.1
262	MJ07	EXH	4	550-700	PTBF	CHIP	CH	CH	-	8.40	9.20	1.70	Flaked	5.2	1.3	Broken	1	0	0	N	-	-	-	<0.1
263	MJ07	EXH	4	550-700	FP	FP	SQ	QU	I	27.50	11.90	6.20	-	-	-	-	2	0	0	N	-	-	-	1.9
264	MJ07	EXH	4	550-700	MPC	UNF	SQ	QU		See Core page														
265	MJ07	EXH	4	550-700	F	CHIP	WQ	QU	-	5.80	12.60	2.20	Faceted	8.1	2.3	Feather	2	60	0	N	-	-	-	0.2

Artefact #	Site	Pit	Spit	Depth	Artefact Type	Pearce Artefact Type	Lithology	Pearce Lithology	Cross-section	Artefact Dimensions			Platform Type	Platform Dimensions		Termination	# Dorsal flake scars	Cortex %	Parallel Arrises	Retouch / Utilisation?	R/U Location	R/U Length	R/U Width	Weight (g)
										Length	Width	Depth		Length	Width									
266	MJ07	EXH	4	550-700	F	FLAKE	CQ	QU	-	16.10	2.40	2.10	Flaked	2.2	1.3	Feather	2	0	1	N	-	-	-	<0.1
267	MJ07	EXH	4	550-700	PTBF	CHIP	SQ	QU	-	10.70	4.50	2.30	Faceted	3.1	1.9	Broken	3	0	2	N	-	-	-	0.2
268	MJ07	EXH	4	550-700	FP	CHIP	SQ	QU	TG	11.60	9.80	4.30	-	-	-	-	1	0	0	N	-	-	-	0.5
269	MJ07	EXH	4	550-700	PTBF	CHIP	SQ	QU	-	7.70	7.20	1.80	Flaked	4.1	1.8	Broken	2	0	1	N	-	-	-	0.1
270	MJ07	EXH	4	550-700	FP	CHIP	SQ	QU	TG	10.80	8.60	3.20	-	-	-	-	2	0	1	N	-	-	-	0.3
271	MJ07	EXH	4	550-700	F	CHIP	WQ	QU	-	9.50	18.90	4.20	Flaked	13.2	3.6	Feather	2	0	0	N	-	-	-	0.6
272	MJ07	EXH	4	550-700	MPC	UNF	SQ	QU		See Core page														
273	MJ07	EXH	4	550-700	F	CHIP	SQ	QU	-	14.40	9.50	3.30	Faceted	6.9	2.7	Broken	2	0	0	N	-	-	-	0.7
274	MJ07	EXH	4	550-700	PTBF	CHIP	CQ	QU	-	12.50	4.80	1.10	Flaked	2.7	0.5	Broken	1	0	0	N	-	-	-	<0.1
275	MJ07	EXH	4	550-700	FP	CHIP	CQ	QU	L	8.70	1.80	1.50	-	-	-	-	0	0	0	N	-	-	-	<0.1
276	MJ07	EXH	4	550-700	DB	FRAGS	CQ	QU	L	4.60	2.90	0.80	-	-	-	-	0	0	0	N	-	-	-	<0.1
277	MJ07	EXH	4	550-700	F	CHIP	SQ	QU	-	10.40	10.90	3.30	Crushed	-	-	Stepped	5	0	1	N	-	-	-	0.3
278	MJ07	EXH	4	550-700	FP	CHIP	SQ	QU	I	7.20	6.00	0.90	-	-	-	-	2	0	0	N	-	-	-	<0.1
279	MJ07	EXH	4	550-700	DB	FRAGS	SQ	QU	I	14.10	7.60	4.40	-	-	-	-	1	0	0	N	-	-	-	0.5
280	MJ07	EXH	4	550-700	F	CHIP	SQ	QU	-	10.90	3.70	1.00	Flaked	2.2	1.2	Feather	2	0	1	N	-	-	-	<0.1
281	MJ07	EXH	4	550-700	TBF	CHIP	SQ	QU	-	8.20	9.20	1.30	Faceted	2.4	0.6	Broken	1	0	0	N	-	-	-	<0.1
282	MJ07	EXH	4	550-700	F	CHIP	SQ	QU	-	8.40	4.90	0.90	Focalised	-	-	Feather	1	0	0	N	-	-	-	<0.1
283	MJ07	EXH	4	550-700	DB	FRAGS	SQ	QU	TB	10.20	5.30	2.40	-	-	-	-	0	0	0	N	-	-	-	0.2
284	MJ07	EXH	4	550-700	PTBF	CHIP	SQ	QU	-	10.70	5.20	1.10	Faceted	2.9	1.3	Broken	2	0	1	N	-	-	-	<0.1
285	MJ07	EXH	4	550-700	DB	FRAGS	WQ	QU	I	6.90	6.50	2.80	-	-	-	-	0	0	0	N	-	-	-	<0.1
286	MJ07	EXH	4	550-700	PTBF	CHIP	SQ	QU	-	9.10	4.60	1.00	Flaked	2.8	1	Broken	1	0	0	N	-	-	-	<0.1
287	MJ07	EXH	4	550-700	DB	FRAGS	SQ	QU	L	6.60	6.70	1.10	-	-	-	-	0	0	0	N	-	-	-	<0.1

Artefact #	Site	Pit	Spit	Depth	Artefact Type	Pearce Artefact Type	Lithology	Pearce Lithology	Cross-section	Artefact Dimensions			Platform Type	Platform Dimensions		Termination	# Dorsal flake scars	Cortex %	Parallel Arrises	Retouch / Utilisation?	R/U Location	R/U Length	R/U Width	Weight (g)
										Length	Width	Depth		Length	Width									
288	MJ07	EXH	4	550-700	F	CHIP	SQ	QU	-	6.30	10.00	2.70	Flaked	9.2	2.8	Feather	0	0	0	N	-	-	-	0.1
289	MJ07	EXH	4	550-700	FP	CHIP	SQ	QU	I	6.00	5.30	2.20	-	-	-	-	0	0	0	N	-	-	-	<0.1
290	MJ07	EXH	4	550-700	MPC	UNF	SQ	QU		See Core page														
291	MJ07	EXH	4	550-700	F	CHIP	SQ	QU	-	3.80	9.30	1.30	Flaked	6.4	2.1	Feather	1	0	0	N	-	-	-	<0.1
292	MJ07	EXH	4	550-700	FP	CHIP	WQ	QU	L	8.40	3.50	1.50	-	-	-	-	1	0	0	N	-	-	-	<0.1
293	MJ07	EXH	4	550-700	DB	FRAGS	SQ	QU	E	5.80	4.70	2.40	-	-	-	-	0	0	0	N	-	-	-	<0.1
294	MJ07	EXH	4	550-700	F	CHIP	SQ	QU	-	7.90	6.30	3.60	Flaked	2.7	0.9	Stepped	2	0	0	N	-	-	-	0.2
295	MJ07	EXH	4	550-700	DB	FRAGS	SQ	QU	E	7.30	3.70	1.40	-	-	-	-	0	0	0	N	-	-	-	<0.1
296	MJ07	EXH	4	550-700	DB	FRAGS	CQ	QU	E	5.70	4.00	1.40	-	-	-	-	0	0	0	N	-	-	-	<0.1
297	MJ07	EXH	4	550-700	DB	FRAGS	CQ	QU	I	7.40	3.10	1.40	-	-	-	-	0	0	0	N	-	-	-	<0.1
298	MJ07	EXH	4	550-700	FP	CHIP	SQ	QU	L	5.70	3.20	0.90	-	-	-	-	0	0	0	N	-	-	-	<0.1
299	MJ07	EXH	4	550-700	DB	FRAGS	SQ	QU	TB	5.60	3.50	2.20	-	-	-	-	0	0	0	N	-	-	-	<0.1
300	MJ07	EXH	4	550-700	FP	CHIP	SQ	QU	TB	5.70	2.20	3.10	-	-	-	-	0	0	0	N	-	-	-	<0.1
301	MJ07	EXH	4	550-700	F	CHIP	WQ	QU	-	5.40	3.80	1.00	Focalised	-	-	Feather	2	0	0	N	-	-	-	<0.1
302	MJ07	EXH	4	550-700	DB	FRAGS	SQ	QU	TG	4.10	4.10	2.50	-	-	-	-	0	0	0	N	-	-	-	<0.1
303	MJ07	EXH	4	550-700	FP	CHIP	SQ	QU	L	3.50	5.00	1.20	-	-	-	-	0	0	0	N	-	-	-	<0.1
304	MJ07	EXH	4	550-700	F	CHIP	SQ	QU	-	5.10	4.90	1.10	Flaked	1.6	0.6	Stepped	1	0	0	N	-	-	-	<0.1
305	MJ07	EXH	4	550-700	DB	FRAGS	SQ	QU	I	6.70	3.90	1.50	-	-	-	-	0	0	0	N	-	-	-	<0.1
306	MJ07	EXH	4	550-700	DB	FRAGS	SQ	QU	E	3.80	2.40	1.00	-	-	-	-	0	0	0	N	-	-	-	<0.1
307	MJ07	EXH	4	550-700	DB	FRAGS	SQ	QU	TB	3.40	2.30	2.50	-	-	-	-	0	0	0	N	-	-	-	<0.1
308	MJ07	EXH	4	550-700	DB	FRAGS	WQ	QU	L	3.70	3.60	1.10	-	-	-	-	0	0	0	N	-	-	-	<0.1
309	MJ07	EXH	4	550-700	DB	FRAGS	SQ	QU	L	2.20	4.10	0.50	-	-	-	-	0	0	0	N	-	-	-	<0.1
310	MJ07	EXH	BULK	NA	FP	CHIP	SQ	QU	I	6.80	4.50	2.60	-	-	-	-	1	0	0	N	-	-	-	0.1
311	MJ07	EXH	BULK	NA	DB	FRAGS	WQ	QU	I	4.60	4.60	2.50	-	-	-	-	0	0	0	N	-	-	-	<0.1

Artefact #	Site	Pit	Spit	Depth	Artefact Type	Pearce Artefact Type	Lithology	Pearce Lithology	Cross-section	Artefact Dimensions			Platform Type	Platform Dimensions		Termination	# Dorsal flake scars	Cortex %	Parallel Arrises	Retouch / Utilisation?	R/U Location	R/U Length	R/U Width	Weight (g)
										Length	Width	Depth		Length	Width									
312	MJ07	EXH	BULK	NA	FP	CHIP	WQ	QU	E	4.90	3.80	0.90	-	-	-	-	0	0	0	N	-	-	-	<0.1
313	MJ06	6PS30	NA	430	RUF	Steep-edged SCRAPER	CQ	QU	-	16.10	8.20	2.60	Flaked	5.1	1.3	Feather	5	0	0	Y	LLM, RLM	15.5, 11.4	2.3, 1.6	0.6
314	MJ06	6PS30	NA	430	FP	CHIP	WQ	QU	I	8.50	3.20	1.20	-	-	-	-	0	0	0	N	-	-	-	<0.1
315	MJ06	6PS30	NA	430	FP	CHIP	CQ	QU	E	7.70	2.50	1.30	-	-	-	-	0	0	0	N	-	-	-	<0.1
316	MJ06	6PS30	NA	430	FP	CHIP	WQ	QU	I	13.00	6.80	3.80	-	-	-	-	0	0	0	N	-	-	-	0.3
317	MJ06	6PS30	NA	430	DB	FRAGS	WQ	QU	L	6.40	4.50	1.10	-	-	-	-	0	0	0	N	-	-	-	<0.1
318	MJ06	6PS30	NA	430	LBF	CHIP	CQ	QU	-	5.60	3.80	1.50	Flaked	3.5	1.4	Feather	1	0	0	N	-	-	-	<0.1
319	MJ06	6PS30	NA	430	F	CHIP	WQ	QU	-	5.30	2.80	1.10	Flaked	2.4	1.2	Feather	1	0	0	N	-	-	-	<0.1
320	MJ06	6PS30	NA	430	DB	FRAGS	WQ	QU	I	5.30	3.90	2.20	-	-	-	-	0	0	0	N	-	-	-	<0.1
321	MJ06	6PS30	NA	430	DB	FRAGS	CQ	QU	I	2.00	1.90	1.20	-	-	-	-	0	0	0	N	-	-	-	<0.1
322	MJ06	6PS30	NA	430	DB	FRAGS	WQ	QU	L	3.60	3.60	0.90	-	-	-	-	0	0	0	N	-	-	-	<0.1
323	MJ06	6PS30	NA	430	DB	FRAGS	WQ	QU	TG	5.30	2.20	1.60	-	-	-	-	0	0	0	N	-	-	-	<0.1
324	MJ06	6PS30	NA	430	DB	FRAGS	CQ	QU	TB	2.40	2.10	0.70	-	-	-	-	0	0	0	N	-	-	-	<0.1
325	MJ06	6PS30	NA	430	DB	FRAGS	WQ	QU	I	2.30	1.70	0.50	-	-	-	-	0	0	0	N	-	-	-	<0.1
326	MJ06	6PS30	NA	430	DB	FRAGS	WQ	QU	E	2.70	2.10	1.10	-	-	-	-	0	0	0	N	-	-	-	<0.1
327	MJ06	6PS30	NA	430	DB	FRAGS	WQ	QU	I	3.50	2.00	0.80	-	-	-	-	0	0	0	N	-	-	-	<0.1
328	MJ06	6PS30	NA	430	MPC	UNF	WQ	QU		See Core page														
329	MJ06	6PE30	NA	430	F	CHIP	WQ	QU	-	11.30	10.00	1.50	Flaked	5.1	1.3	Feather	1	0	0	N	-	-	-	0.2
330	MJ06	6PE30	NA	430	DB	FRAGS	WQ	QU	I	6.00	2.90	2.00	-	-	-	-	0	0	0	N	-	-	-	<0.1
331	MJ06	6PE30	NA	430	DB	FRAGS	WQ	QU	I	7.60	6.10	3.10	-	-	-	-	0	10	0	N	-	-	-	0.2
332	MJ06	6PW50	NA	520	DB	FRAGS	WQ	QU	TG	3.80	3.40	1.60	-	-	-	-	0	0	0	N	-	-	-	<0.1
333	MJ06	6PS60	NA	520	FP	CHIP	CQ	QU	TG	4.80	3.10	1.50	-	-	-	-	1	0	0	N	-	-	-	<0.1
334	MJ06	6PS60	NA	520	DB	FRAGS	WQ	QU	TB	2.60	1.90	0.80	-	-	-	-	0	0	0	N	-	-	-	<0.1
335	MJ06	6PS60	NA	520	DB	FRAGS	WQ	QU	I	3.10	1.70	1.20	-	-	-	-	0	0	0	N	-	-	-	<0.1
336	MJ06	6PS60	NA	520	DB	FRAGS	WQ	QU	I	3.00	2.40	2.10	-	-	-	-	0	0	0	N	-	-	-	<0.1
337	MJ06	6PS60	NA	520	F	CHIP	WQ	QU	-	11.3	11.70	3.80	Faceted	6.2	1.9	Stepped	2	0	0	N	-	-	-	0.5

Artefact #	Site	Pit	Spit	Depth	Artefact Type	Pearce Artefact Type	Lithology	Pearce Lithology	Cross-section	Artefact Dimensions			Platform Type	Platform Dimensions		Termination	# Dorsal flake scars	Cortex %	Parallel Arrises	Retouch / Utilisation?	R/U Location	R/U Length	R/U Width	Weight (g)
										Length	Width	Depth		Length	Width									
338	MJ06	6PS70	NA	540	F	CHIP	WQ	QU	-	10.10	7.50	1.90	Flaked	5	2.4	Stepped	2	0	0	N	-	-	-	0.2
339	MJ06	6PW30	NA	460	F	CHIP	CQ	QU	-	6.50	6.60	1.20	Focalised	-	-	Feather	1	0	0	N	-	-	-	<0.1
340	MJ06	6PW30	NA	460	DB	FRAGS	CQ	QU	L	4.20	2.80	0.70	-	-	-	-	0	0	0	N	-	-	-	<0.1
341	MJ06	6PW30	NA	460	DB	FRAGS	CQ	QU	L	3.10	2.70	1.00	-	-	-	-	0	0	0	N	-	-	-	<0.1
342	MJ06	6PW30	NA	460	DB	FRAGS	CQ	QU	L	3.10	2.00	0.40	-	-	-	-	0	0	0	N	-	-	-	<0.1
343	MJ06	6PW30	NA	460	DB	FRAGS	CQ	QU	I	3.70	1.60	1.30	-	-	-	-	0	0	0	N	-	-	-	<0.1
344	MJ06	6PW30	NA	460	DB	FRAGS	CQ	QU	L	3.30	2.50	0.70	-	-	-	-	0	0	0	N	-	-	-	<0.1
345	MJ06	6PW30	NA	460	DB	FRAGS	WQ	QU	I	4.30	2.30	1.60	-	-	-	-	0	0	0	N	-	-	-	<0.1
346	MJ06	6PW30	NA	460	DB	FRAGS	CQ	QU	L	2.50	2.00	0.60	-	-	-	-	0	0	0	N	-	-	-	<0.1
347	MJ06	6PW30	NA	460	DB	FRAGS	WQ	QU	I	5.60	2.30	2.90	-	-	-	-	0	0	0	N	-	-	-	<0.1
348	MJ06	6PW30	NA	460	DB	FRAGS	WQ	QU	I	3.90	1.70	4.60	-	-	-	-	0	0	0	N	-	-	-	<0.1
349	MJ06	6PW30	NA	460	F	CHIP	CQ	QU	-	5.10	6.00	2.50	Flaked	5.1	2.4	Stepped	0	0	0	N	-	-	-	<0.1
350	MJ06	6PW30	NA	460	F	CHIP	WQ	QU	-	12.50	14.90	4.40	Flaked	13.6	4.9	Feather	0	0	0	N	-	-	-	0.7
351	MJ06	6PW30	NA	460	F	CHIP	WQ	QU	-	13.50	8.20	3.50	Faceted	5	2.5	Stepped	3	0	1	N	-	-	-	0.5
352	MJ06	6PW30	NA	460	FP	FP	WQ	QU	I	17.90	9.80	3.80	-	-	-	-	2	0	0	N	-	-	-	0.8
353	MJ06	6PW30	NA	460	DB	FRAGS	WQ	QU	I	11.80	5.30	3.60	-	-	-	-	1	0	0	N	-	-	-	0.2
354	MJ06	6PW30	NA	460	F	CHIP	WQ	QU	-	8.50	6.00	2.20	Flaked	5	2.3	Feather	2	0	1	N	-	-	-	0.1
355	MJ06	TPA	Cleaning	NA	DB	FRAGS	WQ	QU	I	14.10	11.20	3.60	-	-	-	-	0	0	0	N	-	-	-	0.7
356	MJ06	TPA	Cleaning	NA	DB	FRAGS	WQ	QU	E	8.20	6.50	4.10	-	-	-	-	0	0	0	N	-	-	-	0.2
357	MJ06	TPA	Cleaning	NA	LBF	CHIP	WQ	QU	-	4.70	4.60	2.70	Flaked	4.2	2.9	Feather	2	0	0	N	-	-	-	<0.1
358	MJ06	TPA	Cleaning	NA	F	CHIP	CQ	QU	-	5.90	4.60	1.50	Flaked	4.8	2	Feather	1	0	0	N	-	-	-	<0.1
359	MJ06	TPA	Cleaning	NA	F	CHIP	WQ	QU	-	8.30	12.80	3.20	Flaked	8.6	3.1	Stepped	2	0	0	N	-	-	-	0.3
360	MJ06	TPA	Cleaning	NA	FP	CHIP	WQ	QU	I	11.40	3.40	2.60	-	-	-	-	1	0	0	N	-	-	-	<0.1

Artefact #	Site	Pit	Spit	Depth	Artefact Type	Pearce Artefact Type	Lithology	Pearce Lithology	Cross-section	Artefact Dimensions			Platform Type	Platform Dimensions		Termination	# Dorsal flake scars	Cortex %	Parallel Arrises	Retouch / Utilisation?	R/U Location	R/U Length	R/U Width	Weight (g)
										Length	Width	Depth		Length	Width									
361	MJ06	TPA	Cleaning	NA	F	CHIP	CQ	QU	-	7.20	8.50	1.30	Focalised	-	-	Stepped	1	0	0	N	-	-	-	<0.1
362	MJ06	TPA	Cleaning	NA	FP	CHIP	CQ	QU	I	9.30	5.20	2.50	-	-	-	-	1	0	0	N	-	-	-	<0.1
363	MJ06	TPA	Cleaning	NA	FP	CHIP	CQ	QU	I	6.60	4.20	2.50	-	-	-	-	1	0	0	N	-	-	-	<0.1
364	MJ06	TPA	Cleaning	NA	DB	FRAGS	CQ	QU	TB	5.80	3.20	1.30	-	-	-	-	0	0	0	N	-	-	-	<0.1
365	MJ06	TPA	4	300-400	FP	CHIP	WQ	QU	I	13.80	5.50	2.90	-	-	-	-	1	0	0	N	-	-	-	0.3
366	MJ06	TPA	4	300-400	DB	FRAGS	WQ	QU	E	4.50	2.50	1.60	-	-	-	-	0	0	0	N	-	-	-	<0.1
367	MJ06	TPA	4	300-400	PTBF	CHIP	CQ	QU	-	6.60	6.50	1.60	Focalised	-	-	Broken	1	0	0	N	-	-	-	<0.1
368	MJ06	TPA	5	400-500	F	FLAKE	SQ	QU	-	18.00	6.10	1.80	Focalised	-	-	Feather	2	0	1	N	-	-	-	0.3
369	MJ06	TPA	5	400-500	FP	CHIP	CQ	QU	I	11.50	8.30	2.20	-	-	-	-	0	0	0	N	-	-	-	0.3
370	MJ06	TPA	5	400-500	F	CHIP	WQ	QU	-	9.60	11.80	3.10	Flaked	6.4	1.8	Stepped	2	0	0	N	-	-	-	0.4
371	MJ06	TPA	5	400-500	FP	FP	WQ	QU	I	16.90	9.70	3.10	-	-	-	-	1	0	0	N	-	-	-	0.7
372	MJ06	TPA	5	400-500	FP	CHIP	WQ	QU	I	11.50	8.40	5.50	-	-	-	-	2	0	0	N	-	-	-	0.5
373	MJ06	TPA	5	400-500	FP	CHIP	WQ	QU	E	10.20	9.80	1.60	-	-	-	-	1	0	0	N	-	-	-	0.2
374	MJ06	TPA	5	400-500	PTBF	CHIP	WQ	QU	-	9.80	9.20	3.40	Flaked	7.3	3.6	Broken	2	0	1	N	-	-	-	0.5
375	MJ06	TPA	5	400-500	FP	CHIP	WQ	QU	E	13.00	6.50	3.80	-	-	-	-	1	0	0	N	-	-	-	0.3
376	MJ06	TPA	5	400-500	FP	CHIP	WQ	QU	I	12.50	4.90	3.20	-	-	-	-	0	0	0	N	-	-	-	0.2
377	MJ06	TPA	5	400-500	F	CHIP	WQ	QU	-	14.60	6.00	2.50	Cortical	2.4	2.7	Feather	2	0	1	N	-	-	-	0.3
378	MJ06	TPA	5	400-500	F	CHIP	WQ	QU	-	6.70	8.50	2.00	Focalised	-	-	Outrépassé	1	0	0	N	-	-	-	<0.1
379	MJ06	TPA	5	400-500	DB	FRAGS	WQ	QU	I	10.70	5.30	3.70	-	-	-	-	0	0	0	N	-	-	-	0.3
380	MJ06	TPA	5	400-500	DB	FRAGS	WQ	QU	E	13.70	5.90	1.30	-	-	-	-	0	0	0	N	-	-	-	0.2
381	MJ06	TPA	5	400-500	F	CHIP	CQ	QU	-	8.00	6.30	1.10	Flaked	4.6	0.8	Feather	1	0	0	N	-	-	-	<0.1
382	MJ06	TPA	5	400-500	FP	CHIP	CQ	QU	I	7.40	3.80	1.20	-	-	-	-	0	0	0	N	-	-	-	<0.1
383	MJ06	TPA	5	400-500	F	CHIP	CQ	QU	-	10.10	5.60	1.20	Flaked	2.7	1.1	Feather	1	0	0	N	-	-	-	<0.1

Artefact #	Site	Pit	Spit	Depth	Artefact Type	Pearce Artefact Type	Lithology	Pearce Lithology	Cross-section	Artefact Dimensions			Platform Type	Platform Dimensions		Termination	# Dorsal flake scars	Cortex %	Parallel Arrises	Retouch / Utilisation?	R/U Location	R/U Length	R/U Width	Weight (g)
										Length	Width	Depth		Length	Width									
384	MJ06	TPA	5	400-500	FP	CHIP	WQ	QU	I	11.30	7.00	4.20	-	-	-	-	1	0	0	N	-	-	-	0.4
385	MJ06	TPA	5	400-500	FP	CHIP	CQ	QU	L	9.50	9.00	1.40	-	-	-	-	0	0	0	N	-	-	-	0.2
386	MJ06	TPA	5	400-500	DB	FRAGS	WQ	QU	I	8.70	5.30	4.00	-	-	-	-	0	0	0	N	-	-	-	0.2
387	MJ06	TPA	5	400-500	DB	FRAGS	WQ	QU	I	11.50	10.00	3.00	-	-	-	-	0	0	0	N	-	-	-	0.3
388	MJ06	TPA	5	400-500	F	CHIP	WQ	QU	-	11.90	3.80	1.50	Focalised	-	-	Feather	2	0	1	N	-	-	-	<0.1
389	MJ06	TPA	5	400-500	FP	CHIP	WQ	QU	TB	8.30	4.40	3.40	-	-	-	-	1	0	0	N	-	-	-	0.3
390	MJ06	TPA	5	400-500	FP	CHIP	WQ	QU	TG	9.20	8.50	4.20	-	-	-	-	1	0	0	N	-	-	-	0.3
391	MJ06	TPA	5	400-500	DB	FRAGS	WQ	QU	E	8.80	9.20	1.30	-	-	-	-	0	0	0	N	-	-	-	<0.1
392	MJ06	TPA	5	400-500	FP	CHIP	WQ	QU	I	5.70	6.20	2.10	-	-	-	-	0	0	0	N	-	-	-	<0.1
393	MJ06	TPA	5	400-500	DB	FRAGS	WQ	QU	I	8.00	3.20	2.10	-	-	-	-	0	0	0	N	-	-	-	0.1
394	MJ06	TPA	5	400-500	FP	CHIP	CQ	QU	L	7.70	7.60	1.40	-	-	-	-	0	0	0	N	-	-	-	<0.1
395	MJ06	TPA	5	400-500	FP	CHIP	WQ	QU	TB	7.40	4.30	2.00	-	-	-	-	2	0	0	N	-	-	-	<0.1
396	MJ06	TPA	5	400-500	FP	CHIP	CQ	QU	L	7.60	6.30	0.90	-	-	-	-	0	0	0	N	-	-	-	<0.1
397	MJ06	TPA	5	400-500	FP	CHIP	WQ	QU	L	6.90	4.60	1.20	-	-	-	-	1	0	0	N	-	-	-	<0.1
398	MJ06	TPA	5	400-500	FP	CHIP	CQ	QU	L	5.70	4.10	0.90	-	-	-	-	0	0	0	N	-	-	-	<0.1
399	MJ06	TPA	5	400-500	DB	FRAGS	WQ	QU	TB	7.00	3.00	2.20	-	-	-	-	0	0	0	N	-	-	-	<0.1
400	MJ06	TPA	5	400-500	FP	CHIP	WQ	QU	TG	7.90	3.60	2.10	-	-	-	-	0	0	0	N	-	-	-	<0.1
401	MJ06	TPA	5	400-500	FP	CHIP	WQ	QU	I	6.50	5.50	2.50	-	-	-	-	1	0	0	N	-	-	-	<0.1
402	MJ06	TPA	5	400-500	DB	FRAGS	WQ	QU	TB	6.00	5.80	2.10	-	-	-	-	0	0	0	N	-	-	-	<0.1
403	MJ06	TPA	5	400-500	DB	FRAGS	WQ	QU	I	6.70	6.00	1.70	-	-	-	-	0	0	0	N	-	-	-	<0.1
404	MJ06	TPA	5	400-500	DB	FRAGS	WQ	QU	I	5.90	5.20	1.20	-	-	-	-	0	0	0	N	-	-	-	<0.1
405	MJ06	TPA	5	400-500	FP	CHIP	WQ	QU	L	7.30	4.10	1.80	-	-	-	-	0	0	0	N	-	-	-	<0.1
406	MJ06	TPA	5	400-500	DB	FRAGS	WQ	QU	E	6.80	4.40	1.30	-	-	-	-	0	0	0	N	-	-	-	<0.1

Artefact #	Site	Pit	Spit	Depth	Artefact Type	Pearce Artefact Type	Lithology	Pearce Lithology	Cross-section	Artefact Dimensions			Platform Type	Platform Dimensions		Termination	# Dorsal flake scars	Cortex %	Parallel Arrises	Retouch / Utilisation?	R/U Location	R/U Length	R/U Width	Weight (g)
										Length	Width	Depth		Length	Width									
407	MJ06	TPA	5	400-500	DB	FRAGS	WQ	QU	I	7.20	5.50	3.30	-	-	-	-	0	0	0	N	-	-	-	<0.1
408	MJ06	TPA	5	400-500	DB	FRAGS	WQ	QU	I	7.20	3.60	2.80	-	-	-	-	0	0	0	N	-	-	-	<0.1
409	MJ06	TPA	5	400-500	DB	FRAGS	WQ	QU	L	7.70	5.10	1.00	-	-	-	-	0	0	0	N	-	-	-	<0.1
410	MJ06	TPA	5	400-500	DB	FRAGS	WQ	QU	E	5.40	3.60	1.10	-	-	-	-	0	0	0	N	-	-	-	<0.1
411	MJ06	TPA	5	400-500	DB	FRAGS	WQ	QU	I	5.30	3.60	2.80	-	-	-	-	0	0	0	N	-	-	-	<0.1
412	MJ06	TPA	5	400-500	DB	FRAGS	WQ	QU	I	2.30	2.60	1.70	-	-	-	-	0	0	0	N	-	-	-	<0.1
413	MJ06	TPA	5	400-500	DB	FRAGS	WQ	QU	L	4.30	4.40	1.00	-	-	-	-	0	0	0	N	-	-	-	<0.1
414	MJ06	TPA	5	400-500	DB	FRAGS	WQ	QU	L	7.90	4.40	1.10	-	-	-	-	0	0	0	N	-	-	-	<0.1
415	MJ06	TPA	5	400-500	DB	FRAGS	WQ	QU	TB	5.20	4.20	2.10	-	-	-	-	0	0	0	N	-	-	-	<0.1
416	MJ06	TPA	5	400-500	DB	FRAGS	CQ	QU	L	4.70	3.80	0.90	-	-	-	-	0	0	0	N	-	-	-	<0.1
417	MJ06	TPA	5	400-500	DB	FRAGS	CQ	QU	E	4.60	3.60	1.90	-	-	-	-	0	0	0	N	-	-	-	<0.1
418	MJ06	TPA	5	400-500	DB	FRAGS	WQ	QU	E	6.20	2.40	1.40	-	-	-	-	0	0	0	N	-	-	-	<0.1
419	MJ06	TPA	5	400-500	DB	FRAGS	WQ	QU	E	5.40	3.50	1.30	-	-	-	-	0	0	0	N	-	-	-	<0.1
420	MJ06	TPA	5	400-500	DB	FRAGS	WQ	QU	L	8.20	3.60	1.00	-	-	-	-	0	0	0	N	-	-	-	<0.1
421	MJ06	TPA	5	400-500	DB	FRAGS	WQ	QU	E	4.80	3.70	1.20	-	-	-	-	0	0	0	N	-	-	-	<0.1
422	MJ06	TPA	5	400-500	DB	FRAGS	WQ	QU	E	3.90	3.20	1.10	-	-	-	-	0	0	0	N	-	-	-	<0.1
423	MJ06	TPA	5	400-500	DB	FRAGS	CQ	QU	E	4.70	2.90	1.50	-	-	-	-	0	0	0	N	-	-	-	<0.1
424	MJ06	TPA	5	400-500	DB	FRAGS	CQ	QU	I	6.30	3.40	3.20	-	-	-	-	0	0	0	N	-	-	-	<0.1
425	MJ06	TPA	5	400-500	DB	FRAGS	WQ	QU	I	5.40	3.60	2.30	-	-	-	-	0	0	0	N	-	-	-	<0.1
426	MJ06	TPA	5	400-500	DB	FRAGS	WQ	QU	L	5.50	3.40	1.40	-	-	-	-	0	0	0	N	-	-	-	<0.1
427	MJ06	TPA	5	400-500	DB	FRAGS	WQ	QU	E	6.10	2.80	1.30	-	-	-	-	0	0	0	N	-	-	-	<0.1
428	MJ06	TPA	5	400-500	DB	FRAGS	WQ	QU	L	5.80	5.00	2.00	-	-	-	-	0	0	0	N	-	-	-	<0.1
429	MJ06	TPA	5	400-500	DB	FRAGS	WQ	QU	TB	6.40	2.70	1.60	-	-	-	-	0	0	0	N	-	-	-	<0.1

Artefact #	Site	Pit	Spit	Depth	Artefact Type	Pearce Artefact Type	Lithology	Pearce Lithology	Cross-section	Artefact Dimensions			Platform Type	Platform Dimensions		Termination	# Dorsal flake scars	Cortex %	Parallel Arrises	Retouch / Utilisation?	R/U Location	R/U Length	R/U Width	Weight (g)
										Length	Width	Depth		Length	Width									
430	MJ06	TPA	5	400-500	DB	FRAGS	WQ	QU	L	5.60	3.70	1.10	-	-	-	-	0	0	0	N	-	-	-	<0.1
431	MJ06	TPA	5	400-500	DB	FRAGS	WQ	QU	TB	6.70	2.90	1.90	-	-	-	-	0	0	0	N	-	-	-	<0.1
432	MJ06	TPA	5	400-500	DB	FRAGS	CQ	QU	E	4.40	3.60	1.10	-	-	-	-	0	0	0	N	-	-	-	<0.1
433	MJ06	TPA	5	400-500	DB	FRAGS	WQ	QU	L	6.00	2.80	1.80	-	-	-	-	0	0	0	N	-	-	-	<0.1
434	MJ06	TPA	5	400-500	DB	FRAGS	CQ	QU	L	4.80	3.40	0.90	-	-	-	-	0	0	0	N	-	-	-	<0.1
435	MJ06	TPA	5	400-500	DB	FRAGS	WQ	QU	E	4.80	3.70	1.50	-	-	-	-	0	0	0	N	-	-	-	<0.1
436	MJ06	TPA	5	400-500	DB	FRAGS	WQ	QU	E	3.60	4.10	1.30	-	-	-	-	0	0	0	N	-	-	-	<0.1
437	MJ06	TPA	5	400-500	DB	FRAGS	WQ	QU	L	4.90	3.80	1.20	-	-	-	-	0	0	0	N	-	-	-	<0.1
438	MJ06	TPA	5	400-500	DB	FRAGS	CQ	QU	I	4.80	2.70	2.00	-	-	-	-	0	0	0	N	-	-	-	<0.1
439	MJ06	TPA	5	400-500	DB	FRAGS	WQ	QU	E	3.10	3.70	1.40	-	-	-	-	0	0	0	N	-	-	-	<0.1
440	MJ06	TPA	5	400-500	DB	FRAGS	CQ	QU	E	4.90	3.60	0.70	-	-	-	-	0	0	0	N	-	-	-	<0.1
441	MJ06	TPA	5	400-500	DB	FRAGS	WQ	QU	TG	5.60	3.40	1.10	-	-	-	-	0	0	0	N	-	-	-	<0.1
442	MJ06	TPA	5	400-500	DB	FRAGS	WQ	QU	TB	4.90	4.40	1.70	-	-	-	-	0	0	0	N	-	-	-	<0.1
443	MJ06	TPA	5	400-500	DB	FRAGS	WQ	QU	I	4.70	2.30	2.30	-	-	-	-	0	0	0	N	-	-	-	<0.1
444	MJ06	TPA	5	400-500	MPC	UNF	WQ	QU		See Core page														
445	MJ06	TPA	5	400-500	SPC	UNF	WQ	QU		See Core page														
446	MJ06	TPA	5	400-500	DB	FRAGS	WQ	QU	I	5.00	2.70	2.80	-	-	-	-	0	0	0	N	-	-	-	<0.1
447	MJ06	TPA	5	400-500	DB	FRAGS	WQ	QU	I	5.30	3.00	4.80	-	-	-	-	0	0	0	N	-	-	-	<0.1
448	MJ06	TPA	5	400-500	F	CHIP	WQ	QU	-	5.40	3.30	1.50	Focalised	-	-	Feather	2	0	1	N	-	-	-	<0.1
449	MJ06	TPA	5	400-500	LBF	CHIP	CQ	QU	-	5.90	2.10	0.70	Focalised	-	-	Feather	1	0	0	N	-	-	-	<0.1
450	MJ06	TPA	5	400-500	FP	CHIP	CQ	QU	TG	4.80	5.30	2.50	-	-	-	-	1	0	0	N	-	-	-	<0.1
451	MJ06	TPA	5	400-500	FP	CHIP	WQ	QU	E	5.00	4.00	1.50	-	-	-	-	2	0	1	N	-	-	-	<0.1
452	MJ06	TPA	5	400-500	FP	CHIP	CQ	QU	E	5.40	2.50	1.40	-	-	-	-	0	0	0	N	-	-	-	<0.1

Artefact #	Site	Pit	Spit	Depth	Artefact Type	Pearce Artefact Type	Lithology	Pearce Lithology	Cross-section	Artefact Dimensions			Platform Type	Platform Dimensions		Termination	# Dorsal flake scars	Cortex %	Parallel Arrises	Retouch / Utilisation?	R/U Location	R/U Length	R/U Width	Weight (g)
										Length	Width	Depth		Length	Width									
453	MJ06	TPA	5	400-500	FP	CHIP	CQ	QU	TG	4.50	2.60	1.80	-	-	-	-	2	0	1	N	-	-	-	<0.1
454	MJ06	TPA	5	400-500	DB	FRAGS	WQ	QU	E	2.90	1.20	3.10	-	-	-	-	0	0	0	N	-	-	-	<0.1
455	MJ06	TPA	5	400-500	DB	FRAGS	CQ	QU	L	5.20	2.80	1.00	-	-	-	-	0	0	0	N	-	-	-	<0.1
456	MJ06	TPA	5	400-500	DB	FRAGS	WQ	QU	I	5.60	3.40	1.60	-	-	-	-	0	0	0	N	-	-	-	<0.1
457	MJ06	TPA	5	400-500	DB	FRAGS	WQ	QU	L	5.20	3.90	1.10	-	-	-	-	0	0	0	N	-	-	-	<0.1
458	MJ06	TPA	5	400-500	DB	FRAGS	WQ	QU	I	4.40	3.60	2.90	-	-	-	-	0	0	0	N	-	-	-	<0.1
459	MJ06	TPA	5	400-500	DB	FRAGS	WQ	QU	E	4.70	3.60	1.00	-	-	-	-	0	0	0	N	-	-	-	<0.1
460	MJ06	TPA	5	400-500	F	CHIP	CQ	QU	-	4.70	2.50	1.00	Flaked	1.8	0.8	Feather	0	0	0	N	-	-	-	<0.1
461	MJ06	TPA	5	400-500	FP	CHIP	WQ	QU	I	4.70	3.00	1.50	-	-	-	-	0	0	0	N	-	-	-	<0.1
462	MJ06	TPA	5	400-500	DB	FRAGS	WQ	QU	E	5.30	2.50	1.00	-	-	-	-	0	0	0	N	-	-	-	<0.1
463	MJ06	TPA	5	400-500	DB	FRAGS	CQ	QU	E	3.80	2.60	0.70	-	-	-	-	0	0	0	N	-	-	-	<0.1
464	MJ06	TPA	5	400-500	DB	FRAGS	CQ	QU	E	4.40	2.30	0.90	-	-	-	-	0	0	0	N	-	-	-	<0.1
465	MJ06	TPA	5	400-500	DB	FRAGS	CQ	QU	L	4.50	3.30	0.90	-	-	-	-	0	0	0	N	-	-	-	<0.1
466	MJ06	TPA	5	400-500	DB	FRAGS	WQ	QU	I	4.00	1.10	0.90	-	-	-	-	0	0	0	N	-	-	-	<0.1
467	MJ06	TPA	5	400-500	DB	FRAGS	CQ	QU	TB	2.50	1.00	2.60	-	-	-	-	0	0	0	N	-	-	-	<0.1
468	MJ06	TPA	5	400-500	FP	CHIP	WQ	QU	L	2.80	3.30	0.50	-	-	-	-	0	0	0	N	-	-	-	<0.1
469	MJ06	TPA	5	400-500	DB	FRAGS	WQ	QU	TB	3.40	2.30	1.80	-	-	-	-	0	0	0	N	-	-	-	<0.1
470	MJ06	TPA	5	400-500	DB	FRAGS	WQ	QU	I	5.40	2.50	1.90	-	-	-	-	0	0	0	N	-	-	-	<0.1
471	MJ06	TPA	5	400-500	FP	CHIP	WQ	QU	I	3.20	2.80	1.10	-	-	-	-	0	0	0	N	-	-	-	<0.1
472	MJ06	TPA	5	400-500	DB	FRAGS	WQ	QU	I	4.00	3.90	1.50	-	-	-	-	0	0	0	N	-	-	-	<0.1
473	MJ06	TPA	5	400-500	FP	CHIP	WQ	QU	L	3.60	2.60	1.10	-	-	-	-	0	0	0	N	-	-	-	<0.1
474	MJ06	TPA	5	400-500	DB	FRAGS	CQ	QU	E	3.60	3.00	1.50	-	-	-	-	0	0	0	N	-	-	-	<0.1
475	MJ06	TPA	5	400-500	DB	FRAGS	CQ	QU	L	3.80	2.30	0.40	-	-	-	-	0	0	0	N	-	-	-	<0.1

Artefact #	Site	Pit	Spit	Depth	Artefact Type	Pearce Artefact Type	Lithology	Pearce Lithology	Cross-section	Artefact Dimensions			Platform Type	Platform Dimensions		Termination	# Dorsal flake scars	Cortex %	Parallel Arrises	Retouch / Utilisation?	R/U Location	R/U Length	R/U Width	Weight (g)
										Length	Width	Depth		Length	Width									
476	MJ06	TPA	5	400-500	DB	FRAGS	CQ	QU	E	2.30	1.80	0.30	-	-	-	-	0	0	0	N	-	-	-	<0.1
477	MJ06	TPA	5	400-500	DB	FRAGS	CQ	QU	TG	2.80	1.90	0.80	-	-	-	-	0	0	0	N	-	-	-	<0.1
478	MJ06	TPA	5	400-500	DB	FRAGS	WQ	QU	L	2.90	2.00	0.40	-	-	-	-	0	0	0	N	-	-	-	<0.1
479	MJ06	TPA	5	400-500	FP	CHIP	CQ	QU	E	3.70	2.80	1.20	-	-	-	-	0	0	0	N	-	-	-	<0.1
480	MJ06	TPA	5	400-500	DB	FRAGS	WQ	QU	TB	2.90	2.00	0.40	-	-	-	-	0	0	0	N	-	-	-	<0.1
481	MJ06	TPA	5	400-500	DB	FRAGS	WQ	QU	TG	3.60	2.40	2.00	-	-	-	-	0	0	0	N	-	-	-	<0.1
482	MJ06	TPA	5	400-500	DB	FRAGS	WQ	QU	I	4.10	2.10	1.10	-	-	-	-	0	0	0	N	-	-	-	<0.1
483	MJ06	TPA	5	400-500	DB	FRAGS	CQ	QU	E	2.00	2.30	0.70	-	-	-	-	0	0	0	N	-	-	-	<0.1
484	MJ06	TPA	5	400-500	DB	FRAGS	WQ	QU	E	2.60	2.60	0.70	-	-	-	-	0	0	0	N	-	-	-	<0.1
485	MJ06	TPA	5	400-500	DB	FRAGS	CQ	QU	E	2.90	2.60	1.10	-	-	-	-	0	0	0	N	-	-	-	<0.1
486	MJ06	TPA	5	400-500	DB	FRAGS	WQ	QU	I	3.50	2.90	1.50	-	-	-	-	0	0	0	N	-	-	-	<0.1
487	MJ06	TPA	5	400-500	DB	FRAGS	WQ	QU	E	4.10	3.30	1.50	-	-	-	-	0	0	0	N	-	-	-	<0.1
488	MJ06	TPA	5	400-500	DB	FRAGS	CQ	QU	L	3.10	2.80	0.70	-	-	-	-	0	0	0	N	-	-	-	<0.1
489	MJ06	TPA	5	400-500	DB	FRAGS	WQ	QU	I	3.50	2.30	1.80	-	-	-	-	0	0	0	N	-	-	-	<0.1
490	MJ06	TPA	5	400-500	DB	FRAGS	WQ	QU	I	1.70	2.30	0.90	-	-	-	-	0	0	0	N	-	-	-	<0.1
491	MJ06	TPA	5	400-500	DB	FRAGS	WQ	QU	I	2.70	1.20	0.30	-	-	-	-	0	0	0	N	-	-	-	<0.1
492	MJ06	TPA	5	400-500	DB	FRAGS	WQ	QU	E	3.70	2.00	0.90	-	-	-	-	0	0	0	N	-	-	-	<0.1
493	MJ06	TPA	5	400-500	DB	FRAGS	WQ	QU	TG	2.70	2.00	0.70	-	-	-	-	0	0	0	N	-	-	-	<0.1
494	MJ06	TPA	5	400-500	DB	FRAGS	CQ	QU	L	3.80	1.80	0.80	-	-	-	-	0	0	0	N	-	-	-	<0.1
495	MJ06	TPA	5	400-500	DB	FRAGS	WQ	QU	I	3.10	2.30	1.60	-	-	-	-	0	0	0	N	-	-	-	<0.1
496	MJ06	TPA	5	400-500	DB	FRAGS	WQ	QU	I	2.40	1.70	1.50	-	-	-	-	0	0	0	N	-	-	-	<0.1
497	MJ06	TPA	5	400-500	DB	FRAGS	WQ	QU	I	3.80	2.60	1.10	-	-	-	-	0	0	0	N	-	-	-	<0.1
498	MJ06	TPA	5	400-500	DB	FRAGS	CQ	QU	I	2.70	1.50	0.80	-	-	-	-	0	0	0	N	-	-	-	<0.1

Artefact #	Site	Pit	Spit	Depth	Artefact Type	Pearce Artefact Type	Lithology	Pearce Lithology	Cross-section	Artefact Dimensions			Platform Type	Platform Dimensions		Termination	# Dorsal flake scars	Cortex %	Parallel Arrises	Retouch / Utilisation?	R/U Location	R/U Length	R/U Width	Weight (g)
										Length	Width	Depth		Length	Width									
499	MJ06	TPA	5	400-500	DB	FRAGS	WQ	QU	TB	2.70	1.90	0.80	-	-	-	-	0	0	0	N	-	-	-	<0.1
500	MJ06	TPA	5	400-500	DB	FRAGS	WQ	QU	I	2.20	1.50	0.80	-	-	-	-	0	0	0	N	-	-	-	<0.1
501	MJ06	TPA	5	400-500	FP	CHIP	GR	OTHER	E	5.60	5.50	1.70	-	-	-	-	1	0	0	N	-	-	-	<0.1
502	MJ06	TPA	5	400-500	F	CHIP	GR	OTHER	-	4.50	5.60	1.20	Flaked	3.9	0.7	Hinge	1	0	0	N	-	-	-	<0.1
503	MJ06	TPA	5	400-500	FP	CHIP	GR	OTHER	TB	5.50	4.60	1.70	-	-	-	-	0	0	0	N	-	-	-	<0.1
504	MJ06	TPA	6	500-600	RUF	SES	SQ	QU	-	10.90	11.00	2.70	Faceted	6.2	2	Flaked	3	0	0	Y	LLM, DM	9.8, 10.8	1.7, 1.5	0.4
505	MJ06	TPA	6	500-600	FP	CHIP	WQ	QU	TB	12.50	7.70	4.90	-	-	-	-	1	0	0	N	-	-	-	0.5
506	MJ06	TPA	6	500-600	DB	FRAGS	WQ	QU	I	12.10	6.40	6.60	-	-	-	-	0	0	0	N	-	-	-	0.5
507	MJ06	TPA	6	500-600	FP	CHIP	WQ	QU	I	11.20	7.20	5.60	-	-	-	-	1	0	0	N	-	-	-	0.3
508	MJ06	TPA	6	500-600	F	CHIP	WQ	QU	-	11.20	13.70	4.40	Faceted	7.9	3.7	Feather	2	0	0	N	-	-	-	0.6
509	MJ06	TPA	6	500-600	FP	CHIP	WQ	QU	TB	12.90	3.30	3.10	-	-	-	-	1	0	0	N	-	-	-	0.2
510	MJ06	TPA	6	500-600	LBF	CHIP	WQ	QU	-	8.60	7.90	2.10	Cortical	6.9	2.9	Feather	0	0	0	N	-	-	-	0.2
511	MJ06	TPA	6	500-600	FP	CHIP	WQ	QU	I	9.10	6.20	3.70	-	-	-	-	1	0	0	N	-	-	-	0.3
512	MJ06	TPA	6	500-600	F	CHIP	WQ	QU	-	8.50	6.10	3.10	Flaked	5.5	3.2	Feather	2	0	0	N	-	-	-	0.2
513	MJ06	TPA	6	500-600	DB	FRAGS	CQ	QU	I	14.20	8.40	2.90	-	-	-	-	0	0	0	N	-	-	-	0.4
514	MJ06	TPA	6	500-600	PTBF	CHIP	WQ	QU	-	11.70	7.50	3.60	Flaked	7.2	4.1	Broken	0	0	0	N	-	-	-	0.4
515	MJ06	TPA	6	500-600	DB	FRAGS	WQ	QU	I	8.60	7.50	6.20	-	-	-	-	0	0	0	N	-	-	-	0.5
516	MJ06	TPA	6	500-600	PTBF	CHIP	CQ	QU	-	9.00	6.00	2.20	Flaked	3.4	3	Broken	1	0	0	N	-	-	-	0.2
517	MJ06	TPA	6	500-600	FP	CHIP	CQ	QU	TG	9.60	7.50	3.70	-	-	-	-	0	0	0	N	-	-	-	0.3
518	MJ06	TPA	6	500-600	FP	CHIP	WQ	QU	TG	10.30	5.10	2.70	-	-	-	-	0	0	0	N	-	-	-	0.1
519	MJ06	TPA	6	500-600	FP	CHIP	WQ	QU	L	11.70	7.00	2.00	-	-	-	-	1	0	0	N	-	-	-	0.1
520	MJ06	TPA	6	500-600	F	CHIP	CQ	QU	-	8.10	5.30	1.10	Flaked	3.1	1.1	Feather	2	0	0	N	-	-	-	<0.1

Artefact #	Site	Pit	Spit	Depth	Artefact Type	Pearce Artefact Type	Lithology	Pearce Lithology	Cross-section	Artefact Dimensions			Platform Type	Platform Dimensions		Termination	# Dorsal flake scars	Cortex %	Parallel Arrises	Retouch / Utilisation?	R/U Location	R/U Length	R/U Width	Weight (g)
										Length	Width	Depth		Length	Width									
521	MJ06	TPA	6	500-600	PTBF	CHIP	WQ	QU	-	12.10	4.90	2.30	Faceted	4.9	3	Broken	2	0	1	N	-	-	-	0.2
522	MJ06	TPA	6	500-600	F	CHIP	WQ	QU	-	8.70	5.50	1.90	Flaked	3.4	3	Feather	1	70	0	N	-	-	-	0.1
523	MJ06	TPA	6	500-600	PTBF	CHIP	CQ	QU	-	3.90	7.70	1.20	Focalised	-	-	Broken	0	0	0	N	-	-	-	<0.1
524	MJ06	TPA	6	500-600	FP	CHIP	WQ	QU	TB	9.50	4.00	1.10	-	-	-	-	2	0	1	N	-	-	-	<0.1
525	MJ06	TPA	6	500-600	F	CHIP	CQ	QU	-	8.10	7.10	1.70	Focalised	-	-	Feather	1	0	0	N	-	-	-	<0.1
526	MJ06	TPA	6	500-600	F	CHIP	WQ	QU	-	10.10	5.50	1.40	Flaked	4.8	1.6	Stepped	1	0	0	N	-	-	-	0.2
527	MJ06	TPA	6	500-600	FP	CHIP	WQ	QU	E	7.20	6.50	1.10	-	-	-	-	1	0	0	N	-	-	-	<0.1
528	MJ06	TPA	6	500-600	RUFP	UNF	CQ	QU	-	9.40	6.20	2.70	-	-	-	-	0	0	0	Y	1M	7.90	1.30	0.1
529	MJ06	TPA	6	500-600	DB	FRAGS	CQ	QU	E	7.20	6.90	0.90	-	-	-	-	0	0	0	N	-	-	-	<0.1
530	MJ06	TPA	6	500-600	FP	CHIP	CQ	QU	I	8.80	4.50	3.60	-	-	-	-	1	0	0	N	-	-	-	0.2
531	MJ06	TPA	6	500-600	DB	FRAGS	WQ	QU	E	7.00	6.20	1.50	-	-	-	-	0	0	0	N	-	-	-	<0.1
532	MJ06	TPA	6	500-600	F	CHIP	WQ	QU	-	6.60	5.40	1.40	Faceted	2.7	1.3	Hinge	1	0	0	N	-	-	-	<0.1
533	MJ06	TPA	6	500-600	FP	CHIP	CQ	QU	I	8.90	5.30	2.00	-	-	-	-	1	0	0	N	-	-	-	0.1
534	MJ06	TPA	6	500-600	FP	CHIP	CQ	QU	I	7.00	4.10	1.20	-	-	-	-	0	0	0	N	-	-	-	<0.1
535	MJ06	TPA	6	500-600	F	CHIP	WQ	QU	-	6.40	4.70	2.10	Flaked	4.7	2.3	Feather	2	0	0	N	-	-	-	<0.1
536	MJ06	TPA	6	500-600	FP	CHIP	CQ	QU	L	6.70	3.10	1.10	-	-	-	-	0	0	0	N	-	-	-	<0.1
537	MJ06	TPA	6	500-600	PTBF	CHIP	CQ	QU	-	4.50	5.30	1.00	Flaked	4.4	1.1	Broken	0	0	0	N	-	-	-	<0.1
538	MJ06	TPA	6	500-600	DB	FRAGS	CQ	QU	E	4.90	4.60	1.10	-	-	-	-	0	0	0	N	-	-	-	<0.1
539	MJ06	TPA	6	500-600	LBF	CHIP	CQ	QU	-	8.30	5.00	1.10	Focalised	-	-	Feather	1	0	0	N	-	-	-	<0.1
540	MJ06	TPA	6	500-600	DB	FRAGS	CQ	QU	TB	9.50	3.90	1.70	-	-	-	-	0	0	0	N	-	-	-	<0.1
541	MJ06	TPA	6	500-600	FP	CHIP	WQ	QU	I	8.20	4.60	3.10	-	-	-	-	1	0	0	N	-	-	-	<0.1
542	MJ06	TPA	6	500-600	DB	FRAGS	WQ	QU	TB	6.20	4.40	1.30	-	-	-	-	0	0	0	N	-	-	-	<0.1
543	MJ06	TPA	6	500-600	LBF	CHIP	CQ	QU	-	7.60	3.60	1.10	Focalised	-	-	Feather	1	0	0	N	-	-	-	<0.1

Artefact #	Site	Pit	Spit	Depth	Artefact Type	Pearce Artefact Type	Lithology	Pearce Lithology	Cross-section	Artefact Dimensions			Platform Type	Platform Dimensions		Termination	# Dorsal flake scars	Cortex %	Parallel Arrises	Retouch / Utilisation?	R/U Location	R/U Length	R/U Width	Weight (g)
										Length	Width	Depth		Length	Width									
544	MJ06	TPA	6	500-600	FP	CHIP	WQ	QU	TB	6.10	3.90	1.20	-	-	-	-	1	0	0	N	-	-	-	<0.1
545	MJ06	TPA	6	500-600	DB	FRAGS	WQ	QU	TG	4.10	4.30	2.70	-	-	-	-	0	0	0	N	-	-	-	<0.1
546	MJ06	TPA	6	500-600	DB	FRAGS	CQ	QU	L	4.60	5.10	0.80	-	-	-	-	0	0	0	N	-	-	-	<0.1
547	MJ06	TPA	6	500-600	DB	FRAGS	CQ	QU	L	5.70	4.60	1.80	-	-	-	-	0	0	0	N	-	-	-	<0.1
548	MJ06	TPA	6	500-600	F	CHIP	CQ	QU	-	5.00	4.60	1.20	Flaked	4.7	1	Feather	1	0	0	N	-	-	-	<0.1
549	MJ06	TPA	6	500-600	F	CHIP	CQ	QU	-	5.40	6.70	1.60	Cortical	4.2	1.8	Feather	1	0	0	N	-	-	-	<0.1
550	MJ06	TPA	6	500-600	DB	FRAGS	WQ	QU	I	6.10	2.20	1.40	-	-	-	-	0	0	0	N	-	-	-	<0.1
551	MJ06	TPA	6	500-600	F	CHIP	CQ	QU	-	3.80	5.20	2.00	Flaked	5.4	1.6	Feather	1	0	0	N	-	-	-	<0.1
552	MJ06	TPA	6	500-600	FP	CHIP	CQ	QU	I	7.10	2.20	1.10	-	-	-	-	0	0	0	N	-	-	-	<0.1
553	MJ06	TPA	6	500-600	DB	FRAGS	WQ	QU	I	5.10	3.20	1.60	-	-	-	-	0	0	0	N	-	-	-	<0.1
554	MJ06	TPA	6	500-600	DB	FRAGS	WQ	QU	I	5.50	4.50	1.60	-	-	-	-	0	0	0	N	-	-	-	<0.1
555	MJ06	TPA	6	500-600	LBF	CHIP	WQ	QU	-	9.40	2.80	1.40	Flaked	1.6	0.8	Feather	1	30	0	N	-	-	-	<0.1
556	MJ06	TPA	6	500-600	F	CHIP	CQ	QU	-	4.00	8.50	1.30	Flaked	2.3	0.7	Hinge	1	0	0	N	-	-	-	<0.1
557	MJ06	TPA	6	500-600	FP	CHIP	CQ	QU	E	6.90	3.00	1.00	-	-	-	-	1	0	0	N	-	-	-	<0.1
558	MJ06	TPA	6	500-600	DB	FRAGS	WQ	QU	I	6.60	4.40	1.80	-	-	-	-	0	0	0	N	-	-	-	<0.1
559	MJ06	TPA	6	500-600	FP	CHIP	WQ	QU	I	6.00	3.70	1.70	-	-	-	-	0	0	0	N	-	-	-	<0.1
560	MJ06	TPA	6	500-600	DB	FRAGS	CQ	QU	I	6.30	4.00	3.00	-	-	-	-	0	0	0	N	-	-	-	<0.1
561	MJ06	TPA	6	500-600	FP	CHIP	CQ	QU	L	4.40	5.80	1.60	-	-	-	-	0	0	0	N	-	-	-	<0.1
562	MJ06	TPA	6	500-600	FP	CHIP	WQ	QU	I	5.50	5.70	1.70	-	-	-	-	0	0	0	N	-	-	-	<0.1
563	MJ06	TPA	6	500-600	LBF	CHIP	CQ	QU	-	6.70	3.70	1.20	Flaked	3.8	0.8	Feather	1	0	0	N	-	-	-	<0.1
564	MJ06	TPA	6	500-600	DB	FRAGS	WQ	QU	I	6.00	4.20	2.00	-	-	-	-	0	0	0	N	-	-	-	<0.1
565	MJ06	TPA	6	500-600	F	CHIP	CQ	QU	-	6.90	2.80	1.20	Flaked	3.5	1.8	Feather	2	0	0	N	-	-	-	<0.1
566	MJ06	TPA	6	500-600	DB	FRAGS	CQ	QU	I	7.00	3.40	2.10	-	-	-	-	0	0	0	N	-	-	-	<0.1

Artefact #	Site	Pit	Spit	Depth	Artefact Type	Pearce Artefact Type	Lithology	Pearce Lithology	Cross-section	Artefact Dimensions			Platform Type	Platform Dimensions		Termination	# Dorsal flake scars	Cortex %	Parallel Arrises	Retouch / Utilisation?	R/U Location	R/U Length	R/U Width	Weight (g)
										Length	Width	Depth		Length	Width									
567	MJ06	TPA	6	500-600	FP	CHIP	CQ	QU	L	6.00	2.30	0.80	-	-	-	-	0	0	0	N	-	-	-	<0.1
568	MJ06	TPA	6	500-600	DB	FRAGS	WQ	QU	E	5.30	4.00	0.70	-	-	-	-	0	0	0	N	-	-	-	<0.1
569	MJ06	TPA	6	500-600	DB	FRAGS	CQ	QU	L	7.20	2.90	0.90	-	-	-	-	0	0	0	N	-	-	-	<0.1
570	MJ06	TPA	6	500-600	DB	FRAGS	CQ	QU	TB	6.10	2.00	1.60	-	-	-	-	0	0	0	N	-	-	-	<0.1
571	MJ06	TPA	6	500-600	F	CHIP	CQ	QU	-	4.60	3.00	1.30	Flaked	2.9	1.4	Stepped	1	0	0	N	-	-	-	<0.1
572	MJ06	TPA	6	500-600	DB	FRAGS	CQ	QU	E	4.40	3.30	1.00	-	-	-	-	0	0	0	N	-	-	-	<0.1
573	MJ06	TPA	6	500-600	DB	FRAGS	WQ	QU	E	4.20	4.70	1.40	-	-	-	-	0	0	0	N	-	-	-	<0.1
574	MJ06	TPA	6	500-600	DB	FRAGS	WQ	QU	L	6.70	2.70	0.80	-	-	-	-	0	0	0	N	-	-	-	<0.1
575	MJ06	TPA	6	500-600	DB	FRAGS	WQ	QU	L	5.70	3.20	1.00	-	-	-	-	0	0	0	N	-	-	-	<0.1
576	MJ06	TPA	6	500-600	MPC	UNF	WQ	QU		See Core page														
577	MJ06	TPA	6	500-600	MPC	UNF	WQ	QU		See Core page														
578	MJ06	TPA	6	500-600	MPC	UNF	SQ	QU		See Core page														
579	MJ06	TPA	6	500-600	FP	CHIP	CQ	QU	I	7.70	2.30	1.20	-	-	-	-	1	0	0	N	-	-	-	<0.1
580	MJ06	TPA	6	500-600	DB	CHIP	CQ	QU	E	5.20	2.50	1.00	-	-	-	-	0	0	0	N	-	-	-	<0.1
581	MJ06	TPA	6	500-600	PTBF	CHIP	CQ	QU	-	3.20	4.90	1.30	Flaked	3.7	1.3	Broken	1	0	0	N	-	-	-	<0.1
582	MJ06	TPA	6	500-600	FP	CHIP	CQ	QU	TG	4.00	2.50	1.70	-	-	-	-	0	0	0	N	-	-	-	<0.1
583	MJ06	TPA	6	500-600	FP	CHIP	CQ	QU	I	4.20	4.80	1.20	-	-	-	-	1	0	0	N	-	-	-	<0.1
584	MJ06	TPA	6	500-600	FP	CHIP	CQ	QU	E	5.80	2.70	1.10	-	-	-	-	0	0	0	N	-	-	-	<0.1
585	MJ06	TPA	6	500-600	DB	FRAGS	WQ	QU	I	3.10	3.10	2.50	-	-	-	-	0	0	0	N	-	-	-	<0.1
586	MJ06	TPA	6	500-600	DB	FRAGS	CQ	QU	L	6.00	2.90	0.90	-	-	-	-	0	0	0	N	-	-	-	<0.1
587	MJ06	TPA	6	500-600	DB	FRAGS	CQ	QU	I	5.20	3.40	1.30	-	-	-	-	0	0	0	N	-	-	-	<0.1
588	MJ06	TPA	6	500-600	DB	FRAGS	WQ	QU	E	4.30	3.10	0.90	-	-	-	-	0	0	0	N	-	-	-	<0.1

Artefact #	Site	Pit	Spit	Depth	Artefact Type	Pearce Artefact Type	Lithology	Pearce Lithology	Cross-section	Artefact Dimensions			Platform Type	Platform Dimensions		Termination	# Dorsal flake scars	Cortex %	Parallel Arrises	Retouch / Utilisation?	R/U Location	R/U Length	R/U Width	Weight (g)
										Length	Width	Depth		Length	Width									
589	MJ06	TPA	6	500-600	DB	FRAGS	WQ	QU	I	4.80	4.00	1.40	-	-	-	-	0	0	0	N	-	-	-	<0.1
590	MJ06	TPA	6	500-600	DB	FRAGS	CQ	QU	E	5.40	2.50	0.70	-	-	-	-	0	0	0	N	-	-	-	<0.1
591	MJ06	TPA	6	500-600	DB	FRAGS	WQ	QU	E	5.90	3.90	1.30	-	-	-	-	0	0	0	N	-	-	-	<0.1
592	MJ06	TPA	6	500-600	DB	FRAGS	CQ	QU	L	5.30	3.70	0.60	-	-	-	-	0	0	0	N	-	-	-	<0.1
593	MJ06	TPA	6	500-600	DB	FRAGS	CQ	QU	E	4.30	4.20	1.00	-	-	-	-	0	0	0	N	-	-	-	<0.1
594	MJ06	TPA	6	500-600	DB	FRAGS	CQ	QU	E	5.90	3.50	0.80	-	-	-	-	0	0	0	N	-	-	-	<0.1
595	MJ06	TPA	6	500-600	DB	FRAGS	WQ	QU	I	4.90	3.70	0.80	-	-	-	-	0	0	0	N	-	-	-	<0.1
596	MJ06	TPA	6	500-600	DB	FRAGS	WQ	QU	E	4.50	3.10	1.40	-	-	-	-	0	0	0	N	-	-	-	<0.1
597	MJ06	TPA	6	500-600	DB	FRAGS	CQ	QU	E	6.60	2.60	1.90	-	-	-	-	0	0	0	N	-	-	-	<0.1
598	MJ06	TPA	6	500-600	DB	FRAGS	CQ	QU	E	5.00	3.20	0.70	-	-	-	-	0	0	0	N	-	-	-	<0.1
599	MJ06	TPA	6	500-600	DB	FRAGS	CQ	QU	E	3.90	3.40	0.90	-	-	-	-	0	0	0	N	-	-	-	<0.1
600	MJ06	TPA	6	500-600	FP	CHIP	CQ	QU	E	4.40	3.30	1.50	-	-	-	-	0	0	0	N	-	-	-	<0.1
601	MJ06	TPA	6	500-600	DB	FRAGS	CQ	QU	I	3.80	2.70	1.80	-	-	-	-	0	0	0	N	-	-	-	<0.1
602	MJ06	TPA	6	500-600	DB	FRAGS	WQ	QU	I	4.00	3.40	0.80	-	-	-	-	0	0	0	N	-	-	-	<0.1
603	MJ06	TPA	6	500-600	DB	FRAGS	WQ	QU	TG	6.60	2.40	1.70	-	-	-	-	0	0	0	N	-	-	-	<0.1
604	MJ06	TPA	6	500-600	FP	CHIP	CQ	QU	E	5.50	2.40	1.20	-	-	-	-	0	0	0	N	-	-	-	<0.1
605	MJ06	TPA	6	500-600	DB	FRAGS	WQ	QU	I	3.00	3.70	1.00	-	-	-	-	0	0	0	N	-	-	-	<0.1
606	MJ06	TPA	6	500-600	DB	FRAGS	CQ	QU	L	3.60	3.20	0.70	-	-	-	-	0	0	0	N	-	-	-	<0.1
607	MJ06	TPA	6	500-600	DB	FRAGS	WQ	QU	TB	3.90	2.50	0.70	-	-	-	-	0	0	0	N	-	-	-	<0.1
608	MJ06	TPA	6	500-600	DB	FRAGS	WQ	QU	TG	4.60	2.60	2.20	-	-	-	-	0	0	0	N	-	-	-	<0.1
609	MJ06	TPA	6	500-600	DB	FRAGS	CQ	QU	L	5.20	3.30	1.00	-	-	-	-	0	0	0	N	-	-	-	<0.1
610	MJ06	TPA	6	500-600	DB	FRAGS	WQ	QU	I	4.90	2.30	1.90	-	-	-	-	0	0	0	N	-	-	-	<0.1
611	MJ06	TPA	6	500-600	DB	FRAGS	CQ	QU	E	4.70	2.00	0.70	-	-	-	-	0	0	0	N	-	-	-	<0.1

Artefact #	Site	Pit	Spit	Depth	Artefact Type	Pearce Artefact Type	Lithology	Pearce Lithology	Cross-section	Artefact Dimensions			Platform Type	Platform Dimensions		Termination	# Dorsal flake scars	Cortex %	Parallel Arrises	Retouch / Utilisation?	R/U Location	R/U Length	R/U Width	Weight (g)
										Length	Width	Depth		Length	Width									
612	MJ06	TPA	6	500-600	DB	FRAGS	CQ	QU	E	3.10	2.30	1.10	-	-	-	-	0	0	0	N	-	-	-	<0.1
613	MJ06	TPA	6	500-600	PTBF	CHIP	CQ	QU	-	4.90	3.20	1.80	Facalised	-	-	Broken	1	0	0	N	-	-	-	<0.1
614	MJ06	TPA	6	500-600	F	CHIP	CQ	QU	-	3.10	5.40	1.50	Flaked	4.3	1.5	Feather	1	0	0	N	-	-	-	<0.1
615	MJ06	TPA	6	500-600	DB	FRAGS	WQ	QU	E	4.30	1.00	1.00	-	-	-	-	0	0	0	N	-	-	-	<0.1
616	MJ06	TPA	6	500-600	DB	FRAGS	WQ	QU	I	5.60	2.00	1.20	-	-	-	-	0	0	0	N	-	-	-	<0.1
617	MJ06	TPA	6	500-600	DB	FRAGS	WQ	QU	I	4.70	3.40	1.50	-	-	-	-	0	0	0	N	-	-	-	<0.1
618	MJ06	TPA	6	500-600	DB	FRAGS	WQ	QU	TB	4.60	3.50	0.90	-	-	-	-	0	0	0	N	-	-	-	<0.1
619	MJ06	TPA	6	500-600	DB	FRAGS	CQ	QU	E	4.50	4.50	1.40	-	-	-	-	0	0	0	N	-	-	-	<0.1
620	MJ06	TPA	6	500-600	DB	FRAGS	CQ	QU	TG	3.90	2.80	1.00	-	-	-	-	0	0	0	N	-	-	-	<0.1
621	MJ06	TPA	6	500-600	DB	FRAGS	CQ	QU	I	5.50	2.50	1.40	-	-	-	-	0	0	0	N	-	-	-	<0.1
622	MJ06	TPA	6	500-600	DB	FRAGS	WQ	QU	TG	3.60	2.10	2.20	-	-	-	-	0	0	0	N	-	-	-	<0.1
623	MJ06	TPA	6	500-600	DB	FRAGS	WQ	QU	I	4.60	2.50	2.00	-	-	-	-	0	0	0	N	-	-	-	<0.1
624	MJ06	TPA	6	500-600	DB	FRAGS	WQ	QU	TB	4.70	3.10	1.30	-	-	-	-	0	0	0	N	-	-	-	<0.1
625	MJ06	TPA	6	500-600	DB	FRAGS	WQ	QU	L	4.10	3.10	0.80	-	-	-	-	0	0	0	N	-	-	-	<0.1
626	MJ06	TPA	6	500-600	DB	FRAGS	WQ	QU	I	2.50	2.30	1.10	-	-	-	-	0	0	0	N	-	-	-	<0.1
627	MJ06	TPA	6	500-600	DB	FRAGS	CQ	QU	L	4.80	4.60	0.40	-	-	-	-	0	0	0	N	-	-	-	<0.1
628	MJ06	TPA	6	500-600	FP	CHIP	CQ	QU	L	3.80	2.80	0.80	-	-	-	-	0	0	0	N	-	-	-	<0.1
629	MJ06	TPA	7	600-700	FP	CHIP	WQ	QU	E	18.60	6.10	3.70	-	-	-	-	0	0	0	N	-	-	-	0.5
630	MJ06	TPA	7	600-700	PTBF	CHIP	WQ	QU	-	6.80	3.90	2.00	Flaked	2.4	1.4	Broken	2	0	0	N	-	-	-	<0.1
631	MJ06	TPA	7	600-700	PTBF	CHIP	WQ	QU	-	9.90	4.20	1.20	Flaked	5	1.1	Broken	2	0	1	N	-	-	-	<0.1
632	MJ06	TPA	7	600-700	F	CHIP	WQ	QU	-	8.60	6.20	1.80	Flaked	6.4	2	Feather	1	0	0	N	-	-	-	<0.1
633	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	E	2.60	3.20	1.40	-	-	-	-	0	0	0	N	-	-	-	<0.1
634	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	I	6.10	3.00	2.90	-	-	-	-	0	0	0	N	-	-	-	<0.1

Artefact #	Site	Pit	Spit	Depth	Artefact Type	Pearce Artefact Type	Lithology	Pearce Lithology	Cross-section	Artefact Dimensions			Platform Type	Platform Dimensions		Termination	# Dorsal flake scars	Cortex %	Parallel Arrises	Retouch / Utilisation?	R/U Location	R/U Length	R/U Width	Weight (g)
										Length	Width	Depth		Length	Width									
635	MJ06	TPA	7	600-700	FP	CHIP	CQ	QU	E	6.80	2.80	1.70	-	-	-	-	0	0	0	N	-	-	-	<0.1
636	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	E	4.50	3.60	1.00	-	-	-	-	0	0	0	N	-	-	-	<0.1
637	MJ06	TPA	7	600-700	PTBF	CHIP	WQ	QU	-	5.50	7.60	2.10	Flaked	4.6	1.3	Broken	1	0	0	N	-	-	-	<0.1
638	MJ06	TPA	7	600-700	PTBF	CHIP	WQ	QU	-	7.00	7.50	1.70	Flaked	4.8	1.5	Broken	1	0	1	N	-	-	-	<0.1
639	MJ06	TPA	7	600-700	F	CHIP	WQ	QU	-	8.00	6.10	1.80	Flaked	3.9	1.5	Stepped	1	0	0	N	-	-	-	0.1
640	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	TG	13.10	10.20	4.40	-	-	-	-	0	0	0	N	-	-	-	0.4
641	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	I	9.70	6.10	2.80	-	-	-	-	0	0	0	N	-	-	-	0.2
642	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	I	18.90	12.00	6.00	-	-	-	-	0	0	0	N	-	-	-	1.3
643	MJ06	TPA	7	600-700	FP	CHIP	CQ	QU	I	8.50	5.80	4.10	-	-	-	-	0	0	0	N	-	-	-	0.2
644	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	TB	7.60	6.60	2.60	-	-	-	-	0	0	0	N	-	-	-	0.2
645	MJ06	TPA	7	600-700	FP	CHIP	WQ	QU	E	10.60	6.70	2.70	-	-	-	-	0	0	0	N	-	-	-	0.3
646	MJ06	TPA	7	600-700	F	FLAKE	WQ	QU	-	20.70	19.90	3.80	Flaked	10.2	2.4	Feather	3	0	0	N	-	-	-	2.2
647	MJ06	TPA	7	600-700	FP	CHIP	WQ	QU	TG	13.50	10.50	7.00	-	-	-	-	1	0	0	N	-	-	-	0.5
648	MJ06	TPA	7	600-700	F	CHIP	WQ	QU	-	11.50	9.60	3.00	Flaked	9.2	2.7	Feather	1	0	0	N	-	-	-	0.4
649	MJ06	TPA	7	600-700	FP	CHIP	WQ	QU	-	14.50	8.40	4.60	-	-	-	-	2	0	1	N	-	-	-	0.4
650	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	I	14.20	7.40	1.70	-	-	-	-	0	0	0	N	-	-	-	0.2
651	MJ06	TPA	7	600-700	F	FLAKE	WQ	QU	-	15.30	15.20	5.10	Flaked	7.7	3.1	Stepped	2	50	0	N	-	-	-	1
652	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	TG	11.20	5.50	3.60	-	-	-	-	0	0	0	N	-	-	-	0.3
653	MJ06	TPA	7	600-700	F	CHIP	CQ	QU	-	9.50	12.20	2.20	Flaked	7.9	0.8	Feather	1	0	0	N	-	-	-	0.2
654	MJ06	TPA	7	600-700	FP	CHIP	WQ	QU	I	14.30	6.60	4.30	-	-	-	-	1	0	0	N	-	-	-	0.5
655	MJ06	TPA	7	600-700	F	CHIP	WQ	QU	-	7.30	7.60	2.50	Flaked	6.9	1.3	Feather	2	0	0	N	-	-	-	0.2
656	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	TB	6.60	6.10	3.60	-	-	-	-	0	0	0	N	-	-	-	0.2
657	MJ06	TPA	7	600-700	PTBF	CHIP	WQ	QU	-	9.20	6.20	2.50	Flaked	4.1	1.9	Broken	2	0	1	N	-	-	-	0.2

Artefact #	Site	Pit	Spit	Depth	Artefact Type	Pearce Artefact Type	Lithology	Pearce Lithology	Cross-section	Artefact Dimensions			Platform Type	Platform Dimensions		Termination	# Dorsal flake scars	Cortex %	Parallel Arrises	Retouch / Utilisation?	R/U Location	R/U Length	R/U Width	Weight (g)
										Length	Width	Depth		Length	Width									
658	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	L	11.60	5.00	2.20	-	-	-	-	0	50	0	N	-	-	-	0.1
659	MJ06	TPA	7	600-700	F	CHIP	WQ	QU	-	6.20	7.50	2.40	Focalised	-	-	Feather	2	0	0	N	-	-	-	0.1
660	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	I	15.00	8.40	3.90	-	-	-	-	0	0	0	N	-	-	-	0.5
661	MJ06	TPA	7	600-700	F	CHIP	WQ	QU	-	10.40	16.10	4.80	Faceted	14	4.8	Feather	2	0	0	N	-	-	-	1.3
662	MJ06	TPA	7	600-700	F	CHIP	CQ	QU	-	11.90	8.90	1.90	Focalised	-	-	Feather	2	0	0	N	-	-	-	0.2
663	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	I	8.90	6.90	3.80	-	-	-	-	0	0	0	N	-	-	-	0.3
664	MJ06	TPA	7	600-700	FP	CHIP	WQ	QU	E	11.90	9.30	3.80	-	-	-	-	0	0	0	N	-	-	-	0.5
665	MJ06	TPA	7	600-700	FP	CHIP	WQ	QU	E	13.00	6.50	3.40	-	-	-	-	0	0	0	N	-	-	-	0.3
666	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	I	10.60	6.00	2.30	-	-	-	-	0	0	0	N	-	-	-	0.2
667	MJ06	TPA	7	600-700	PTBF	CHIP	WQ	QU	-	10.1	17.10	4.50	Faceted	9.9	3.6	Broken	2	0	0	N	-	-	-	0.7
668	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	I	10.80	6.10	7.00	-	-	-	-	0	0	0	N	-	-	-	0.6
669	MJ06	TPA	7	600-700	FP	CHIP	CQ	QU	E	9.00	5.80	2.10	-	-	-	-	0	0	0	N	-	-	-	<0.1
670	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	I	17.70	10.10	5.80	-	-	-	-	0	0	0	N	-	-	-	0.8
671	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	I	7.50	8.50	5.20	-	-	-	-	0	0	0	N	-	-	-	0.5
672	MJ06	TPA	7	600-700	LBF/TBF	CHIP	CQ	QU	-	9.00	11.80	2.40	Flaked	4.4	1.2	Broken	2	0	0	N	-	-	-	0.3
673	MJ06	TPA	7	600-700	FP	CHIP	CQ	QU	E	9.40	6.90	1.60	-	-	-	-	0	0	0	N	-	-	-	0.1
674	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	TG	10.30	5.10	5.60	-	-	-	-	0	0	0	N	-	-	-	0.2
675	MJ06	TPA	7	600-700	FP	CHIP	WQ	QU	E	11.70	9.90	2.50	-	-	-	-	0	0	0	N	-	-	-	0.3
676	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	TB	9.00	7.50	2.00	-	-	-	-	0	0	0	N	-	-	-	0.2
677	MJ06	TPA	7	600-700	F	CHIP	WQ	QU	-	8.90	11.70	1.90	Focalised	-	-	Feather	2	0	0	N	-	-	-	0.2
678	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	E	15.50	7.10	1.60	-	-	-	-	0	0	0	N	-	-	-	0.4
679	MJ06	TPA	7	600-700	F	CHIP	CQ	QU	-	11.40	11.60	4.40	Flaked	6.9	1.8	Stepped	2	10	1	N	-	-	-	0.5
680	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	TB	24.90	14.20	3.90	-	-	-	-	0	0	0	N	-	-	-	1.4

Artefact #	Site	Pit	Spit	Depth	Artefact Type	Pearce Artefact Type	Lithology	Pearce Lithology	Cross-section	Artefact Dimensions			Platform Type	Platform Dimensions		Termination	# Dorsal flake scars	Cortex %	Parallel Arrises	Retouch / Utilisation?	R/U Location	R/U Length	R/U Width	Weight (g)
										Length	Width	Depth		Length	Width									
681	MJ06	TPA	7	600-700	FP	CHIP	WQ	QU	I	14.00	14.10	3.90	-	-	-	-	0	0	0	N	-	-	-	1.1
682	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	I	16.80	14.30	4.00	-	-	-	-	0	0	0	N	-	-	-	1.1
683	MJ06	TPA	7	600-700	F	CHIP	CQ	QU	-	10.00	11.20	2.60	Focalised	-	-	Feather	1	0	0	N	-	-	-	0.3
684	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	I	11.00	12.30	4.80	-	-	-	-	0	0	0	N	-	-	-	0.5
685	MJ06	TPA	7	600-700	FP	CHIP	WQ	QU	TG	12.30	8.80	4.90	-	-	-	-	0	0	0	N	-	-	-	0.6
686	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	TG	8.80	7.80	8.60	-	-	-	-	0	0	0	N	-	-	-	0.5
687	MJ06	TPA	7	600-700	FP	FP	WQ	QU	L	19.50	8.90	2.30	-	-	-	-	0	0	0	N	-	-	-	0.6
688	MJ06	TPA	7	600-700	FP	CHIP	WQ	QU	TG	11.60	5.60	4.40	-	-	-	-	0	0	0	N	-	-	-	0.2
689	MJ06	TPA	7	600-700	FP	CHIP	WQ	QU	E	9.10	7.60	1.90	-	-	-	-	0	0	0	N	-	-	-	0.2
690	MJ06	TPA	7	600-700	F	CHIP	WQ	QU	-	10.70	7.70	4.30	Flaked	6.9	3.4	Stepped	2	20	0	N	-	-	-	0.4
691	MJ06	TPA	7	600-700	FP	CHIP	WQ	QU	TG	8.20	7.10	4.40	-	-	-	-	0	0	0	N	-	-	-	0.3
692	MJ06	TPA	7	600-700	FP	CHIP	WQ	QU	I	10.30	8.30	3.30	-	-	-	-	1	0	0	N	-	-	-	0.3
693	MJ06	TPA	7	600-700	F	CHIP	WQ	QU	-	10.80	12.90	3.50	Flaked	9.9	3.6	Feather	2	0	0	N	-	-	-	0.5
694	MJ06	TPA	7	600-700	F	CHIP	WQ	QU	-	13.30	11.10	4.60	Flaked	9.2	4.6	Feather	3	0	0	N	-	-	-	0.7
695	MJ06	TPA	7	600-700	FP	CHIP	WQ	QU	I	11.40	9.20	4.90	-	-	-	-	2	0	0	N	-	-	-	0.6
696	MJ06	TPA	7	600-700	F	CHIP	WQ	QU	-	7.30	8.90	2.20	Flaked	7.3	2	Feather	1	50	0	N	-	-	-	0.2
697	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	L	10.70	6.70	2.50	-	-	-	-	0	0	0	N	-	-	-	0.2
698	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	TG	12.90	5.50	5.00	-	-	-	-	0	0	0	N	-	-	-	0.4
699	MJ06	TPA	7	600-700	FP	CHIP	WQ	QU	E	11.90	11.10	3.90	-	-	-	-	0	0	0	N	-	-	-	0.5
700	MJ06	TPA	7	600-700	FP	CHIP	WQ	QU	E	12.30	12.40	4.70	-	-	-	-	1	0	0	N	-	-	-	0.9
701	MJ06	TPA	7	600-700	FP	CHIP	WQ	QU	E	9.70	7.50	2.70	-	-	-	-	0	0	0	N	-	-	-	0.2
702	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	I	14.10	11.00	2.40	-	-	-	-	0	0	0	N	-	-	-	0.3
703	MJ06	TPA	7	600-700	DB	FRAGS	SQ	QU	I	12.10	4.30	3.70	-	-	-	-	0	0	0	N	-	-	-	0.3

Artefact #	Site	Pit	Spit	Depth	Artefact Type	Pearce Artefact Type	Lithology	Pearce Lithology	Cross-section	Artefact Dimensions			Platform Type	Platform Dimensions		Termination	# Dorsal flake scars	Cortex %	Parallel Arrises	Retouch / Utilisation?	R/U Location	R/U Length	R/U Width	Weight (g)
										Length	Width	Depth		Length	Width									
704	MJ06	TPA	7	600-700	FP	FP	WQ	QU	I	15.60	7.10	4.00	-	-	-	-	1	0	0	N	-	-	-	0.5
705	MJ06	TPA	7	600-700	FP	FP	WQ	QU	E	15.30	15.00	3.70	-	-	-	-	0	0	0	N	-	-	-	1
706	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	TG	9.10	3.20	5.60	-	-	-	-	0	0	0	N	-	-	-	0.1
707	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	I	11.40	6.40	2.60	-	-	-	-	0	0	0	N	-	-	-	0.3
708	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	I	10.50	7.10	4.60	-	-	-	-	0	0	0	N	-	-	-	0.3
709	MJ06	TPA	7	600-700	FP	CHIP	WQ	QU	L	9.60	6.70	1.70	-	-	-	-	0	0	0	N	-	-	-	0.2
710	MJ06	TPA	7	600-700	FP	CHIP	WQ	QU	I	11.50	4.00	3.80	-	-	-	-	0	0	0	N	-	-	-	0.2
711	MJ06	TPA	7	600-700	FP	CHIP	WQ	QU	E	13.00	6.90	1.80	-	-	-	-	0	0	0	N	-	-	-	0.3
712	MJ06	TPA	7	600-700	FP	CHIP	WQ	QU	I	8.70	7.70	2.60	-	-	-	-	1	0	0	N	-	-	-	0.2
713	MJ06	TPA	7	600-700	FP	CHIP	WQ	QU	I	11.10	9.40	3.20	-	-	-	-	2	0	0	N	-	-	-	0.6
714	MJ06	TPA	7	600-700	F	CHIP	WQ	QU	-	10.20	8.30	2.60	Flaked	8.8	4	Feather	2	0	0	N	-	-	-	0.3
715	MJ06	TPA	7	600-700	F	CHIP	WQ	QU	-	9.80	12.30	2.80	Flaked	7.3	1.7	Feather	3	0	0	N	-	-	-	0.3
716	MJ06	TPA	7	600-700	F	CHIP	CQ	QU	-	9.40	9.00	2.30	Faceted	6.5	2.9	Feather	1	0	0	N	-	-	-	0.2
717	MJ06	TPA	7	600-700	LBF	CHIP	WQ	QU	-	11.90	12.30	2.20	Flaked	6.9	3	Feather	1	0	0	N	-	-	-	0.5
718	MJ06	TPA	7	600-700	F	CHIP	WQ	QU	-	9.30	9.30	3.10	Flaked	7.8	2.7	Feather	2	0	0	N	-	-	-	0.3
719	MJ06	TPA	7	600-700	FP	FP	WQ	QU	I	18.90	7.20	2.50	-	-	-	-	0	0	0	N	-	-	-	0.5
720	MJ06	TPA	7	600-700	FP	CHIP	SQ	QU	I	6.70	3.80	3.50	-	-	-	-	0	0	0	N	-	-	-	0.2
721	MJ06	TPA	7	600-700	FP	CHIP	WQ	QU	E	12.60	9.60	3.40	-	-	-	-	2	0	0	N	-	-	-	0.5
722	MJ06	TPA	7	600-700	FP	CHIP	WQ	QU	E	9.30	8.20	3.40	-	-	-	-	1	0	0	N	-	-	-	0.3
723	MJ06	TPA	7	600-700	LBF	CHIP	CQ	QU	-	14.00	6.20	3.00	-	-	-	Feather	2	0	0	N	-	-	-	0.3
724	MJ06	TPA	7	600-700	PTBF	CHIP	WQ	QU	-	8.50	14.30	1.90	Faceted	8.2	3.1	Broken	1	10	0	N	-	-	-	0.3
725	MJ06	TPA	7	600-700	F	CHIP	WQ	QU	-	9.90	7.00	3.80	Flaked	4.6	1	Feather	1	70	0	N	-	-	-	0.3
726	MJ06	TPA	7	600-700	F	CHIP	CQ	QU	-	5.90	11.40	2.90	Flaked	11.3	3	Feather	2	0	0	N	-	-	-	0.2

Artefact #	Site	Pit	Spit	Depth	Artefact Type	Pearce Artefact Type	Lithology	Pearce Lithology	Cross-section	Artefact Dimensions			Platform Type	Platform Dimensions		Termination	# Dorsal flake scars	Cortex %	Parallel Arrises	Retouch / Utilisation?	R/U Location	R/U Length	R/U Width	Weight (g)
										Length	Width	Depth		Length	Width									
727	MJ06	TPA	7	600-700	F	CHIP	CQ	QU	-	8.40	13.90	1.80	Flaked	8.5	1.7	Feather	1	0	0	N	-	-	-	0.3
728	MJ06	TPA	7	600-700	FP	CHIP	WQ	QU	I	11.40	4.90	3.40	-	-	-	Feather	1	0	0	N	-	-	-	0.2
729	MJ06	TPA	7	600-700	F	CHIP	CQ	QU	-	8.90	5.60	1.50	Faceted	4.5	2.3	Feather	2	0	0	N	-	-	-	0.1
730	MJ06	TPA	7	600-700	FP	CHIP	CQ	QU	L	8.10	5.50	2.10	-	-	-	-	0	0	0	N	-	-	-	0.2
731	MJ06	TPA	7	600-700	FP	CHIP	WQ	QU	E	7.60	7.50	4.20	-	-	-	-	1	0	1	N	-	-	-	0.3
732	MJ06	TPA	7	600-700	FP	CHIP	CQ	QU	E	9.10	5.10	2.00	-	-	-	-	1	0	0	N	-	-	-	<0.1
733	MJ06	TPA	7	600-700	FP	CHIP	CQ	QU	E	6.90	5.10	1.10	-	-	-	-	0	0	0	N	-	-	-	<0.1
734	MJ06	TPA	7	600-700	FP	CHIP	WQ	QU	I	10.40	7.10	2.90	-	-	-	-	1	0	0	N	-	-	-	0.2
735	MJ06	TPA	7	600-700	FP	CHIP	WQ	QU	I	10.60	8.30	2.80	-	-	-	-	1	0	0	N	-	-	-	0.3
736	MJ06	TPA	7	600-700	FP	CHIP	CQ	QU	E	11.90	6.00	2.70	-	-	-	-	2	0	0	N	-	-	-	0.2
737	MJ06	TPA	7	600-700	FP	CHIP	WQ	QU	I	9.90	8.30	4.70	-	-	-	-	2	0	0	N	-	-	-	0.4
738	MJ06	TPA	7	600-700	FP	CHIP	CQ	QU	L	12.20	5.90	2.20	-	-	-	-	1	0	0	N	-	-	-	0.1
739	MJ06	TPA	7	600-700	F	CHIP	WQ	QU	-	11.60	5.00	2.30	Flaked	5.9	3.8	Feather	1	0	0	N	-	-	-	0.3
740	MJ06	TPA	7	600-700	F	CHIP	CQ	QU	-	5.80	9.10	1.60	Faceted	6.8	1.2	Feather	1	0	0	N	-	-	-	<0.1
741	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	I	10.20	8.70	5.70	-	-	-	-	0	0	0	N	-	-	-	0.4
742	MJ06	TPA	7	600-700	FP	CHIP	WQ	QU	E	10.40	5.70	1.40	-	-	-	-	2	0	0	N	-	-	-	<0.1
743	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	E	6.60	4.80	0.50	-	-	-	-	0	0	0	N	-	-	-	<0.1
744	MJ06	TPA	7	600-700	FP	CHIP	CQ	QU	E	7.50	5.50	0.90	-	-	-	-	0	0	0	N	-	-	-	<0.1
745	MJ06	TPA	7	600-700	LBF	CHIP	WQ	QU	-	8.70	6.60	1.40	Flaked	5	1.8	Feather	2	0	0	N	-	-	-	<0.1
746	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	L	6.70	3.20	0.70	-	-	-	-	0	0	0	N	-	-	-	<0.1
747	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	E	9.90	5.60	0.80	-	-	-	-	0	0	0	N	-	-	-	<0.1
748	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	I	10.70	7.60	3.60	-	-	-	-	0	0	0	N	-	-	-	0.3
749	MJ06	TPA	7	600-700	FP	CHIP	CQ	QU	E	8.90	4.20	0.90	-	-	-	-	0	0	0	N	-	-	-	<0.1

Artefact #	Site	Pit	Spit	Depth	Artefact Type	Pearce Artefact Type	Lithology	Pearce Lithology	Cross-section	Artefact Dimensions			Platform Type	Platform Dimensions		Termination	# Dorsal flake scars	Cortex %	Parallel Arrises	Retouch / Utilisation?	R/U Location	R/U Length	R/U Width	Weight (g)
										Length	Width	Depth		Length	Width									
750	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	TB	8.00	3.70	1.60	-	-	-	-	0	0	0	N	-	-	-	<0.1
751	MJ06	TPA	7	600-700	F	CHIP	CQ	QU	-	8.40	5.80	1.20	Flaked	3	0.7	Feather	0	0	0	N	-	-	-	<0.1
752	MJ06	TPA	7	600-700	FP	CHIP	WQ	QU	I	11.70	6.20	2.60	-	-	-	-	1	0	0	N	-	-	-	0.2
753	MJ06	TPA	7	600-700	FP	CHIP	CQ	QU	I	9.00	4.90	2.10	-	-	-	-	1	0	0	N	-	-	-	<0.1
754	MJ06	TPA	7	600-700	FP	CHIP	CQ	QU	I	14.30	5.40	1.60	-	-	-	-	1	0	0	N	-	-	-	<0.1
755	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	E	8.00	5.90	1.40	-	-	-	-	0	0	0	N	-	-	-	<0.1
756	MJ06	TPA	7	600-700	FP	CHIP	WQ	QU	E	10.10	6.10	2.30	-	-	-	-	2	0	0	N	-	-	-	0.1
757	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	I	8.40	5.80	2.60	-	-	-	-	0	0	0	N	-	-	-	0.1
758	MJ06	TPA	7	600-700	FP	CHIP	CQ	QU	L	9.70	6.70	1.00	-	-	-	-	1	0	0	N	-	-	-	<0.1
759	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	I	9.20	4.40	1.80	-	-	-	-	0	0	0	N	-	-	-	<0.1
760	MJ06	TPA	7	600-700	FP	CHIP	CQ	QU	I	7.00	6.40	1.90	-	-	-	-	1	0	0	N	-	-	-	0.1
761	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	I	6.60	6.50	2.30	-	-	-	-	0	0	0	N	-	-	-	0.2
762	MJ06	TPA	7	600-700	FP	CHIP	CQ	QU	I	7.40	5.50	2.80	-	-	-	-	0	0	0	N	-	-	-	<0.1
763	MJ06	TPA	7	600-700	FP	CHIP	CQ	QU	E	8.00	3.90	0.90	-	-	-	-	1	0	0	N	-	-	-	<0.1
764	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	E	10.40	3.20	2.20	-	-	-	-	0	0	0	N	-	-	-	<0.1
765	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	I	15.00	4.60	3.30	-	-	-	-	0	0	0	N	-	-	-	0.3
766	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	L	6.50	5.30	0.90	-	-	-	-	0	0	0	N	-	-	-	<0.1
767	MJ06	TPA	7	600-700	FP	CHIP	WQ	QU	TB	6.20	4.60	2.40	-	-	-	-	1	0	0	N	-	-	-	0.1
768	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	I	6.60	6.60	3.60	-	-	-	-	0	0	0	N	-	-	-	0.2
769	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	E	9.90	5.40	3.10	-	-	-	-	0	0	0	N	-	-	-	0.3
770	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	TB	6.70	5.10	2.00	-	-	-	-	0	0	0	N	-	-	-	0.2
771	MJ06	TPA	7	600-700	FP	CHIP	WQ	QU	L	9.60	3.40	1.20	-	-	-	-	1	0	0	N	-	-	-	<0.1
772	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	I	9.80	4.20	2.80	-	-	-	-	0	0	0	N	-	-	-	0.1

Artefact #	Site	Pit	Spit	Depth	Artefact Type	Pearce Artefact Type	Lithology	Pearce Lithology	Cross-section	Artefact Dimensions			Platform Type	Platform Dimensions		Termination	# Dorsal flake scars	Cortex %	Parallel Arrises	Retouch / Utilisation?	R/U Location	R/U Length	R/U Width	Weight (g)
										Length	Width	Depth		Length	Width									
773	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	E	6.40	3.70	1.30	-	-	-	-	0	0	0	N	-	-	-	<0.1
774	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	TG	6.70	5.40	3.20	-	-	-	-	0	0	0	N	-	-	-	0.1
775	MJ06	TPA	7	600-700	FP	CHIP	CQ	QU	L	7.40	7.60	1.60	-	-	-	-	1	0	0	N	-	-	-	0.1
776	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	I	7.00	5.00	1.50	-	-	-	-	0	0	0	N	-	-	-	<0.1
777	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	TB	7.70	5.00	1.20	-	-	-	-	0	0	0	N	-	-	-	<0.1
778	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	E	7.80	3.00	2.30	-	-	-	-	0	0	0	N	-	-	-	<0.1
779	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	I	3.20	4.10	3.60	-	-	-	-	0	0	0	N	-	-	-	<0.1
780	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	TG	7.90	7.40	4.10	-	-	-	-	0	0	0	N	-	-	-	0.2
781	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	E	4.80	3.00	1.70	-	-	-	-	0	0	0	N	-	-	-	<0.1
782	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	L	6.90	4.80	2.50	-	-	-	-	0	0	0	N	-	-	-	<0.1
783	MJ06	TPA	7	600-700	FP	CHIP	CQ	QU	TB	10.50	5.40	1.80	-	-	-	-	2	0	1	N	-	-	-	0.1
784	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	I	8.20	4.60	1.40	-	-	-	-	0	0	0	N	-	-	-	<0.1
785	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	I	7.10	6.60	2.00	-	-	-	-	0	0	0	N	-	-	-	<0.1
786	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	L	3.20	3.20	0.50	-	-	-	-	0	0	0	N	-	-	-	<0.1
787	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	TG	6.40	5.60	2.20	-	-	-	-	0	0	0	N	-	-	-	<0.1
788	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	I	7.60	3.20	1.30	-	-	-	-	0	0	0	N	-	-	-	<0.1
789	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	I	10.30	5.90	0.90	-	-	-	-	0	0	0	N	-	-	-	<0.1
790	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	I	8.50	4.70	1.40	-	-	-	-	0	0	0	N	-	-	-	<0.1
791	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	I	7.40	3.00	1.10	-	-	-	-	0	0	0	N	-	-	-	<0.1
792	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	I	4.90	4.40	0.80	-	-	-	-	0	0	0	N	-	-	-	<0.1
793	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	I	7.90	5.80	1.20	-	-	-	-	0	0	0	N	-	-	-	<0.1
794	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	E	4.20	2.60	0.90	-	-	-	-	0	0	0	N	-	-	-	<0.1
795	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	E	7.90	3.70	1.20	-	-	-	-	0	0	0	N	-	-	-	<0.1

Artefact #	Site	Pit	Spit	Depth	Artefact Type	Pearce Artefact Type	Lithology	Pearce Lithology	Cross-section	Artefact Dimensions			Platform Type	Platform Dimensions		Termination	# Dorsal flake scars	Cortex %	Parallel Arrises	Retouch / Utilisation?	R/U Location	R/U Length	R/U Width	Weight (g)
										Length	Width	Depth		Length	Width									
796	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	L	7.30	5.00	1.70	-	-	-	-	0	0	0	N	-	-	-	<0.1
797	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	TB	6.40	5.60	1.70	-	-	-	-	0	0	0	N	-	-	-	<0.1
798	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	L	8.00	6.10	2.00	-	-	-	-	0	0	0	N	-	-	-	0.2
799	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	I	6.70	3.70	2.00	-	-	-	-	0	0	0	N	-	-	-	<0.1
800	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	I	6.40	4.40	3.00	-	-	-	-	0	0	0	N	-	-	-	<0.1
801	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	I	6.50	3.50	3.30	-	-	-	-	0	0	0	N	-	-	-	<0.1
802	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	I	7.30	5.80	2.00	-	-	-	-	0	0	0	N	-	-	-	<0.1
803	MJ06	TPA	7	600-700	DB	FRAGS	PQ	QU	I	6.90	4.40	2.60	-	-	-	-	0	0	0	N	-	-	-	<0.1
804	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	L	8.30	4.50	0.70	-	-	-	-	0	0	0	N	-	-	-	<0.1
805	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	I	5.20	2.70	2.70	-	-	-	-	0	0	0	N	-	-	-	<0.1
806	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	L	7.20	3.70	1.80	-	-	-	-	0	0	0	N	-	-	-	<0.1
807	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	I	7.40	4.60	3.40	-	-	-	-	0	0	0	N	-	-	-	<0.1
808	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	TG	4.70	3.10	2.50	-	-	-	-	0	0	0	N	-	-	-	<0.1
809	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	E	7.60	4.30	1.10	-	-	-	-	0	0	0	N	-	-	-	<0.1
810	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	TB	6.40	4.00	1.80	-	-	-	-	0	0	0	N	-	-	-	<0.1
811	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	I	7.00	2.80	1.40	-	-	-	-	0	0	0	N	-	-	-	<0.1
812	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	I	6.20	5.60	1.70	-	-	-	-	0	0	0	N	-	-	-	<0.1
813	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	TG	7.70	4.70	2.40	-	-	-	-	0	0	0	N	-	-	-	<0.1
814	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	E	5.20	4.20	1.50	-	-	-	-	0	0	0	N	-	-	-	<0.1
815	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	I	8.20	2.80	1.10	-	-	-	-	0	0	0	N	-	-	-	<0.1
816	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	E	8.80	3.20	1.00	-	-	-	-	0	0	0	N	-	-	-	<0.1
817	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	E	3.70	3.80	0.70	-	-	-	-	0	0	0	N	-	-	-	<0.1
818	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	TB	6.90	5.40	1.90	-	-	-	-	0	0	0	N	-	-	-	<0.1

Artefact #	Site	Pit	Spit	Depth	Artefact Type	Pearce Artefact Type	Lithology	Pearce Lithology	Cross-section	Artefact Dimensions			Platform Type	Platform Dimensions		Termination	# Dorsal flake scars	Cortex %	Parallel Arrises	Retouch / Utilisation?	R/U Location	R/U Length	R/U Width	Weight (g)
										Length	Width	Depth		Length	Width									
819	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	L	7.50	5.00	1.40	-	-	-	-	0	0	0	N	-	-	-	<0.1
820	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	E	5.40	4.70	1.50	-	-	-	-	0	0	0	N	-	-	-	<0.1
821	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	E	5.60	2.30	0.70	-	-	-	-	0	0	0	N	-	-	-	<0.1
822	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	I	9.50	3.40	3.10	-	-	-	-	0	0	0	N	-	-	-	<0.1
823	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	I	5.90	3.90	2.40	-	-	-	-	0	0	0	N	-	-	-	<0.1
824	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	E	5.40	2.10	0.90	-	-	-	-	0	0	0	N	-	-	-	<0.1
825	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	E	7.20	2.10	0.80	-	-	-	-	0	0	0	N	-	-	-	<0.1
826	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	I	6.90	3.50	3.00	-	-	-	-	0	0	0	N	-	-	-	<0.1
827	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	I	7.00	3.40	1.30	-	-	-	-	0	0	0	N	-	-	-	<0.1
828	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	E	4.40	2.30	1.00	-	-	-	-	0	0	0	N	-	-	-	<0.1
829	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	TB	4.90	4.00	1.30	-	-	-	-	0	0	0	N	-	-	-	<0.1
830	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	TG	6.00	4.60	2.00	-	-	-	-	0	0	0	N	-	-	-	<0.1
831	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	I	6.40	5.20	1.50	-	-	-	-	0	0	0	N	-	-	-	<0.1
832	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	L	7.20	3.90	1.20	-	-	-	-	0	0	0	N	-	-	-	<0.1
833	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	I	5.20	5.70	2.10	-	-	-	-	0	0	0	N	-	-	-	<0.1
834	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	L	5.90	3.90	0.70	-	-	-	-	0	0	0	N	-	-	-	<0.1
835	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	E	8.00	6.80	1.90	-	-	-	-	0	0	0	N	-	-	-	0.2
836	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	TG	5.50	5.10	2.10	-	-	-	-	0	0	0	N	-	-	-	<0.1
837	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	TG	7.10	2.50	1.30	-	-	-	-	0	0	0	N	-	-	-	<0.1
838	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	L	6.70	4.30	0.80	-	-	-	-	0	0	0	N	-	-	-	<0.1
839	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	I	6.20	3.90	1.80	-	-	-	-	0	0	0	N	-	-	-	<0.1
840	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	E	9.30	2.90	1.10	-	-	-	-	0	0	0	N	-	-	-	<0.1
841	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	E	4.30	5.50	1.00	-	-	-	-	0	0	0	N	-	-	-	<0.1

Artefact #	Site	Pit	Spit	Depth	Artefact Type	Pearce Artefact Type	Lithology	Pearce Lithology	Cross-section	Artefact Dimensions			Platform Type	Platform Dimensions		Termination	# Dorsal flake scars	Cortex %	Parallel Arrises	Retouch / Utilisation?	R/U Location	R/U Length	R/U Width	Weight (g)
										Length	Width	Depth		Length	Width									
842	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	E	4.70	4.90	0.90	-	-	-	-	0	0	0	N	-	-	-	<0.1
843	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	E	7.00	2.40	0.90	-	-	-	-	0	0	0	N	-	-	-	<0.1
844	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	I	5.30	3.30	1.30	-	-	-	-	0	0	0	N	-	-	-	<0.1
845	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	E	9.50	3.90	1.50	-	-	-	-	0	0	0	N	-	-	-	<0.1
846	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	E	5.10	3.80	0.90	-	-	-	-	0	0	0	N	-	-	-	<0.1
847	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	E	5.10	3.60	1.50	-	-	-	-	0	0	0	N	-	-	-	<0.1
848	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	I	5.80	2.80	1.00	-	-	-	-	0	0	0	N	-	-	-	<0.1
849	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	I	5.30	2.70	1.80	-	-	-	-	0	0	0	N	-	-	-	<0.1
850	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	I	4.50	3.80	2.00	-	-	-	-	0	0	0	N	-	-	-	<0.1
851	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	E	5.50	3.50	0.60	-	-	-	-	0	0	0	N	-	-	-	<0.1
852	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	TB	7.60	2.30	1.60	-	-	-	-	0	0	0	N	-	-	-	<0.1
853	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	I	7.20	3.60	3.10	-	-	-	-	0	0	0	N	-	-	-	0.1
854	MJ06	TPA	7	600-700	F	CHIP	CQ	QU	-	6.60	7.60	2.80	Flaked	6.4	3.6	Feather	1	0	0	N	-	-	-	0.2
855	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	L	9.70	4.10	1.40	-	-	-	-	0	0	0	N	-	-	-	<0.1
856	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	I	5.70	5.30	1.20	-	-	-	-	0	0	0	N	-	-	-	<0.1
857	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	I	7.90	2.90	2.50	-	-	-	-	0	0	0	N	-	-	-	<0.1
858	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	E	4.30	2.10	1.30	-	-	-	-	0	0	0	N	-	-	-	<0.1
859	MJ06	TPA	7	600-700	F	CHIP	CQ	QU	-	7.40	5.10	1.10	Faceted	2.8	1.9	Feather	1	40	0	N	-	-	-	<0.1
860	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	I	7.30	4.60	1.30	-	-	-	-	0	0	0	N	-	-	-	<0.1
861	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	I	7.30	5.10	1.60	-	-	-	-	0	0	0	N	-	-	-	<0.1
862	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	I	3.50	2.70	2.10	-	-	-	-	0	0	0	N	-	-	-	<0.1
863	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	E	4.30	2.80	0.60	-	-	-	-	0	0	0	N	-	-	-	<0.1
864	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	TB	5.00	3.20	0.90	-	-	-	-	0	0	0	N	-	-	-	<0.1

Artefact #	Site	Pit	Spit	Depth	Artefact Type	Pearce Artefact Type	Lithology	Pearce Lithology	Cross-section	Artefact Dimensions			Platform Type	Platform Dimensions		Termination	# Dorsal flake scars	Cortex %	Parallel Arrises	Retouch / Utilisation?	R/U Location	R/U Length	R/U Width	Weight (g)
										Length	Width	Depth		Length	Width									
865	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	I	5.40	5.20	1.90	-	-	-	-	0	0	0	N	-	-	-	<0.1
866	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	E	6.60	4.90	1.20	-	-	-	-	0	0	0	N	-	-	-	<0.1
867	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	E	5.60	3.70	0.80	-	-	-	-	0	0	0	N	-	-	-	<0.1
868	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	I	6.60	4.60	2.40	-	-	-	-	0	0	0	N	-	-	-	<0.1
869	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	TG	4.70	3.10	3.20	-	-	-	-	0	0	0	N	-	-	-	<0.1
870	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	E	3.80	4.00	1.00	-	-	-	-	0	0	0	N	-	-	-	<0.1
871	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	E	7.10	3.10	1.10	-	-	-	-	0	0	0	N	-	-	-	<0.1
872	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	I	5.00	5.30	1.20	-	-	-	-	0	0	0	N	-	-	-	<0.1
873	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	E	5.60	2.50	0.60	-	-	-	-	0	0	0	N	-	-	-	<0.1
874	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	E	7.00	3.00	0.80	-	-	-	-	0	0	0	N	-	-	-	<0.1
875	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	I	5.40	3.90	2.30	-	-	-	-	0	0	0	N	-	-	-	<0.1
876	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	E	5.00	3.60	0.60	-	-	-	-	0	0	0	N	-	-	-	<0.1
877	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	L	5.40	3.90	1.40	-	-	-	-	0	0	0	N	-	-	-	<0.1
878	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	TG	5.10	4.00	1.00	-	-	-	-	0	0	0	N	-	-	-	<0.1
879	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	E	7.20	2.70	1.80	-	-	-	-	0	0	0	N	-	-	-	<0.1
880	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	TG	4.90	5.60	2.10	-	-	-	-	0	0	0	N	-	-	-	<0.1
881	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	E	4.50	4.70	0.70	-	-	-	-	0	0	0	N	-	-	-	<0.1
882	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	I	4.10	4.40	2.00	-	-	-	-	0	0	0	N	-	-	-	<0.1
883	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	I	4.90	2.50	2.20	-	-	-	-	0	0	0	N	-	-	-	<0.1
884	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	L	6.70	4.20	1.60	-	-	-	-	0	0	0	N	-	-	-	<0.1
885	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	E	6.90	4.60	2.00	-	-	-	-	0	0	0	N	-	-	-	<0.1
886	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	I	3.90	2.90	1.00	-	-	-	-	0	0	0	N	-	-	-	<0.1
887	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	TB	7.40	4.80	1.70	-	-	-	-	0	0	0	N	-	-	-	<0.1

Artefact #	Site	Pit	Spit	Depth	Artefact Type	Pearce Artefact Type	Lithology	Pearce Lithology	Cross-section	Artefact Dimensions			Platform Type	Platform Dimensions		Termination	# Dorsal flake scars	Cortex %	Parallel Arrises	Retouch / Utilisation?	R/U Location	R/U Length	R/U Width	Weight (g)
										Length	Width	Depth		Length	Width									
888	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	I	2.40	1.80	1.60	-	-	-	-	0	0	0	N	-	-	-	<0.1
889	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	E	5.10	2.80	1.00	-	-	-	-	0	0	0	N	-	-	-	<0.1
890	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	E	5.00	3.00	1.20	-	-	-	-	0	0	0	N	-	-	-	<0.1
891	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	E	6.20	2.70	0.50	-	-	-	-	0	0	0	N	-	-	-	<0.1
892	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	E	5.30	4.30	1.20	-	-	-	-	0	0	0	N	-	-	-	<0.1
893	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	E	8.30	3.70	0.60	-	-	-	-	0	0	0	N	-	-	-	<0.1
894	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	I	4.60	2.60	1.40	-	-	-	-	0	0	0	N	-	-	-	<0.1
895	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	L	5.90	3.90	1.30	-	-	-	-	0	0	0	N	-	-	-	<0.1
896	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	I	4.50	2.80	1.00	-	-	-	-	0	0	0	N	-	-	-	<0.1
897	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	TG	4.60	4.80	1.80	-	-	-	-	0	0	0	N	-	-	-	<0.1
898	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	E	5.70	3.10	0.70	-	-	-	-	0	0	0	N	-	-	-	<0.1
899	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	I	6.10	1.90	1.20	-	-	-	-	0	0	0	N	-	-	-	<0.1
900	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	I	6.30	2.60	1.60	-	-	-	-	0	0	0	N	-	-	-	<0.1
901	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	L	5.90	4.30	0.90	-	-	-	-	0	0	0	N	-	-	-	<0.1
902	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	E	6.90	6.00	1.20	-	-	-	-	0	0	0	N	-	-	-	<0.1
903	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	I	5.90	3.90	2.40	-	-	-	-	0	0	0	N	-	-	-	<0.1
904	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	E	6.10	2.70	2.10	-	-	-	-	0	0	0	N	-	-	-	<0.1
905	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	TB	7.70	4.60	1.90	-	-	-	-	0	0	0	N	-	-	-	<0.1
906	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	E	9.60	2.00	2.00	-	-	-	-	0	0	0	N	-	-	-	<0.1
907	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	I	3.80	3.30	1.60	-	-	-	-	0	0	0	N	-	-	-	<0.1
908	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	L	3.40	3.70	0.70	-	-	-	-	0	0	0	N	-	-	-	<0.1
909	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	I	3.00	1.70	0.90	-	-	-	-	0	0	0	N	-	-	-	<0.1
910	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	L	4.70	4.80	1.20	-	-	-	-	0	0	0	N	-	-	-	<0.1

Artefact #	Site	Pit	Spit	Depth	Artefact Type	Pearce Artefact Type	Lithology	Pearce Lithology	Cross-section	Artefact Dimensions			Platform Type	Platform Dimensions		Termination	# Dorsal flake scars	Cortex %	Parallel Arrises	Retouch / Utilisation?	R/U Location	R/U Length	R/U Width	Weight (g)
										Length	Width	Depth		Length	Width									
911	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	I	10.80	6.10	1.20	-	-	-	-	0	0	0	N	-	-	-	0.1
912	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	TG	4.80	2.60	1.60	-	-	-	-	0	0	0	N	-	-	-	<0.1
913	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	E	6.90	2.40	0.90	-	-	-	-	0	0	0	N	-	-	-	<0.1
914	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	I	6.50	2.70	2.90	-	-	-	-	0	0	0	N	-	-	-	<0.1
915	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	L	7.30	3.60	0.90	-	-	-	-	0	0	0	N	-	-	-	<0.1
916	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	E	5.60	3.70	1.00	-	-	-	-	0	0	0	N	-	-	-	<0.1
917	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	L	6.30	4.10	1.30	-	-	-	-	0	0	0	N	-	-	-	<0.1
918	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	E	3.50	4.00	0.80	-	-	-	-	0	0	0	N	-	-	-	<0.1
919	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	L	7.00	4.50	0.80	-	-	-	-	0	0	0	N	-	-	-	<0.1
920	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	I	7.20	4.10	2.30	-	-	-	-	0	0	0	N	-	-	-	<0.1
921	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	L	4.10	4.10	0.50	-	-	-	-	0	0	0	N	-	-	-	<0.1
922	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	I	4.40	2.20	1.10	-	-	-	-	0	0	0	N	-	-	-	<0.1
923	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	L	6.60	3.60	1.20	-	-	-	-	0	0	0	N	-	-	-	<0.1
924	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	I	7.10	4.10	2.90	-	-	-	-	0	0	0	N	-	-	-	<0.1
925	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	I	6.30	5.20	1.10	-	-	-	-	0	0	0	N	-	-	-	<0.1
926	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	E	7.20	5.40	1.60	-	-	-	-	0	0	0	N	-	-	-	<0.1
927	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	TB	7.00	3.90	1.80	-	-	-	-	0	0	0	N	-	-	-	<0.1
928	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	I	4.70	3.50	1.00	-	-	-	-	0	0	0	N	-	-	-	<0.1
929	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	I	5.20	2.00	1.60	-	-	-	-	0	0	0	N	-	-	-	<0.1
930	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	L	4.60	3.70	1.10	-	-	-	-	0	0	0	N	-	-	-	<0.1
931	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	TB	5.30	3.50	1.10	-	-	-	-	0	0	0	N	-	-	-	<0.1
932	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	E	6.50	4.30	1.40	-	-	-	-	0	0	0	N	-	-	-	<0.1
933	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	I	5.10	2.40	1.80	-	-	-	-	0	0	0	N	-	-	-	<0.1

Artefact #	Site	Pit	Spit	Depth	Artefact Type	Pearce Artefact Type	Lithology	Pearce Lithology	Cross-section	Artefact Dimensions			Platform Type	Platform Dimensions		Termination	# Dorsal flake scars	Cortex %	Parallel Arrises	Retouch / Utilisation?	R/U Location	R/U Length	R/U Width	Weight (g)
										Length	Width	Depth		Length	Width									
934	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	L	6.00	4.20	1.30	-	-	-	-	0	0	0	N	-	-	-	<0.1
935	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	E	7.80	3.40	1.40	-	-	-	-	0	0	0	N	-	-	-	<0.1
936	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	I	8.50	3.20	3.20	-	-	-	-	0	0	0	N	-	-	-	<0.1
937	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	E	5.10	4.30	0.90	-	-	-	-	0	0	0	N	-	-	-	<0.1
938	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	E	7.00	5.80	1.40	-	-	-	-	0	0	0	N	-	-	-	<0.1
939	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	I	4.20	3.50	1.00	-	-	-	-	0	0	0	N	-	-	-	<0.1
940	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	TB	4.50	2.30	0.90	-	-	-	-	0	0	0	N	-	-	-	<0.1
941	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	I	5.90	5.50	3.10	-	-	-	-	0	0	0	N	-	-	-	<0.1
942	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	E	3.90	2.60	1.30	-	-	-	-	0	0	0	N	-	-	-	<0.1
943	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	TB	4.00	3.20	1.40	-	-	-	-	0	0	0	N	-	-	-	<0.1
944	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	I	3.70	3.00	1.40	-	-	-	-	0	0	0	N	-	-	-	<0.1
945	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	I	6.60	3.50	1.00	-	-	-	-	0	0	0	N	-	-	-	<0.1
946	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	I	5.10	2.60	0.80	-	-	-	-	0	0	0	N	-	-	-	<0.1
947	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	E	4.60	4.30	0.70	-	-	-	-	0	0	0	N	-	-	-	<0.1
948	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	E	4.70	3.10	1.20	-	-	-	-	0	0	0	N	-	-	-	<0.1
949	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	I	5.10	3.20	1.70	-	-	-	-	0	0	0	N	-	-	-	<0.1
950	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	L	5.20	4.30	1.00	-	-	-	-	0	0	0	N	-	-	-	<0.1
951	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	TG	6.00	3.90	1.40	-	-	-	-	0	0	0	N	-	-	-	<0.1
952	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	E	7.40	2.80	0.80	-	-	-	-	0	0	0	N	-	-	-	<0.1
953	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	I	3.30	3.90	2.50	-	-	-	-	0	0	0	N	-	-	-	<0.1
954	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	E	4.30	3.20	1.40	-	-	-	-	0	0	0	N	-	-	-	<0.1
955	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	I	4.20	3.10	1.20	-	-	-	-	0	0	0	N	-	-	-	<0.1
956	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	E	8.30	5.00	0.90	-	-	-	-	0	0	0	N	-	-	-	<0.1

Artefact #	Site	Pit	Spit	Depth	Artefact Type	Pearce Artefact Type	Lithology	Pearce Lithology	Cross-section	Artefact Dimensions			Platform Type	Platform Dimensions		Termination	# Dorsal flake scars	Cortex %	Parallel Arrises	Retouch / Utilisation?	R/U Location	R/U Length	R/U Width	Weight (g)
										Length	Width	Depth		Length	Width									
957	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	I	3.60	3.00	1.40	-	-	-	-	0	0	0	N	-	-	-	<0.1
958	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	E	6.80	3.20	1.30	-	-	-	-	0	0	0	N	-	-	-	<0.1
959	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	I	5.60	5.80	1.10	-	-	-	-	0	0	0	N	-	-	-	<0.1
960	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	I	4.20	4.50	3.00	-	-	-	-	0	0	0	N	-	-	-	<0.1
961	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	TB	5.00	3.00	0.50	-	-	-	-	0	0	0	N	-	-	-	<0.1
962	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	I	4.30	4.70	2.00	-	-	-	-	0	0	0	N	-	-	-	<0.1
963	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	E	6.10	4.70	0.80	-	-	-	-	0	0	0	N	-	-	-	<0.1
964	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	I	6.60	2.40	1.60	-	-	-	-	0	0	0	N	-	-	-	<0.1
965	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	I	4.30	3.40	2.50	-	-	-	-	0	0	0	N	-	-	-	<0.1
966	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	I	2.70	2.80	0.70	-	-	-	-	0	0	0	N	-	-	-	<0.1
967	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	L	4.80	3.30	0.70	-	-	-	-	0	0	0	N	-	-	-	<0.1
968	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	TG	5.00	3.40	1.60	-	-	-	-	0	0	0	N	-	-	-	<0.1
969	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	I	5.90	1.90	1.90	-	-	-	-	0	0	0	N	-	-	-	<0.1
970	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	E	5.20	1.60	0.90	-	-	-	-	0	0	0	N	-	-	-	<0.1
971	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	I	7.40	3.30	0.90	-	-	-	-	0	0	0	N	-	-	-	<0.1
972	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	I	4.90	4.60	1.40	-	-	-	-	0	0	0	N	-	-	-	<0.1
973	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	E	7.30	3.50	0.70	-	-	-	-	0	0	0	N	-	-	-	<0.1
974	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	I	7.00	4.70	2.20	-	-	-	-	0	0	0	N	-	-	-	<0.1
975	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	E	5.90	5.00	0.50	-	-	-	-	0	0	0	N	-	-	-	<0.1
976	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	L	7.00	3.70	1.20	-	-	-	-	0	0	0	N	-	-	-	<0.1
977	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	I	5.70	5.20	1.70	-	-	-	-	0	0	0	N	-	-	-	<0.1
978	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	TG	3.60	3.20	1.60	-	-	-	-	0	0	0	N	-	-	-	<0.1
979	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	E	3.60	3.10	0.90	-	-	-	-	0	0	0	N	-	-	-	<0.1

Artefact #	Site	Pit	Spit	Depth	Artefact Type	Pearce Artefact Type	Lithology	Pearce Lithology	Cross-section	Artefact Dimensions			Platform Type	Platform Dimensions		Termination	# Dorsal flake scars	Cortex %	Parallel Arrises	Retouch / Utilisation?	R/U Location	R/U Length	R/U Width	Weight (g)
										Length	Width	Depth		Length	Width									
980	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	I	2.90	2.30	2.40	-	-	-	-	0	0	0	N	-	-	-	<0.1
981	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	I	5.80	4.40	1.00	-	-	-	-	0	0	0	N	-	-	-	<0.1
982	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	TG	5.10	2.90	0.70	-	-	-	-	0	0	0	N	-	-	-	<0.1
983	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	TB	4.90	1.60	1.50	-	-	-	-	0	0	0	N	-	-	-	<0.1
984	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	I	3.10	2.80	0.80	-	-	-	-	0	0	0	N	-	-	-	<0.1
985	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	E	4.50	3.10	0.90	-	-	-	-	0	0	0	N	-	-	-	<0.1
986	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	I	4.50	3.30	1.50	-	-	-	-	0	0	0	N	-	-	-	<0.1
987	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	I	4.50	2.80	1.30	-	-	-	-	0	0	0	N	-	-	-	<0.1
988	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	I	2.60	2.50	1.70	-	-	-	-	0	0	0	N	-	-	-	<0.1
989	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	I	4.40	1.90	2.30	-	-	-	-	0	0	0	N	-	-	-	<0.1
990	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	I	4.90	2.20	1.20	-	-	-	-	0	0	0	N	-	-	-	<0.1
991	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	L	5.30	3.20	0.80	-	-	-	-	0	0	0	N	-	-	-	<0.1
992	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	E	9.60	2.80	0.90	-	-	-	-	0	0	0	N	-	-	-	<0.1
993	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	TB	4.50	3.00	0.80	-	-	-	-	0	0	0	N	-	-	-	<0.1
994	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	E	4.40	3.10	0.80	-	-	-	-	0	0	0	N	-	-	-	<0.1
995	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	E	5.70	2.30	0.90	-	-	-	-	0	0	0	N	-	-	-	<0.1
996	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	E	4.10	3.30	0.90	-	-	-	-	0	0	0	N	-	-	-	<0.1
997	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	I	5.40	4.10	2.10	-	-	-	-	0	0	0	N	-	-	-	<0.1
998	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	L	4.70	3.30	0.70	-	-	-	-	0	0	0	N	-	-	-	<0.1
999	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	TB	6.50	2.10	1.30	-	-	-	-	0	0	0	N	-	-	-	<0.1
1000	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	L	4.60	3.60	1.10	-	-	-	-	0	0	0	N	-	-	-	<0.1
1001	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	I	4.20	1.90	1.80	-	-	-	-	0	0	0	N	-	-	-	<0.1
1002	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	E	2.60	2.90	1.30	-	-	-	-	0	0	0	N	-	-	-	<0.1

Artefact #	Site	Pit	Spit	Depth	Artefact Type	Pearce Artefact Type	Lithology	Pearce Lithology	Cross-section	Artefact Dimensions			Platform Type	Platform Dimensions		Termination	# Dorsal flake scars	Cortex %	Parallel Arrises	Retouch / Utilisation?	R/U Location	R/U Length	R/U Width	Weight (g)
										Length	Width	Depth		Length	Width									
1003	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	E	4.90	3.30	0.70	-	-	-	-	0	0	0	N	-	-	-	<0.1
1004	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	L	4.10	3.00	0.70	-	-	-	-	0	0	0	N	-	-	-	<0.1
1005	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	E	5.90	3.40	0.70	-	-	-	-	0	0	0	N	-	-	-	<0.1
1006	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	E	5.90	2.40	1.20	-	-	-	-	0	0	0	N	-	-	-	<0.1
1007	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	I	5.20	4.40	1.20	-	-	-	-	0	0	0	N	-	-	-	<0.1
1008	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	L	5.20	2.80	0.80	-	-	-	-	0	0	0	N	-	-	-	<0.1
1009	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	E	5.60	2.00	1.40	-	-	-	-	0	0	0	N	-	-	-	<0.1
1010	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	E	5.90	3.80	0.70	-	-	-	-	0	0	0	N	-	-	-	<0.1
1011	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	I	4.00	3.50	1.40	-	-	-	-	0	0	0	N	-	-	-	<0.1
1012	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	E	4.40	3.10	0.80	-	-	-	-	0	0	0	N	-	-	-	<0.1
1013	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	E	5.60	4.40	1.00	-	-	-	-	0	0	0	N	-	-	-	<0.1
1014	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	E	3.50	2.20	0.30	-	-	-	-	0	0	0	N	-	-	-	<0.1
1015	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	E	5.00	4.50	1.00	-	-	-	-	0	0	0	N	-	-	-	<0.1
1016	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	I	3.60	3.30	1.10	-	-	-	-	0	0	0	N	-	-	-	<0.1
1017	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	E	6.30	2.60	0.50	-	-	-	-	0	0	0	N	-	-	-	<0.1
1018	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	E	4.60	2.80	0.80	-	-	-	-	0	0	0	N	-	-	-	<0.1
1019	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	I	5.10	4.50	1.10	-	-	-	-	0	0	0	N	-	-	-	<0.1
1020	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	TG	5.60	2.60	1.30	-	-	-	-	0	0	0	N	-	-	-	<0.1
1021	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	L	6.40	3.30	1.30	-	-	-	-	0	0	0	N	-	-	-	<0.1
1022	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	E	4.00	3.70	1.10	-	-	-	-	0	0	0	N	-	-	-	<0.1
1023	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	E	4.70	4.00	1.10	-	-	-	-	0	0	0	N	-	-	-	<0.1
1024	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	E	5.40	3.50	1.30	-	-	-	-	0	0	0	N	-	-	-	<0.1
1025	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	TG	3.80	3.10	1.10	-	-	-	-	0	0	0	N	-	-	-	<0.1

Artefact #	Site	Pit	Spit	Depth	Artefact Type	Pearce Artefact Type	Lithology	Pearce Lithology	Cross-section	Artefact Dimensions			Platform Type	Platform Dimensions		Termination	# Dorsal flake scars	Cortex %	Parallel Arrises	Retouch / Utilisation?	R/U Location	R/U Length	R/U Width	Weight (g)
										Length	Width	Depth		Length	Width									
1026	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	L	5.60	2.80	1.10	-	-	-	-	0	0	0	N	-	-	-	<0.1
1027	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	E	4.20	2.70	0.60	-	-	-	-	0	0	0	N	-	-	-	<0.1
1028	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	E	5.60	1.80	1.20	-	-	-	-	0	0	0	N	-	-	-	<0.1
1029	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	I	3.80	2.30	1.00	-	-	-	-	0	0	0	N	-	-	-	<0.1
1030	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	E	4.00	3.30	1.20	-	-	-	-	0	0	0	N	-	-	-	<0.1
1031	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	E	3.90	3.20	1.20	-	-	-	-	0	0	0	N	-	-	-	<0.1
1032	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	E	5.60	2.60	0.90	-	-	-	-	0	0	0	N	-	-	-	<0.1
1033	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	I	4.40	2.40	2.20	-	-	-	-	0	0	0	N	-	-	-	<0.1
1034	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	E	3.70	4.20	1.50	-	-	-	-	0	0	0	N	-	-	-	<0.1
1035	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	I	4.50	2.80	1.80	-	-	-	-	0	0	0	N	-	-	-	<0.1
1036	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	E	6.90	2.70	1.40	-	-	-	-	0	0	0	N	-	-	-	<0.1
1037	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	E	5.20	2.50	0.80	-	-	-	-	0	0	0	N	-	-	-	<0.1
1038	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	E	4.40	2.90	1.40	-	-	-	-	0	0	0	N	-	-	-	<0.1
1039	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	E	4.50	2.20	1.50	-	-	-	-	0	0	0	N	-	-	-	<0.1
1040	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	L	4.50	2.90	0.60	-	-	-	-	0	0	0	N	-	-	-	<0.1
1041	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	L	3.70	2.60	0.90	-	-	-	-	0	0	0	N	-	-	-	<0.1
1042	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	L	5.00	3.40	1.20	-	-	-	-	0	0	0	N	-	-	-	<0.1
1043	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	E	3.80	3.60	0.90	-	-	-	-	0	0	0	N	-	-	-	<0.1
1044	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	I	4.70	4.50	1.10	-	-	-	-	0	0	0	N	-	-	-	<0.1
1045	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	I	5.30	1.90	1.30	-	-	-	-	0	0	0	N	-	-	-	<0.1
1046	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	E	2.80	4.90	1.20	-	-	-	-	0	0	0	N	-	-	-	<0.1
1047	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	E	3.40	3.10	0.70	-	-	-	-	0	0	0	N	-	-	-	<0.1
1048	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	I	3.40	2.50	1.50	-	-	-	-	0	0	0	N	-	-	-	<0.1

Artefact #	Site	Pit	Spit	Depth	Artefact Type	Pearce Artefact Type	Lithology	Pearce Lithology	Cross-section	Artefact Dimensions			Platform Type	Platform Dimensions		Termination	# Dorsal flake scars	Cortex %	Parallel Arrises	Retouch / Utilisation?	R/U Location	R/U Length	R/U Width	Weight (g)
										Length	Width	Depth		Length	Width									
1049	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	E	3.90	3.70	0.70	-	-	-	-	0	0	0	N	-	-	-	<0.1
1050	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	TG	2.90	1.70	1.00	-	-	-	-	0	0	0	N	-	-	-	<0.1
1051	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	E	4.90	2.80	1.20	-	-	-	-	0	0	0	N	-	-	-	<0.1
1052	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	E	3.30	3.20	0.60	-	-	-	-	0	0	0	N	-	-	-	<0.1
1053	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	E	3.20	3.30	0.60	-	-	-	-	0	0	0	N	-	-	-	<0.1
1054	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	I	4.70	2.70	1.10	-	-	-	-	0	0	0	N	-	-	-	<0.1
1055	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	E	3.50	2.50	1.20	-	-	-	-	0	0	0	N	-	-	-	<0.1
1056	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	E	6.10	2.20	0.70	-	-	-	-	0	0	0	N	-	-	-	<0.1
1057	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	E	3.50	2.60	0.80	-	-	-	-	0	0	0	N	-	-	-	<0.1
1058	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	E	2.70	2.20	0.40	-	-	-	-	0	0	0	N	-	-	-	<0.1
1059	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	I	5.50	3.10	0.90	-	-	-	-	0	0	0	N	-	-	-	<0.1
1060	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	E	3.40	4.00	1.00	-	-	-	-	0	0	0	N	-	-	-	<0.1
1061	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	L	4.90	1.50	0.40	-	-	-	-	0	0	0	N	-	-	-	<0.1
1062	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	I	2.80	1.90	1.80	-	-	-	-	0	0	0	N	-	-	-	<0.1
1063	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	L	4.00	2.90	0.40	-	-	-	-	0	0	0	N	-	-	-	<0.1
1064	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	E	4.10	2.80	0.40	-	-	-	-	0	0	0	N	-	-	-	<0.1
1065	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	E	4.40	2.80	0.40	-	-	-	-	0	0	0	N	-	-	-	<0.1
1066	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	I	3.00	2.10	0.70	-	-	-	-	0	0	0	N	-	-	-	<0.1
1067	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	I	1.90	1.80	0.90	-	-	-	-	0	0	0	N	-	-	-	<0.1
1068	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	I	3.50	2.10	1.20	-	-	-	-	0	0	0	N	-	-	-	<0.1
1069	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	E	3.10	4.40	0.70	-	-	-	-	0	0	0	N	-	-	-	<0.1
1070	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	E	3.10	3.30	0.40	-	-	-	-	0	0	0	N	-	-	-	<0.1
1071	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	I	3.60	3.70	0.70	-	-	-	-	0	0	0	N	-	-	-	<0.1

Artefact #	Site	Pit	Spit	Depth	Artefact Type	Pearce Artefact Type	Lithology	Pearce Lithology	Cross-section	Artefact Dimensions			Platform Type	Platform Dimensions		Termination	# Dorsal flake scars	Cortex %	Parallel Arrises	Retouch / Utilisation?	R/U Location	R/U Length	R/U Width	Weight (g)
										Length	Width	Depth		Length	Width									
1072	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	E	4.00	2.40	0.70	-	-	-	-	0	0	0	N	-	-	-	<0.1
1073	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	I	3.30	2.40	1.00	-	-	-	-	0	0	0	N	-	-	-	<0.1
1074	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	I	5.50	2.50	0.80	-	-	-	-	0	0	0	N	-	-	-	<0.1
1075	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	E	4.00	2.20	0.40	-	-	-	-	0	0	0	N	-	-	-	<0.1
1076	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	E	2.40	2.20	0.70	-	-	-	-	0	0	0	N	-	-	-	<0.1
1077	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	E	2.70	2.20	0.40	-	-	-	-	0	0	0	N	-	-	-	<0.1
1078	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	E	3.30	2.10	0.20	-	-	-	-	0	0	0	N	-	-	-	<0.1
1079	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	E	3.60	1.30	0.90	-	-	-	-	0	0	0	N	-	-	-	<0.1
1080	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	E	4.00	2.50	0.40	-	-	-	-	0	0	0	N	-	-	-	<0.1
1081	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	E	2.20	1.80	0.50	-	-	-	-	0	0	0	N	-	-	-	<0.1
1082	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	I	5.80	2.40	1.00	-	-	-	-	0	0	0	N	-	-	-	<0.1
1083	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	I	3.20	2.40	0.70	-	-	-	-	0	0	0	N	-	-	-	<0.1
1084	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	TB	2.20	1.70	2.70	-	-	-	-	0	0	0	N	-	-	-	<0.1
1085	MJ06	TPA	7	600-700	DB	FRAGS	WQ	QU	E	3.80	3.40	0.50	-	-	-	-	0	0	0	N	-	-	-	<0.1
1086	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	TB	3.80	1.10	0.90	-	-	-	-	0	0	0	N	-	-	-	<0.1
1087	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	E	3.40	3.00	0.40	-	-	-	-	0	0	0	N	-	-	-	<0.1
1088	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	E	3.80	2.00	0.40	-	-	-	-	0	0	0	N	-	-	-	<0.1
1089	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	E	2.00	1.30	0.30	-	-	-	-	0	0	0	N	-	-	-	<0.1
1090	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	I	2.90	2.00	1.50	-	-	-	-	0	0	0	N	-	-	-	<0.1
1091	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	I	3.10	2.00	0.80	-	-	-	-	0	0	0	N	-	-	-	<0.1
1092	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	E	2.40	2.70	0.20	-	-	-	-	0	0	0	N	-	-	-	<0.1
1093	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	E	2.50	1.30	0.20	-	-	-	-	0	0	0	N	-	-	-	<0.1
1094	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	TG	3.40	2.00	1.20	-	-	-	-	0	0	0	N	-	-	-	<0.1

Artefact #	Site	Pit	Spit	Depth	Artefact Type	Pearce Artefact Type	Lithology	Pearce Lithology	Cross-section	Artefact Dimensions			Platform Type	Platform Dimensions		Termination	# Dorsal flake scars	Cortex %	Parallel Arrises	Retouch / Utilisation?	R/U Location	R/U Length	R/U Width	Weight (g)
										Length	Width	Depth		Length	Width									
1095	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	L	5.10	2.60	0.30	-	-	-	-	0	0	0	N	-	-	-	<0.1
1096	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	E	3.60	1.70	0.60	-	-	-	-	0	0	0	N	-	-	-	<0.1
1097	MJ06	TPA	7	600-700	DB	FRAGS	CQ	QU	E	2.70	2.00	0.40	-	-	-	-	0	0	0	N	-	-	-	<0.1
1098	MJ06	TPA	7	600-700	FP	FP	WQ	QU	E	18.00	10.20	3.90	-	-	-	-	2	0	1	N	-	-	-	0.8
1099	MJ06	TPA	7	600-700	FP	CHIP	WQ	QU	I	12.50	8.50	4.90	-	-	-	-	1	0	0	N	-	-	-	0.7
1100	MJ06	TPA	7	600-700	FP	FP	WQ	QU	E	19.00	8.70	5.30	-	-	-	-	2	0	1	N	-	-	-	1.4
1101	MJ06	TPA	7	600-700	DB	FRAGS	GR	OTHER	I	8.20	3.60	2.30	-	-	-	-	0	0	0	N	-	-	-	0.1
1102	MJ06	TPA	7	600-700	FP	CHIP	GR	OTHER	I	14.40	6.80	5.60	-	-	-	-	3	0	0	N	-	-	-	0.9
1103	MJ06	TPA	7	600-700	FP	FP	GR	OTHER	L	24.10	9.40	7.60	-	-	-	-	2	0	0	N	-	-	-	2.1
1104	MJ06	TPA	7	600-700	FP	CHIP	CH	CH	I	12.10	6.90	2.70	-	-	-	-	1	0	0	N	-	-	-	0.3
1105	MJ06	TPA	7	600-700	MPC	UNF	SQ	QU		See Core page														
1106	MJ06	TPA	7	600-700	SPC	UNF	WQ	QU		See Core page														
1107	MJ06	TPA	7	600-700	MPC	UNF	WQ	QU		See Core page														
1108	MJ06	TPA	7	600-700	MPC	UNF	WQ	QU		See Core page														
1109	MJ06	TPA	7	600-700	MPC	UNF	WQ	QU		See Core page														
1110	MJ06	TPA	7	600-700	MPC	UNF	WQ	QU		See Core page														
1111	MJ06	TPA	7	600-700	SPC	UNF	WQ	QU		See Core page														
1112	MJ06	TPA	7	600-700	MPC	UNF	WQ	QU		See Core page														
1113	MJ06	TPA	7	600-700	SPC	UNF	WQ	QU		See Core page														

Artefact #	Site	Pit	Spit	Depth	Artefact Type	Pearce Artefact Type	Lithology	Pearce Lithology	Cross-section	Artefact Dimensions			Platform Type	Platform Dimensions		Termination	# Dorsal flake scars	Cortex %	Parallel Arrises	Retouch / Utilisation?	R/U Location	R/U Length	R/U Width	Weight (g)
										Length	Width	Depth		Length	Width									
1114	MJ06	TPA	7	600-700	FP	FP	WQ	QU	I	23.20	12.50	8.90	-	-	-	-	0	0	0	N	-	-	-	3
1115	MJ06	TPA	7	600-700	FP	FP	WQ	QU	I	28.60	15.20	7.50	-	-	-	-	2	0	1	N	-	-	-	3.2
1116	MJ06	TPA	7	600-700	FP	CHIP	WQ	QU	I	11.60	10.70	6.10	-	-	-	-	0	0	0	N	-	-	-	1.1
1117	MJ06	TPA	7	600-700	FP	FP	WQ	QU	I	15.90	10.40	7.50	-	-	-	-	1	0	0	N	-	-	-	1
1118	MJ06	TPA	7	600-700	FP	FP	WQ	QU	I	15.10	19.70	7.50	-	-	-	-	0	0	0	N	-	-	-	2
1119	MJ06	TPA	7	600-700	FP	FP	WQ	QU	I	19.40	14.90	3.90	-	-	-	-	3	0	0	N	-	-	-	1.3
1120	MJ06	TPA	7	600-700	F	FLAKE	WQ	QU	-	25.50	19.20	9.50	Faceted	11.3	5.5	Feather	5	0	0	N	-	-	-	5.8
1121	MJ06	TPA	7	600-700	FP	FP	WQ	QU	I	17.10	14.60	6.10	-	-	-	-	0	0	0	N	-	-	-	2.1
1122	MJ06	TPA	7	600-700	FP	FP	WQ	QU	L	23.50	15.90	5.30	-	-	-	-	2	0	0	N	-	-	-	2.5
1123	MJ06	TPA	7	600-700	F	CHIP	WQ	QU	-	13.10	10.40	4.40	Flaked	7.1	2.2	Feather	1	0	0	N	-	-	-	0.6
1124	MJ06	TPA	7	600-700	FP	FP	BQ	QU	I	19.10	13.90	11.00	-	-	-	-	0	0	0	N	-	-	-	3.3
1125	MJ06	TPA	7	600-700	FP	FP	SQ	QU	TB	20.50	11.40	10.20	-	-	-	-	0	0	0	N	-	-	-	2.6
1126	MJ06	TPA	8	700-800	DB	FRAGS	CQ	QU	E	6.10	4.40	1.40	-	-	-	-	0	0	0	N	-	-	-	<0.1
1127	MJ06	TPA	8	700-800	DB	FRAGS	CQ	QU	I	6.50	3.40	1.30	-	-	-	-	0	0	0	N	-	-	-	<0.1
1128	MJ06	TPA	8	700-800	FP	CHIP	WQ	QU	TG	10.00	5.70	4.80	-	-	-	-	1	0	0	N	-	-	-	0.2
1129	MJ06	TPA	8	700-800	PTBF	CHIP	WQ	QU	-	6.70	6.10	1.70	Flaked	4.1	1.8	Broken	2	0	1	N	-	-	-	<0.1
1130	MJ06	TPA	8	700-800	DB	FRAGS	WQ	QU	I	7.60	5.30	3.80	-	-	-	-	0	0	0	N	-	-	-	0.2
1131	MJ06	TPA	8	700-800	FP	CHIP	CQ	QU	E	6.80	4.90	1.80	-	-	-	-	2	0	1	N	-	-	-	<0.1
1132	MJ06	TPA	8	700-800	DB	FRAGS	WQ	QU	I	7.80	3.60	2.60	-	-	-	-	0	0	0	N	-	-	-	<0.1
1133	MJ06	TPA	8	700-800	DB	FRAGS	CQ	QU	E	7.00	3.60	1.50	-	-	-	-	0	0	0	N	-	-	-	<0.1
1134	MJ06	TPA	8	700-800	DB	FRAGS	CQ	QU	I	5.80	3.20	1.50	-	-	-	-	0	0	0	N	-	-	-	<0.1
1135	MJ06	TPA	8	700-800	DB	FRAGS	CQ	QU	I	4.90	1.80	1.00	-	-	-	-	0	0	0	N	-	-	-	<0.1
1136	MJ06	TPA	8	700-800	DB	FRAGS	CQ	QU	E	5.30	2.40	0.40	-	-	-	-	0	0	0	N	-	-	-	<0.1

Artefact #	Site	Pit	Spit	Depth	Artefact Type	Pearce Artefact Type	Lithology	Pearce Lithology	Cross-section	Artefact Dimensions			Platform Type	Platform Dimensions		Termination	# Dorsal flake scars	Cortex %	Parallel Arrises	Retouch / Utilisation?	R/U Location	R/U Length	R/U Width	Weight (g)
										Length	Width	Depth		Length	Width									
1137	MJ06	TPA	8	700-800	DB	FRAGS	CQ	QU	I	7.30	4.60	1.60	-	-	-	-	0	0	0	N	-	-	-	<0.1
1138	MJ06	TPA	8	700-800	DB	FRAGS	WQ	QU	I	3.40	2.50	2.50	-	-	-	-	0	0	0	N	-	-	-	<0.1
1139	MJ06	TPA	8	700-800	DB	FRAGS	CQ	QU	E	5.70	4.70	1.70	-	-	-	-	0	0	0	N	-	-	-	<0.1
1140	MJ06	TPA	8	700-800	DB	FRAGS	CQ	QU	E	4.90	2.60	0.50	-	-	-	-	0	0	0	N	-	-	-	<0.1
1141	MJ06	TPA	8	700-800	DB	FRAGS	CQ	QU	I	5.00	2.50	1.70	-	-	-	-	0	0	0	N	-	-	-	<0.1
1142	MJ06	TPA	8	700-800	DB	FRAGS	CQ	QU	TG	6.80	3.50	1.60	-	-	-	-	0	0	0	N	-	-	-	<0.1
1143	MJ06	TPA	8	700-800	DB	FRAGS	WQ	QU	I	4.30	3.50	0.80	-	-	-	-	0	0	0	N	-	-	-	<0.1
1144	MJ06	TPA	8	700-800	DB	FRAGS	WQ	QU	E	4.20	3.60	1.20	-	-	-	-	0	0	0	N	-	-	-	<0.1
1145	MJ06	TPA	8	700-800	DB	FRAGS	WQ	QU	I	2.90	2.40	1.90	-	-	-	-	0	0	0	N	-	-	-	<0.1
1146	MJ06	TPA	8	700-800	MANU	LUMP	UNID	OTHER	-	42.60	26.40	14.10	-	-	-	-	0	0	0	N	-	-	-	16.3
1147	MJ06	TPA	9	800-900	FP	CHIP	WQ	QU	L	10.90	5.30	2.20	-	-	-	-	0	0	0	N	-	-	-	0.2
1148	MJ06	TPA	9	800-900	DB	FRAGS	WQ	QU	E	8.00	4.50	2.30	-	-	-	-	0	10	0	N	-	-	-	<0.1
1149	MJ05	TPD	1	0-100	DB	FRAGS	WQ	QU	I	3.10	3.10	0.90	-	-	-	-	0	0	0	N	-	-	-	<0.1
1150	MJ05	TPD	1	0-100	DB	FRAGS	CQ	QU	E	4.40	3.10	0.70	-	-	-	-	0	0	0	N	-	-	-	<0.1
1151	MJ05	TPD	1	0-100	DB	FRAGS	WQ	QU	E	3.80	1.60	1.00	-	-	-	-	0	0	0	N	-	-	-	<0.1
1152	MJ05	TPD	1	0-100	DB	FRAGS	WQ	QU	E	3.90	2.20	0.50	-	-	-	-	0	0	0	N	-	-	-	<0.1
1153	MJ05	TPD	1	0-100	DB	FRAGS	WQ	QU	E	3.30	2.00	1.20	-	-	-	-	0	0	0	N	-	-	-	<0.1
1154	MJ05	TPD	1	0-100	DB	FRAGS	WQ	QU	E	2.50	2.00	0.60	-	-	-	-	0	0	0	N	-	-	-	<0.1
1155	MJ05	TPD	2	100-200	RUF	UNF	WQ	QU	-	13.20	13.40	5.50	Flaked	12	5	Feather	3	0	0	Y	RLM	13.50	5.10	0.8
1156	MJ05	TPD	2	100-200	FP	CHIP	WQ	QU	I	12.00	6.40	4.10	-	-	-	-	1	0	0	N	-	-	-	0.5
1157	MJ05	TPD	2	100-200	F	CHIP	WQ	QU	-	8.60	7.10	1.10	Flaked	1.3	0.8	Feather	1	0	0	N	-	-	-	<0.1
1158	MJ05	TPD	2	100-200	FP	CHIP	CQ	QU	L	10.00	5.00	1.20	-	-	-	-	0	0	0	N	-	-	-	<0.1
1159	MJ05	TPD	2	100-200	FP	CHIP	WQ	QU	E	7.20	5.70	1.80	-	-	-	-	0	0	0	N	-	-	-	0.2
1160	MJ05	TPD	2	100-200	FP	CHIP	WQ	QU	E	6.50	4.40	1.50	-	-	-	-	0	0	0	N	-	-	-	<0.1
1161	MJ05	TPD	2	100-200	DB	FRAGS	CQ	QU	E	5.00	2.40	0.80	-	-	-	-	0	0	0	N	-	-	-	<0.1

Artefact #	Site	Pit	Spit	Depth	Artefact Type	Pearce Artefact Type	Lithology	Pearce Lithology	Cross-section	Artefact Dimensions			Platform Type	Platform Dimensions		Termination	# Dorsal flake scars	Cortex %	Parallel Arrises	Retouch / Utilisation?	R/U Location	R/U Length	R/U Width	Weight (g)
										Length	Width	Depth		Length	Width									
1162	MJ05	TPD	2	100-200	DB	FRAGS	WQ	QU	I	2.50	2.40	1.70	-	-	-	-	0	0	0	N	-	-	-	<0.1
1163	MJ05	TPD	2	100-200	MPC	UNF	PQ	QU		See Core page														
1164	MJ05	TPD	3	200-300	FP	FP	WQ	QU	E	19.70	7.10	2.90	-	-	-	-	0	0	0	N	-	-	-	0.6
1165	MJ05	TPD	3	200-300	FP	CHIP	WQ	QU	L	10.00	9.40	1.60	-	-	-	-	1	0	0	N	-	-	-	0.2
1166	MJ05	TPD	3	200-300	DB	FRAGS	CQ	QU	I	5.30	3.40	1.20	-	-	-	-	0	0	0	N	-	-	-	<0.1
1167	MJ05	TPD	3	200-300	DB	FRAGS	WQ	QU	E	4.20	3.40	1.00	-	-	-	-	0	0	0	N	-	-	-	<0.1
1168	MJ05	TPD	3	200-300	DB	FRAGS	WQ	QU	I	4.30	3.10	0.90	-	-	-	-	0	0	0	N	-	-	-	<0.1
1169	MJ05	TPD	3	200-300	DB	FRAGS	CQ	QU	E	4.40	3.00	0.50	-	-	-	-	0	0	0	N	-	-	-	<0.1
1170	MJ05	TPD	4	300-400	DB	FRAGS	WQ	QU	E	5.40	4.40	1.10	-	-	-	-	0	0	0	N	-	-	-	<0.1
1171	MJ05	TPD	4	300-400	DB	FRAGS	CQ	QU	E	3.30	2.60	1.00	-	-	-	-	0	0	0	N	-	-	-	<0.1
1172	MJ05	TPD	5	400-500	DB	FRAGS	WQ	QU	E	6.00	2.20	0.80	-	-	-	-	0	0	0	N	-	-	-	<0.1
1173	MJ05	TPD	5	400-500	DB	FRAGS	WQ	QU	TB	5.40	2.70	2.00	-	-	-	-	0	0	0	N	-	-	-	<0.1
1174	MJ05	TPD	5	400-500	DB	FRAGS	WQ	QU	L	6.40	1.80	1.60	-	-	-	-	0	0	0	N	-	-	-	<0.1
1175	MJ05	TPD	5	400-500	DB	FRAGS	WQ	QU	E	4.60	3.40	2.20	-	-	-	-	0	0	0	N	-	-	-	<0.1
1176	MJ05	TPD	5	400-500	DB	FRAGS	WQ	QU	E	5.40	4.00	0.90	-	-	-	-	0	0	0	N	-	-	-	<0.1
1177	MJ05	TPD	5	400-500	DB	FRAGS	CQ	QU	I	6.70	2.80	2.00	-	-	-	-	0	0	0	N	-	-	-	<0.1
1178	MJ05	TPD	5	400-500	DB	FRAGS	WQ	QU	E	4.40	3.00	0.50	-	-	-	-	0	0	0	N	-	-	-	<0.1
1179	MJ05	TPD	5	400-500	DB	FRAGS	WQ	QU	I	3.30	2.70	2.30	-	-	-	-	0	0	0	N	-	-	-	<0.1
1180	MJ05	TPD	5	400-500	DB	FRAGS	WQ	QU	I	3.30	2.80	0.80	-	-	-	-	0	0	0	N	-	-	-	<0.1
1181	MJ05	TPD	5	400-500	DB	FRAGS	WQ	QU	E	3.40	2.60	1.20	-	-	-	-	0	0	0	N	-	-	-	<0.1
1182	MJ05	TPD	5	400-500	DB	FRAGS	CQ	QU	E	4.70	2.80	0.70	-	-	-	-	0	0	0	N	-	-	-	<0.1
1183	MJ05	TPD	5	400-500	DB	FRAGS	CQ	QU	E	3.90	2.20	0.70	-	-	-	-	0	0	0	N	-	-	-	<0.1
1184	MJ05	TPD	5	400-500	DB	FRAGS	WQ	QU	E	4.00	2.10	1.00	-	-	-	-	0	0	0	N	-	-	-	<0.1

Artefact #	Site	Pit	Spit	Depth	Artefact Type	Pearce Artefact Type	Lithology	Pearce Lithology	Cross-section	Artefact Dimensions			Platform Type	Platform Dimensions		Termination	# Dorsal flake scars	Cortex %	Parallel Arrises	Retouch / Utilisation?	R/U Location	R/U Length	R/U Width	Weight (g)
										Length	Width	Depth		Length	Width									
1185	MJ05	TPD	5	400-500	DB	FRAGS	CQ	QU	E	3.10	2.70	1.10	-	-	-	-	0	0	0	N	-	-	-	<0.1
1186	MJ05	TPD	5	400-500	DB	FRAGS	WQ	QU	TB	3.80	2.80	1.00	-	-	-	-	0	0	0	N	-	-	-	<0.1
1187	MJ05	TPD	5	400-500	DB	FRAGS	CQ	QU	I	3.70	2.50	1.20	-	-	-	-	0	0	0	N	-	-	-	<0.1
1188	MJ05	TPD	5	400-500	DB	FRAGS	WQ	QU	I	3.10	1.80	0.70	-	-	-	-	0	0	0	N	-	-	-	<0.1
1189	MJ05	TPD	5	400-500	DB	FRAGS	WQ	QU	E	3.70	2.30	0.50	-	-	-	-	0	0	0	N	-	-	-	<0.1
1190	MJ05	TPD	5	400-500	DB	FRAGS	WQ	QU	E	3.60	2.10	1.00	-	-	-	-	0	0	0	N	-	-	-	<0.1
1191	MJ05	TPD	5	400-500	DB	FRAGS	CQ	QU	I	5.20	2.10	0.80	-	-	-	-	0	0	0	N	-	-	-	<0.1
1192	MJ05	TPD	6	500-600	FP	FP	WQ	QU	E	21.50	19.10	8.10	-	-	-	-	2	0	0	N	-	-	-	2.4
1193	MJ05	TPD	6	500-600	DB	FRAGS	WQ	QU	TB	10.50	4.30	2.10	-	-	-	-	0	0	0	N	-	-	-	<0.1
1194	MJ05	TPD	6	500-600	DB	FRAGS	WQ	QU	I	5.50	3.60	2.40	-	-	-	-	0	0	0	N	-	-	-	<0.1
1195	MJ05	TPD	6	500-600	DB	FRAGS	WQ	QU	E	5.40	4.90	1.50	-	-	-	-	0	0	0	N	-	-	-	<0.1
1196	MJ05	TPD	6	500-600	DB	FRAGS	WQ	QU	E	6.60	3.40	1.00	-	-	-	-	0	0	0	N	-	-	-	<0.1
1197	MJ05	TPD	6	500-600	DB	FRAGS	WQ	QU	TB	6.30	3.50	1.30	-	-	-	-	0	0	0	N	-	-	-	<0.1
1198	MJ05	TPD	6	500-600	DB	FRAGS	WQ	QU	I	5.20	3.60	1.30	-	-	-	-	0	0	0	N	-	-	-	<0.1
1199	MJ05	TPD	6	500-600	DB	FRAGS	WQ	QU	I	4.90	4.10	1.20	-	-	-	-	0	0	0	N	-	-	-	<0.1
1200	MJ05	TPD	6	500-600	DB	FRAGS	WQ	QU	I	4.20	3.40	2.30	-	-	-	-	0	0	0	N	-	-	-	<0.1
1201	MJ05	TPD	6	500-600	DB	FRAGS	WQ	QU	I	5.50	3.60	1.40	-	-	-	-	0	0	0	N	-	-	-	<0.1
1202	MJ05	TPD	6	500-600	DB	FRAGS	WQ	QU	I	6.70	2.50	1.90	-	-	-	-	0	0	0	N	-	-	-	<0.1
1203	MJ05	TPD	6	500-600	DB	FRAGS	WQ	QU	I	3.90	2.60	0.90	-	-	-	-	0	0	0	N	-	-	-	<0.1
1204	MJ05	TPD	6	500-600	DB	FRAGS	WQ	QU	L	5.80	2.30	1.00	-	-	-	-	0	0	0	N	-	-	-	<0.1
1205	MJ05	TPD	6	500-600	DB	FRAGS	CQ	QU	L	5.20	2.60	0.80	-	-	-	-	0	0	0	N	-	-	-	<0.1
1206	MJ05	TPD	6	500-600	DB	FRAGS	WQ	QU	I	5.80	3.70	1.90	-	-	-	-	0	0	0	N	-	-	-	<0.1
1207	MJ05	TPD	6	500-600	DB	FRAGS	WQ	QU	E	5.20	3.30	1.00	-	-	-	-	0	0	0	N	-	-	-	<0.1

Artefact #	Site	Pit	Spit	Depth	Artefact Type	Pearce Artefact Type	Lithology	Pearce Lithology	Cross-section	Artefact Dimensions			Platform Type	Platform Dimensions		Termination	# Dorsal flake scars	Cortex %	Parallel Arrises	Retouch / Utilisation?	R/U Location	R/U Length	R/U Width	Weight (g)
										Length	Width	Depth		Length	Width									
1208	MJ05	TPD	6	500-600	DB	FRAGS	CQ	QU	E	8.00	3.10	1.70	-	-	-	-	0	0	0	N	-	-	-	<0.1
1209	MJ05	TPD	6	500-600	DB	FRAGS	WQ	QU	I	2.30	2.70	0.70	-	-	-	-	0	0	0	N	-	-	-	<0.1
1210	MJ05	TPD	6	500-600	DB	FRAGS	WQ	QU	I	4.70	3.00	1.30	-	-	-	-	0	0	0	N	-	-	-	<0.1
1211	MJ05	TPD	6	500-600	DB	FRAGS	CQ	QU	L	4.60	2.40	1.70	-	-	-	-	0	0	0	N	-	-	-	<0.1
1212	MJ05	TPD	6	500-600	DB	FRAGS	WQ	QU	E	4.30	3.30	0.40	-	-	-	-	0	0	0	N	-	-	-	<0.1
1213	MJ05	TPD	6	500-600	DB	FRAGS	CQ	QU	E	3.80	3.00	0.50	-	-	-	-	0	0	0	N	-	-	-	<0.1
1214	MJ05	TPD	6	500-600	DB	FRAGS	WQ	QU	E	5.30	3.10	0.90	-	-	-	-	0	0	0	N	-	-	-	<0.1
1215	MJ05	TPD	6	500-600	DB	FRAGS	CQ	QU	TG	2.90	2.00	1.10	-	-	-	-	0	0	0	N	-	-	-	<0.1
1216	MJ05	TPD	6	500-600	DB	FRAGS	WQ	QU	I	5.30	1.90	0.70	-	-	-	-	0	0	0	N	-	-	-	<0.1
1217	MJ05	TPD	6	500-600	DB	FRAGS	WQ	QU	I	2.90	2.30	1.20	-	-	-	-	0	0	0	N	-	-	-	<0.1
1218	MJ05	TPD	6	500-600	DB	FRAGS	WQ	QU	E	3.60	2.30	0.60	-	-	-	-	0	0	0	N	-	-	-	<0.1
1219	MJ05	TPD	6	500-600	DB	FRAGS	WQ	QU	TB	3.30	2.80	1.10	-	-	-	-	0	0	0	N	-	-	-	<0.1
1220	MJ05	TPD	6	500-600	LBF/TBF	FP	WQ	QU	-	15.50	13.00	3.80	Flaked	9.5	3.2	Broken	2	0	0	N	-	-	-	1
1221	MJ05	TPD	7	600-700	FP	CHIP	CQ	QU	E	11.60	5.20	0.90	-	-	-	-	0	0	0	N	-	-	-	<0.1
1222	MJ05	TPD	7	600-700	F	CHIP	CQ	QU	-	14.10	10.70	3.60	Faceted	9	4	Feather	3	0	2	N	-	-	-	0.7
1223	MJ05	TPD	7	600-700	F	CHIP	CQ	QU	-	12.10	8.20	2.20	Flaked	9.7	4.8	Stepped	1	0	0	N	-	-	-	0.4
1224	MJ05	TPD	7	600-700	LBF	CHIP	CQ	QU	-	9.80	6.70	1.50	Faceted	5.5	1.6	Feather	1	0	0	N	-	-	-	0.1
1225	MJ05	TPD	7	600-700	DB	FRAGS	WQ	QU	I	7.70	3.20	2.80	-	-	-	-	0	0	0	N	-	-	-	0.1
1226	MJ05	TPD	7	600-700	F	CHIP	CQ	QU	-	6.90	7.20	1.20	Flaked	5.5	1.3	Feather	2	0	0	N	-	-	-	<0.1
1227	MJ05	TPD	7	600-700	FP	CHIP	WQ	QU	E	5.70	4.20	1.10	-	-	-	-	0	0	0	N	-	-	-	<0.1
1228	MJ05	TPD	7	600-700	DB	FRAGS	CQ	QU	E	5.60	2.60	1.10	-	-	-	-	0	0	0	N	-	-	-	<0.1
1229	MJ05	TPD	7	600-700	FP	CHIP	CQ	QU	I	5.20	2.20	0.80	-	-	-	-	0	0	0	N	-	-	-	<0.1
1230	MJ05	TPD	7	600-700	FP	CHIP	WQ	QU	E	3.10	1.80	0.70	-	-	-	-	0	0	0	N	-	-	-	<0.1

Artefact #	Site	Pit	Spit	Depth	Artefact Type	Pearce Artefact Type	Lithology	Pearce Lithology	Cross-section	Artefact Dimensions			Platform Type	Platform Dimensions		Termination	# Dorsal flake scars	Cortex %	Parallel Arrises	Retouch / Utilisation?	R/U Location	R/U Length	R/U Width	Weight (g)
										Length	Width	Depth		Length	Width									
1231	MJ05	TPD	7	600-700	FP	CHIP	CQ	QU	I	4.50	2.70	0.60	-	-	-	-	0	0	0	N	-	-	-	<0.1
1232	MJ05	TPD	7	600-700	FP	CHIP	CQ	QU	L	3.00	2.40	0.60	-	-	-	-	0	0	0	N	-	-	-	<0.1
1233	MJ05	TPD	7	600-700	FP	CHIP	CQ	QU	I	5.10	4.70	1.80	-	-	-	-	0	0	0	N	-	-	-	<0.1
1234	MJ05	TPD	7	600-700	FP	CHIP	CQ	QU	E	4.90	2.40	1.40	-	-	-	-	0	0	0	N	-	-	-	<0.1
1235	MJ05	TPD	7	600-700	DB	FRAGS	WQ	QU	I	4.80	4.10	1.80	-	-	-	-	0	0	0	N	-	-	-	<0.1
1236	MJ05	TPD	7	600-700	DB	FRAGS	CQ	QU	L	3.70	2.80	0.90	-	-	-	-	0	0	0	N	-	-	-	<0.1
1237	MJ05	TPD	7	600-700	DB	FRAGS	WQ	QU	I	5.20	2.00	1.30	-	-	-	-	0	0	0	N	-	-	-	<0.1
1238	MJ05	TPD	7	600-700	DB	FRAGS	WQ	QU	I	4.60	3.50	1.60	-	-	-	-	0	0	0	N	-	-	-	<0.1
1239	MJ05	TPD	7	600-700	DB	FRAGS	WQ	QU	L	3.50	3.10	1.10	-	-	-	-	0	0	0	N	-	-	-	<0.1
1240	MJ05	TPD	7	600-700	SPC	UNF	SQ	QU		See Core page														
1241	MJ05	TPD	7	600-700	MPC	UNF	WQ	QU		See Core page														
1242	MJ05	TPD	8	700-800	MANU	LUMP	WQ	QU	-	4.50	4.10	2.10	-	-	-	-	0	0	0	N	-	-	-	<0.1
1243	MJ05	TPD	8	700-800	RUF	UNF	CQ	QU	-	16.50	8.60	2.00	Faceted	2.9	0.6	Feather	3	0	1	Y	LLM	8.20	2.10	0.2
1244	MJ05	TPD	8	700-800	LBF	CHIP	WQ	QU	-	12.50	7.10	2.20	Flaked	5.7	1.4	Feather	1	0	0	N	-	-	-	0.2
1245	MJ05	TPD	8	700-800	DB	FRAGS	CQ	QU	I	7.50	4.30	1.80	-	-	-	-	0	0	0	N	-	-	-	<0.1
1246	MJ05	TPD	8	700-800	DB	FRAGS	WQ	QU	I	6.50	6.90	3.40	-	-	-	-	0	0	0	N	-	-	-	0.2
1247	MJ05	TPD	8	700-800	DB	FRAGS	WQ	QU	I	3.60	3.10	2.40	-	-	-	-	0	0	0	N	-	-	-	<0.1
1248	MJ05	TPD	8	700-800	FP	CHIP	CQ	QU	TB	8.80	5.70	0.80	-	-	-	-	0	0	0	N	-	-	-	<0.1
1249	MJ05	TPD	8	700-800	FP	CHIP	CQ	QU	TB	7.30	4.10	2.40	-	-	-	-	0	0	0	N	-	-	-	<0.1
1250	MJ05	TPD	8	700-800	DB	FRAGS	WQ	QU	TB	6.40	2.70	1.20	-	-	-	-	0	0	0	N	-	-	-	<0.1
1251	MJ05	TPD	8	700-800	DB	FRAGS	WQ	QU	L	6.70	2.60	2.00	-	-	-	-	0	0	0	N	-	-	-	<0.1
1252	MJ05	TPD	8	700-800	DB	FRAGS	WQ	QU	TG	4.10	2.50	1.90	-	-	-	-	0	0	0	N	-	-	-	<0.1
1253	MJ05	TPD	8	700-800	DB	FRAGS	CQ	QU	L	4.10	3.00	0.70	-	-	-	-	0	0	0	N	-	-	-	<0.1

Artefact #	Site	Pit	Spit	Depth	Artefact Type	Pearce Artefact Type	Lithology	Pearce Lithology	Cross-section	Artefact Dimensions			Platform Type	Platform Dimensions		Termination	# Dorsal flake scars	Cortex %	Parallel Arrises	Retouch / Utilisation?	R/U Location	R/U Length	R/U Width	Weight (g)
										Length	Width	Depth		Length	Width									
1254	MJ05	TPD	8	700-800	DB	FRAGS	CQ	QU	TG	4.90	2.10	1.50	-	-	-	-	0	0	0	N	-	-	-	<0.1
1255	MJ05	TPD	8	700-800	DB	FRAGS	CQ	QU	I	4.50	3.10	1.40	-	-	-	-	0	0	0	N	-	-	-	<0.1
1256	MJ05	TPD	8	700-800	DB	FRAGS	WQ	QU	L	4.50	3.40	1.10	-	-	-	-	0	0	0	N	-	-	-	<0.1
1257	MJ05	TPD	8	700-800	MPC	UNF	WQ	QU		See Core page														
1258	MJ05	TPD	9	800-900	FP	CHIP	CQ	QU	I	6.30	4.70	2.80	-	-	-	-	0	0	0	N	-	-	-	<0.1
1259	MJ05	TPD	9	800-900	FP	CHIP	CQ	QU	L	5.00	4.30	0.70	-	-	-	-	0	0	0	N	-	-	-	<0.1
1260	MJ05	TPD	9	800-900	FP	CHIP	WQ	QU	I	6.80	4.00	2.20	-	-	-	-	0	0	0	N	-	-	-	<0.1
2161	MJ05	TPD	9	800-900	FP	CHIP	CQ	QU	E	5.70	2.40	1.50	-	-	-	-	0	0	0	N	-	-	-	<0.1
1262	MJ05	TPD	9	800-900	MPC	UNF	WQ	QU		See Core page														
1263	MJ05	TPD	9	800-900	MPC	UNF	WQ	QU		See Core page														
1264	MJ05	TPD	10	900-1000	DB	FRAGS	WQ	QU	TG	7.30	3.20	4.50	-	-	-	-	0	0	0	N	-	-	-	0.2
1265	MJ05	TPD	10	900-1000	DB	FRAGS	WQ	QU	E	3.20	3.40	0.50	-	-	-	-	0	0	0	N	-	-	-	<0.1
1266	MJ05	TPD	10	900-1000	FP	CHIP	WQ	QU	I	7.30	4.50	3.00	-	-	-	-	0	0	0	N	-	-	-	<0.1
1267	MJ05	TPD	10	900-1000	DB	FRAGS	WQ	QU	I	3.00	2.10	1.70	-	-	-	-	0	0	0	N	-	-	-	<0.1
1268	MJ05	TPD	10	900-1000	DB	FRAGS	WQ	QU	I	3.10	2.50	3.20	-	-	-	-	0	0	0	N	-	-	-	<0.1
1269	MJ05	TPD	North Wall Clean Up	NA	DB	FRAGS	WQ	QU	I	6.20	6.00	1.60	-	-	-	-	0	0	0	N	-	-	-	<0.1
1270	MJ05	TPD	South Wall Clean Up	NA	DB	FRAGS	WQ	QU	I	7.20	5.40	1.80	-	-	-	-	0	0	0	N	-	-	-	<0.1
1271	MJ05	TPD	South Wall Clean Up	NA	FP	CHIP	WQ	QU	I	10.60	4.50	2.40	-	-	-	-	0	0	0	N	-	-	-	<0.1

Artefact #	Site	Pit	Spit	Depth	Artefact Type	Pearce Artefact Type	Lithology	Pearce Lithology	Cross-section	Artefact Dimensions			Platform Type	Platform Dimensions		Termination	# Dorsal flake scars	Cortex %	Parallel Arrises	Retouch / Utilisation?	R/U Location	R/U Length	R/U Width	Weight (g)
										Length	Width	Depth		Length	Width									
1272	MJ05	TPD	South Wall Clean Up	NA	DB	FRAGS	WQ	QU	I	5.00	3.00	1.20	-	-	-	-	0	0	0	N	-	-	-	<0.1
1273	MJ05	TPD	West Wall Clean Up	NA	F	CHIP	WQ	QU	-	9.10	10.80	1.60	Faceted	8.6	2.1	Feather	1	0	0	N	-	-	-	0.2
1274	MJ05	TPD	West Wall Clean Up	NA	DB	FRAGS	WQ	QU	I	7.80	4.80	2.10	-	-	-	-	0	0	0	N	-	-	-	<0.1
1275	MJ05	TPD	West Wall Clean Up	NA	FP	CHIP	WQ	QU	TB	6.10	4.40	0.90	-	-	-	-	0	0	0	N	-	-	-	<0.1
1276	MJ05	TPD	West Wall Clean Up	NA	DB	FRAGS	WQ	QU	I	6.00	2.80	1.00	-	-	-	-	0	0	0	N	-	-	-	<0.1
1277	MJ05	TPD	West Wall Clean Up	NA	DB	FRAGS	WQ	QU	L	4.60	3.20	0.80	-	-	-	-	0	0	0	N	-	-	-	<0.1
1278	MJ05	TPD	West Wall Clean Up	NA	DB	FRAGS	WQ	QU	I	5.30	1.50	1.40	-	-	-	-	0	0	0	N	-	-	-	<0.1
1279	MJ05	TPD	West Wall Clean Up	NA	FP	CHIP	CQ	QU	L	4.10	4.20	1.00	-	-	-	-	0	0	0	N	-	-	-	<0.1
1280	MJ05	5PW60	NA	400	FP	CHIP	WQ	QU	I	13.00	6.40	3.90	-	-	-	-	0	0	0	N	-	-	-	0.3
1281	MJ05	5PW60	NA	400	DB	FRAGS	WQ	QU	L	5.30	3.60	1.00	-	-	-	-	0	0	0	N	-	-	-	<0.1
1282	MJ05	5PW60	NA	400	F	CHIP	CQ	QU	-	4.70	6.80	1.00	Flaked	3.7	1.3	Feather	1	0	0	N	-	-	-	<0.1
1283	MJ05	5PW60	NA	400	FP	CHIP	CQ	QU	L	8.40	4.60	2.00	-	-	-	-	0	0	0	N	-	-	-	<0.1
1284	MJ05	5PW60	NA	400	DB	FRAGS	WQ	QU	TB	5.10	4.80	1.50	-	-	-	-	0	0	0	N	-	-	-	<0.1
1285	MJ05	5PW60	NA	400	DB	FRAGS	CQ	QU	L	4.50	3.70	0.90	-	-	-	-	0	0	0	N	-	-	-	<0.1
1286	MJ05	5PW60	NA	400	DB	FRAGS	CQ	QU	L	5.20	3.40	1.10	-	-	-	-	0	0	0	N	-	-	-	<0.1
1287	MJ05	5PW60	NA	400	DB	FRAGS	CQ	QU	E	3.30	3.00	0.60	-	-	-	-	0	0	0	N	-	-	-	<0.1

Artefact #	Site	Pit	Spit	Depth	Artefact Type	Pearce Artefact Type	Lithology	Pearce Lithology	Cross-section	Artefact Dimensions			Platform Type	Platform Dimensions		Termination	# Dorsal flake scars	Cortex %	Parallel Arrises	Retouch / Utilisation?	R/U Location	R/U Length	R/U Width	Weight (g)
										Length	Width	Depth		Length	Width									
1288	MJ05	5PW60	NA	400	DB	FRAGS	CQ	QU	TB	4.60	2.60	0.80	-	-	-	-	0	0	0	N	-	-	-	<0.1
1289	MJ05	5PW60	NA	400	FP	CHIP	CQ	QU	L	3.60	2.90	0.60	-	-	-	-	0	0	0	N	-	-	-	<0.1
1290	MJ05	5PW60	NA	400	FP	CHIP	CQ	QU	L	5.10	4.00	1.50	-	-	-	-	0	0	0	N	-	-	-	<0.1
1291	MJ05	5PW60	NA	400	DB	FRAGS	CQ	QU	E	5.20	3.70	1.30	-	-	-	-	0	0	0	N	-	-	-	<0.1
1292	MJ05	5PW60	NA	400	DB	FRAGS	CQ	QU	I	5.40	2.10	0.90	-	-	-	-	0	0	0	N	-	-	-	<0.1
1293	MJ05	5PW60	NA	400	FP	CHIP	CQ	QU	L	2.90	3.90	0.50	-	-	-	-	0	0	0	N	-	-	-	<0.1
1294	MJ05	5PW60	NA	400	DB	FRAGS	WQ	QU	I	6.90	3.80	1.50	-	-	-	-	0	0	0	N	-	-	-	<0.1
1295	MJ05	5PW60	NA	400	DB	FRAGS	WQ	QU	E	6.00	4.70	1.60	-	-	-	-	0	0	0	N	-	-	-	<0.1
1296	MJ05	5PW60	NA	400	FP	CHIP	CQ	QU	E	5.70	3.90	0.80	-	-	-	-	0	0	0	N	-	-	-	<0.1
1297	MJ05	5PW60	NA	400	DB	FRAGS	CQ	QU	I	5.70	5.90	2.70	-	-	-	-	0	0	0	N	-	-	-	<0.1
1298	MJ05	5PN90	NA	600	DB	FRAGS	WQ	QU	I	6.10	4.50	3.10	-	-	-	-	0	0	0	N	-	-	-	<0.1
1299	MJ05	5PN90	NA	600	DB	FRAGS	WQ	QU	I	3.50	2.00	2.50	-	-	-	-	0	0	0	N	-	-	-	<0.1
1300	MJ05	5PE60	NA	500	FP	CHIP	CQ	QU	E	7.00	5.30	1.60	-	-	-	-	0	0	0	N	-	-	-	<0.1
1301	MJ05	5PE60	NA	500	FP	CHIP	WQ	QU	I	12.70	7.90	5.20	-	-	-	-	1	0	0	N	-	-	-	0.5
1302	MJ05	5PE60	NA	500	DB	FRAGS	WQ	QU	I	7.10	4.70	4.40	-	-	-	-	0	0	0	N	-	-	-	0.2
1303	MJ05	5PE60	NA	500	DB	FRAGS	WQ	QU	TB	8.30	5.20	2.50	-	-	-	-	0	0	0	N	-	-	-	0.2
1304	MJ05	5PE60	NA	500	DB	FRAGS	WQ	QU	I	7.40	6.00	6.00	-	-	-	-	0	0	0	N	-	-	-	0.3
1305	MJ05	5PE60	NA	500	FP	CHIP	CQ	QU	E	7.10	4.00	1.00	-	-	-	-	0	0	0	N	-	-	-	<0.1
1306	MJ05	5PE60	NA	500	DB	FRAGS	WQ	QU	I	5.20	3.40	1.20	-	-	-	-	0	0	0	N	-	-	-	<0.1
1307	MJ05	5PE60	NA	500	FP	CHIP	CQ	QU	E	5.00	2.90	1.70	-	-	-	-	0	0	0	N	-	-	-	<0.1
1308	MJ05	5PS90	NA	550	FP	CHIP	CQ	QU	E	4.30	3.50	1.00	-	-	-	-	0	0	0	N	-	-	-	<0.1
1309	MJ05	5PS90	NA	550	FP	CHIP	CQ	QU	E	8.50	3.50	1.80	-	-	-	-	0	0	0	N	-	-	-	<0.1
1310	MJ05	5PS90	NA	550	DB	FRAGS	WQ	QU	I	6.00	2.60	1.80	-	-	-	-	0	0	0	N	-	-	-	<0.1

Artefact #	Site	Pit	Spit	Depth	Artefact Type	Pearce Artefact Type	Lithology	Pearce Lithology	Cross-section	Artefact Dimensions			Platform Type	Platform Dimensions		Termination	# Dorsal flake scars	Cortex %	Parallel Arrises	Retouch / Utilisation?	R/U Location	R/U Length	R/U Width	Weight (g)
										Length	Width	Depth		Length	Width									
1311	MJ05	5PS90	NA	550	SPC	UNF	WQ	QU		See Core page														
1312	MJ05	EXG	1	0-50	LBF	FP	WQ	QU	-	18.20	23.10	7.10	Faceted	11.3	6.5	Feather	4	0	0	N	-	-	-	3.5
1313	MJ05	EXG	1	0-50	LBF	FP	WQ	QU	-	18.20	5.80	2.40	Flaked	4.8	1.9	Feather	0	0	0	N	-	-	-	0.3
1314	MJ05	EXG	1	0-50	F	CHIP	CQ	QU	-	7.30	4.80	1.60	Flaked	3.4	0.4	Feather	3	0	0	N	-	-	-	<0.1
1315	MJ05	EXG	1	0-50	FP	CHIP	WQ	QU	L	11.50	3.30	1.40	-	-	-	-	0	0	0	N	-	-	-	<0.1
1316	MJ05	EXG	1	0-50	DB	FRAGS	CQ	QU	I	6.60	3.90	1.30	-	-	-	-	0	0	0	N	-	-	-	<0.1
1317	MJ05	EXG	1	0-50	FP	CHIP	CQ	QU	I	6.60	5.40	1.80	-	-	-	-	0	0	0	N	-	-	-	<0.1
1318	MJ05	EXG	1	0-50	FP	CHIP	CQ	QU	I	6.60	4.30	1.10	-	-	-	-	0	0	0	N	-	-	-	<0.1
1319	MJ05	EXG	1	0-50	DB	FRAGS	CQ	QU	I	7.30	5.20	1.40	-	-	-	-	0	0	0	N	-	-	-	<0.1
1320	MJ05	EXG	1	0-50	DB	FRAGS	WQ	QU	E	5.40	3.60	0.60	-	-	-	-	0	0	0	N	-	-	-	<0.1
1321	MJ05	EXG	1	0-50	FP	CHIP	CQ	QU	L	6.70	5.20	1.10	-	-	-	-	0	0	0	N	-	-	-	<0.1
1322	MJ05	EXG	1	0-50	DB	FRAGS	WQ	QU	I	7.10	4.60	2.00	-	-	-	-	0	0	0	N	-	-	-	<0.1
1323	MJ05	EXG	1	0-50	DB	FRAGS	WQ	QU	L	5.50	3.90	1.30	-	-	-	-	0	0	0	N	-	-	-	<0.1
1324	MJ05	EXG	1	0-50	DB	FRAGS	WQ	QU	E	5.90	4.20	0.80	-	-	-	-	0	0	0	N	-	-	-	<0.1
1325	MJ05	EXG	1	0-50	DB	FRAGS	CQ	QU	E	5.20	1.80	1.00	-	-	-	-	0	0	0	N	-	-	-	<0.1
1326	MJ05	EXG	1	0-50	DB	FRAGS	WQ	QU	L	5.30	4.50	0.90	-	-	-	-	0	0	0	N	-	-	-	<0.1
1327	MJ05	EXG	1	0-50	DB	FRAGS	WQ	QU	E	4.20	3.10	0.70	-	-	-	-	0	0	0	N	-	-	-	<0.1
1328	MJ05	EXG	1	0-50	DB	FRAGS	WQ	QU	I	3.60	3.50	0.70	-	-	-	-	0	0	0	N	-	-	-	<0.1
1329	MJ05	EXG	1	0-50	MPC	UNF	PQ	QU		See Core page														
1330	MJ05	EXG	1	0-50	MPC	UNF	WQ	QU		See Core page														
1331	MJ05	EXG	1	0-50	SPC	UNF	WQ	QU		See Core page														
1332	MJ05	EXG	2	50-100	FP	FP	WQ	QU	I	18.90	10.10	2.50	-	-	-	-	1	0	0	N	-	-	-	0.6
1333	MJ05	EXG	2	50-100	FP	CHIP	WQ	QU	I	11.40	7.10	5.50	-	-	-	-	1	0	0	N	-	-	-	0.5
1334	MJ05	EXG	2	50-100	FP	CHIP	WQ	QU	E	11.20	4.90	4.20	-	-	-	-	1	0	0	N	-	-	-	0.2
1335	MJ05	EXG	2	50-100	FP	CHIP	CQ	QU	TB	10.00	4.80	4.20	-	-	-	-	1	0	0	N	-	-	-	0.2
1336	MJ05	EXG	2	50-100	FP	CHIP	WQ	QU	I	10.50	5.20	2.60	-	-	-	-	0	0	0	N	-	-	-	0.2

Artefact #	Site	Pit	Spit	Depth	Artefact Type	Pearce Artefact Type	Lithology	Pearce Lithology	Cross-section	Artefact Dimensions			Platform Type	Platform Dimensions		Termination	# Dorsal flake scars	Cortex %	Parallel Arrises	Retouch / Utilisation?	R/U Location	R/U Length	R/U Width	Weight (g)
										Length	Width	Depth		Length	Width									
1337	MJ05	EXG	2	50-100	FP	CHIP	WQ	QU	E	12.60	8.70	3.80	-	-	-	-	3	0	2	N	-	-	-	0.3
1338	MJ05	EXG	2	50-100	DB	FRAGS	WQ	QU	L	9.40	5.90	2.50	-	-	-	-	0	0	0	N	-	-	-	0.1
1339	MJ05	EXG	2	50-100	FP	CHIP	WQ	QU	TG	6.60	2.90	3.70	-	-	-	-	1	0	0	N	-	-	-	<0.1
1340	MJ05	EXG	2	50-100	FP	CHIP	CQ	QU	E	4.80	4.80	1.40	-	-	-	-	0	0	0	N	-	-	-	<0.1
1341	MJ05	EXG	2	50-100	FP	CHIP	WQ	QU	I	8.90	7.50	2.20	-	-	-	-	0	0	0	N	-	-	-	0.2
1342	MJ05	EXG	2	50-100	DB	FRAGS	WQ	QU	E	6.30	4.40	1.40	-	-	-	-	0	0	0	N	-	-	-	<0.1
1343	MJ05	EXG	2	50-100	FP	CHIP	CQ	QU	TB	12.60	5.40	4.70	-	-	-	-	0	0	0	N	-	-	-	0.5
1344	MJ05	EXG	2	50-100	SPC	UNF	WQ	QU		See Core page														
1345	MJ05	EXG	2	50-100	MPC	UNF	YQ	QU		See Core page														
1346	MJ05	EXG	2	50-100	FP	FP	WQ	QU	-	49.70	37.30	18.40	-	-	-	-	1	0	0	N	-	-	-	43.6
1347	MJ05	EXG	3	100-200	PTBF	CHIP	CQ	QU	-	7.60	5.60	1.80	Flaked	3.1	1.6	Broken	1	0	0	N	-	-	-	<0.1
1348	MJ05	EXG	3	100-200	F	CHIP	WQ	QU	-	10.70	8.70	1.60	Focalised	-	-	Feather	1	0	0	N	-	-	-	0.2
1349	MJ05	EXG	3	100-200	DB	FRAGS	WQ	QU	E	7.30	5.50	1.60	-	-	-	-	0	0	0	N	-	-	-	<0.1
1350	MJ05	EXG	3	100-200	LBF	CHIP	WQ	QU	-	4.20	7.00	1.70	Focalised	-	-	Feather	1	0	0	N	-	-	-	<0.1
1351	MJ05	EXG	3	100-200	FP	CHIP	CQ	QU	I	7.90	4.40	2.10	-	-	-	-	1	0	0	N	-	-	-	<0.1
1352	MJ05	EXG	3	100-200	DB	FRAGS	WQ	QU	L	6.70	4.30	1.00	-	-	-	-	0	0	0	N	-	-	-	<0.1
1353	MJ05	EXG	3	100-200	DB	FRAGS	WQ	QU	E	9.00	4.40	1.30	-	-	-	-	0	0	0	N	-	-	-	<0.1
1354	MJ05	EXG	3	100-200	DB	FRAGS	WQ	QU	I	6.00	2.00	1.90	-	-	-	-	0	0	0	N	-	-	-	<0.1
1355	MJ05	EXG	3	100-200	DB	FRAGS	CQ	QU	E	6.30	2.50	0.70	-	-	-	-	0	0	0	N	-	-	-	<0.1
1356	MJ05	EXG	3	100-200	DB	FRAGS	WQ	QU	E	4.90	2.00	0.90	-	-	-	-	0	0	0	N	-	-	-	<0.1
1357	MJ05	EXG	3	100-200	DB	FRAGS	WQ	QU	TB	6.70	6.00	1.50	-	-	-	-	0	0	0	N	-	-	-	<0.1
1358	MJ05	EXG	3	100-200	DB	FRAGS	CQ	QU	E	7.50	4.40	1.40	-	-	-	-	0	0	0	N	-	-	-	<0.1

Artefact #	Site	Pit	Spit	Depth	Artefact Type	Pearce Artefact Type	Lithology	Pearce Lithology	Cross-section	Artefact Dimensions			Platform Type	Platform Dimensions		Termination	# Dorsal flake scars	Cortex %	Parallel Arrises	Retouch / Utilisation?	R/U Location	R/U Length	R/U Width	Weight (g)
										Length	Width	Depth		Length	Width									
1359	MJ05	EXG	3	100-200	DB	FRAGS	CQ	QU	I	3.90	3.50	1.50	-	-	-	-	0	0	0	N	-	-	-	<0.1
1360	MJ05	EXG	4	200-300	MANU	LUMP	UNID	OTHER	-	34.40	27.30	5.20	-	-	-	-	0	0	0	N	-	-	-	5.2
1361	MJ05	EXG	4	200-300	DB	FRAGS	SQ	QU	TB	9.30	6.70	3.40	-	-	-	-	0	0	0	N	-	-	-	0.3
1362	MJ05	EXG	4	200-300	FP	CHIP	WQ	QU	E	10.30	3.90	1.50	-	-	-	-	1	0	0	N	-	-	-	<0.1
1363	MJ05	EXG	4	200-300	DB	FRAGS	WQ	QU	I	6.40	7.00	2.40	-	-	-	-	0	0	0	N	-	-	-	0.1
1364	MJ05	EXG	4	200-300	FP	FP	WQ	QU	TG	18.60	8.00	6.80	-	-	-	-	1	0	0	N	-	-	-	1
1365	MJ05	EXG	4	200-300	DB	FRAGS	WQ	QU	TG	12.30	6.60	6.40	-	-	-	-	0	0	0	N	-	-	-	0.3
1366	MJ05	EXG	4	200-300	FP	CHIP	WQ	QU	E	6.30	3.90	2.00	-	-	-	-	0	0	0	N	-	-	-	<0.1
1367	MJ05	EXG	4	200-300	FP	CHIP	CQ	QU	TG	10.40	6.90	3.30	-	-	-	-	0	0	0	N	-	-	-	0.3
1368	MJ05	EXG	4	200-300	DB	FRAGS	WQ	QU	TB	8.60	1.10	4.00	-	-	-	-	0	0	0	N	-	-	-	<0.1
1369	MJ05	EXG	4	200-300	DB	FRAGS	WQ	QU	I	8.70	8.00	1.40	-	-	-	-	0	0	0	N	-	-	-	<0.1
1370	MJ05	EXG	4	200-300	DB	FRAGS	CQ	QU	E	4.60	4.70	0.70	-	-	-	-	0	0	0	N	-	-	-	<0.1
1371	MJ05	EXG	4	200-300	DB	FRAGS	WQ	QU	I	11.80	6.10	2.30	-	-	-	-	0	0	0	N	-	-	-	0.3
1372	MJ05	EXG	4	200-300	DB	FRAGS	CQ	QU	I	7.50	7.30	0.90	-	-	-	-	0	0	0	N	-	-	-	<0.1
1373	MJ05	EXG	4	200-300	MPC	UNF	WQ	QU		See Core page														
1374	MJ05	EXG	5	300-400	DB	FRAGS	WQ	QU	I	8.50	5.80	2.80	-	-	-	-	0	0	0	N	-	-	-	<0.1
1375	MJ05	EXG	5	300-400	DB	FRAGS	WQ	QU	L	4.70	3.00	0.50	-	-	-	-	0	0	0	N	-	-	-	<0.1
1376	MJ05	EXG	5	300-400	DB	FRAGS	CQ	QU	L	5.00	3.00	0.80	-	-	-	-	0	0	0	N	-	-	-	<0.1
1377	MJ05	EXG	5	300-400	DB	FRAGS	CQ	QU	I	5.30	2.80	1.00	-	-	-	-	0	0	0	N	-	-	-	<0.1
1378	MJ05	EXG	7	500-600	DB	FRAGS	CQ	QU	E	7.60	3.70	1.40	-	-	-	-	0	0	0	N	-	-	-	<0.1
1379	MJ05	EXG	7	500-600	DB	FRAGS	WQ	QU	E	5.70	3.80	0.90	-	-	-	-	0	0	0	N	-	-	-	<0.1
1380	MJ05	EXG	9	700-800	DB	FRAGS	WQ	QU	TB	3.20	1.60	1.20	-	-	-	-	0	0	0	N	-	-	-	<0.1

Artefact #	Site	Pit	Spit	Depth	Artefact Type	Pearce Artefact Type	Lithology	Pearce Lithology	Cross-section	Artefact Dimensions			Platform Type	Platform Dimensions		Termination	# Dorsal flake scars	Cortex %	Parallel Arrises	Retouch / Utilisation?	R/U Location	R/U Length	R/U Width	Weight (g)
										Length	Width	Depth		Length	Width									
1381	MJ05	EXG	9	700-800	DB	FRAGS	CQ	QU	I	5.50	4.10	2.00	-	-	-	-	0	0	0	N	-	-	-	<0.1
1382	MJ05	EXG	10	800-900	DB	FRAGS	WQ	QU	TB	8.00	4.70	1.60	-	-	-	-	0	0	0	N	-	-	-	<0.1
1383	MJ05	EXG	10	800-900	DB	FRAGS	CQ	QU	L	4.60	2.90	1.40	-	-	-	-	0	0	0	N	-	-	-	<0.1
1384	MJ05	EXG	14	1200-1300	DB	FRAGS	CQ	QU	E	5.40	3.50	1.80	-	-	-	-	0	0	0	N	-	-	-	<0.1
1385	MJ05	EXG	14	1200-1300	DB	FRAGS	WQ	QU	L	6.70	5.70	1.10	-	-	-	-	0	0	0	N	-	-	-	<0.1
1386	MJ05	EXG	14	1200-1300	DB	FRAGS	WQ	QU	E	4.90	2.40	0.70	-	-	-	-	0	0	0	N	-	-	-	<0.1
1387	MJ05	EXG	14	1200-1300	DB	FRAGS	CQ	QU	I	5.90	3.90	1.40	-	-	-	-	0	0	0	N	-	-	-	<0.1
1388	MJ05	EXG	14	1200-1300	DB	FRAGS	WQ	QU	TB	5.00	2.80	1.40	-	-	-	-	0	0	0	N	-	-	-	<0.1
1389	MJ05	EXG	14	1200-1300	DB	FRAGS	WQ	QU	E	5.10	2.50	0.60	-	-	-	-	0	0	0	N	-	-	-	<0.1
1390	MJ05	EXG	15	1300-1400	FP	CHIP	WQ	QU	E	8.30	6.00	1.50	-	-	-	-	0	0	0	N	-	-	-	<0.1
1391	MJ05	EXG	15	1300-1400	DB	FRAGS	WQ	QU	TG	5.10	2.30	2.10	-	-	-	-	0	0	0	N	-	-	-	<0.1
1392	MJ05	EXG	16	1400-1500	FP	FP	WQ	QU	TB	17.60	5.30	1.60	-	-	-	-	2	0	0	N	-	-	-	0.3
1393	MJ05	EXG	16	1400-1500	DB	FRAGS	BQTZ	QTZ	E	10.30	6.00	2.60	-	-	-	-	0	0	0	N	-	-	-	0.2
1394	MJ05	EXG	16	1400-1500	DB	FRAGS	CH	CH	L	8.7	4.20	1.00	-	-	-	-	0	0	0	N	-	-	-	<0.1
1395	MJ05	EXG	16	1400-1500	LBF	CHIP	QTZ	QU	-	13.30	8.00	3.20	Flaked	6.5	2.7	Feather	1	0	0	N	-	-	-	0.3
1396	MJ05	EXG	16	1400-1500	DB	FRAGS	CQ	QU	E	6.00	6.30	1.00	-	-	-	-	0	0	0	N	-	-	-	<0.1
1397	MJ05	EXG	16	1400-1500	FP	CHIP	WQ	QU	I	7.10	4.10	1.30	-	-	-	-	1	0	0	N	-	-	-	<0.1
1398	MJ05	EXG	16	1400-1500	DB	FRAGS	WQ	QU	I	4.40	2.50	1.90	-	-	-	-	0	0	0	N	-	-	-	<0.1
1399	MJ05	EXG	16	1400-1500	DB	FRAGS	WQ	QU	I	5.60	5.00	2.70	-	-	-	-	0	0	0	N	-	-	-	0.1
1400	MJ05	EXG	17	1500-1600	DB	FRAGS	PQ	QU	I	5.00	3.50	2.60	-	-	-	-	0	0	0	N	-	-	-	<0.1
1401	MJ05	EXG	17	1500-1600	FP	CHIP	QTZ	QU	E	10.80	6.70	1.60	-	-	-	-	2	0	1	N	-	-	-	0.1
1402	MJ05	EXG	18	1600-1700	FP	CHIP	BQTZ	QTZ	E	9.4	6.70	1.50	-	-	-	-	1	0	0	N	-	-	-	0.1
1403	MJ05	EXG	18	1600-1700	FP	CHIP	QTZ	QU	I	13.10	6.30	3.10	-	-	-	-	2	0	0	N	-	-	-	0.2

Artefact #	Site	Pit	Spit	Depth	Artefact Type	Pearce Artefact Type	Lithology	Pearce Lithology	Cross-section	Artefact Dimensions			Platform Type	Platform Dimensions		Termination	# Dorsal flake scars	Cortex %	Parallel Arrises	Retouch / Utilisation?	R/U Location	R/U Length	R/U Width	Weight (g)
										Length	Width	Depth		Length	Width									
1404	MJ05	EXG	18	1600-1700	DB	FRAGS	CH	CH	E	7.70	4.30	0.70	-	-	-	-	0	0	0	N	-	-	-	<0.1
1405	MJ05	EXG	18	1600-1700	FP	CHIP	WQ	QU	TG	8.30	7.20	4.00	-	-	-	Feather	1	0	0	N	-	-	-	0.2
1406	MJ05	EXG	18	1600-1700	DB	FRAGS	WQ	QU	I	8.50	5.20	3.10	-	-	-	-	0	0	0	N	-	-	-	0.1
1407	MJ05	EXG	18	1600-1700	DB	FRAGS	WQ	QU	I	5.80	3.10	2.00	-	-	-	-	0	0	0	N	-	-	-	<0.1
1408	MJ05	EXG	18	1600-1700	DB	FRAGS	WQ	QU	I	4.30	2.80	1.60	-	-	-	-	0	0	0	N	-	-	-	<0.1
1409	MJ05	EXG	19	1700-1800	DB	FRAGS	QTZ	QTZ	I	29.40	16.70	9.00	-	-	-	-	0	0	0	N	-	-	-	6.5
1410	MJ05	EXG	19	1700-1800	FP	CHIP	CQ	QU	L	5.10	4.50	0.80	-	-	-	-	1	0	0	N	-	-	-	<0.1
1411	MJ05	EXG	19	1700-1800	FP	CHIP	CQ	QU	I	6.80	5.60	1.00	-	-	-	-	1	0	0	N	-	-	-	<0.1
1412	MJ05	EXG	19	1700-1800	DB	FRAGS	CQ	QU	E	5.90	4.50	1.80	-	-	-	-	0	0	0	N	-	-	-	<0.1
1413	MJ05	EXG	19	1700-1800	DB	FRAGS	WQ	QU	I	9.00	3.50	2.40	-	-	-	-	0	0	0	N	-	-	-	<0.1
1414	MJ05	EXG	19	1700-1800	DB	FRAGS	WQ	QU	TB	4.70	2.30	2.40	-	-	-	-	0	0	0	N	-	-	-	<0.1
1415	MJ05	EXG	19	1700-1800	DB	FRAGS	WQ	QU	I	3.80	2.80	1.60	-	-	-	-	0	0	0	N	-	-	-	<0.1
1416	MJ05	EXG	19	1700-1800	DB	FRAGS	WQ	QU	I	3.40	1.90	2.10	-	-	-	-	0	0	0	N	-	-	-	<0.1
1417	MJ05	EXG	20	1800-1900	PTBF	CHIP	WQ	QU	-	13.60	6.00	1.70	Flaked	2.5	0.6	Broken	3	0	1	N	-	-	-	0.2
1418	MJ05	EXG	20	1800-1900	FP	CHIP	CQ	QU	L	3.40	2.50	0.80	-	-	-	-	1	0	0	N	-	-	-	<0.1
1419	MJ05	EXG	20	1800-1900	FP	CHIP	BQTZ	QTZ	E	7.70	6.30	2.50	-	-	-	-	0	0	0	N	-	-	-	0.1
1420	MJ05	EXG	20	1800-1900	DB	FRAGS	WQ	QU	TG	6.30	3.20	3.20	-	-	-	-	0	0	0	N	-	-	-	<0.1
1421	MJ05	EXG	20	1800-1900	DB	FRAGS	WQ	QU	I	4.40	2.50	1.40	-	-	-	-	0	0	0	N	-	-	-	<0.1
1422	MJ05	EXG	20	1800-1900	FP	CHIP	WQ	QU	E	5.80	4.60	1.20	-	-	-	Feather	0	0	0	N	-	-	-	<0.1
1423	MJ05	EXG	20	1800-1900	DB	FRAGS	WQ	QU	I	5.80	2.70	0.80	-	-	-	-	0	0	0	N	-	-	-	<0.1
1424	MJ05	EXG	20	1800-1900	DB	FRAGS	WQ	QU	I	2.60	2.40	2.30	-	-	-	-	0	0	0	N	-	-	-	<0.1
1425	MJ05	EXG	21	1900-2000	RUFP	SES	WQ	QU	I	15.30	10.20	3.80	-	-	-	-	3	0	1	Y	2M	10.6, 6.8	1.3, 5.4	0.7
1426	MJ05	EXG	21	1900-2000	RUF	UNF	CH	CH	-	8.80	12.60	3.90	Flaked	6.7	3.7	Feather	1	0	0	Y	LLM	6.70	3.20	0.3

Artefact #	Site	Pit	Spit	Depth	Artefact Type	Pearce Artefact Type	Lithology	Pearce Lithology	Cross-section	Artefact Dimensions			Platform Type	Platform Dimensions		Termination	# Dorsal flake scars	Cortex %	Parallel Arrises	Retouch / Utilisation?	R/U Location	R/U Length	R/U Width	Weight (g)
										Length	Width	Depth		Length	Width									
1427	MJ05	EXG	21	1900-2000	FP	CHIP	CH	CH	I	12.00	7.80	4.90	-	-	-	-	2	0	0	N	-	-	-	0.3
1428	MJ05	EXG	21	1900-2000	RUF	UNF	UNID	OTHER	-	12.10	6.40	3.10	Flaked	6.2	3.3	Flaked	3	0	0	Y	DM	6.10	3.40	0.3
1429	MJ05	EXG	21	1900-2000	F	CHIP	WQ	QU	-	12.00	10.30	5.30	Faceted	7.3	4.1	Stepped	1	0	0	N	-	-	-	0.7
1430	MJ05	EXG	21	1900-2000	FP	CHIP	WQ	QU	L	12.30	7.10	3.10	-	-	-	-	1	0	0	N	-	-	-	0.3
1431	MJ05	EXG	21	1900-2000	DB	FRAGS	WQ	QU	TG	8.60	6.80	5.30	-	-	-	-	0	0	0	N	-	-	-	0.3
1432	MJ05	EXG	21	1900-2000	DB	FRAGS	WQ	QU	E	7.30	6.90	0.80	-	-	-	-	0	0	0	N	-	-	-	<0.1
1433	MJ05	EXG	21	1900-2000	FP	FP	WQ	QU	L	16.10	9.50	2.20	-	-	-	-	0	0	0	N	-	-	-	0.6
1434	MJ05	EXG	21	1900-2000	DB	FRAGS	WQ	QU	I	6.20	5.00	2.90	-	-	-	-	0	0	0	N	-	-	-	<0.1
1435	MJ05	EXG	21	1900-2000	FP	CHIP	CQ	QU	E	9.50	7.50	1.60	-	-	-	Feather	0	0	0	N	-	-	-	0.1
1436	MJ05	EXG	21	1900-2000	PTBF	CHIP	WQ	QU	-	10.30	11.40	1.50	Faceted	5.3	1.3	Broken	1	0	0	N	-	-	-	0.2
1437	MJ05	EXG	21	1900-2000	DB	FRAGS	WQ	QU	I	11.30	9.70	5.90	-	-	-	-	0	0	0	N	-	-	-	0.6
1438	MJ05	EXG	21	1900-2000	FP	CHIP	WQ	QU	I	10.20	6.30	2.90	-	-	-	-	0	0	0	N	-	-	-	0.2
1439	MJ05	EXG	21	1900-2000	FP	CHIP	WQ	QU	I	9.30	5.80	2.40	-	-	-	-	1	0	0	N	-	-	-	0.2
1440	MJ05	EXG	21	1900-2000	DB	FRAGS	WQ	QU	L	7.30	4.30	1.10	-	-	-	-	0	0	0	N	-	-	-	<0.1
1441	MJ05	EXG	21	1900-2000	DB	FRAGS	CQ	QU	I	6.20	5.30	1.30	-	-	-	-	0	0	0	N	-	-	-	<0.1
1442	MJ05	EXG	21	1900-2000	FP	CHIP	WQ	QU	I	9.70	7.10	2.30	-	-	-	-	1	0	0	N	-	-	-	0.1
1443	MJ05	EXG	21	1900-2000	DB	FRAGS	WQ	QU	I	6.50	3.10	2.00	-	-	-	-	0	0	0	N	-	-	-	<0.1
1444	MJ05	EXG	21	1900-2000	DB	FRAGS	WQ	QU	TG	5.90	5.50	1.80	-	-	-	-	0	0	0	N	-	-	-	<0.1
1445	MJ05	EXG	21	1900-2000	DB	FRAGS	WQ	QU	I	6.90	4.10	1.60	-	-	-	-	0	0	0	N	-	-	-	<0.1
1446	MJ05	EXG	21	1900-2000	DB	FRAGS	WQ	QU	I	5.60	2.70	1.10	-	-	-	-	0	0	0	N	-	-	-	<0.1
1447	MJ05	EXG	21	1900-2000	DB	FRAGS	CQ	QU	I	7.20	3.60	1.10	-	-	-	-	0	0	0	N	-	-	-	<0.1
1448	MJ05	EXG	21	1900-2000	DB	FRAGS	WQ	QU	TB	3.50	2.40	1.20	-	-	-	-	0	0	0	N	-	-	-	<0.1
1449	MJ05	EXG	21	1900-2000	DB	FRAGS	CQ	QU	E	3.80	3.10	1.20	-	-	-	-	0	0	0	N	-	-	-	<0.1

Artefact #	Site	Pit	Spit	Depth	Artefact Type	Pearce Artefact Type	Lithology	Pearce Lithology	Cross-section	Artefact Dimensions			Platform Type	Platform Dimensions		Termination	# Dorsal flake scars	Cortex %	Parallel Arrises	Retouch / Utilisation?	R/U Location	R/U Length	R/U Width	Weight (g)
										Length	Width	Depth		Length	Width									
1450	MJ05	EXG	21	1900-2000	DB	FRAGS	CQ	QU	I	5.00	2.40	1.50	-	-	-	-	0	0	0	N	-	-	-	<0.1
1451	MJ05	EXG	21	1900-2000	DB	FRAGS	WQ	QU	L	4.00	4.00	0.70	-	-	-	-	0	0	0	N	-	-	-	<0.1
1452	MJ05	EXG	21	1900-2000	DB	FRAGS	WQ	QU	I	4.30	3.10	1.00	-	-	-	-	0	0	0	N	-	-	-	<0.1
1453	MJ05	EXG	21	1900-2000	MPC	UNF	UNID	OTHER		See Core page														
1454	MJ05	EXG	21	1900-2000	SPC	UNF	WQ	QU		See Core page														
1455	MJ05	EXG	22	2000-2100	DB	FRAGS	WQ	QU	E	3.90	3.30	0.80	-	-	-	-	0	0	0	N	-	-	-	<0.1
1456	MJ05	EXG	22	2000-2100	FP	CHIP	WQ	QU	I	12.00	8.90	6.30	-	-	-	-	0	0	0	N	-	-	-	0.7
1457	MJ05	EXG	22	2000-2100	FP	CHIP	WQ	QU	TB	12.50	6.30	4.40	-	-	-	-	0	0	0	N	-	-	-	0.5
1458	MJ05	EXG	22	2000-2100	DB	FRAGS	CQ	QU	TG	6.40	3.80	4.10	-	-	-	-	0	0	0	N	-	-	-	0.1
1459	MJ05	EXG	22	2000-2100	SPC	UNF	WQ	QU		See Core page														
1460	MJ05	EXG	22	2000-2100	MPC	UNF	WQ	QU		See Core page														
1461	MJ05	EXG	23	2100-2200	DB	FRAGS	WQ	QU	I	10.80	8.80	5.20	-	-	-	-	0	0	0	N	-	-	-	0.5
1462	MJ05	EXG	23	2100-2200	FP	CHIP	WQ	QU	E	9.30	4.50	2.50	-	-	-	Feather	1	0	0	N	-	-	-	<0.1
1463	MJ05	EXG	23	2100-2200	MPC	UNF	WQ	QU		See Core page														
1464	MJ05	EXG	23	2100-2200	SPC	UNF	WQ	QU		See Core page														
1465	MJ05	EXG	24	2200-2230	DB	FRAGS	WQ	QU	E	5.50	5.90	1.90	-	-	-	-	0	0	0	N	-	-	-	<0.1
1466	MJ05	EXG	24	2200-2230	DB	FRAGS	WQ	QU	TG	4.40	3.00	1.50	-	-	-	-	0	0	0	N	-	-	-	<0.1
1467	MJ05	EXG	24	2200-2230	DB	FRAGS	WQ	QU	E	9.80	2.70	1.90	-	-	-	-	0	0	0	N	-	-	-	<0.1
1468	MJ05	EXG	24	2200-2230	DB	FRAGS	CQ	QU	TG	5.50	2.20	0.60	-	-	-	-	0	0	0	N	-	-	-	<0.1
1469	MJ05	EXG	24	2200-2230	DB	FRAGS	WQ	QU	I	6.10	3.20	2.00	-	-	-	-	0	0	0	N	-	-	-	<0.1
1470	MJ05	DEFL	SURF	NA	MANU	LUMP	CONG	OTHER	-	73.20	52.90	49.50	-	-	-	-	0	0	0	N	-	-	-	>250

Artefact #	Site	Pit	Spit	Depth	Artefact Type	Pearce Artefact Type	Lithology	Pearce Lithology	Cross-section	Artefact Dimensions			Platform Type	Platform Dimensions		Termination	# Dorsal flake scars	Cortex %	Parallel Arrises	Retouch / Utilisation?	R/U Location	R/U Length	R/U Width	Weight (g)
										Length	Width	Depth		Length	Width									
1471	MJ05	DEFL	SURF	NA	MANU	LUMP	CONG	OTHER	-	46.70	46.50	14.20	-	-	-	-	0	0	0	N	-	-	-	40.4
1472	MJ05	DEFL	SURF	NA	MANU	LUMP	CONG	OTHER	-	50.60	31.40	29.50	-	-	-	-	0	0	0	N	-	-	-	67
1473	MJ05	DEFL	SURF	NA	MANU	LUMP	UNID SCHIST	OTHER	-	87.10	46.60	20.10	-	-	-	-	0	0	0	N	-	-	-	137.9
1474	MJ05	DEFL	SURF	NA	MANU	LUMP	UNID	OTHER	-	21.20	26.70	17.10	-	-	-	-	0	0	0	N	-	-	-	10.8
1475	MJ05	DEFL	SURF	NA	LBF	FP	WQ	QU	-	17.20	11.30	3.60	Flaked	4.4	2.1	Feather	2	0	0	N	-	-	-	0.9
1476	MJ05	DEFL	SURF	NA	RUF	UNF	WQ	QU	-	24.30	27.10	9.70	Faceted	17.4	7	Flaked	1	90	0	Y	LLM, RLM, DM	18.2, 10.5, 17.6	2.2, 2.2, 3.8	6.8
1477	MJ05	DEFL	SURF	NA	F	FLAKE	DOL	DOL	-	26.90	26.40	11.10	Flaked	8.7	4.9	Feather	1	0	0	N	-	-	-	9.3
1478	MJ05	DEFL	SURF	NA	MANU	LUMP	DOL	DOL	-	36.60	32.20	34.30	-	-	-	-	0	0	0	**N**	-	-	-	68.7
1479	MJ05	DEFL	SURF	NA	SPC	UNF	WQ	QU		See Core page														
1480	MJ05	DEFL	SURF	NA	MPC	UNF	WQ	QU		See Core page														
1481	MJ05	DEFL	SURF	NA	MPC	UNF	SQ	QU		See Core page														
1482	MJ05	DEFL	SURF	NA	MPC	UNF	SQ	QU		See Core page														
1483	MJ05	DEFL	SURF	NA	MPC	UNF	WQ	QU		See Core page														
1484	MJ05	DEFL	SURF	NA	MPC	UNF	WQ	QU		See Core page														
1485	MJ05	DEFL	SURF	NA	SPC	UNF	DOL	DOL		See Core page														

Excavation artefact data (all sites) – Cores

Artefact #	Site	Pit	Spit	Core type	Lithology	Artefact Dimensions			Number of platforms	Number of flake scars	Flake scar dimensions		Cortex %	Weight (g)
						Length	Width	Depth			Length	Width		
23	MJ01	TPE	1	SPC	WQ	16.46	11.68	7.48	1	1	11.06	7.93	0	1.6
106	MJ02	TPB	2	MPC	WQ	15.1	15.5	14.7	2	2	8.6	5.8	0	4.2
											9.6	6.8		
150	MJ04	TPC	1	MPC	WQ	15.5	12.8	5.4	3	4	8.1	6.9	0	1.1
											6	7		
											6.9	6.1		
											8.3	5.8		
165	MJ04	TPC	4	MPC	WQ	31	16	12.6	2	2	9.6	8.4	0	8
											3.5	8.1		
211	MJ06	EXJ	9	MPC	WQ	12.1	7.5	7.8	3	3	7.3	8.6	0	0.7
											7.7	6.5		
											6.5	6.7		
244	MJ06	EXJ	16	SPC	WQ	20.8	10.6	5.1	1	1	10.4	10.6	0	1.6
252	MJ06	EXJ	16	MPC	WQ	17.8	11.6	6.7	3	3	7	6.1	0	1.9
											7.4	5.5		
											16.2	6.8		
255	MJ06	EXJ	16	MPC	SQ	22.9	14.9	10.7	2	2	12.1	9.3	0	4.3
											12.4	10.9		
264	MJ07	EXH	4	MPC	SQ	12	9.2	7.4	5	5	8.5	11.9	0	1
											9.6	5		
											9.1	5.8		
											7.5	8.9		
											6.3	6.3		
272	MJ07	EXH	4	MPC	SQ	16.8	11.9	5.3	3	4	14.4	4	0	0.8
											9.1	9.5		
											6.5	6.6		
											5.8	6.9		
290	MJ07	EXH	4	MPC	SQ	9.2	7.3	5.6	4	4	7.5	4.7	0	0.4
											7.2	5.1		
											5.6	5.5		
											2.2	7.7		
328	MJ06	6PS30		MPC	WQ	28.4	16.10	2.9	3	3	11.5	7.5	0	6.3
											9.4	9.5		
											6.3	9.3		

444	MJ06	TPA	5	MPC	WQ	28.9	15.6	7	2	3	7	10.5	0	3.6
											5.9	7.6		
											8.4	16		
445	MJ06	TPA	5	SPC	WQ	20.8	14.9	10.6	1	1	12.5	10.1	0	3.7
576	MJ06	TPA	6	MPC	WQ	24.5	7	12.3	2	2	11.1	9.4	30	2
											11.8	11.1		
577	MJ06	TPA	6	MPC	WQ	17.9	10.7	10.1	2	2	7.2	4.4	0	2
											5.1	5.8		
578	MJ06	TPA	6	MPC	SQ	26.6	25.9	15.8	4	6	8.3	9.7	0	11.4
											15.1	6.8		
											5.5	9.2		
											7.9	6.9		
											6.9	7.6		
											13.8	10.6		
1105	MJ06	TPA	7	MPC	SQ	12.3	7.9	3.6	4	6	5.1	4.3	5	0.3
											6.3	5.6		
											7.3	3.3		
											5.5	2.9		
											2.9	4.1		
											3.5	4.2		
1106	MJ06	TPA	7	SPC	WQ	20.6	10.7	9.6	1	1	12.3	10.7	0	1.7
1107	MJ06	TPA	7	MPC	WQ	20.2	15.9	13.4	2	3	13.9	11.8	0	4
											5	6.5		
											8.7	6.2		
1108	MJ06	TPA	7	MPC	WQ	22.5	14.9	9.7	3	3	16.8	11.3	0	3.8
											3.5	7.2		
											7.3	7.2		
1109	MJ06	TPA	7	MPC	WQ	16.7	8.3	6.3	2	2	15	8.1	0	1.2
											8.6	8.7		
1110	MJ06	TPA	7	MPC	WQ	25.9	22.8	12.1	3	4	20.2	8.2	30	9.2
											9.8	14.4		
											17.5	7		
											5.5	9		
1111	MJ06	TPA	7	SPC	WQ	28	24.5	11.7	1	1	11.6	15.9	10	11.9
1112	MJ06	TPA	7	MPC	WQ	18.8	19.2	14.8	2	3	6	9.9	0	8.4
											7.3	3.8		
											5.8	6.1		
1113	MJ06	TPA	7	SPC	WQ	20.1	16.8	16.3	1	1	16.6	13.1	30	6.7

1163	MJ05	TPD	2	MPC	PQ	42	26.8	26.4	6	6	15.9	20.5	0	29.3
											11.6	9.9		
											8.2	9.6		
											9.6	9.1		
											22.8	15		
											8.4	10.6		
1240	MJ05	TPD	7	SPC	SQ	19.9	13.5	10.1	1	1	10.2	12.4	0	3.7
1241	MJ05	TPD	7	MPC	WQ	17.6	13.9	10.5	3	3	7.2	6.1	0	2.9
											7.9	6		
											12	6.4		
1257	MJ05	TPD	8	MPC	WQ	26	14.2	8.9	3	6	7.5	10	0	4.4
											5.2	6.7		
											8.7	9.8		
											5.4	6.1		
											4	5.9		
											5.2	8.1		
1262	MJ05	TPD	9	MPC	WQ	24.9	18.4	11.4	5	5	12.7	10.9	0	5.6
											6.2	9.1		
											5.8	13.6		
											5.7	6.3		
											10.3	10.5		
1263	MJ05	TPD	9	MPC	WQ	17.7	12.5	10.6	2	3	7	6.6	0	2.2
											8.9	5.1		
											11	5.9		
1311	MJ05	5PS90		SPC	WQ	19.3	9.8	5.5	1	2	4.7	7.9	0	1
											13.6	6.5		
1329	MJ05	EXG	1	MPC	PQ	10.7	7.4	9.1	2	4	5.5	7.3	0	0.8
											4.1	7.5		
											7.1	7.5		
											4.6	7.3		
1330	MJO5	EXG	1	MPC	WQ	15.4	9.2	3	2	2	6.9	6.2	0	0.5
											2.5	7.1		

1331	MJO5	EXG	1	SPC	WQ	28.2	10	8.5	1	3	8.9	6.3	0	3.1
											4.3	3.4		
											7.8	8.7		
1344	MJ05	EXG	2	SPC	WQ	26.9	15.2	10.9	1	3	11	9.4	0	3.5
											10.1	6.2		
											8.1	15.5		
1345	MJ05	EXG	2	MPC	YQ	24.8	23.5	20.4	3	4	15.6	12.6	0	9.2
											8.2	9.8		
											21.1	10.4		
											13.2	16.6		
											5.2	9.5		
1373	MJ05	EXG	4	MPC	WQ	18	11.8	13.3	2	2	12.7	12	0	3.9
											7	11.6		
1453	MJ05	EXG	21	MPC	UNID	22.1	19.2	7.1	3	6	5.8	4.2	0	2.1
											6.9	11.1		
											8.5	12.4		
											7	3.9		
											6.4	4.9		
											6.8	9.2		
1454	MJ05	EXG	21	SPC	WQ	13.9	13.3	8.4	1	2	7.2	10.7	0	1..2
											6.9	9.7		
1459	MJ05	EXG	22	SPC	WQ	17.5	12	10.7	1	1	11.8	11.3	0	3
1460	MJ05	EXG	22	MPC	WQ	32.7	9.8	11.6	2	3	8	6.4	0	4.4
											9.5	6.7		
											10.9	9.7		
1463	MJ05	EXG	23	MPC	WQ	21.8	19.3	10	3	5	11.1	8.2	0	3.5
											7.9	7.1		
											8	5.5		
											2.4	5.4		
											6	8		

1464	MJ05	EXG	23	SPC	WQ	26.8	12.9	11.7	1	1	16	11.3	0	3.1
1479	MJ05	DEFL	SURF	SPC	WQ	26.2	17.4	12.8	1	1	13	15.6	0	6.1
1480	MJ05	DEFL	SURF	MPC	WQ	30.8	20.2	8.3	3	3	11.9	8.1	0	6
											5.9	5.9		
											7.2	17.9		
1481	MJ05	DEFL	SURF	MPC	SQ	28.4	28	18.6	3	3	7.6	7.1	0	20.3
											12.4	5.8		
											10.8	6		
1482	MJ05	DEFL	SURF	MPC	SQ	25.4	16.2	10.5	2	2	7.5	11	0	5.7
											15.6	16.4		
1483	MJ05	DEFL	SURF	MPC	WQ	41.6	27.2	27.6	2	2	16.1	12.7	0	41.1
											10	8.6		
1484	MJ05	DEFL	SURF	MPC	WQ	20	11.7	9.6	2	7	4.2	6.4	0	3.7
											6.4	2.6		
											4.9	6		
											2.6	6.3		
											4	6.3		
											3.1	8.3		
											4.1	6.4		
	MJ05	DEFL	SURF	SPC	BAS	54.4	42.7	34.1	1	8	12.7	9.9	0	104
											13.5	12.6		
											4.3	6.8		
											3.8	5.6		
											20.6	15.6		
											22.2	12.7		
											19.1	9.8		
											22.2	10.7		

Appendix 10 – Artefact data analysis tables

Table 48. Artefact types by site

Site	Artefact type	Core	Debris	Flake	Flaked piece	Longitudinally. broken flake	Longitudinally & transversally broken flake	Manuport	Retouched flake	Retouched flake piece	Transversally broken flake	Total
MJ-01	Count	1	34	13	22	2	1	0	1	1	2	77
	% of Site Total	1.3%	44.2%	16.9%	28.6%	2.6%	1.3%		1.3%	1.3%	2.6%	100%
MJ-02	Count	1	18	7	23	0	0	0	0	1	5	55
	% of Site Total	1.8%	32.7%	12.7%	41.8%					1.8%	9.1%	100%
MJ-04	Count	2	17	5	8	0	0	1	0	0	1	34
	% of Site Total	5.9%	50.0%	14.7%	23.5%			2.9%			2.9%	100%
DIA Id 3648 (MJ-05)	Count	26	197	10	79	7	1	8	5	1	3	337
	% of Site Total	7.7%	58.5%	3.0%	23.4%	2.1%	0.3%	2.4%	1.5%	0.3%	0.9%	100%
MJ-06	Count	19	611	83	166	13	1	1	2	2	18	916
	% of Site Total	2.1%	66.7%	9.1%	18.1%	1.4%	0.1%	0.1%	0.2%	0.2%	2.0%	100%
MJ-07	Count	3	17	13	12						7	52
	% of Site Total	5.8%	32.7%	25.0%	23.1%						13.5%	100%
Grand Total	Count	52	894	131	310	22	3	10	8	5	36	1471
	% of Artefacts	3.5%	60.8%	8.9%	21.1%	1.5%	0.2%	0.7%	0.5%	0.3%	2.4%	100%

Table 49. Raw material types by site

Site	Raw material	BQ	BQTZ	CH	CONG	CQ	DOL	GR	MYL	PQ	QTZ	SQ	UNID	SCHIST	WQ	YQ
MJ-01	**Count**	0	0	1	0	21	0	0	0	0	1	10	0	0	44	0
	% of Site			1.3%		27.3%					1.3%	13.0%			57.1%	
MJ-02	**Count**	0	0	0	0	16	0	0	0	0	0	1	0	0	38	0
	% of Site					29.1%						1.8%			69.1%	
MJ-04	**Count**	1	0	0	0	13	1	0	0	0	0	0	0	0	19	0
	% of Site	2.9%				38.2%	2.9%								55.9%	
DIA Id 3648 (MJ-05)	**Count**	0	3	4	3	95	3	0	0	3	4	4	4	1	212	1
	% of Site		0.9%	1.2%	0.9%	28.2%	0.9%			0.9%	1.2%	1.2%	1.2%	0.3%	62.9%	0.3%
MJ-06	**Count**	1	0	5	0	383	0	14	0	2	0	8	1	0	502	0
	% of Site	0.1%		0.5%		41.8%		1.5%		0.2%		0.9%	0.1%		54.8%	
MJ-07	**Count**	0	0	0	0	6	0	0	2	0	0	36	0	0	8	0
	% of Site					11.5%			3.8%			69.2%			15.4%	
Total	**Count**	2	3	10	3	534	4	14	2	5	5	59	5	1	823	1
	% of Site	0.1%	0.2%	0.7%	0.2%	36.3%	0.3%	1.0%	0.1%	0.3%	0.3%	4.0%	0.3%	0.1%	55.9%	0.1%

Key: *BQ= Brown Quartz, BQTZ= Brown Quartzite, CH= Fossiliferous Chert, CONG= Conglomerate, CQ= Crystal Quartz, DOL= Dolerite, GR= Granite, MYL= Mylonite, PQ= Pink Quartz, QTZ= Quartzite, SQ= Smokey Quartz, Schist= Schist, WQ= White Quartz and YQ= Yellow Quartz.*

Table 50. Artefacts weight by site and spit

Spit	1	2	3	4	5	6	7	8	9	10	12	13	14	15	16	17	18	19	20	21	22	23	Deflation	NA	Total
MJ-01																									
0-5g	35	15	6	4	8	4	2	1			1			1											77
MJ-02																									
0-5g	14	5	3		1	19							1	5										7	55
MJ-04																									
0-5g	12	2	4	4	10																				32
5-10g				1																					1
135-140g					1																				1
DAA Id 3648 (MJ-05)																									
0-5g	39	21	19	24	28	37	21	18	7	5		6	2	8	2	7	7	8	30	6	4	5	2	11	317
5-10g	1		1						1								1						5		9
10-15g																							1		1
20-25g																							1		1
25-30g		1																							1
40-45g	1																						2		3
65-70g																							2		2
100-105g																							1		1
135-140g																							1		1
245-250g																							1		1
MJ-06																									
0-5g		2	1	6	175	132	494	20	2	5	4	4	4	6	9	12	4	1						26	907
5-10g					1		4									1									6
10-15g						1	1																		2
15-20g								1																	1
MJ-07																									
0-5g							49																	3	52
Total	102	46	34	39	224	193	571	40	10	10	5	10	7	20	11	20	12	9	30	6	4	5	16	47	1471

Table 51. Artefact length by site and spit

Spit	1	2	3	4	5	6	7	8	9	10	12	13	14	15	16	17	18	19	20	21	22	23	Deflation	NA	Total
MJ-01																									
0-5mm	8	3	5	3	2	3		1			1			1											27
5-10mm	18	9	1	1	4	1	2																		36
10-15mm	8	2			1																				11
15-20mm	1	1			1																				3
MJ-02																									
0-5mm	4		2			2								2										1	11
5-10mm	9	3	1		1	9								2										5	30
10-15mm	1	1				7							1	1										1	12
15-20mm		1				1																			2
MJ-04																									
0-5mm	2	2	3	1	3																				11
5-10mm	5		1	1	4																				11
10-15mm	3			2	3																				8
15-20mm	2																								2
30-35mm				1																					1
85-90mm					1																				1
DAA Id 3648 (MJ-05)																									
0-5mm	9	4	4	8	14	14	8	8	1	3		1		1		1	3	3	4	1		1		2	90
5-10mm	16	13	7	15	13	19	8	7	5	2		5	2	4	1	5	4	4	15	1	1	4		8	159
10-15mm	8	4	5	1	1	1	3	1						2	1	1		1	8	2	1			1	41
15-20mm	4		3			2	2	1	1					1					2	1			1		18
20-25mm	1					1			1										1		1		3		8
25-30mm	2							1									1				1		4		9
30-35mm			1																	1			1		3
35-40mm																							1		1
40-45mm		1																					1		2
45-50mm	1																						1		2

Spit	1	2	3	4	5	6	7	8	9	10	12	13	14	15	16	17	18	19	20	21	22	23	Deflation	NA	Total
50-55mm																							2		2
70-75mm																							1		1
85-90mm																							1		1
MJ-06																									
0-5mm				2	77	50	143	6		2	2		3	3	3	1	3	1						8	304
5-10mm		1	1	2	74	65	253	13	1	2	2	3	1	3	6	7	1							13	448
10-15mm		1		1	18	14	67	1	1	1														4	108
15-20mm				1	4	2	22					1				1								1	32
20-25mm					1	1	10									2									14
25-30mm					2	1	4									2									9
40-45mm								1																	1
MJ-07																									
0-5mm							8																	2	10
5-10mm							27																	1	28
10-15mm							11																		11
15-20mm							2																		2
25-30mm							1																		1
Total	102	46	34	39	224	193	571	40	10	10	5	10	7	20	11	20	12	9	30	6	4	5	16	47	1471

Table 52. Artefact type per site and spit

Spit	1	2	3	4	5	6	7	8	9	10	12	13	14	15	16	17	18	19	20	21	22	23	Def	NA	Total
MJ-01																									
Core	1																								1
Debitage	12	7	4	4	4	1		1			1														34
Flake	7	2	1		1	2																			13
FP	11	5	1		1	1	2							1											22
LBF	2																								2
L&TBF					1																				1
RF	1																								1
RFP		1																							1
TBF	1				1																				2
MJ-02																									
Core		1																							1
Debitage	6	2				7								2										1	18
Flake	1	1				3								2											7
FP	6	1	2		1	6								1										6	23
RFP						1																			1
TBF	1		1			2							1												5
MJ-04																									
Core	1			1																					2
Debitage	7	2	4	1	3																				17
Flake	2			2	1																				5
FP	2			1	5																				8
Manuport					1																				1
TBF					1																				1
DAA 3648 (MJ-05)																									
Core	5	1	1			1	2	1	2										2	2	2		7		26
Debitage	18	11	12	17	24	32	7	12	2	4		6	1	5	1	4	6	4	16	2	1	5		7	197
Flake	1	2		1			3												1				1	1	10

Spit	1	2	3	4	5	6	7	8	9	10	12	13	14	15	16	17	18	19	20	21	22	23	Def	NA	Total
FP	15	5	6	6	4	3	8	2	4	1			1	2	1	3	2	3	7	2	1			3	79
LBF	2	1					1	1						1									1		7
L&TBF						1																			1
Manuport			1					1															6		8
RF		1						1											2				1		5
RFP																			1						1
TBF		1																1	1						3
MJ-06																									
Core					3	3	9			1						3									19
Debitage		1		3	114	69	371	17	1	3	1	1	2	4	2	3	4	1						14	611
Flake					17	17	32					1		1	4	6								5	83
FP		1	1	2	38	30	76	2	1	1	3	2			3	1								5	166
LBF					2	5	3							1										2	13
L&TBF							1																		1
Manuport								1																	1
RF					1	1																			2
RFP						1							1												2
TBF				1	1	7	7	1					1												18
MJ-07																									
Core							3																		3
Debitage							16																	1	17
Flake							13																		13
FP							10																	2	12
TBF							7																		7
Total	102	46	34	39	224	193	571	40	10	10	5	10	7	20	11	20	12	9	30	6	4	5	16	47	1471

Table 53. Raw material types by site and spit

Spit	1	2	3	4	5	6	7	8	9	10	12	13	14	15	16	17	18	19	20	21	22	23	Deflation	NA	Total
MJ-01																									
CH							1																		1
CQ	12	5			2	1	1																		21
QTZ		1																							1
SQ	8	2																							10
WQ	15	7	6	4	6	3		1			1			1											44
MJ-02																									
CQ	1	1			1	8																		5	16
SQ						1																			1
WQ	13	4	3			10							1	5										2	38
MJ-04																									
BQ	1																								1
CQ	7	1	1	2	2																				13
DOL					1																				1
WQ	4	1	3	3	8																				19
DAA Id 3648 (MJ-05)																									
BQTZ														1		1		1							3
CH														1		1			2						4
CONG																							3		3
CQ	11	7	5	16	9	8	12	8	4			2		1			3	1	5	1		1		1	95
DOL																							3		3
PQ	1	1													1										3
QTZ														1	1	1	1								4
SQ			1				1																2		4
UNID			1																2				1		4
SCH																							1		1
WQ	28	14	13	8	19	29	8	10	4	5		4	2	4		4	4	6	21	5	4	4	6	10	212
YQ	1																								1

Spit	1	2	3	4	5	6	7	8	9	10	12	13	14	15	16	17	18	19	20	21	22	23	Deflation	NA	Total
MJ-06																									
BQ							1																		1
CH							1				1		2	1											5
CQ				1	49	65	238	12			1			2	3	2								10	383
GR		2	1		3		3					1												4	14
PQ							1									1									2
SQ					1	2	4									1									8
UNID								1																	1
WQ				5	123	66	251	8	2	5	2	3	2	3	6	9	4	1						12	502
MJ-07																									
CQ							6																		6
MYL							2																		2
SQ							35																	1	36
WQ							6																	2	8
Total	102	46	34	39	224	193	571	40	10	10	5	10	7	20	11	20	12	9	30	6	4	5	16	47	1471

Table 54. Artefacts with cortex by site and spit

Spit	1	5	6	7	9	14	Deflation	Total
MJ-02								
10			1 (SQ)					1
20	1 (WQ)							1
MJ-04								
10	1 (BQ)							1
MJ-05								
90							1 (WQ)	1
MJ-06								
10		1 (WQ)		2 (CQ, WQ)	1 (WQ)			4
20				1 (WQ)				1
30			1 (WQ)					1
40				1 (CQ)				1
50				3 (WQ)		1 (WQ)		4
70			1 (WQ)	1 (WQ)				2
MJ-07								
60				1 (WQ)				1
Total	2	1	3	9	1	1	1	18

Table 55. Site and spit location of the platform types identified

Spit	1	2	3	4	5	6	7	8	13	14	15	16	17	19	20	DEF	NA	Total
MJ-01																		
Faceted	3																	3
Flaked	8	2	1		3	2												16
MJ-02																		
Faceted						2				1	1							4
Flaked	1	1	1			3					1							7
Focalised	1																	1
MJ-04																		
Crushed				1														1
Flaked	1			1	1													3
Focalised	1				1													2
DAA Id 3648 (MJ-05)																		
Faceted	1						2	1							2	1	1	8
Flaked	2	3		1		1	2	1			1			1	2	2		16
Focalised		2																2
MJ-06																		
Cortical					1	2							1					4
Faceted					1	5	8					1						15
Flaked					13	18	30	1	1		2	2	4				6	77
Focalised				1	6	5	4					1	1				1	19
MJ-07																		
Crushed							1											1
Faceted							5											5
Flaked							12											12
Focalised							2											2
Total	18	8	2	4	26	38	66	3	1	1	5	4	6	1	4	3	8	198

Table 56. Artefact termination type by site and spit

Spit	1	2	3	4	5	6	7	8	13	15	16	17	19	20	22	Deflation	NA	Total
MJ-01																		
Feather	8		1		1	2												12
Hinge		1																1
Stepped	3	1																4
MJ-02																		
Feather	1					1				2								4
Stepped		1				2												3
MJ-04																		
Feather				2	1													3
Stepped	2																	2
DAA Id 3648 (MJ-05)																		
Feather	3	4		1			3	2		1		1	1	2	1	2	1	22
Stepped							1							1				2
MJ-06																		
Feather					15	16	32			1	3	4					5	76
Hinge					1	2												3
Outré passé					1													1
Stepped					3	4	4		1		1	2					2	17
MJ-07																		
Feather							9											9
Stepped							3											3
Total	17	7	1	3	22	27	52	2	1	4	4	7	1	3	1	2	8	162

Appendix F

Noise Assessment

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PEET LIMITED

TAYLOR ROAD, MUNDIJONG

LOCAL STRUCTURE PLAN

ROAD AND RAIL NOISE ASSESSMENT

DECEMBER 2015

OUR REFERENCE: 19997-3-15293

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ACOUSTIC ASSESSMENT
MUNDIJONG

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FOR

PEET LIMITED

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APPENDICIES

A Figure A1 – Site Layout
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B Road Traffic Contour Plot

C Rail Traffic Contour Plot

D Quiet House Design Guidelines

EXECUTIVE SUMMARY

Herring Storer Acoustics were commissioned by Peet Limited to carry out an acoustical assessment of noise received at the Local Structure Plan (LSP) stage of the residential development located at the corner of Bishop and Taylor Road, Mundijong.

Under the Western Australian Planning Commission (WAPC) Planning Policy 5.4 "Road and Rail Transport Noise and Freight Considerations in Land Use Planning" (SPP 5.4), the appropriate criteria for assessment for this development are:

EXTERNAL

$L_{Aeq(Day)}$ of 60 dB(A);
$L_{Aeq(Night)}$ of 55 dB(A).

INTERNAL

$L_{Aeq(Day)}$ of 40 dB(A) in living and work areas; and
$L_{Aeq(Night)}$ of 35 dB(A) in bedrooms.

Additional to the above, noise received at an outdoor area should also be reduced as far as practicable, with an aim of achieving an L_{Aeq} of 50 dB(A) during the night period.

For noise associate with road traffic from the future Tonkin Highway, the difference between the $L_{Aeq(16hr)}$ and the $L_{Aeq(8hr)}$ would be greater than 5 dB(A). Therefore, if compliance with the day period noise limit is achieved, then compliance with the night period noise limits would also be achieved.

For noise associate with rail (current and future) traffic, the difference between the $L_{Aeq(16hr)}$ and the $L_{Aeq(8hr)}$ would be less than 5 dB(A). Therefore, if compliance with the night period noise limit is achieved, then compliance with the day period noise limits would also be achieved.

The results of the acoustic assessment indicate that without any noise amelioration, noise received at the residences in the future would exceed the "Noise Limits" as outlined in the Western Australian Planning Commission (WAPC) Planning Policy 5.4 "Road and Rail Transport Noise and Freight Considerations in Land Use Planning" by up to 5 dB(A) for road traffic and up to 8 dB(A) for rail traffic.

For residential developments, the possible noise amelioration options that are normally considered are:

- Noise bunds and / or barriers.
- "Quiet House" design applied to the first row of residences.

Therefore, based on these possible noise amelioration options, the following advice is provided:

ROAD NOISE (TONKIN HIGHWAY) EFFECTED LOTS

Generally, the façade Lots on the western side of the development range in noise levels from 54 to 61 dB(A). This is based on no attenuation in the form of barriers or setbacks. As the Lots have not been identified at this stage of the study, the following options have been provided:

Option 1 – Setbacks / Quiet House Design

If residential buildings are constructed further towards the Tonkin Highway, past the 59- 60 dB(A) contour, quiet house design would be required. It is noted that the highest noise level assessed is 61 dB(A) hence falling into the package B category.

A general guide to the required packages are as follows, with detailed requirements contained in Appendix C:

- 59-60 dB(A) Package A
- 60-63 dB(A) Package B
- 64-65 dB(A) Package C

We note that under the Planning Policy, as noise received within the proposed development would exceed the "Noise Target", notification on Titles is required for the identified Lots.

Option 2 – Barrier (1.8 metres)

With the inclusion of a 1.8 metre barrier at the western boundary of the development, noise levels are reduced such that there is likely only to be a requirement for quiet house design in the form of Package A. This barrier could be in the form of a wall, or an earthen bund.

Noise levels would still be above the 55 dB(A) limit, hence notification on title would be required.

We note that under SPP5.4 the infrastructure provider would, with the construction of the road, achieve compliance at the ground floor with the "Noise Limits" (60 dB(A) Day).

RAIL NOISE – EFFECTED LOTS

Generally, the façade Lots on the northern and eastern sides of the development range in noise levels from 57 to 63 dB(A). This can be compared to the night time limit noise level criteria of 55 dB(A). This is based on no attenuation in the form of barriers or setbacks.

Due to the high levels, it is recommended that a solid barrier, such as a noise wall (minimum 15kg/m^2 surface area) be constructed along the façade of the development. Modelling shows that the height of the wall required varies from 2.2 metres through to 3 metres. For information initial lengths of the wall are as follows:

2.2m high wall – 890 metres
3.0m high wall – 870 metres

With the inclusion of the walls as a barrier for noise, the noise level at façade Lots would be within the margin (between noise targets and noise limits) hence quiet house design in the form of Package A would be required.

Additionally, noise levels would still be above the 50 dB(A) limit, hence notification on title would be required.

Note: Given the location of the development and the projected market, we understand that 2 storey residences are unlikely, hence the Quiet House Design is for single storey residence only. If double storey residences are proposed, then specialist acoustic advice would need to be sought by the proponent.

1. INTRODUCTION

Herring Storer Acoustics were commissioned by Peet Limited to carry out an acoustical assessment of noise received at the Local Structure Plan (LSP) stage of the residential development located at Lot 33 Hopkinson Road, Cardup.

The LSP is approximately 100 hectares of rural land in Mundijong. Proposed residential premises located on the western side of the development have potential to be affected by road traffic noise associated with the future Tonkin Highway which has not been constructed.

Additionally, as the southwest rail line runs along the northern and eastern boundary there is the potential for residence premises to be affected by noise from passing freight trains.

As part of the study, the following was carried out:

- Monitor noise levels associated with the freight train movements.
- Determine by noise modelling the noise that would be received at residences within the LSP from vehicles travelling on the roadway (Tonkin Highway) for the future.
- Determine by noise modelling the noise that would be received at residences within the LSP from freight trains travelling on the south west rail line for the future.
- Assess the predicted noise levels for compliance with the appropriate criteria.
- Provide information as to noise control requirements such as quiet house design, noise barriers and notification on titles.

The plan for the LSP in shown below in Figure 1. It is noted that this is only a concept plan and may be subject to changes. It has been include for informational purposes.

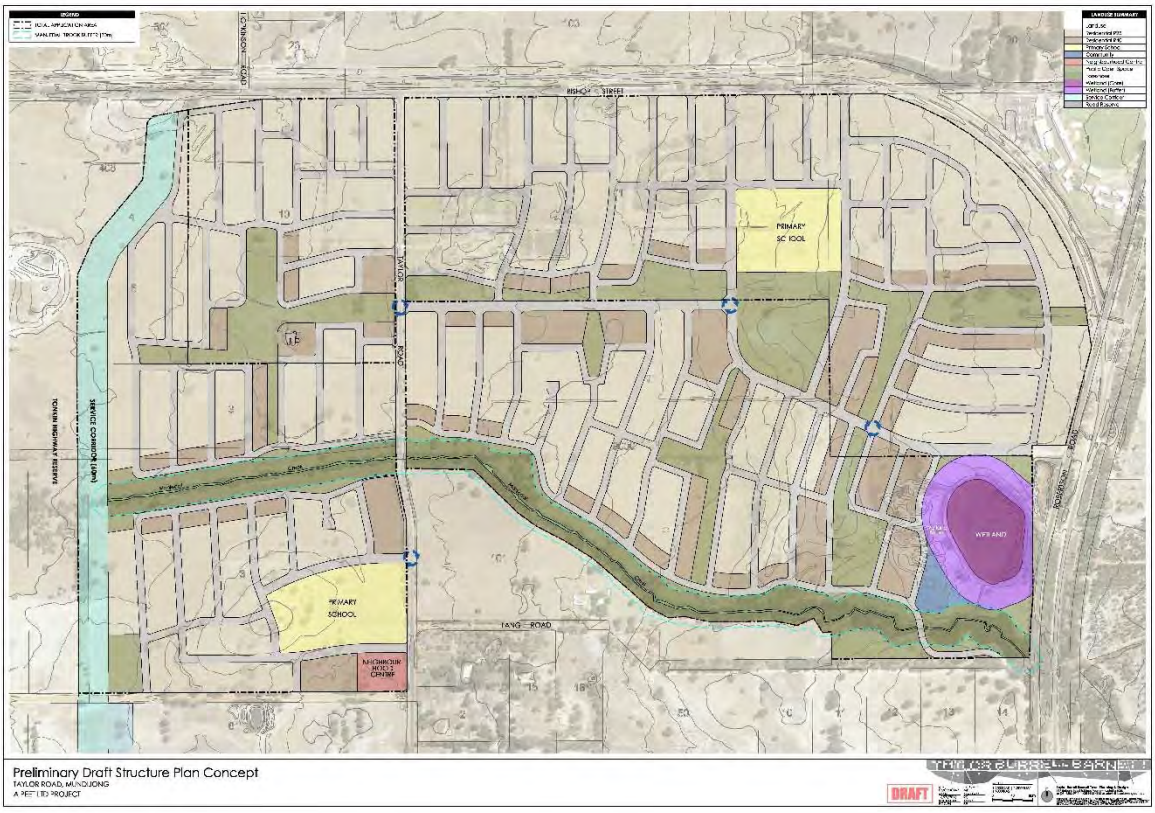


FIGURE 1 – MUNDIJONG CONCEPT STRUCTURE PLAN

2. CRITERIA

The WAPC released on 22 September 2009 State Planning Policy 5.4 *"Road and Rail Transport Noise and Freight Considerations In Land Use Planning"*. Section 5.3 – Noise Criteria, which outlines the acoustic criteria, states:

> "5.3 - NOISE CRITERIA
>
> *Table 1 sets out the outdoor noise criteria that apply to proposals for new noise-sensitive development or new major roads and railways assessed under this policy.*
>
> *These criteria do not apply to—*
>
> - *proposals for redevelopment of existing major roads or railways, which are dealt with by a separate approach as described in section 5.4.1; and*
> - *proposals for new freight handling facilities, for which a separate approach is described in section 5.4.2.*
>
> *The outdoor noise criteria set out in Table 1 apply to the emission of road and rail transport noise as received at a noise-sensitive land use. These noise levels apply at the following locations —*
>
> - *for new road or rail infrastructure proposals, at 1 m from the most exposed, habitable façade of the building receiving the noise, at ground floor level only; and*
> - *for new noise-sensitive development proposals, at 1 m from the most exposed, habitable façade of the proposed building, at each floor level, and within at least one outdoor living area on each residential lot.*
>
> *Further information is provided in the guidelines.*

TABLE 1: OUTDOOR NOISE CRITERIA

Time of day	*Noise Target*	*Noise Limit*
Day (6 am–10 pm)	$L_{Aeq(Day)}$ *= 55 dB(A)*	$L_{Aeq(Day)}$ *= 60 dB(A)*
Night (10 pm–6 am)	$L_{Aeq(Night)}$ *= 50 dB(A)*	$L_{Aeq(Night)}$ *= 55 dB(A)*

> *The 5 dB difference between the outdoor noise target and the outdoor noise limit, as prescribed in Table 1, represents an acceptable margin for compliance. In most situations in which either the noise-sensitive land use or the major road or railway already exists, it should be practicable to achieve outdoor noise levels within this acceptable margin. In relation to the development, however, there is an expectation that the design of the proposal will be consistent with the target ultimately being achieved.*
>
> *Because the range of noise amelioration measures available for implementation is dependent upon the type of proposal being considered, the application of the noise criteria will vary slightly for each different type. Policy interpretation of the criteria for each type of proposal is outlined in sections 5.3.1 and 5.3.2.*
>
> *The noise criteria were developed after consideration of road and rail transport noise criteria in Australia and overseas, and after a series of case studies to assess whether the levels were practicable. The noise criteria take into account the considerable body of research into the effects of noise on humans, particularly community annoyance, sleep disturbance, long-term effects on cardiovascular health, effects on children's learning performance, and impacts on vulnerable groups such as children and the elderly. Reference is made to the World Health Organization (WHO) recommendations*

for noise policies in their publications on community noise and the Night Noise Guidelines for Europe. See the policy guidelines for suggested further reading.

5.3.1 Interpretation and application for noise-sensitive development proposals

In the application of these outdoor noise criteria to new noise-sensitive developments, the objective of this policy is to achieve –

- *acceptable indoor noise levels in noise-sensitive areas (for example, bedrooms and living rooms of houses, and school classrooms); and*
- *a reasonable degree of acoustic amenity in at least one outdoor living area on each residential lot[1].*

If a noise-sensitive development takes place in an area where outdoor noise levels will meet the noise target, no further measures are required under this policy.

In areas where the noise target is likely to be exceeded, but noise levels are likely to be within the 5dB margin, mitigation measures should be implemented by the developer with a view to achieving the target levels in a least one outdoor living area on each residential lot[1]. Where indoor spaces are planned to be facing any outdoor area in the margin, noise mitigation measures should be implemented to achieve acceptable indoor noise levels in those spaces. In this case, compliance with this policy can be achieved for residential buildings through implementation of the deemed-to-comply measures detailed in the guidelines.

In areas where the outdoor noise limit is likely to be exceeded (i.e. above $L_{Aeq(Day)}$ of 60 dB(A) or $L_{Aeq(Night)}$ of 55 dB(A)), a detailed noise assessment in accordance with the guidelines should be undertaken by the developer. Customised noise mitigation measures should be implemented with a view to achieving the noise target in at least one outdoor living or recreation area on each noise-sensitive lot or, if this is not practicable, within the margin. Where indoor spaces will face outdoor areas that are above the noise limit, mitigation measures should be implemented to achieve acceptable indoor noise levels in those spaces, as specified in the following paragraphs.
For residential buildings, acceptable indoor noise levels are $L_{Aeq(Day)}$ of 40 dB(A) in living and work areas and $L_{Aeq(Night)}$ of 35 dB(A) in bedrooms[2]. For all other noise-sensitive buildings, acceptable indoor noise levels under this policy comprise noise levels that meet the recommended design sound levels in Table 1 of Australian Standard AS 2107:2000 Acoustics—Recommended design sound levels and reverberation times for building interiors.

These requirements also apply in the case of new noise-sensitive developments in the vicinity of a major transport corridor where there is no existing railway or major road (bearing in mind the policy's 15-20 year planning horizon). In these instances, the developer should engage in dialogue with the relevant infrastructure provider to develop a noise management plan to ascertain individual responsibilities, cost sharing arrangements and construction time frame.

1 For non residential noise-sensitive developments, (e.g. schools and child care centres) consideration should be given to providing a suitable outdoor area that achieves the noise target, where this is appropriate to the type of use.
2 For residential buildings, indoor noise levels are not set for utility spaces such as bathrooms. This policy encourages effective "quiet house" design, which positions these non-sensitive spaces to shield the more sensitive spaces from transport noise (see guidelines for further information).

If the policy objectives for noise-sensitive developments are not achievable, best practicable measures should be implemented, having regard to section 5.8 and the guidelines."

The Policy, under Section 5.7, also provides the following information regarding "Notifications on Titles" :

"5.7 - NOTIFICATION ON TITLE

If the measures outlined previously cannot practicably achieve the target noise levels for new noise-sensitive developments, this should be notified on the certificate of title.

Notifications on certificates of title and/or advice to prospective purchasers advising of the potential for noise impacts from major road and rail corridors can be effective in warning people who are sensitive to the potential impacts of transport noise. Such advice can also bring to the attention of prospective developers the need to reduce the impact of noise through sensitive design and construction of buildings and the location of outdoor living areas.

The notification is to ensure that prospective purchasers are advised of –

- *the potential for transport noise impacts; and*
- *the potential for quiet house design requirements to minimise noise intrusion through house layout and noise insulation (see the guidelines).*

Notification should be provided to prospective purchasers and be required as a condition of subdivision (including strata subdivision) for the purposes of noise-sensitive development as well as planning approval involving noise-sensitive development, where noise levels are forecast or estimated to exceed the target outdoor noise criteria, regardless of proposed noise attenuation measures. The requirement for notification as a condition of subdivision and the land area over which the notification requirement applies, should be identified in the noise management plan in accordance with the guidelines.

An example of a standard form of wording for notifications is presented in the guidelines."

3. MEASUREMENTS AND OBSERVATIONS

Monitoring was undertaken of noise received from train movements on the Southwest line running along the north and eastern side of the proposed development as part of the noise study.

In summary, noise emissions from passing trains were measured for a continuous 24 hour period at one hour intervals. The monitoring location was at a point towards the eastern end of the development at a distance of 20m from the nearest rail line. Monitoring was conducted on the 9th, 10th and 11th November 2015.

Calculations of the day and night time noise levels have been made based on the measured noise level. As such the assessable noise level at the 20m monitoring location from train noise are:

- Day Time $L_{Aeq16hr}$ - 61 dB(A)
- Night Time L_{Aeq8hr} - 65 dB(A)

For information, the results of the monitoring are shown graphically in Appendix G with a location map contained in Figure 2.

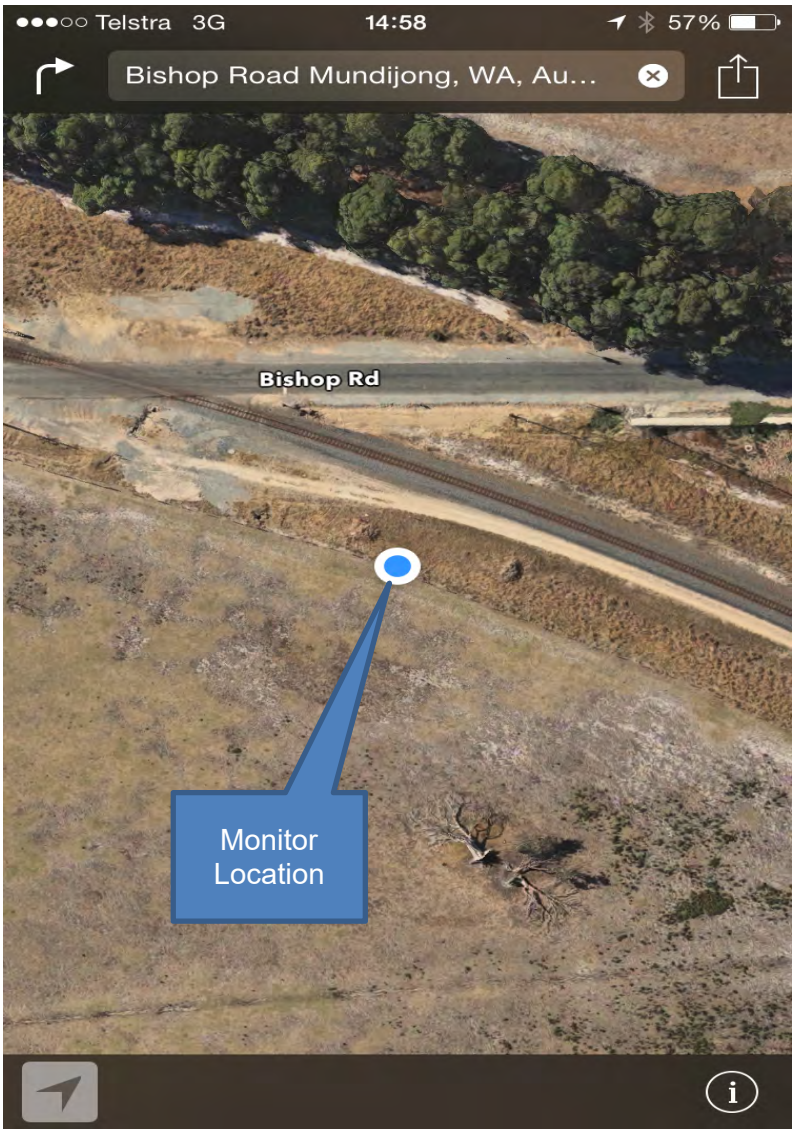


FIGURE 2 – MONITORING LOCATION

4. MODELLING

To determine the noise level received within the proposed development site, acoustic modelling was carried out using SoundPlan. Noise modelling was undertaken in accordance with the "Implementation Guidelines" for the State Planning Policy 5.4.

Modelling was based on the following data, as used for the acoustic assessment of previous stage:

- LSP Concept Plan (Appendix A, Figure 2);
- Ground contours as for previous studies;
- Other traffic data as listed in Table 4.1;
- A +2.5 dB adjustment to allow for façade reflection.

ROAD NOISE MODELLING

For road traffic noise level predictions from future Tonkin Highway were calculated. The SoundPlan model used the Calculation of Road Traffic Noise (CoRTN)3 algorithms to predict the noise from the road source.

The input data for the base case model is contained in Table 4.1.

TABLE 4.1 - NOISE MODELLING INPUT DATA

Parameter	Tonkin Highway 2031
Traffic (vpd)	34,900
18 Hour Traffic (%)	94%
Heavy Vehicles (%)	4%
Speed (km/hr)	100
Receiver Level (m)	+1.5 above ground level
Façade Correction	+2.5 dB(A)
Road Surface	Dense Graded Asphalt
Modelling Adjustment	-1.7 dB

We note that in this case, we believe that under SPP5.4, the infrastructure provider would, with the construction of the road, include noise amelioration to achieve compliance at the ground floor with the "Noise Limits". Thus noise modelling was undertaken for the following scenarios:

1. Future traffic flow – no noise control.

2. Future traffic flows with 1.8 metre wall at boundary of the development.

We note that for Tonkin Highway, the difference between the $L_{Aeq,8hr}$ and the $L_{Aeq,16hr}$ would be greater than 5 dB(A), hence the day period is the critical period for compliance and achieving compliance with the day period criteria will also result in compliance with the night period criteria. Therefore, noise modelling was only undertaken for the day period and the results are shown as Figures in Appendix B.

Additionally, previous information provided is that Bishop road will be an overpass over Tonkin Highway in the future. Therefore noise modelling includes the overpass as outlined in Figure 3.

3 *Calculation of Road Traffic Noise* UK Department of Transport 1987



FIGURE 3 – FUTURE BISHOP ROAD OVERPASS

RAIL NOISE MODELLING

For rail noise emissions from train movements on the southwest line, calculations were based on the measured noise levels. Inputs for the model were calibrated to the monitoring location.

Data input into the model for future rail movements were based on:

- 16 train events for day time period;
- 8 train events for the night time period.

As there are a variety of train types, lengths and general configurations modelling was based on a 2 locomotive, 7-wagon train at 80km/hr. The resultant predicted noise level was calibrated to the measured level and the calculated day and night time equivalent level has been used.

As there is no information regarding future train movements, it has been assumed that the current quantity of trains will remain reasonably consistent. This assumption is based on the fact that there are already around 8 train movements for the night period with the train types ranging from passenger through to large freight.

Additionally, we understand that there are future proposals for possible realignment of the rail line. It is understood that if this occurs, the alignment will follow Tonkin Highway, on the developments western side. To allow for a conservative assessment, the rail line has been assessed as its current location. This will ensure noise levels are addressed for the worst case location of the rail line.

5. RESULTS

Under the WAPC State Planning Policy 5.4, for this development, the Noise Limits as listed in Table 1 are the appropriate noise levels for to be achieved for this development. Using the DEFRA calculation, the difference between the $L_{Aeq(16hr)}$ and the $L_{Aeq(8hr)}$ would be greater than 5 dB(A). Note the DEFRA calculation results are contained in Table 5.1.Therefore, if compliance with the day period noise limit is achieved, then compliance with the night period noise limits would also be achieved. The policy states that the outdoor criteria applies to the ground floor level only, however, it also states that noise mitigation measures should be implemented with a view to achieving the target levels in least one outdoor living area.

TABLE 5.1 – DEFRA CALCULATION (FUTURE TONKIN HIGHWAY)

Parameter	Difference between $L_{10(18hour)}$ and $L_{Aeq(parameter)}$ dB(A)
$L_{A10\ (18\ hour)}$	N/A
$L_{Aeq,\ day\ (6am\ to\ 10pm)}$	= $L_{A10\ (18\ hour)}$ – 2.2
$L_{Aeq,\ night\ (10pm\ to\ 6am)}$	= $L_{A10(18\ hour)}$ – 9.9

As the LSP is a concept at this stage, reference locations for potential future Lots have been made based on the proximity to the noise source. The reference locations (noise receivers) for both road and rail are shown in Figure 4.

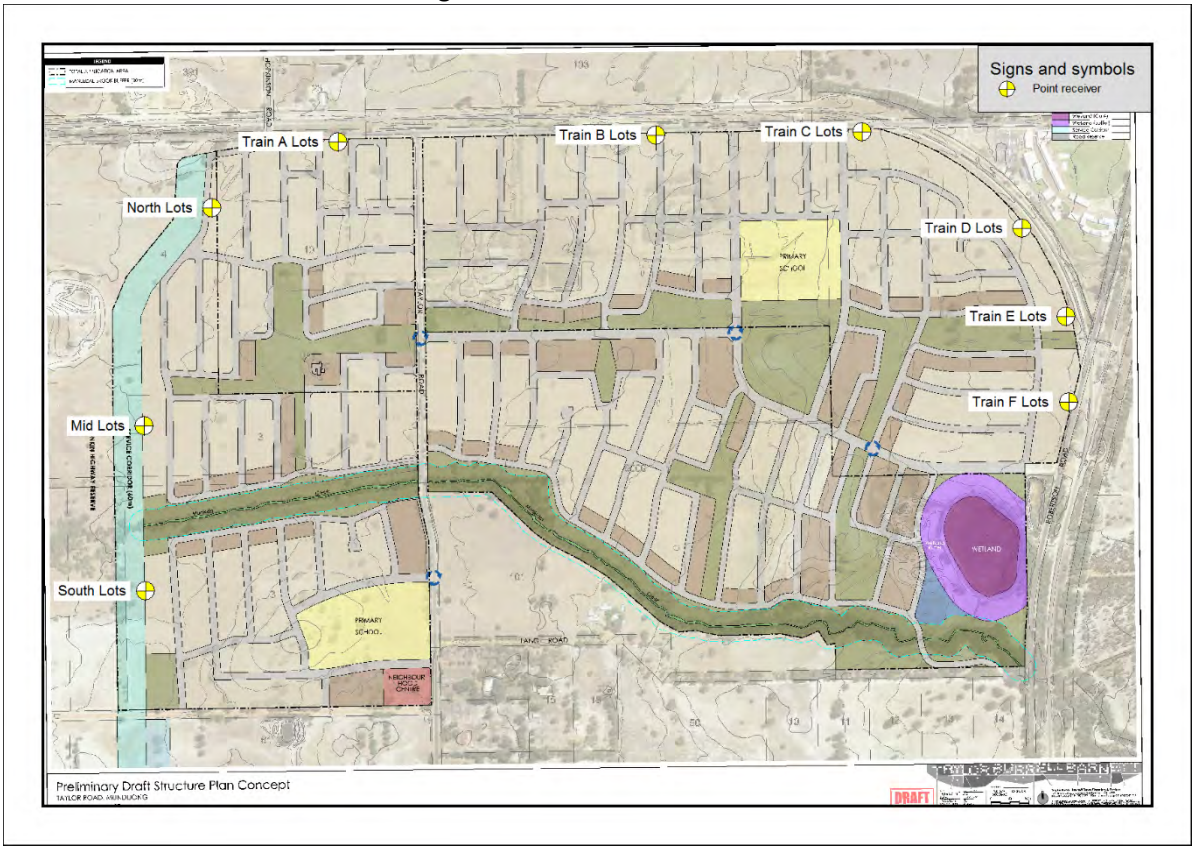


FIGURE 4 – RECEIVER LOCATIONS

5.1 PREDICTED FUTURE ROAD TRAFFIC NOISE LEVELS

The SoundPlan model for the site has been set up for the 2031 traffic conditions as defined in Table 4.1. The following assumptions have been made:

- The same diurnal relationship will exist in the future between the $L_{A10(18hour)}$ and the L_{Aeq} parameters; namely
- Lots will generally be retained at the natural contours.

As the difference in noise levels between the day and night periods is greater than or equal to 5 dB(A), under SPP 5.4, the day period would be the critical period for compliance. Therefore, only noise contours for the day period are contained within this report.

Noise predictions for future road traffic base case, without any noise control and the resultant noise levels received have been carried out at the various locations throughout the development with the closest lots to Tonkin Highway presented in Table 5.2.

TABLE 5.1 – PREDICTED TRAFFIC NOISE LEVELS AT CLOSEST LOTS

Lot Nearest to Tonkin Highway	Noise Level, dB(A)	
	$L_{Aeq\ Day}$	$L_{Aeq\ night}$
North Lots	54	44
Mid Lots	61	51
South Lots	60	50

Note: Adjustment included for façade reflection (+2.5 dB(A))

Day period noise contour plot for the base case are attached in Appendix B, as Figure B1.

The results of the modelling indicate that the noise levels across the lots closest to the Highway could exceed the “Noise Limits”, as required under SPP 5.4.

The additional scenario where a barrier at 1.8m high has been included in the results to provide an alternative.

Appendix B details the layout of the Lots (area), with the noise contour range for each scenario.

5.2 PREDICTED RAIL NOISE LEVELS

Calculated noise levels based on the calibrated predictive model for train movements on the South West line are summarised below in Table 5.2.

TABLE 5.2 – PREDICTED TRAIN NOISE LEVELS AT CLOSEST LOTS

Location	Noise Level, dB(A)
	$L_{Aeq\ night}$
A	57
B	61
C	62
D	63
E	63
F	60

Note: Adjustment included for façade reflection (+2.5 dB(A))

For trains noise, as the difference in noise levels between the day and night periods is less than 5 dB(A), under SPP 5.4, the night period would be the critical period for compliance. Therefore, only noise contours for the night period are contained within this report.

Night period noise contour plots for the base case are shown in Appendix C, as Figure C1. Based on the train events on the South West line, compliance at these locations would not be achieved. Therefore noise control option as outlined below were modelled and the results are summarised in Table 5.3. Noise control considered in the model was:

- Construct a 3m (above rail height) noise wall required for the eastern side of the development, running parallel to south west line.
- Construct a 2.2 metre noise wall around the northern side of the development, running parallel to the rail line.

TABLE 5.3– PREDICTED TRAIN NOISE LEVELS AT CLOSEST LOTS – WITH NOISE CONTROL

Location	Noise Level, dB(A)
	$L_{Aeq\ night}$
A	57
B	55
C	56
D	56
E	56
F	54

Note: Adjustment included for façade reflection (+2.5 dB(A))

The noise contour plot detailing the night period noise levels with the inclusion of the above noise control are shown in Appendix C, Figure C2.

Predicted noise levels for night time period from train noise emissions generally comply with the allowable criteria at the lots abutting the southwest line, although quiet house design requirements will still be required in conjunction with the barriers.

6. ASSESSMENT / RECOMMENDATIONS

Based on the calculated noise level the following options have been provided. Due to the variable location for residential premises, alternative options are provided dependant on the residential location and the inclusion of barriers combination.

6.1 ROAD NOISE (TONKIN HIGHWAY) ROAD NOISE

Generally, the façade Lots on the western side of the development range in noise levels from 54 to 61 dB(A). This is based on no attenuation in the form of barriers or setbacks. As the Lots have not been identified at this stage of the study, the following options have been provided:

Option 1 – Setbacks / Quiet House Design

If residential buildings are constructed further towards the Tonkin Highway, past the 59 - 60 dB(A) contour, quiet house design would be required. It is noted that the highest noise level assessed is 61 dB(A) hence falling into the package B category.

A general guide to the required packages are as follows, with detailed requirements contained in Appendix C:

- 59-60 dB(A) Package A
- 60-63 dB(A) Package B
- 64-65 dB(A) Package C

We note that under the Planning Policy, as noise received within the proposed development would exceed the "Noise Target", notification on Titles is required for the identified Lots.

Option 2 – Barrier (1.8 metres)

With the inclusion of a 1.8 metre barrier at the western boundary of the development, noise levels are reduced such that there is likely only to be a requirement for quiet house design in the form of Package A. This barrier could be in the form of a wall, or an earthen bund.

Noise levels would still be above the 55 dB(A) limit, hence notification on title would be required.

We note that under SPP5.4 the infrastructure provider would, with the construction of the road, achieve compliance at the ground floor with the "Noise Limits" (60 dB(A) Day).

6.2 RAIL NOISE – EFFECTED LOTS

Generally, the façade Lots on the northern and eastern sides of the development range in noise levels from 57 to 63 dB(A). This can be compared to the night time limit noise level criteria of 55 dB(A). This is based on no attenuation in the form of barriers or setbacks.

Due to the high levels, recommendations are that a solid barrier, such as a noise wall (minimum 15kg/m2 surface area) be constructed along the façade of the development. Modelling shows that the height of the wall required varies from 2.2 metres through to 3 metres. For information initial lengths of the wall are as follows:

- 2.2m high wall – 890 metres
- 3.0m high wall – 870 metres

With the inclusion of the walls as a barrier for noise, the noise level at façade Lots would be within the margin (between noise targets and noise limits) hence quiet house design in the form of Package A would be required.

Additionally, noise levels would still be above the 50 dB(A) limit, hence notification on title would be required.

Note: Given the location of the development and the projected market, we understand that 2 storey residences are unlikely, hence the Quiet House Design is for single storey residence only. If double storey residences are proposed, then specialist acoustic advice would need to be sought by the proponent.

APPENDIX A

FIGURE A1 – SITE LAYOUT
FIGURE A2 – SITE LOCATION

FIGURE A1 – SITE LAYOUT

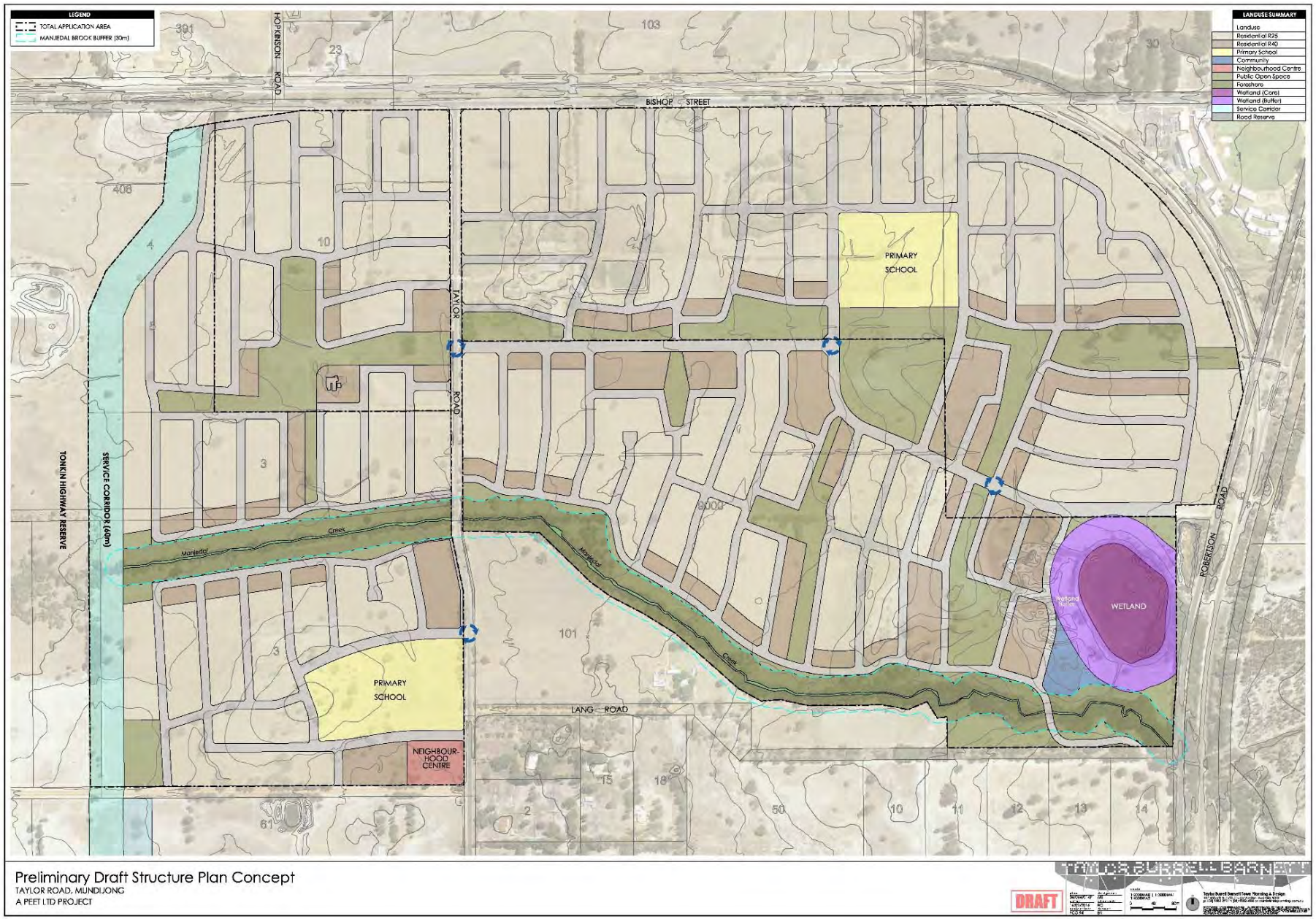


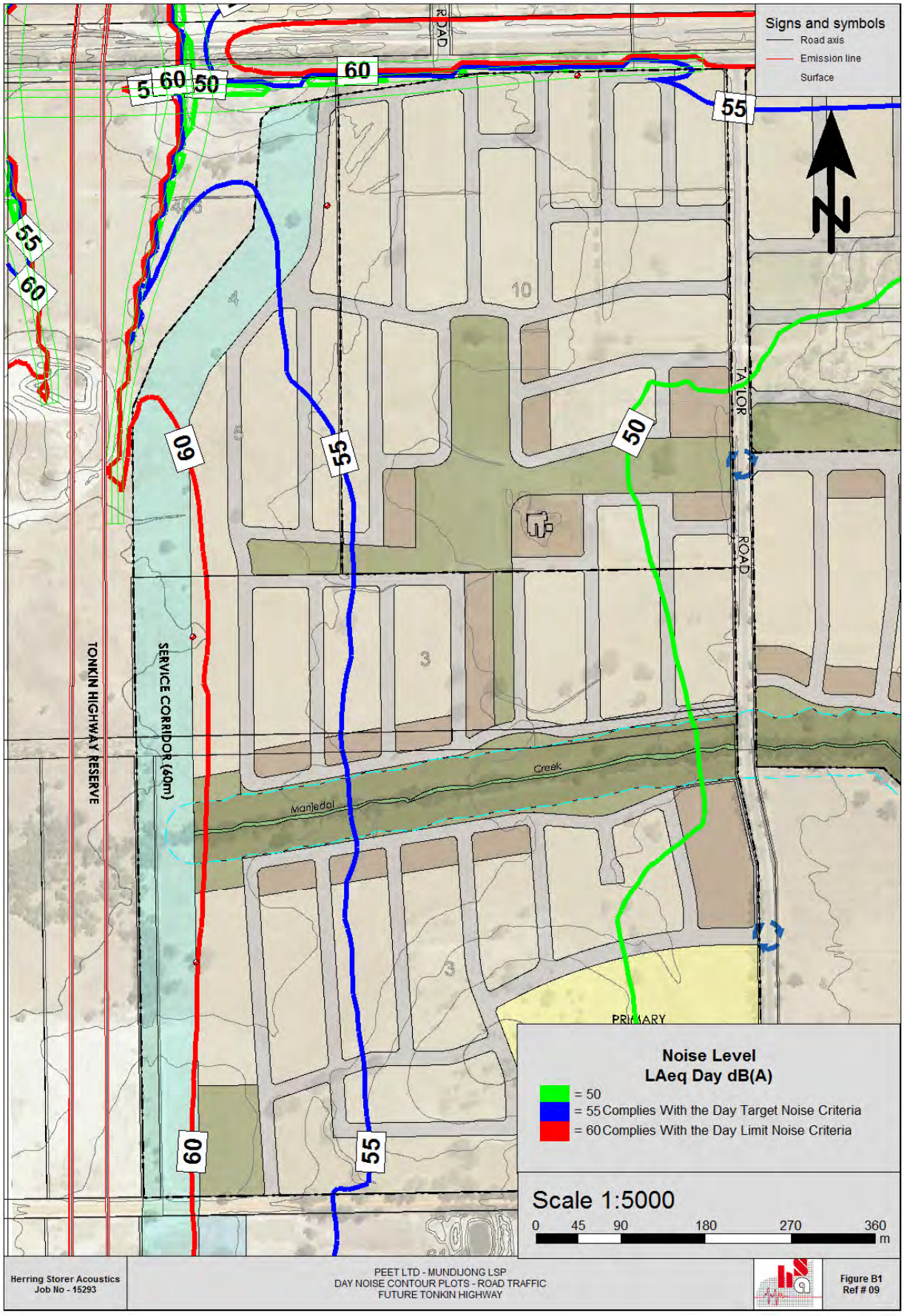
FIGURE A2 – SITE LOCATION



APPENDIX B

ROAD CONTOUR PLOTS

Figure B1 - $L_{Aeq(Day)}$ Noise Contours No Noise Control



APPENDIX C

RAIL CONTOUR PLOTS

Figure C1 – $L_{Aeq\ Night}$ Noise Contour Plot – No Noise Control

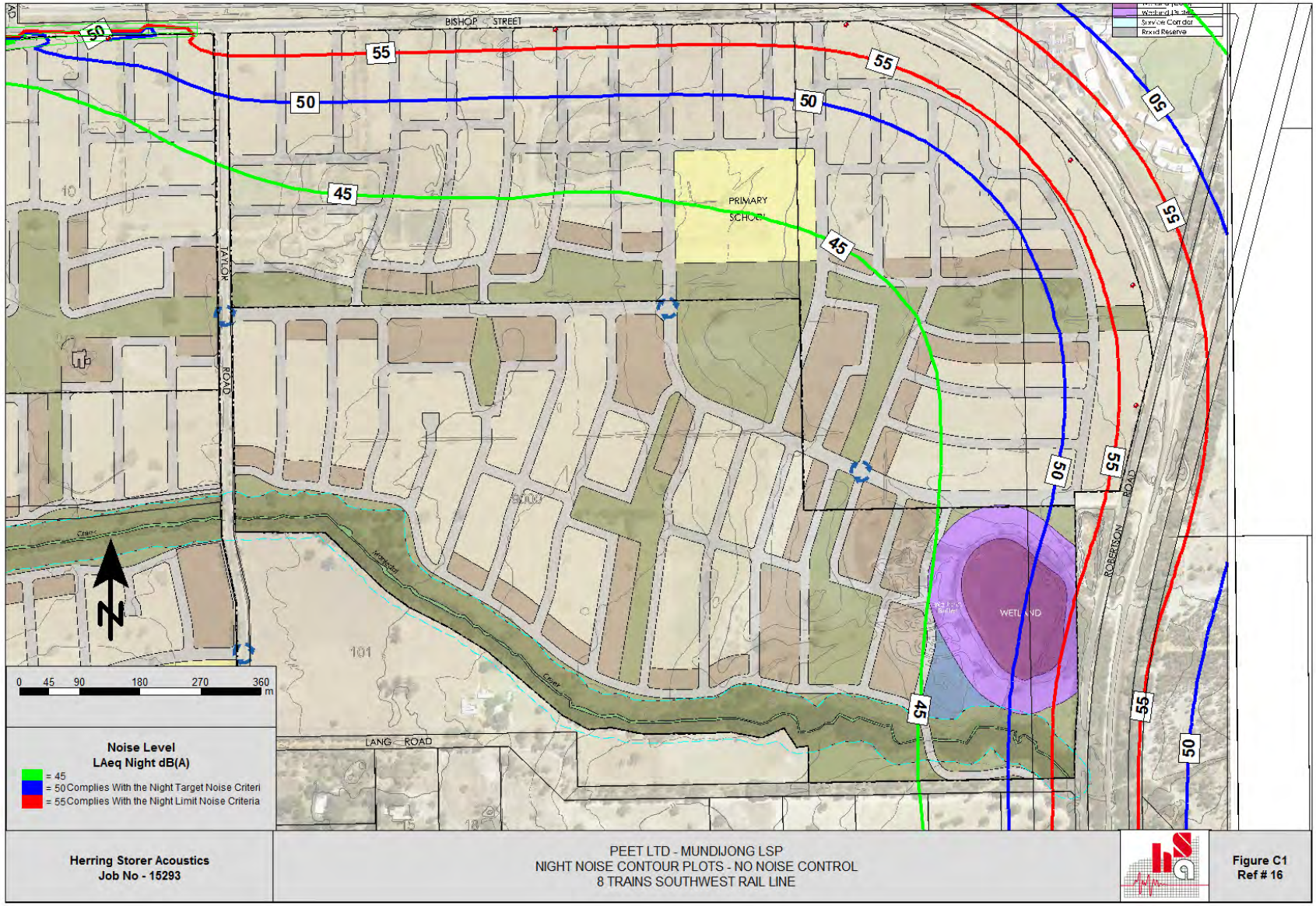
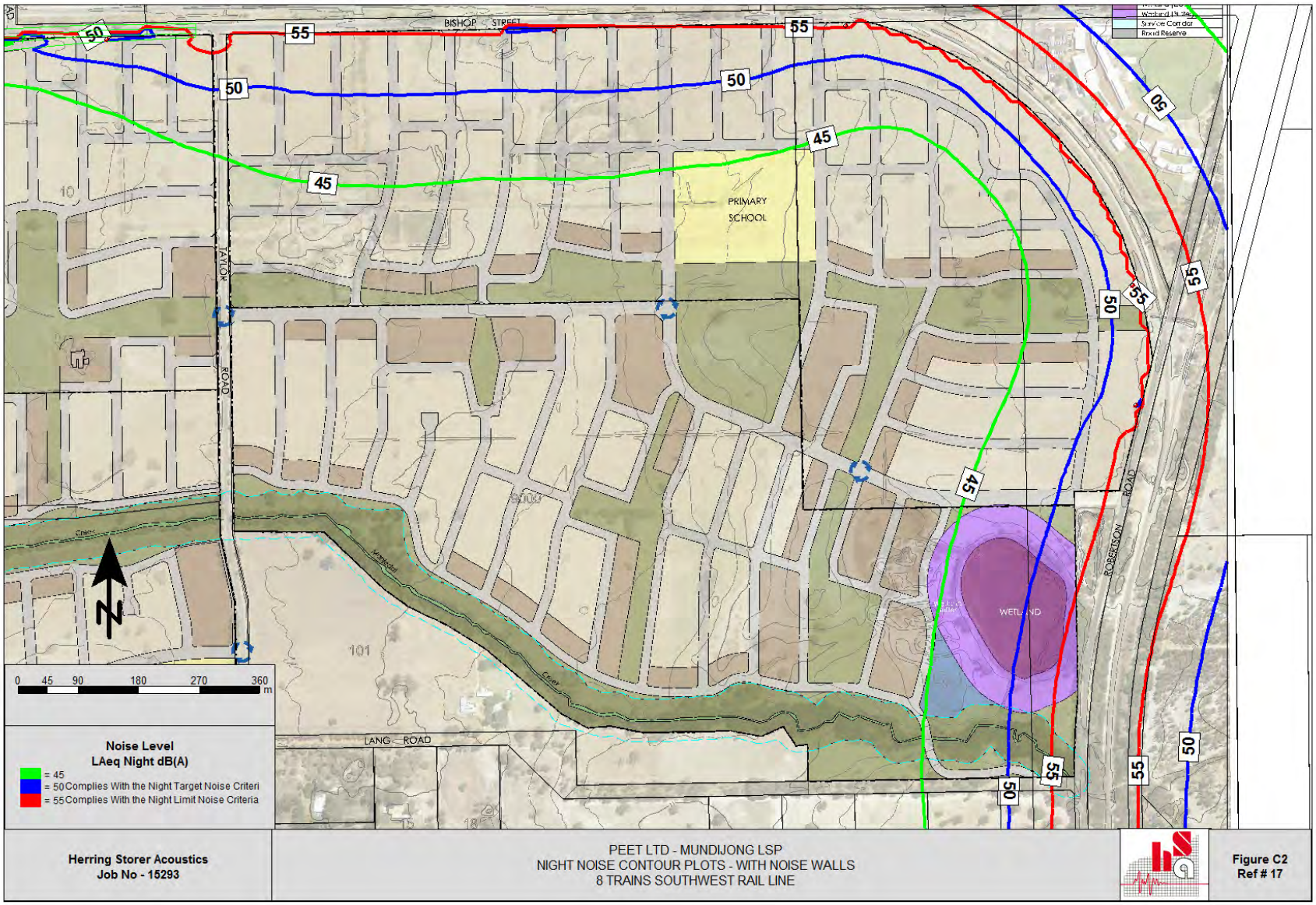


Figure C2 – $L_{Aeq\ Night}$ Noise Contour Plot – With Barriers



APPENDIX D

QUIET HOUSE DESIGN GUIDELINES

Area	Orientation to road or rail corridor	Package A L_{Aeq},Day up to 60dB L_{Aeq},Night up to 55dB	Package B L_{Aeq},Day up to 63dB L_{Aeq},Night up to 58dB	Package C L_{Aeq},Day up to 65dB L_{Aeq},Night up to 60dB
Bedrooms	Facing	• Walls to R_w+C_{tr} 45dB • Windows and external door systems: Minimum R_w+C_{tr} 28dB (Table 6.4), total glazing area up to 40% of room floor area. [if R_w+C_{tr} 31dB: 60%] [if R_w+C_{tr} 34dB: 80%] • Roof and ceiling to R_w+C_{tr} 35dB (1 layer 10mm plasterboard) • Mechanical ventilation as per Section 6.3.1	• Walls to R_w+C_{tr} 50dB • Windows and external door systems: Minimum R_w+C_{tr} 31dB (Table 6.4), total glazing area up to 40% of room floor area. [if R_w+C_{tr} 34dB: 60%] • Roof and ceiling to R_w+C_{tr} 35dB (1 layer 10mm plasterboard) • Mechanical ventilation as per Section 6.3.1	• Walls to R_w+C_{tr} 50dB • Windows and external door systems: Minimum R_w+C_{tr} 34dB (Table 6.4), total glazing area limited to 40% of room floor area [if 20% of floor area or less, R_w+C_{tr} 31dB] • Roof and ceiling to R_w+C_{tr} 40dB (2 layers 10mm plasterboard) • Mechanical ventilation as per Section 6.3.1
	Side-on	•As above, except glazing Rw+Ctr values for each package may be 3dB less, or max % area increased by 20%		
	Opposite	• No requirements • As per Package A 'Side On' • As per Package A 'Facing'	• No requirements • As per Package A 'Side On' • As per Package A 'Facing'	• No requirements • As per Package A 'Side On' • As per Package A 'Facing'
Indoor living and work Areas	Facing	• Walls to Rw+Ctr 45dB • Windows and external door systems: Minimum Rw+Ctr 25dB (Table 6.4), total glazing area limited to 40% of room floor area. [if Rw+Ctr 28dB: 60%] [if Rw+Ctr 31dB: 80%] • External doors other than glass doors to Rw+Ctr 26dB (Table 6.4) • Mechanical ventilation as per Section 6.3.1	• Walls to Rw+Ctr 50dB • Windows and external door systems: Minimum Rw+Ctr 28dB (Table 6.4), total glazing area up to 40% of room floor area. [if Rw+Ctr 31dB: 60%] [if Rw+Ctr 34dB: 80%] • External doors other than glass doors to Rw+Ctr 26dB (Table 6.4) • Mechanical ventilation as per Section 6.3.1	• Walls to R_w+C_{tr} 50dB • Windows and external door systems: Minimum R_w+C_{tr} 31dB (Table 6.4), total glazing area up to 40% of room floor area. [if R_w+C_{tr} 34dB: 60%] • External doors other than glass doors to R_w+C_{tr} 30dB (Table 6.4) • Mechanical ventilation as per Section 6.3.1
	Side-on	• As above, except the glazing R_w+C_{tr} values for each package may be 3dB less, or max % area increased by 20%		
	Opposite	• No requirements	• As per Package A 'Side On'	• As per Package A 'Facing'
Other indoor areas	Any	• No requirements	• No requirements	• No requirements
Outdoor living areas	Any (Section 6.2.3)	• As per Package C, and/or • At least one ground level outdoor living area screened using a solid continuous fence or other structure of minimum 2 metres height above ground level	• As per Package C, and/or • At least one ground level outdoor living area screened using a solid continuous fence or other structure of minimum 2.4 metres height above ground level	• At least one outdoor living area located on the opposite side of the building from the transport corridor

PEET LIMITED

TAYLOR ROAD, MUNDIJONG
LOCAL STRUCTURE PLAN ADDENDUM

SPP 5.4 NOISE MANAGEMENT PLAN

APRIL 2023

OUR REFERENCE: 30874-3-23115

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B	Road Contour Plots
C	Rail Contour Plots
D	Quiet House Design Packages

1. INTRODUCTION

Herring Storer Acoustics were commissioned by Peet Limited to update a previous local structure noise management plan (document 19997-3-15293) to reflect changes and updates to the concept plan, noise criteria and the assessment as a result. The development is located at the corner of Bishop Road and Taylor Road, Mundijong.

This assessment is for a revised LSP. An updated noise management plan will need to be provided at Subdivision stage once the individual lot design has been finalised.

For information the revised concept plan is attached in Appendix A.

2. CRITERIA

Since the previous assessment, SPP 5.4 has been revised. Thus, the revised criteria would be as outlined below.

2.1 ACOUSTIC CRITERIA - NOISE

The Western Australian Planning Commission (WAPC) released on 6th September 2019 State Planning Policy 5.4 *"Road and Rail Noise".* The requirements of State Planning Policy 5.4 are outlined below.

POLICY APPLICATION (Section 4)

When and where it applies (Section 4.1)

SPP 5.4 applies to the preparation and assessment of planning instruments, including region and local planning schemes; planning strategies, structure plans; subdivision and development proposals in Western Australia, where there is proposed:

a) *noise-sensitive land-use within the policy's trigger distance of a transport corridor as specified in* ***Table 1****;*

b) *New or major upgrades of roads as specified in* ***Table 1*** *and maps* ***(Schedule 1,2 and 3);*** *or*

c) *New railways or major upgrades of railways as specified in maps (****Schedule 1, 2 and 3);*** *or any other works that increase capacity for rail vehicle storage or movement and will result in an increased level of noise.*

Policy trigger distances (Section 4.1.2)

Table 1 *identifies the State's transport corridors and the trigger distances to which the policy applies.*

The designation of land within the trigger distances outlined in ***Table 1*** *should not be interpreted to imply that land is affected by noise and/or that areas outside the trigger distances are un-affected by noise.*

*Where any part of the lot is within the specified trigger distance, an assessment against the policy is required to determine the likely level of transport noise and management/ mitigation required. An initial screening assessment (****guidelines: Table 2: noise exposure forecast****) will determine if the lot is affected and to what extent."*

TABLE 1: TRANSPORT CORRIDOR CLASSIFICATION AND TRIGGER DISTANCES

Transport corridor classification	***Trigger distance***	***Distance measured from***
Roads		
Strategic freight and major traffic routes *Roads as defined by Perth and Peel Planning Frameworks and/or roads with either 500 or more Class 7 to 12 Austroads vehicles per day, and/or 50,000 per day traffic volume*	*300 metres*	*Road carriageway edge*
Other significant freight/traffic routes *These are generally any State administered road and/or local government road identified as being a future State administered road (red road) and other roads that meet the criteria of either >=23,000 daily traffic count (averaged equivalent to 25,000 vehicles passenger car units under region schemes)*	*200 metres*	*Road carriageway edge*
Passenger railways		
	100 metres	*Centreline of the closest track*
Freight railways		
	200 metres	*Centreline of the closest track*

Proponents are advised to consult with the decision making authority as site specific conditions (significant differences in ground levels, extreme noise levels) may influence the noise mitigation measures required, that may extend beyond the trigger distance.

POLICY MEASURES (Section 6)

The policy applies a performance-based approach to the management and mitigation of transport noise. The policy measures and resultant noise mitigation will be influenced by the function of the transport corridor and the type and intensity of the land-use proposed. Where there is risk of future land-use conflict in close proximity to strategic freight routes, a precautionary approach should be applied. Planning should also consider other broader planning policies. This is to ensure a balanced approach takes into consideration reasonable and practical considerations.

Noise Targets (Section 6.1)

***Table 2** sets out noise targets that are to be achieved by proposals under which the policy applies. Where exceeded, an assessment is required to determine the likely level of transport noise and management/mitigation required.*

In the application of the noise targets the objective is to achieve:

- *indoor noise levels as specified in **Table 2** in noise sensitive areas (for example, bedrooms and living rooms of houses, and school classrooms); and*
- *a reasonable degree of acoustic amenity for outdoor living areas on each residential lot. For non-residential noise-sensitive developments, for example schools and child care centres the design of outdoor areas should take into consideration the noise target.*

It is recognised that in some instances, it may not be reasonable and/or practicable to meet the outdoor noise targets. Where transport noise is above the noise targets, measures are expected to be implemented that balance reasonable and practicable considerations with the need to achieve acceptable noise protection outcomes.

TABLE 2: NOISE TARGETS

Proposals	***New/Upgrade***	***Noise Targets***		
		Outdoor		***Indoor***
		Day (L_{Aeq}(Day) dB) (6 am-10 pm)	***Night (L_{Aeq}(Night)dB) (10 pm-6 am)***	***(L_{Aeq} dB)***
Noise-sensitive land-use and/or development	*New noise sensitive land use and/or development within the trigger distance of an existing/proposed transport corridor*	*55*	*50*	*L_{Aeq} (Day) 40(Living and work areas) L_{Aeq} (Night) 35 (bedrooms)*
Roads	*New*	*55*	*50*	*N/A*
	Upgrade	*60*	*55*	*N/A*
Railways	*New*	*55*	*50*	*N/A*
	Upgrade	*60*	*55*	*N/A*

Notes:

- *The noise target is to be measured at one metre from the most exposed, habitable façade of the proposed building, which has the greatest exposure to the noise-source. A habitable room has the same meaning as defined in State Planning Policy 3.1 Residential Design Codes.*
- *For all noise-sensitive land-use and/or development, indoor noise targets for other room usages may be reasonably drawn from Table 1 of Australian Standard/New Zealand Standard AS/NZS 2107:2016 Acoustics – Recommended design sound levels and reverberation times for building interiors (as amended) for each relevant time period.*
- *The 5dB difference in the criteria between new and upgrade infrastructure proposals acknowledges the challenges in achieving noise level reduction where existing infrastructure is surrounded by existing noise-sensitive development.*
- *Outdoor targets are to be met at all outdoor areas as far as is reasonable and practical to do so using the various noise mitigation measures outlined in the guidelines. For example, it is likely unreasonable for a transport infrastructure provider to achieve the outdoor targets at more than 1 or 2 floors of an adjacent development with direct line of sight to the traffic.*

<u>Noise Exposure Forecast (Section 6.2)</u>

*When it is determined that SPP 5.4 applies to a planning proposal as outlined in Section 4, proponents and/or decision makers are required to undertake a preliminary assessment using **Table 2**: noise exposure forecast in the guidelines. This will provide an estimate of the potential noise impacts on noise-sensitive land-use and/ or development within the trigger distance of a specified transport corridor. The outcomes of the initial assessment will determine whether:*

- *no further measures is required;*
- *noise-sensitive land-use and/or development is acceptable subject to deemed-to-comply mitigation measures; or*
- *noise-sensitive land-use and/or development is not recommended. Any noise-sensitive land-use and/ or development is subject to mitigation measures outlined in a noise management plan."*

3. UPDATED NOISE MODELLING

3.1 ROAD TRAFFIC

Noise modelling was undertaken based on the updated data, as outlined in Table 3.1.

TABLE 3.1 – UPDATED NOISE MODELLING INPUT DATA

Parameter	Tonkin Highway 2043
Traffic (vpd)	43,180
18 hour Traffic(%)	94%
Heavy Vehicles (%)	4%
Speed (km/hr)	100
Receiver (m)	+1.5 above ground level
Façade Correction	+2.5dB(A)
Road Surface	Dense Graded Asphalt
Modelling Adjustment	-1.7dB

The future road traffic volumes were based on information provided by the MRWA ROM department and the traffic maps.

Other input data for the model included:

- Noise source heights for the three road source strings (Passenger Vehicles, Heavy Vehicles Engine and Heavy Vehicle Exhausts) are +0.5, +1.5 and +3.6m, with a noise correction of -0.8 and -8.0 applied to the heavy vehicle's engine and exhaust noise sources.
- Topographical data, with the ground level within the development based on natural ground levels as per surveys conducted.
- A +2.5 dB adjustment to allow for façade reflection.
- Development receiver heights at 1.4m above ground level.
- Future buildings located on the boundary Lots of the development (assumed to be present for future road traffic volumes).
- Calculations based on CoRTN algorithms.
- Other parameter listed in SPP 5.4 as to guidance for modelling road traffic noise / assessment.

The future road traffic volumes were based on information provided by the MRWA ROM department and the traffic maps.

The noise contour plot is attached as Figure B1 in Appendix B.

It is to be noted that all noise walls are to be a minimum of 15kg/m^2 density.

3.2 RAIL

Noise modelling was based on the same parameters as stated in the previous report (HSA reference : 19997-3-15293).

Noise modelling was undertaken for the following scenarios :

- No noise control implemented.
- With barrier (15kg/m^2) along the boundary of the railway reserve.

The noise contour plots are attached as Figures C1 and C2 in Appendix C.

4. ASSESSMENT

The policy states that the outdoor criteria applies to the ground floor level only, however, it also states that noise mitigation measures should be implemented with a view to achieving the target levels in least one outdoor living area.

For residential premises, the Policy states that residence should be designed to meet the following acceptable internal noise levels:

Living and Work Areas	$L_{Aeq(Day)}$ of 40 dB(A)
Bedrooms	$L_{Aeq(Night)}$ of 35 dB(A)

For lots where noise level would be above the 55 dB(A) limit, notifications on titles are required.

For road traffic noise, the difference between the $L_{Aeq(16hr)}$ and the $L_{Aeq(8hr)}$ would be greater than 5 dB(A) (according to the DEFRA publication (*Method for Converting the UK Road Traffic Noise $L_{A10,18h}$ to the EU Noise Indices for Road Noise Mapping, ref: st/05/91/AGG04442)*). Thus, the day period would be the critical period for compliance and if compliance with the day period noise limit is achieved, then compliance with the night period noise limits would also be achieved. However, with regards to rail noise, the difference between the $L_{Aeq(16hr)}$ and the $L_{Aeq(8hr)}$ would be less than 5 dB(A) and the night period would be the critical period for compliance and if compliance with the night period noise limit is achieved, then compliance with the day period noise limits would also be achieved.

A general guide to the required packages are as follows, with detailed requirements contained in Appendix C:

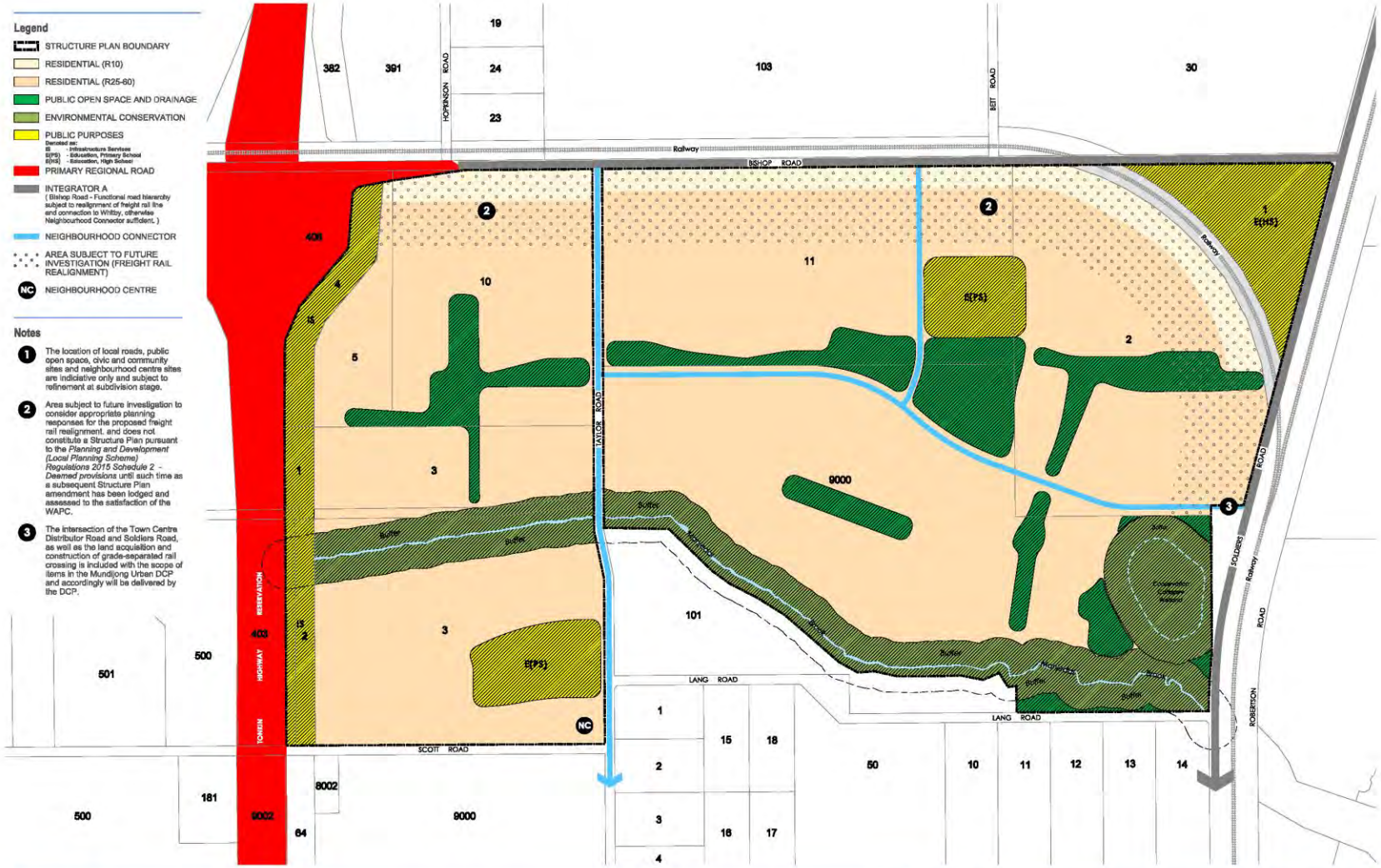
- 56-58 dB(A) Package A
- 59-62 dB(A) Package B
- 63-66 dB(A) Package C

We note that under the Planning Policy, as noise received within the proposed development would exceed the “Noise Target”, notification on Titles is required for the identified Lots.

Information on the deemed to satisfy constructions for the various “Quiet House Design” packages are contained in Appendix D.

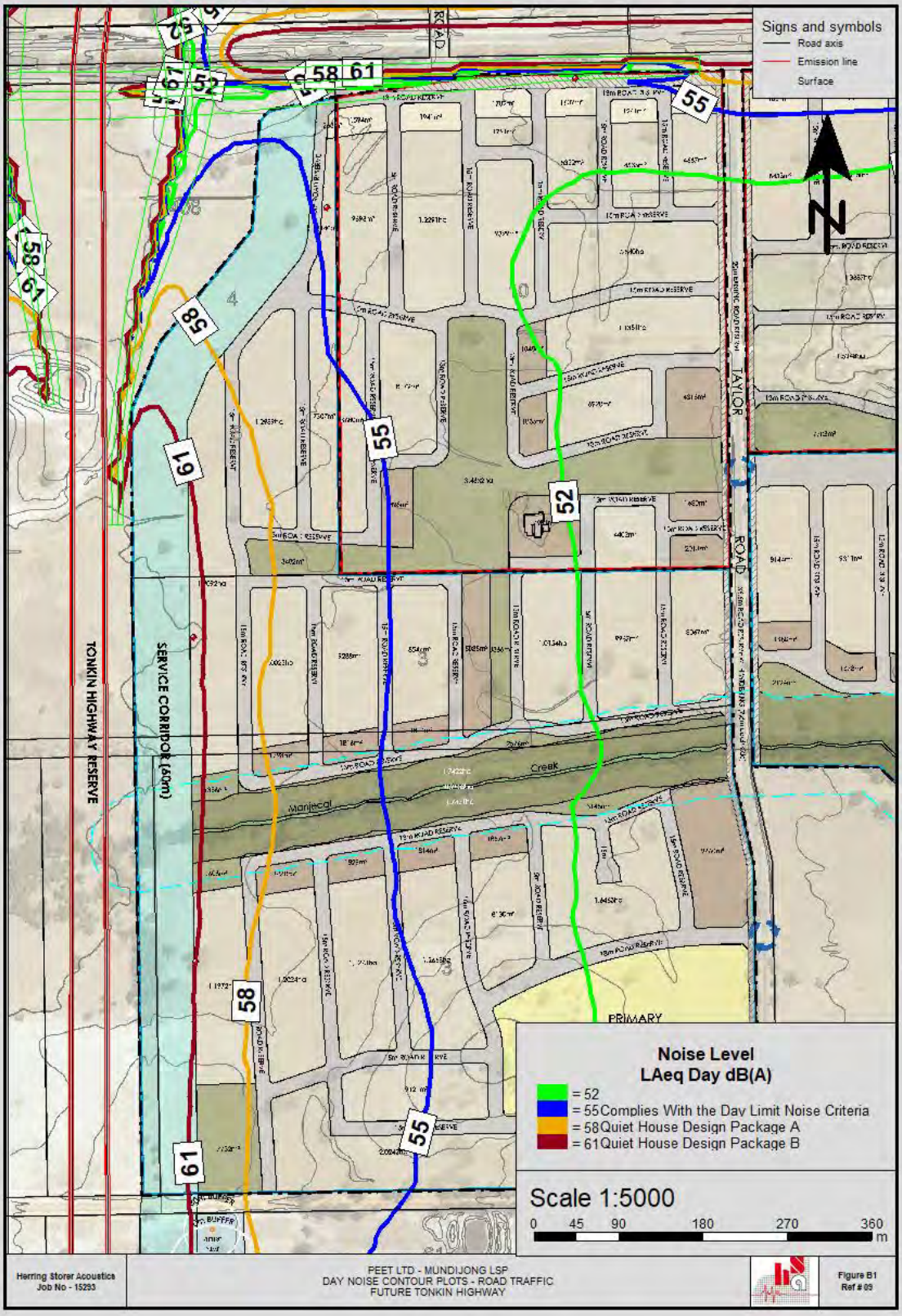
APPENDIX A

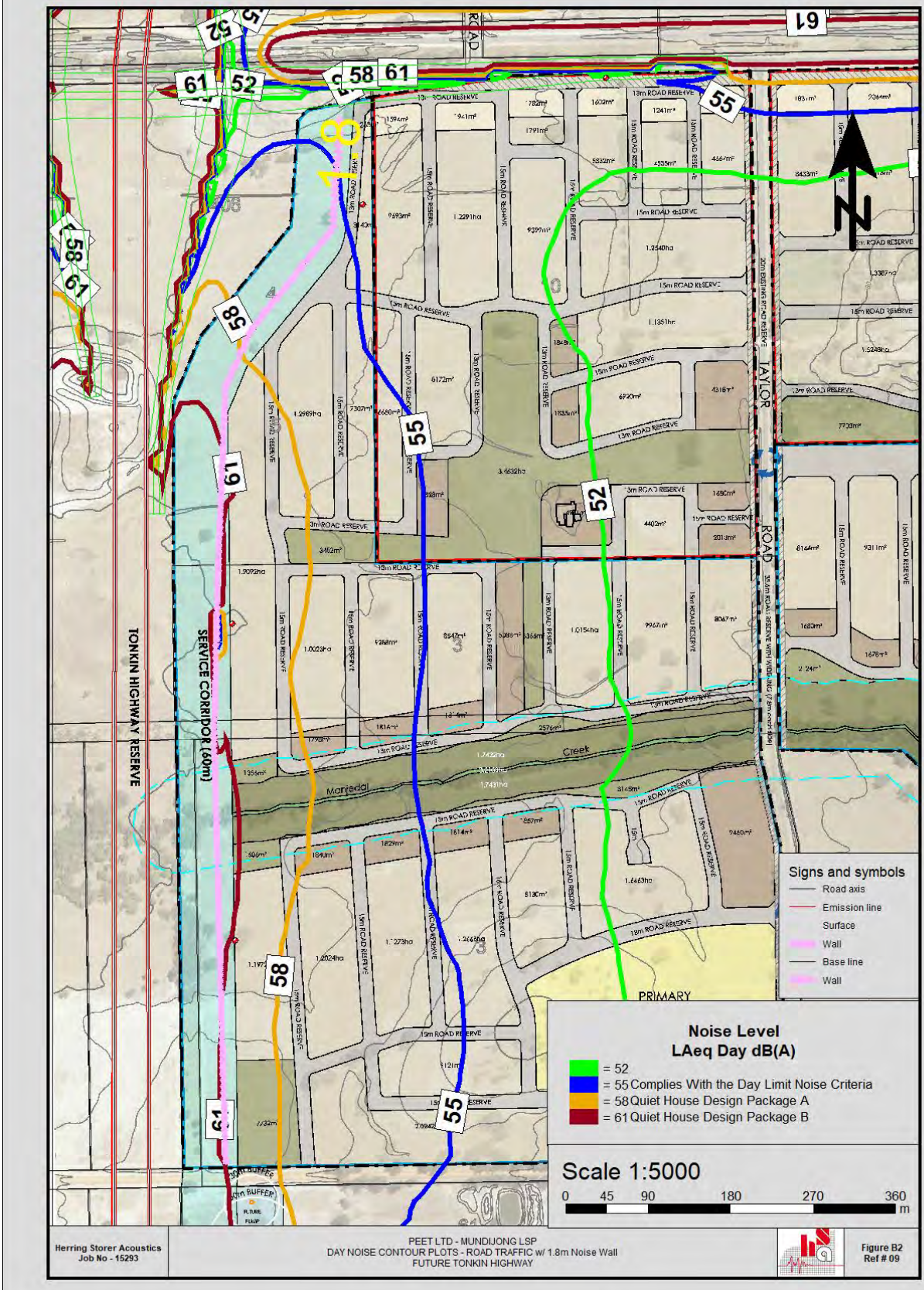
Updated Structure Plan


Legend
STRUCTURE PLAN BOUNDARY
RESIDENTIAL (R10)
RESIDENTIAL (R25-60)
PUBLIC OPEN SPACE AND DRAINAGE
ENVIRONMENTAL CONSERVATION
PUBLIC PURPOSES
Denoted as:
IS - Infrastructure Services
E(PS) - Education, Primary School
E(HS) - Education, High School
PRIMARY REGIONAL ROAD
INTEGRATOR A
(Bishop Road - Functional road hierarchy subject to realignment of freight rail line and connection to Whitby, otherwise Neighbourhood Connector sufficient.)
NEIGHBOURHOOD CONNECTOR
AREA SUBJECT TO FUTURE INVESTIGATION (FREIGHT RAIL REALIGNMENT)
NC NEIGHBOURHOOD CENTRE
Notes
1 The location of local roads, public open space, civic and community sites and neighbourhood centre sites are indicative only and subject to refinement at subdivision stage.
2 Area subject to future investigation to consider appropriate planning responses for the proposed freight rail realignment, and does not constitute a Structure Plan pursuant to the Planning and Development (Local Planning Scheme) Regulations 2015 Schedule 2 - Deemed provisions until such time as a subsequent Structure Plan amendment has been lodged and assessed to the satisfaction of the WAPC.
3 The intersection of the Town Centre Distributor Road and Soldiers Road, as well as the land acquisition and construction of grade-separated rail crossing is included with the scope of items in the Mundijong Urban DCP and accordingly will be delivered by the DCP.
HOPKINSON ROAD
BISHOP ROAD
NBT ROAD
Railway
TAYLOR ROAD
SOLDIERS ROAD
ROBERTSON ROAD
LANG ROAD
SCOTT ROAD
RESERVATION
HIGHWAY
TONKIN
Buffer
Equestrian Complex Arena
E(PS)
E(HS)
NC
19
24
23
382
391
103
30
401
4
15
5
10
11
1
2
3
9000
101
501
500
403
181
9002
8002
64
18
17
50
12
13
14
Structure Plan
TAYLOR & BISHOP ROAD, MUNDIJONG
A Peet Limited Project
scale: 1:7000@A3
0 50 100m
plan: 06C065/043G
date: 19/04/2023
aerial: n/a
Taylor Burrell Barnett Town Planning & Design
Level 7, 160 St Georges Terrace, Perth WA 6000
e: admin@tbbplanning.com.au
p: (08) 9226 4276
Taylor Burrell Barnett

APPENDIX B

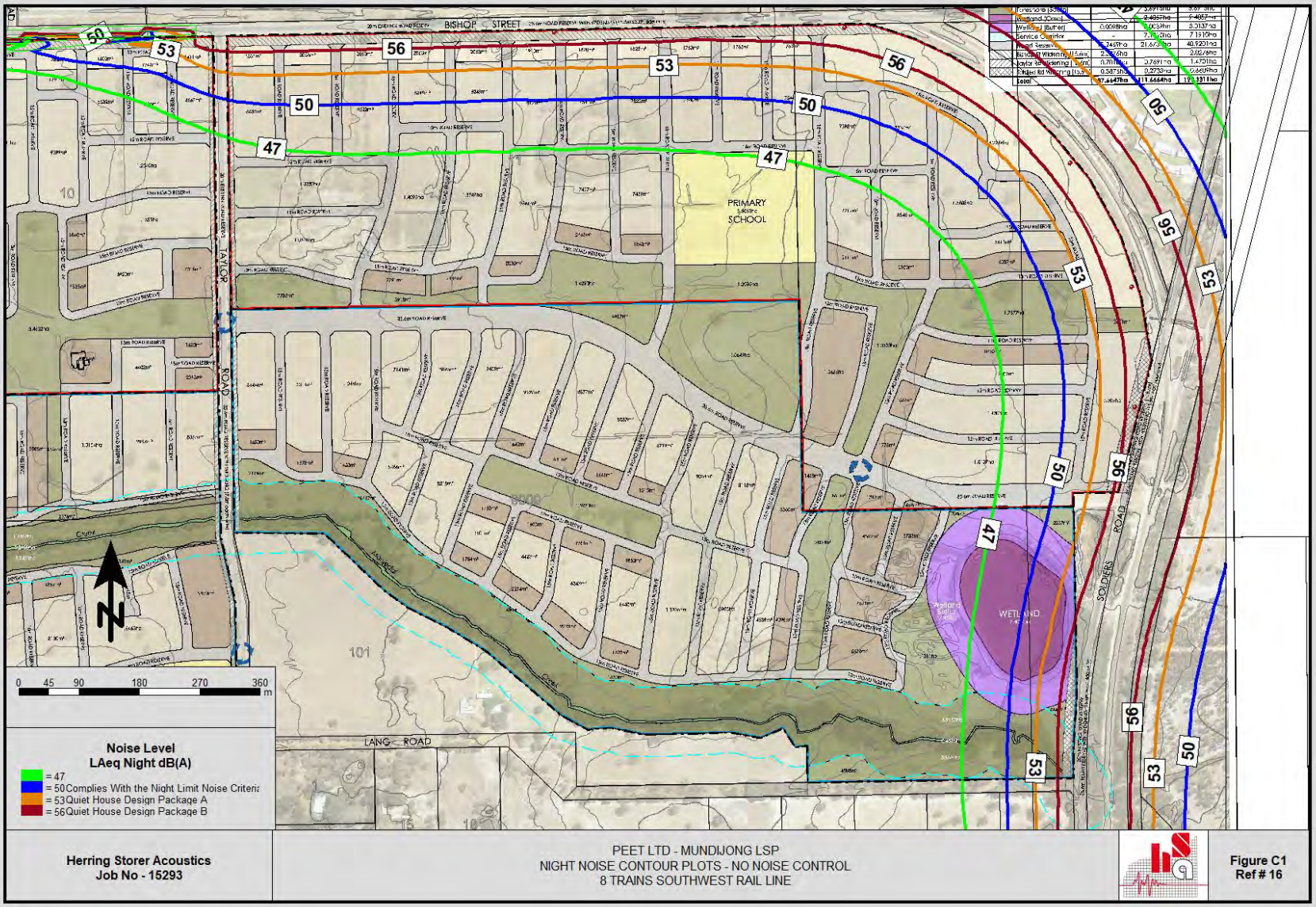
Road Contour Plots


Signs and symbols
Road axis
Emission line
Surface
TONKIN HIGHWAY RESERVE
SERVICE CORRIDOR (40m)
TAYLOR
ROAD
Creek
PRIMARY
Noise Level
LAeq Day dB(A)
= 52
= 55 Complies With the Day Limit Noise Criteria
= 58 Quiet House Design Package A
= 61 Quiet House Design Package B
Scale 1:5000
0 45 90 180 270 360 m
Herring Storer Acoustics
Job No - 15293
PEET LTD - MUNDIJONG LSP
DAY NOISE CONTOUR PLOTS - ROAD TRAFFIC
FUTURE TONKIN HIGHWAY
Figure B1
Ref # 09


TONKIN HIGHWAY RESERVE
SERVICE CORRIDOR (60m)
TAYLOR ROAD
Manjedal Creek
PRIMARY
Signs and symbols
Road axis
Emission line
Surface
Wall
Base line
Wall
Noise Level
LAeq Day dB(A)
= 52
= 55 Complies With the Day Limit Noise Criteria
= 58 Quiet House Design Package A
= 61 Quiet House Design Package B
Scale 1:5000
0 45 90 180 270 360 m
Herring Storer Acoustics
Job No - 15293
PEET LTD - MUNDIJONG LSP
DAY NOISE CONTOUR PLOTS - ROAD TRAFFIC w/ 1.8m Noise Wall
FUTURE TONKIN HIGHWAY
Figure B2
Ref # 09

APPENDIX C

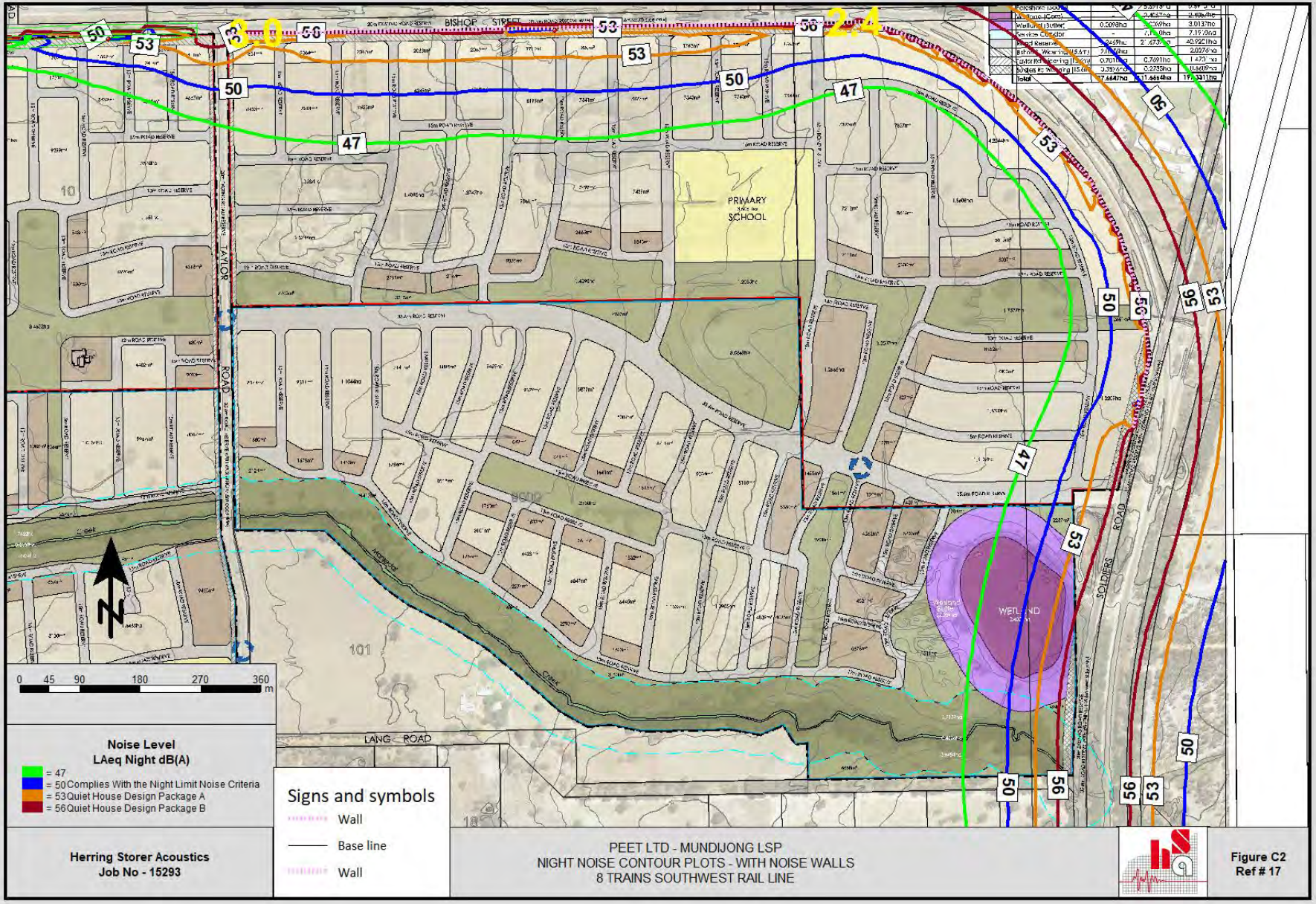
Rail Contour Plots



Herring Storer Acoustics
Job No - 15293

PEET LTD - MUNDIJONG LSP
NIGHT NOISE CONTOUR PLOTS - NO NOISE CONTROL
8 TRAINS SOUTHWEST RAIL LINE

Figure C1
Ref # 16


BISHOP STREET
TAYLOR ROAD
PRIMARY SCHOOL
WETLAND
SOLDIERS ROAD
LANG ROAD
50
53
47
56
0 45 90 180 270 360 m
Noise Level
LAeq Night dB(A)
= 47
= 50 Complies With the Night Limit Noise Criteria
= 53 Quiet House Design Package A
= 56 Quiet House Design Package B
Signs and symbols
Wall
Base line
Wall
Herring Storer Acoustics
Job No - 15293
PEET LTD - MUNDIJONG LSP
NIGHT NOISE CONTOUR PLOTS - WITH NOISE WALLS
8 TRAINS SOUTHWEST RAIL LINE
Figure C2
Ref # 17

APPENDIX D

QUIET HOUSE DESIGN PACKAGES

Road Traffic and Passenger Rail
Quiet House Requirements
(*Based on Table 3 of State Planning Policy 5.4 2019*)

Exposure Category	Orientation to corridor	Acoustic rating and example constructions					Mechanical ventilation/air conditioning considerations
		Walls	**External doors**	**Windows**	**Roofs and ceilings of highest floors**	**Outdoor Living areas**	
A **Quiet House A**	**Facing**	**Bedroom and Indoor Living and work areas to Rw + Ctr 45dB** **Stud Frame Walls** ➢ One row of 92mm studs at 60mm centres with: ➢ Resilient steel channels fixed to the outside of the studs; and ➢ 9.5mm hardboard or 9mm fibre cement weatherboards or one layer of 19mm board cladding fixed to the outside of the channels; and ➢ 75mm glass wool (11kg/m3) or 75mm polyester (14kg/m3) insulation, positioned between the studs; and ➢ -Two layers of 16mm fire-protective grade plasterboard fixed to the inside face of the studs. **Brick Walls** ➢ Single leaf of 150mm brick masonry with 13mm cement render on each face: **OR** ➢ Double brick: two leaves of 90 mm clay brick masonry with a 20mm cavity between leaves.	**Bedrooms**: ➢ Fully glazed hinged door with certified **R_w+C_{tr} 28dB** rated door and frame including seals and 6mm glass **Indoor Living and work areas:** ➢ 35mm solid core timber hinged door and frame system certified to **Rw 28dB** including seals**: OR** ➢ Glazed sliding door with 10 mm glass and weather seals	**Bedrooms**: ➢ Total external door and window system area up to 40% of room floor area: Sliding or double hung with minimum 10 mm single or 6mm-12mm-10mm double insulted glazing (**R_w+C_{tr} 28 dB**). Sealed awning or casement windows may use 6 mm glazing instead**: OR** ➢ Up to 60% floor area: as per above but must be sealed awning or casement type windows (**R_w+C_{tr} 31dB**). **Indoor Living and work areas** ➢ Up to 40% floor area: Sliding, awning, casement or double hung with minimum 6mm single pane or 6mm-12mm-6mm double insulted glazing (**R_w+C_{tr} 25dB**)**: OR** ➢ Up to 60% floor area: As per Bedrooms at up to 40% area (**Rw+Ctr28 dB : OR** ➢ Up to 80% floor area: As per Bedrooms at up to 60% area (**R_w+C_{tr} 31 dB**).	**To R_w+C_{tr} 35dB** ➢ Concrete or terracotta tile or metal sheet roof with sarking and at least 10mm plasterboard ceiling	➢ At least one outdoor living area located on the opposite side of the building from the transport corridor and/or at least one ground level outdoor living area screened using a solid continuous fence or other structure of minimum **2 metres** height above ground level	➢ Acoustically rated openings and ductwork to provide a minimum sound reduction performance of **Rw 40dB** into sensitive spaces ➢ Evaporative systems require attenuated ceiling air vents to allow closed windows ➢ Refrigerant-based systems need to be designed to achieve National Construction Code fresh air ventilation requirements ➢ Openings such as eaves, vents and air inlets must be acoustically treated, closed or relocated to building sides facing away from the corridor where practicable
	Side On		As per "Facing" above, except R_w+C_{tr} values may be 3dB less, e.g. glazed sliding door with 10 mm glass and weather seals for bedrooms	As above, except R_w+C_{tr} values may be 3dB less, or max % area increased by 20%			
	Opposite		No specific requirements	No specific requirements			

Road Traffic and Passenger Rail
Quiet House Requirements
(*Based on Table 3 of State Planning Policy 5.4 2019*)

Exposure Category	Orientation to corridor	Acoustic rating and example constructions					Mechanical ventilation/air conditioning considerations
		Walls	**External doors**	**Windows**	**Roofs and ceilings of highest floors**	**Outdoor Living areas**	
B **Quiet House B**	**Facing**	**Bedroom and indoor living and work areas to R_w+C_{tr} 50dB** **Single leaf of 90 mm clay brick masonry with:** ➢ A row of 70 mm x 35 mm timber studs or 64 mm steel studs at 600 mm centres; ➢ A cavity of 25 mm between leaves; ➢ 50 mm glass wool or polyester cavity insulation (R2.0+) insulation between studs; and ➢ One layer of 10mm plasterboard fixed to the inside face ➢ Single leaf of 220mm brick masonry with 13mm cement render on each face ➢ 150mm thick unlined concrete panel or 200mm thick concrete panel with one layer of 13mm plasterboard or 13mm cement render on each face **Double brick: two leaves of 90mm clay brick masonry with:** ➢ A 50mm cavity between leaves ➢ 50mm glass wool or polyester cavity insulation (R2.0+) ➢ Resilient ties where required to connect leaves **Double brick: two leaves of 110mm clay brick masonry with** ➢ 50mm cavity between leaves and R2.0+ cavity insulation	**Bedrooms** ➢ Fully glazed hinged door with certified **R_w+C_{tr} 31dB** rated door and frame including seals and 10mm glass **Indoor Living and work areas** ➢ 35mm solid core timber hinged door and frame system certified to **Rw 28dB** including seals**: OR** ➢ Glazed sliding door with 10 mm glass and weather seals	**Bedrooms**: ➢ Total external door and window system area up to 40% of room floor areas: Fixed sash, awning or casement with minimum 6mm single or 6mm-12mm-6mm double insulted glazing (**Rw+Ctr 31dB**). ➢ Up to 60% floor area: as per above but must be minimum10mm single or 6mm-12mm-10mm double insulated glazing (**Rw+Ctr 34dB**) **Indoor Living and work areas** ➢ Up to 40% floor area; Sliding or double hung with minimum 6mm single pane or 6mm-12mm-6mm double insulted glazing (R_w+C_{tr} 28dB). Sealed awning or casement windows may use 6mm glazing instead. **: OR** ➢ Up to 60% floor area: As per Bedrooms at up to 40% area (**R_w+C_{tr} 31dB**). **: OR** ➢ Up to 80% floor area: As per Bedrooms at up to 60% area (**R_w+C_{tr} 34dB).**	**To R_w+C_{tr} 35dB** ➢ Concrete or terracotta tile sarking and at least 10mm plasterboard ceiling, R3.0+ insulation **OR** ➢ Metal sheet roof, sarking and at least 10mm plasterboard ceiling, R3.0+ insulation	➢ At least one outdoor living area located on the opposite side of the building from the corridor and/or at least one ground level outdoor living area screened using a solid continuous fence or other structure of minimum **2.4 metres** height above ground level	➢ Acoustically rated openings and ductwork to provide a minimum sound reduction performance of **Rw 40dB** into sensitive spaces ➢ Evaporative systems require attenuated ceiling air vents to allow closed windows ➢ Refrigerant-based systems need to be designed to achieve National Construction Code fresh air ventilation requirements ➢ Openings such as eaves, vents and air inlets must be acoustically treated, closed or relocated to building sides facing away from the corridor where practicable
	Side-On		**Bedrooms**: ➢ Fully glazed hinged door with certified **R_w+C_{tr} 28dB** rated door and frame including seals and 6mm glass **Indoor Living and work areas:** ➢ 35mm solid core timber hinged door and frame system certified to **Rw 28dB** including seals**: OR** ➢ Glazed sliding door with 10 mm glass and weather seals	**Bedrooms**: ➢ Total external door and window system area up to 40% of room floor area: Sliding or double hung with minimum 10 mm single or 6mm-12mm-10mm double insulted glazing (**R_w+C_{tr} 28 dB**). Sealed awning or casement windows may use 6 mm glazing instead. **: OR** ➢ Up to 60% floor area: as per above but must be sealed awning or casement type windows (**R_w+C_{tr} 31dB**). **Indoor Living and work areas** ➢ Up to 40% floor area: Sliding, awning, casement or double hung with minimum 6mm single pane or 6mm-12mm-6mm double insulted glazing (**R_w+C_{tr} 25dB**). **: OR** ➢ Up to 60% floor area: As per Bedrooms at up to 40% area (**Rw+Ctr28 dB**) **: OR** ➢ Up to 80% floor area: As per Bedrooms at up to 60% area (**R_w+C_{tr} 31 dB**).			
	Opposite		As above, except R_w+C_{tr} values may be 3dB less, or max % area increased by 20%	As above, except R_w+C_{tr} values may be 3dB less, or max % area increased by 20%			

Road Traffic and Passenger Rail
Quiet House Requirements
(*Based on Table 3 of State Planning Policy 5.4 2019*)

Exposure Category	Orientation to corridor	Acoustic rating and example constructions					
		Walls	**External doors**	**Windows**	**Roofs and ceilings of highest floors**	**Outdoor Living areas**	**Mechanical ventilation/air conditioning considerations**
C **Quiet House C**	**Facing**	**Bedroom and indoor living and work areas to R_w+C_{tr} 50dB** **Single leaf of 90 mm clay brick masonry with:** ➢ A row of 70 mm x 35 mm timber studs or 64 mm steel studs at 600 mm centres; ➢ A cavity of 25 mm between leaves; ➢ 50 mm glass wool or polyester cavity insulation (R2.0+) insulation between studs; and ➢ One layer of 10mm plasterboard fixed to the inside face **Double brick: two leaves of 90mm clay brick masonry with:** ➢ A 50mm cavity between leaves ➢ 50mm glass wool or polyester cavity insulation (R2.0+) ➢ Resilient ties where required to connect leaves	**Bedrooms** ➢ External doors to bedrooms facing the corridor are not recommended. **Indoor Living and work areas** ➢ Fully glazed hinged door with certified **Rw+Ctr 31dB** rated door and frame including seals and 10mm glass**: OR** 40mm solid core timber frame and door (without glass or with glass inserts not less than 6mm), side hinged with certified **Rw 32dB** acoustically rated door and frame system including seals	**Bedrooms**: ➢ Total external door and window system area up to 20% of room floor area: Fixed sash, awning or casement with minimum 6mm single or 6mm-12mm-6mm double insulted glazing (**R_w+C_{tr} 31dB): OR** ➢ Up to 40% floor area; as per above but must be minimum 10mm single or 6mm-12mm-10mm double insulted glazing (**R_w+C_{tr} 34dB**). **Indoor Living and work areas** ➢ Up to 40% floor area: Sliding or double hung with minimum 6mm single pane or 6mm-12mm-6mm double insulated glazing (**R_w+C_{tr} 31dB**). Sealed awning or casement windows may use 6mm glazing instead**: OR** ➢ Up to 60% floor area: As per Bedrooms at up to 40% area (**Rw+Ctr 34dB)**	**To R_w+C_{tr} 40dB** ➢ To al bedrooms, 2 layers of 10mm plasterboard, or one layer 13mm high density sealed plasterboard (minimum surface density of 12.5 kg/m2), affixed using steel furring channels beneath ceiling rafters/supports**: and** ➢ R3.0+ insulation batts laid in cavity **: and** ➢ Concrete or terracotta tile roof with sarking, or metal sheet roof with foil backed R2.0+ fibre insulation between steel sheeting and roof battens	➢ At least one outdoor living area located on the opposite side of the building from the corridor and/or at least one ground level outdoor living area screened using a solid continuous fence or other structure of minimum **2.4 metres** height above ground level	➢ Acoustically rated openings and ductwork to provide a minimum sound reduction performance of Rw 40dB into sensitive spaces. ➢ Evaporative systems require attenuated ceiling air cents to allow closed windows. ➢ Refrigerant-based systems need to be designed to achieve National Construction Code fresh air ventilation requirements ➢ Openings such as eaves, vents and air inlets must be acoustically treated, close or relocated to building sides facing away from the corridor where practicable.
	Side-on	**Double brick: two leaves of 90mm clay brick masonry with:** ➢ 150mm thick unlined concrete panel or 200mm thick concrete panel with one layer of 13mm plasterboard or 13mm cement render on each face ➢ Single leaf of 220mm brick masonry with 13mm cement render on each face	**Bedrooms** ➢ Fully glazed hinged door with certified **R_w+C_{tr} 31dB** rated door and frame including seals and 10mm glass **Indoor Living and work areas** ➢ 35mm solid core timber hinged door and frame system certified to **Rw 28dB** including seals**: OR** ➢ Glazed sliding door with 10 mm glass and weather seals				
	Opposite	**Double brick: two leaves of 110mm clay brick masonry with** ➢ 50mm cavity between leaves and R2.0+ cavity insulation	**Bedrooms**: ➢ Fully glazed hinged door with certified **R_w+C_{tr} 28dB** rated door and frame including seals and 6mm glass **Indoor Living and work areas:** ➢ 35mm solid core timber hinged door and frame system certified to **Rw 28dB** including seals**: OR** ➢ Glazed sliding door with 10 mm glass and weather seals	**Bedrooms**: ➢ Total external door and window system area up to 40% of room floor area: Sliding or double hung with minimum 10 mm single or 6mm-12mm-10mm double insulted glazing (**R_w+C_{tr} 28 dB**). Sealed awning or casement windows may use 6 mm glazing instead**: OR** ➢ Up to 60% floor area: as per above but must be sealed awning or casement type windows (**R_w+C_{tr} 31dB**). **Indoor Living and work areas** ➢ Up to 40% floor area: Sliding, awning, casement or double hung with minimum 6mm single pane or 6mm-12mm-6mm double insulted glazing (**R_w+C_{tr} 25dB): OR** ➢ Up to 60% floor area: As per Bedrooms at up to 40% area (**Rw+Ctr28 dB : OR** ➢ Up to 80% floor area: As per Bedrooms at up to 60% area (**R_w+C_{tr} 31 dB**).			

Appendix G

Integrated Landscape & Management Strategy

INTEGRATED LANDSCAPE AND MANAGEMENT STRATEGY

TAYLOR ROAD, MUNDIJONG LOCAL STRUCTURE PLAN

Project Number EP15-036(03)

Prepared for Peet Mundijong Syndicate Ltd
May 2023



Document Control

DOC NAME	INTEGRATED LANDSCAPE AND MANAGEMENT STRATEGY – TAYLOR ROAD, MUNDIJONG LOCAL STRUCTURE PLAN				
DOC NO.	EP15-036(03)—003C VMK				
REVISION	DATE	AUTHOR		REVIEWER	
1	February 2016	Vanessa Keating	VMK	Jen Longstaff	JL
	Draft report for client review/comment.				
A	February 2016	Vanessa Keating	VMK	Jen Longstaff	JL
	Updated following comment from project team.				
B	May 2023	Sophie McClintock	SAM	Kirsten Knox	KK
	Minor updates based on revised structure plan and adjustments throughout.				
C	May 2023	Kirsten Knox	KK	Kirsten Knox	KK
	Minor updates following project team review				

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Executive Summary

Taylor Burrell Barnett (TBB), on behalf of Peet Mundijong Syndicate Ltd (Peet), have prepared a Local Structure Plan (LSP) for urban development within Lot 2 Bishop Road, and Lots 3, 5, 10, 11 29, 52 and 9000 Taylor Road, in the locality of Mundijong, within the Shire of Serpentine Jarrahdale. This area is herein referred to as "the site".

The LSP for the site has been prepared by TBB to provide a framework for the future implementation of residential land use. The LSP design incorporates the inputs from a multi-disciplinary project team and the outcomes from various technical studies.

Emerge Associates have been engaged to provide a suite of environmental consultancy services to support the preparation of the LSP, which has included numerous investigations to identify and assess the environmental attributes and values within the site. This included review of existing information and historic environmental assessments, and undertaking further site specific assessments and reporting, including:

- *Bushfire Management Plan* (Emerge Associates 2023b)
- *Environmental Assessment and Management Strategy (Emerge Associates 2023c)*
- *Spring Flora and Vegetation Survey (Emerge Associates 2017)*

This Integrated Landscape Management Strategy (ILMS) details the environmental values and attributes of the site and the legislation, policies and guidelines informing the management of these values within the site. This strategy provides guidance on the management of these values within public open space or conservation reserves within the broader development by outlining 'management elements', which detail the management requirements for various environmental values and landscape considerations.

A number of environmental values and attributes were found within or adjacent to the site, and have been summarised below:

- The majority of the site was historically cleared for agricultural purposes, primarily cattle grazing.
- Based on a detailed flora and vegetation survey undertaken in 2017 there are no Threatened Flora (TF) or Priority Flora (PF) species, Threatened Ecological Communities (TECs) or Priority Ecological Communities (PECs) present within the site.
- Vegetation within the site is generally in "Completely Degraded" or "Degraded" condition (based upon the flora and vegetation survey (Emerge Associates 2017). A small portion of vegetation in the south-east of the site, associated with an area of Conservation Category Wetland, is considered to range from "Good - degraded" to "Excellent – very good" condition.
- Bush Forever Site 350 occurs immediately east of the site, within the Soldiers Road and railway reserve. This Bush Forever Site is known to support significant flora and vegetation values. There are no Bush Forever sites within the site.
- Environmentally Sensitive Areas (ESAs) extend into the east of the site, associated with the flora and vegetation values known to occur within Bush Forever Site 350 and south associated with Manjedal Brook.
- Based on the flora and vegetation survey for the site (Emerge Associates 2017), the site potentially has value as habitat for threatened or priority fauna species, specifically suitable foraging and potential breeding habitat for black cockatoo species, but is largely associated with the remnant vegetation along Manjedal Brook.

- Manjedal Brook runs through the southern portion of the site. This creekline conveys surface flows through the site to the west, and joins with Cardup Brook and eventually the Serpentine River west of the site.
- The majority of the site is covered by Multiple Use Wetlands (MUW), and there are three Conservation Category Wetlands (CCW) in the south of the site, two of which are associated with Manjedal Brook.
- An existing railway line occurs adjacent to the northern and eastern site boundary, while a Primary Regional Road reserve associated with the Tonkin Highway extension and Water Corporation service corridor lies adjacent to the western boundary of the site. These existing and future adjacent land uses will pose acoustic and potential vibration implications to residential development within the site.
- Vegetation surrounding the site, as well as that associated with Manjedal Brook, presents a permanent bushfire hazard to future residential development.

A Local Structure Plan (LSP) has been prepared for the site which has provided for the retention of Manjedal Brook and areas of CCW in the south of the site, with the provision of appropriate foreshore and buffer, and drainage reserves for the maintenance of pre-development surface water and groundwater conditions.

Based on the LSP design, a number of 'management areas' have been identified which will guide the application of various 'management elements' across the site. The 'management areas' are listed below and are detailed in **Section 4** of this strategy:

- Multiple use corridors
- Neighbourhood parks
- Drainage basins
- Local sport open space
- Manjedal Brook foreshore reserve
- Pocket parks
- Conservation Category Wetland buffer
- Subdivision area.

In order to provide for the management of the environmental values within the site, this strategy has outlined a number of 'management elements' which provide for the different types of management that are required to be applied within the 'management areas' as part of subdivision and ongoing maintenance. These 'management elements' are based on the environmental values and landscape principles outlined for the site, as well as federal, state and local expectations (based on legislation, policy and guidelines).

The management elements are listed below and include:

- Planting and revegetation
- Fauna management
- Disease (Dieback) management
- Indigenous heritage management
- Bushfire hazard management
- Construction management

Landscape Management Plans will be prepared for each subdivision area which will address the management elements that will be implemented for the applicable management areas. A *Landscape Management Plan*, in addressing the principles outlined in this strategy, replaces the requirement for

various separate management plans and instead will provide a comprehensive plan which addresses all landscape management aspects. The management areas present within a subdivision area will influence the management elements that will need to be addressed in a *Landscape Management Plan*.

The implementation of a *Landscape Management Plan* and the maintenance of the management areas will be the responsibility of the developers, or where appropriate and agreed, the Shire of Serpentine Jarrahdale. As part of the subdivision process, it is expected that the developer, following practical completion will maintain the relevant management areas for two years before handing over to the Shire of Serpentine Jarrahdale.

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Appendices

Appendix A
Taylor Road, Mundijong Local Structure Plan

Appendix B
Landscape Masterplan (Emerge Associates 2023)

Appendix C
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Appendix D
Outline of monitoring and evaluation requirements

1 Introduction

1.1 Background

Taylor Burrell Barnett (TBB), on behalf of Peet Mundijong Syndicate Ltd (Peet), have prepared a Local Structure Plan (LSP) for urban development within Lot 2 Bishop Road, and Lots 3, 5, 10, 11 29, 52 and 9000 Taylor Road, in the locality of Mundijong. This area is herein referred to as "the site." The site is approximately 199 hectares (ha) in size, located in the Shire of Serpentine Jarrahdale, approximately 37 km south-east of the Perth Central Business District (CBD), as shown in **Figure 1**.

The site is bound by Bishop Road to the north and east, Manjedal Brook and Scott Road to the south, and rural landholdings to the west, as shown in **Figure 2**. The site is zoned "Urban" under the Metropolitan Region Scheme (MRS) and "Urban Development" under the Shire of Serpentine Jarrahdale's Town Planning Scheme (TPS) No. 2.

1.2 Planning context

The broader area in which the site is located (Mundijong Whitby area) has been identified as an area for urban development. The *Mundijong District Structure Plan* was prepared by the Hames Sharley on behalf of the Shire of Serpentine Jarrahdale (Hames Sharley 2021) to guide the future urban expansion of the area. The vision for the *Mundijong District Structure Plan* was to provide "*a contemporary, connected place reflecting the community's rural character, green values and vibrant village feel"*. The plan aims to create a viable and liveable town for around 35,000 residents over the next 30 years, to be a well-connected community that is appropriate to the rural setting of the wider area and the associated natural landscape values (Hames Sharley 2021).

The LSP provides the sequential level of land use planning detail associated with implementing the Mundijong District Structure Plan (DSP). The Mundijong DSP was adopted by the Shire of Serpentine Jarrahdale in 2011 to provide overall guidance on the structure, vision and objectives for the planning and development of the Mundijong and Whitby areas.

The environmental planning principles outlined within the Mundijong DSP and to be considered as a part of LSP are that:

- The natural environment will be protected, repaired, enhanced and respected within the natural context;
- Urban development will promote green power initiatives;
- The total water cycle will be sustainably repaired, maintained and enhanced;
- Feasible water cycle management approaches will be promoted; and
- Existing landform must be respected and maintained and be utilised to enhance the built form.

The LSP has been developed in general accordance with these environmental principles and the broader Mundijong DSP.

1.3 Purpose of the ILMS

This report provides a comprehensive management strategy to address the future management requirements for a variety of environmental values and attributes found within the or adjacent to the

site, as well as consider the integration and enhancement of public open space within the existing landscape values as a part of the eventual urban development of the site.

This Integrated Landscape Management Strategy (ILMS) details the environmental values and attributes of the site, the policies and principles informing the management of areas within the site, and broadly outlines the future management requirements and how this will be delivered as a part of future subdivision and development.

Specifically, the ILMS aims to address the requirements of the Shire of Serpentine Jarrahdale, outlined in the Mundijong DSP and various local planning policies, and the Department of Biodiversity, Conservation and Attractions (DBCA). These requirements include:

- Wetland Management Strategy
- Foreshore Management Plan for Manjedal Brook
- Flora and Fauna Management Plan
- Landscape Strategy and Master Plan.

1.4 Scope of work

Emerge Associates have been engaged to provide a suite of environmental services to support the preparation of the LSP. This has included numerous site specific technical investigations to identify and assess the environmental attributes and values/constraints present within the site and those areas for which the LSP formally covers.

To date, these services include:

- Desktop environmental investigation and review of historic investigations.
- Preparation of a *Bushfire Management Plan* (Emerge Associates 2023b)
- Preparation of an *Environmental Assessment and Management Strategy* (EAMS) (Emerge Associates 2023c).
- Preparation of preliminary landscape concept drawings to inform this report.

This report and the above reports have been updated recently (2023), where applicable, to address the revised structure plan.

1.5 Environmental and site specific investigations

In addition to the above, there has been a significant body of investigations undertaken historically to understand the site. This has included:

- *Spring Flora and Vegetation Survey* (Emerge Associates 2017)
- *Mundijong North- Environmental Assessment Report* (PGV 2014)
- *Mundijong North – Spring Flora and Vegetation Survey* (PGV 2012)
- *Level 2 Flora and Vegetation Survey* (PGV 2012)
- *Level 1 Fauna Survey* (Terrestrial Ecosystems 2011)
- *Fauna Survey of wetland and waterway* (Terrestrial Ecosystems 2012)
- *Habitat and targeted vegetation assessment* (Strategen 2015b)
- *EPBC Act significance assessment* (Strategen 2015a)
- *Preliminary Site Investigation of Lot 2 Bishop Road and Lot 11 Taylor Road* (Aurora Environmental 2014a)

- *Sampling and Analysis Plan for Lot 2 Bishop Road and Lot 11 Taylor Road* (Aurora Environmental 2014b)
- *Groundwater monitoring* (BGE 2009)
- *Addendum to the Local Water Management Strategy* (RPS 2023)
- *Local Water Management Strategy* (Wave International 2016)
- *Report on Geotechnical Study* (Galt Geotechnics 2011)
- *Noise Report (Herring Storer Acoustics 2023)*

1.6 Structure of this report

The structure of this ILMS is as follows:

- **Section 1** introduces the management strategy, outlining its purpose and objectives.
- **Section 2** describes the existing environment within the site.
- **Section 3** outlines the legislation, policies and guidelines relevant to the site.
- **Section 4** describes the landscape design principles proposed to inform the future development process.
- **Section 5** details the management elements that will be considered as part of the future development process.
- **Section 6** details the required management actions to implement the management strategy and the proposed ongoing maintenance and asset management.
- **Section 7** provides a conclusion and summary of the management strategy.
- **Appendix A** contains the proposed LSP (TBB 2023).
- **Appendix B** contains landscape masterplan (Emerge Associates 2023a).
- **Appendix C** contains an indicative planting palette for future planting and revegetation works.
- **Appendix D** contains an outline of future monitoring and evaluation of revegetation works within conservation areas.

2 Existing Environment

2.1 Local context

The site is approximately 200 ha in size, and is bound by Bishop Road to the north and east, Manjedal Brook and Scott Road to the south, and rural landholdings to the west, as shown in **Figure 2**. The site is zoned "Urban" under the Metropolitan Region Scheme (MRS) and "Urban Development" under the Shire of Serpentine Jarrahdale's Town Planning Scheme (TPS) No. 2.

The site is bound by "Urban" zoned land to the east and south, with a Railway reserve associated with the existing railway line adjacent to the eastern and northern site boundaries, and a "Primary Regional Road" reserve immediately west of the site, associated with the future Tonkin Highway extension (see **Figure 2**). Landholdings further west of the site are currently zoned for "Rural" land uses, and are intended for future industrial land uses under the West Mundijong Industrial Area Structure Plan (Shire of Serpentine Jarrahdale 2022).

Landholdings east of the site are currently undergoing separate residential subdivision processes in line with the endorsed Whitby Local Structure Plan (Roberts Day 2012) and will form an urban district centre and residential neighbourhood along with the site, in accordance with the Mundijong DSP.

2.2 Climate

The climate of the site which applies to the broader south west region of Western Australia is described as Mediterranean with hot, dry summers and moderately wet, mild winters. The majority of rainfall within the region occurs between May and October each year, and on average is between 600 to 1000 mm per year. However, in the last 40 years there has been a marked decrease in rainfall (between 10 to 15% decrease), with a noticeable shift to a drier climate across the south-west of Western Australia (CSIRO 2009).

The closest inland weather station to the site is the Karnet weather station, located approximately 18 km south-east of the site. Average climate statistics recorded at the Karnet weather station between 1963 and December 2022 (BoM 2023) is summarised in **Table 1** below.

Table 1: Rainfall and temperature averages for the Karnet weather station (1963 to December 2022) (BoM 2023)

STATISTICS	J	F	M	A	M	J	J	A	S	O	N	D
Mean Maximum Temperature (°C)	30.6	30.4	27.8	23.3	19.2	16.5	15.5	16.0	17.7	20.8	24.4	28.3
Mean Minimum Temperature (°C)	15.3	15.8	14.4	11.8	9.0	7.3	6.4	6.4	7.3	9.0	11.4	13.6
Mean Rainfall (mm)	18.1	20.9	25.2	64.6	139.8	205.1	220.3	182.7	131.1	74.7	44.7	18.1

2.3 Landform and soils

2.3.1 Topography

The site is generally flat, with a westerly aspect. Topography ranges from approximately 40 metres Australian Height Datum (m AHD) in the north-east, and slopes down to approximately 25 m AHD in the west. Available topographic contours for the site are shown in **Figure 3**.

2.3.2 Regional geomorphology

The site is located on the Swan Coastal Plain, which forms the central portion of the Perth basin. The Perth basin extends from the Darling Fault in the east to the continental slope west of Rottnest Island, and from the Murchison River in the north and the Southern Ocean in the south. The Perth basin is sedimentary in original and is marginal to the west of the Australian Shield (Seddon 2004).

The Swan Coastal Plain is generally flat and is approximately 20 – 30 km wide, consisting of a series of geomorphic entities running parallel to the coastline. The youngest and most western of these geomorphic entities is the Quindalup Dunes, followed by the Spearwood Dunes and at the most eastern extent the Bassendean Dunes. The site is located on the eastern side of the Swan Coastal Plain, and falls within the Pinjarra, Bassendean Dunes, and Forrestfield Systems.

2.3.3 Landform and soils

Environmental geology (surface soils) across the site has been mapped by the Geological Survey of Western Australia (Gozzard 1986). The site is largely comprised of sandy clay of the Guildford Formation (Cs), with pockets of sand (S_8) and sand over clay (S_{10}) associated with Bassendean Sands throughout the site. A small portion of clayey sandy silt occurs in the south-east of the site, associated with the Alluvium soils of Manjedal Brook. Landform and soil mapping for the site is shown in **Figure 4**.

A geotechnical survey (Galt Geotechnics 2011) was undertaken across the site which found soils within the site are consistent with the regional mapping. Based on the geotechnical survey of the site (Galt Geotechnics 2011), soil conditions across the site can be described by two typical soil profiles:

- Sand, comprising of the following:
  - Sand (SP) – Medium to coarse grained, sub-rounded to sub-angular material with occasional 5mm to 15mm weakly to moderately cemented ferruginised modules. (between 0.5m and 2.5m, however average thickness 1.4m); overlaying
  - Ferricrete Gravels (GP/GC) – Located in 9 out of 18 test pits at depths below 1.0m. Fine to medium gravels in sand and clayey sand, becoming cemented in areas. Refusal encountered between 0.9m to 2.0m.
  - Clayey sand (SC) – Located in 2 out of 18 test-pits and present below sand layer. Localised layer/lenses of medium to course sub-rounded to sub-angular varying between 10-30% low to medium plasticity clay fines with occasional 5mm to 15mm weakly to moderately cemented ferruginised modules. (0.4m thick).
- Clayey sand, comprising of the following:
  - Sand (SP) – Medium to coarse grained, sub-rounded to sub-angular material between 0.0m and 1.3m. (average thickness 0.7m); overlaying
  - Clayey sand (SC)/Sandy Clay (CL) –Medium to course grained sub-rounded to sub-angular varying between 20-60% low to medium plasticity clay fines (localised high plasticity) with occasional weakly to moderately cemented ferruginised modules present between 1.2m to 2.6m.

2.3.4 Acid Sulfate Soils

Acid Sulfate Soils (ASS) is the name commonly given to naturally occurring soils and sediment containing iron sulphide (iron pyrite) materials. In their natural state ASS are generally present in waterlogged anoxic conditions and do not present any risk to the environment. When oxidised, ASS produce sulphuric acid, which can pose risks to the surrounding environment, infrastructure and human health.

The Department of Water and Environmental Regulation (DWER) provides broad-scale mapping indicating areas of potential ASS risk (DWER 2023a). Available information indicates that the majority of the site has been classified as having 'moderate to low' risk of ASS occurring within three metres of the natural soil surface. Two areas in the south-east portion of the site have a 'high to moderate' risk of ASS occurring, generally associated with wetlands in this area, as shown in **Figure 5**.

A geotechnical assessment was undertaken for the site by Galt Geotechnics in 2011, which determined that there is a low likelihood of ASS occurring within the site (Galt Geotechnics 2011).

2.4 Biodiversity and natural assets

2.4.1 Flora and vegetation

2.4.1.1 Regional context

The site lies within the Swan Coastal Plain Interim Biogeographic Regionalisation for Australia (IBRA) region (Thackway and Cresswell 1995). The Swan Coastal Plain IBRA region is broadly compatible with the Swan Coastal Plain (Drummond Botanical Subdistrict) Phytogeographical Subregion as described by (Beard 1990). This region is characterised by *Banksia* low woodlands on leached sands, woodlands of tuart (*Eucalyptus gomphocephala*), jarrah (*Eucalyptus marginata*) and marri (*Corymbia calophylla*) on less leached soils and *Melaleuca* swamps.

At a local level, vegetation complex mapping for the Swan Coastal Plain undertaken by Heddle *et al.* (1980) indicates that the site is mapped within the Beermullah complex, the Forrestfield complex, and the Guildford complex, as shown in **Figure 6.**

The Beermullah complex is described by Heddle *et al.* (1980) as consisting of a mixture of low open forest of *Casuarina obesa* and open woodland of *C.calophylla - Eucalyptus wandoo - Eucalyptus marginata*. Components include closed scrub of *Melaleuca* spp. Minor components include closed scrub of *Melaleuca* spp. and occurrence of *Actinostrobus pyramidalis*. DBCA and DWER provided statistics regarding pre-European and current extent of the vegetation complexes in the south-west of Western Australia (Government of Western Australia 2019). Remnant vegetation calculations undertaken in 2018 determined that approximately 6.7% of the pre-European extent of the Beermullah complex remains on the Swan Coastal Plain (Government of Western Australia 2019). Approximately 2.1% formally protected within Bush Forever or conservation reserves.

Vegetation of the Forrestfield complex ranges from open forest of *Coryimbia calophylla - Eucalyptus wandoo*, *Eucalyptus marginata* to open forest of *Eucalyptus marginata - Corymbia calophylla*, *Allocasuarina fraserana - Banksia* spp. Fringing woodland of *Eucalyptus rudis* in the gullies that dissect this landform (Heddle *et al.* 1980). Approximately 10.5% of the pre-European extent of this vegetation complex remains on the Swan Coastal Plain, with approximately 1.6% under formal conservation protection (Government of Western Australia 2019).

The Guildford complex is described as a mixture of open forest to tall open forest of *Corymbia calophylla - Eucalyptus wandoo - Eucalyptus marginata* and woodland of *Eucalyptus wandoo* (with rare occurrences of *Eucalyptus* l*ane-poolei*). Minor components include *Eucalyptus rudis - Melaleuca rhaphiophylla* (Heddle *et al.* 1980). Approximately 5.0% of the pre-European extent of the Guildford complex remains on the Swan Coastal Plain, with approximately 0.3% under formal conservation protection (Government of Western Australia 2019).

The EPA's *Environmental Guidance for Planning and Development* (EPA 2008) states that the loss of biodiversity caused by habitat fragmentation is significantly greater once a habitat type falls below 30% of its original extent. The Guidance also references the biodiversity conservation national objective and target of retaining 30% of the original extent of each vegetation complex, and the states' minimum target of 10% for constrained urban areas such as the Swan Coastal Plain. The Beermullah and Guildford vegetation complexes have less than 10% remaining, while the Forrestfield has approximately 10.5% is below the 30% retention objective and marginally above or equal to the 10% minimum retention target for the Swan Coastal Plain.

2.4.1.2 Extent and condition of remnant vegetation

A spring flora and vegetation surveys (Emerge Associates 2017) was undertaken in order to understand the extent of remnant vegetation values within the site and is in addition to early surveys including *Mundijong North- Spring Flora and Vegetation Survey* (PGV 2012). Based on these detailed surveys, the majority of remnant vegetation across that site was found to be in "Completely Degraded" condition, as shown in **Figure 7**. Remnant vegetation associated with Manjedal Brook in the south of the site is in "Degraded" condition due to the high degree of disturbance of the understorey through historic clearing and cattle grazing.

The site is devoid of large areas of intact remnant vegetation due to the long history of cropping and stock grazing. Non-native pasture species are dominant across the site with scattered native trees such as *Corymbia calophylla, Eucalyptus rudis* and *Melaleuca preissiana* (see **Plate 1**). The vegetation interpreted from aerial imagery was confirmed during the field survey. A small rise in the south-western corner of the site (within Lot 3 Taylor Road) contains a variety of different scattered native trees such as *Banksia ilicifolia*, *Eucalyptus marginata* and *Xylomelum occidentale* over similar non-native pasture grasses. Stands of non-native planted trees also occur across the site, particularly in the north of the site and surrounding the dairy located in Lot 11 Taylor Road.

Limited remnant vegetation occurs in the south of the site associated with Manjedal Brook and an area of Conservation Category Wetland (CCW). Vegetation within Manjedal Brook is comprised mainly of *Corymbia calophylla*, *Melaleuca preissiana* and *Melaleuca rhaphiophylla* over pasture grasses, as shown in **Plate 2**. Due to the extent of disturbance from cattle grazing within the waterway, vegetation associated with Manjedal Brook is considered to be in "Degraded" condition.

The CCW (UFI 7835) retains the highest quality vegetation in the site and is located between the easternmost wetland feature and the site boundary and is in 'excellent - very good' condition. Native species diversity was relatively low but this is expected for this type of dense inundated wetland vegetation. The remaining vegetation surrounding this feature is altered from its original form and is in 'degraded' condition. The CCW supports a large area of remnant vegetation consisting mainly of *Melaleuca preissiana*, *Melaleuca rhaphiophylla* and planted Eucalypt species over *Baumea articulata*, *Lepidosperma longitudinale* and *Juncus pallidus,* as shown in **Plate 3** and **Plate 4**. The majority of remnant wetland vegetation in this area was found to be in "Excellent – very good" condition, with areas of "Very good – good", "Good" and "Degraded" vegetation at the perimeter of the wetland

(shown in **Figure 7** and **Plate 5**), due to the extensive clearing of overstorey and understorey species (Emerge Associates 2017).



Plate 1: Scattered paddock trees over pasture grass, dominant across the site



Plate 2: Remnant riparian vegetation within Manjedal Brook in the south of the site



Plate 3: Remnant wetland vegetation within the CCW in the south-east of the site



Plate 4: Area of CCW in the south-east of the site



Plate 5: Vegetation within the CCW buffer area in the south-east of the site

2.4.1.3 Significant flora and vegetation

Certain flora species that are considered to be rare or under threat warrant special protection under federal and/or state legislation. At a federal level, flora species may be listed as 'threatened' pursuant to the EPBC Act. Threatened flora species listed under the EPBC Act are assigned a conservation status according to attributes such as population size and geographic distribution. Any action likely to have a significant impact on a taxon listed under the EPBC Act requires Ministerial approval.

At a state level, plant species may also be classed as 'threatened' under the BC Act. Similarly, it is an offence to 'take' or 'disturb' threatened flora listed under the BC Act without Ministerial approval.

Flora species that do not currently meet the criteria for listing as threatened but are potentially rare or threatened may be added to the DBCA's *Priority Flora List*. These species are classified into 'priority' levels based on threat. Whilst priority species are not under direct statutory protection, they are considered during State approval processes.

Based on the findings of the *Flora and Vegetation Survey* (Emerge Associates 2017) one regionally significant flora species (but is not identified as threatened or priority flora), *Dielsia stenostachya*, was recorded in vegetation between the easternmost wetland feature and the site boundary. This species is identified in *Significant Flora of the Foothills and Pinjarra Plain in the Perth Metropolitan Region* as it is endemic to the Swan Coastal Plain (Government of WA 2000b).

2.4.1.4 Plant communities

Eleven plant communities were identified within the site from the detailed flora and vegetation survey undertaken by Emerge Associates (2017), as shown in **Figure 8**, and included in **Table 2** below:

Table 2: Plant communities identified within the site.

Plant community	Description	Area (ha)
ErCcMr	**Manjedal Brook** Low open forest *Eucalyptus rudis* and *Corymbia calophylla* over low open woodland *Melaleuca rhaphiophylla* over isolated forbs *Juncus pallidus* and *Alternanthera nodiflora* over closed grassland non-native pasture grasses. Pools of standing water were present in the brook at the time of the survey.	7.12
MpTlBaLl	**Far eastern sumpland – eastern side** Low woodland *Melaleuca preissiana* over tall shrubland *Taxandra linearifolia* over sedgeland *Baumea articulata* and *Lepidosperma longitudinale* over open forbland *Cycnogeton lineare.* Most of this community was waterlogged at the time of the survey.	0.94
BaJp	**Far eastern sumpland – remaining perimeter** Closed sedgeland *Baumea articulata* and *Juncus pallidus*. The majority of this community was inundated at the time of the survey.	0.37
MpTl	**Sumpland west of the far eastern sumpland – north-eastern corner** Low woodland *Melaleuca preissiana* over closed shrubland *Taxandra linearifolia* over isolated sedges *Juncus pallidus* over forbland *Lemna dispersa* and **Briza minor.* Some *Melaleuca preissiana* canopy trees in this community were inundated.	0.13

Table 2: Plant communities identified within the site (continued)

Plant community	Description	Area (ha)
CcJp	**Sumpland west of the far eastern sumpland – eastern side** Low open woodland *Corymbia calophylla* over sparse sedgeland *Juncus pallidus* over open grassland of non-native pasture species such as **Ehrharta calycina* and **Pennisetum clandestinum*. The two areas of this community were moist to dry at the time of the survey.	0.06
MpJfAf	**Swales between the two sumplands** Open low woodland *Melaleuca preissiana* over Tall open shrubland *Jacksonia furcellata* over shrubland *Astartea fascicularis*. The lower lying areas of this community were waterlogged at the time of the survey.	0.36
Non-native vegetation	Heavily disturbed areas comprising scattered planted trees and shrubs over closed grassland of scattered introduced pasture weeds such as **Ehrharta calycina* and **Bromus diandrus* (**Plate 2**).	188.85

2.4.1.5 Threatened and/or Priority Ecological Communities

In Western Australia, Threatened Ecological Communities (TECs) are defined by the Western Australian Threatened Ecological Communities Scientific Advisory Committee. Generally these can be described as vegetation communities that are assemblages of species that occur together in a particular type of habitat. They are the sum of species within an ecosystem and, as a whole provide many of the processes which support a specific ecosystem. TECs are recognised as specific ecological communities that are rare or under threat.

Selected TECs are afforded statutory protection at a federal level under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). TECs listed under the EPBC Act are assigned a conservation status. Any action likely to have a significant impact on a community listed under the EPBC Act requires Ministerial approval.

TECs are also listed within Western Australia under the *Biodiversity Conservation Act 2016* (BC Act) and the Biodiversity Conservation Regulations 2018 (BC Regulations). Their significance is also acknowledged through other state environmental approval processes such as 'environmental impact assessment' pursuant to Part IV of the *Environmental Protection Act 1986* (EP Act) and the *Environmental Protection (Clearing of Native Vegetation) Regulations 2004.*

In addition to a listing as a TEC, a community may be listed as a Priority Ecological Community (PEC). This is an ecological community that is under consideration for listing as a TEC, but does not yet meet survey criteria or has not been adequately defined.

Based on the detailed spring survey undertaken for the site, no TECs or PECs occur within the site. Vegetation within the CCW in the south-east of the site and within Manjedal Brook in the south of the site are considered to have once represented Floristic Community Type (FCT) 13 and FCT 11 respectively, neither of which are listed as TECs or PECs at a state or federal level (Emerge Associates 2017).

Bush Forever Site 350 east of the site is known to support several TECs (Government of WA 2000b), as discussed further below, however this TEC does not extend within the site.

2.4.2 Bush Forever

The Government of Western Australia's *Bush Forever Policy* is a strategic plan for conserving regionally significant bushland within the Swan Coastal Plain portion of the Perth Metropolitan Region. The objective of Bush Forever is to protect comprehensive representations of all original ecological communities by targeting a minimum of 10 % of each vegetation complex for protection (Government of WA 2000a). Bush Forever Sites are representative of regional ecosystems and habitat and have a key role in the conservation of Perth's biodiversity.

There are no Bush Forever sites located within the site, however Bush Forever Site 350 "Byford to Serpentine Rail/Road Reserves and Adjacent Bushland" (Bush Forever Site 350) is located immediately east of the site, and is known to contain Threatened Flora species and TECs in need of protection (Government of WA 2000b). The location of Bush Forever Site 350 is shown in **Figure 9.**

2.4.3 Local Natural Areas

The Shire of Serpentine Jarrahdale adopted a Local Biodiversity Strategy in 2008, prepared in accordance with the Perth Biodiversity Project's *Local Government Biodiversity Planning Guidelines for the Perth Metropolitan Region* (WALGA and PBP 2004). Within the Local Biodiversity Strategy, the Shire of Serpentine Jarrahdale has defined Local Natural Areas (LNAs) based on their conservation significance, land zoning, and other planning constraints such as structure plans and lot size. LNAs are natural areas that exist outside of Bush Forever Sites (Swan Coastal Plain), the CALM Managed Estate and Regional Parks. Based on a review of the Shire of Serpentine Jarrahdale's Local Biodiversity Strategy, there are no LNAs identified within or in close proximity to the site.

2.4.4 Environmentally Sensitive Areas

'Environmentally sensitive areas' (ESAs) are prescribed under the *Environmental Protection (Clearing of Native Vegetation) Regulations 2004* to protect native vegetation values of areas surrounding significant, threatened or scheduled flora, vegetation communities or ecosystems. Within an ESA none of the exemptions under the *Environmental Protection (Clearing of Native Vegetation) Regulations 2004* apply. However, exemptions under Schedule 6 of the EP Act still apply, including any clearing in accordance with a subdivision approval under the *Planning and Development Act 2005* (a recognised exemption under the Schedule 6 of the EP Act).

ESAs cover portions of the site in the east and south, as shown in **Figure 9**, generally associated with the CCW, Bush Forever Site 350, and the associated flora and vegetation values known to occur in these areas.

2.4.5 Ecological Linkages

Ecological linkages support the movement of fauna, flora and genetic material between areas of fragmented remnant habitat. The movement of fauna and the exchange of genetic material between vegetation remnants improve the viability of those remnants by allowing greater access to breeding partners, food sources, refuge from disturbances such as fire, and maintenance of genetic diversity of plant communities and populations. Ecological linkages are often continuous or near-continuous as the more fractured a linkage is, the less ease flora and fauna have in moving within the corridor (Molloy *et al.* 2009).

Ecological linkages have been generally identified by the State Government in Bush Forever, Perth's Greenways and the System 6 study and have been published by the Perth Biodiversity Project. These

identified linkages reflect the on-ground linkages throughout the Perth Metropolitan area (Molloy *et al.* 2009). The dataset is employed as a conservation tool aimed to conserve and enhance our regional biological linkages.

Part of a mapped ecological linkage occurs within the eastern extent of the site, associated with Bush Forever Site 350 and the vegetation values known to occur in this area. This ecological linkage is shown in **Figure 9**. While revegetation works proposed within the CCW buffer in the south-eastern portion of the site will contribute to the linkage, the connectivity of this linkage will be maintained through the long term retention of vegetation within Bush Forever east of the site, and is not dependent on the retention of vegetation within the site, nor will it be impacted by the proposed development of the site.

2.4.6 Terrestrial fauna

Fauna species that are considered to be rare or under threat warrant special protection under state and/or federal legislation. At a federal level, fauna species may be listed as 'threatened' pursuant to the EPBC Act and any action likely to have a significant impact on a listed threatened species requires approval from the federal Minister for the Environment.

At a state level, fauna species are listed as 'threatened' under section sections 13, 19 and 26(2) of the BC Act. It is an offence to 'take' or 'disturb' threatened fauna without Ministerial approval. In addition to this, the Department of Biodiversity Conservation and Attractions (DBCA) maintains a list of priority fauna species which, while not considered threatened under the BC Act and therefore not protected directly, involve some concern over their long-term survival.

Due to the significant historic disturbance that has occurred within the site, and the overall condition of remnant vegetation, it is unlikely that the site supports any significant fauna habitat values other than some opportunistic values for mobile fauna species.

A targeted black cockatoo habitat assessment for three species of black cockatoo was undertaken for the site (Strategen 2015a) which concluded that while the site supports some scattered habitat species that are considered suitable potential foraging or breeding habitat for black cockatoos, there is no evidence that vegetation within the site is being actively used by black cockatoos (Strategen 2015a).

Potential black cockatoo foraging and breeding habitat within the site is illustrated in **Figure 10** (DBCA 2019), however due to the completely degraded nature of vegetation within the site, and the large area of intact habitat vegetation reserved in Bush Forever Sites 354 and 361 approximately 650 m north-east of the site, it is unlikely that the site supports any significant foraging and/or breeding activities.

2.5 Hydrology

2.5.1 Groundwater

Information on groundwater from the *Water Register* (DWER 2022) indicates that groundwater beneath the site is a multi-layered system comprised of the following:

- Perth – Superficial Swan (allocation available)
- Perth – Cattamarra Coal Measures (allocation available)
- Perth – Leederville (allocation available)
- Lower Serpentine (limited information)

Groundwater data from the DWER Perth Groundwater Map (DWER 2023b) shows minimum groundwater levels across the site occur approximately 1 to 2 metres below ground level (m BGL), with groundwater flowing in a westerly direction.

The Local Water Management Strategy (LWMS) and addendum to the LWMS (addendum) prepared for the site (Wave International 2016; RPS 2023) outlines groundwater levels of the underlying superficial aquifer occur at depths of approximately 19 to 32 m BGL. However, monitoring has shown that the site is hydrologically distinct and isolated from the underlying superficial aquifer by localized low permeability soils (i.e. clay), which causes the seasonal peak groundwater levels to be perched (i.e. unable to permeate through clay layer underlying the site) to a maximum of 2 m BGL (Wave International 2016; RPS 2023), which is consistent with the mapping provided by the Department of Water and Environmental Regulation outlined above.

Groundwater quality at the site was monitored by Brown Geotechnical (BGE 2009) and samples were analysed for physical parameters and nutrients. Groundwater was found to be slightly acidic, and Nitrogen and Phosphorous levels were found to be slightly higher than the ANZECC and ARMCANZ (2000) Guidelines for Southwest Australian Aquatic Ecosystems, however this is not uncommon in agricultural land (Wave International 2016; RPS 2023).

Further information and relevant data is provided in the addendum to the LWMS and addendum (Wave International 2016; RPS 2023) prepared to support the LSP.

2.5.2 Surface water

Manjedal Brook traverses the south of the site, as shown in **Figure 11**, and flows in an east to west direction. A number of agricultural drains dissect the site, associated with the historic rural land uses, which convey flows through the site to Manjedal Brook in the south of the site.

The Manjedal Brook has a defined channel through the site, however extensive disturbance through cattle grazing has resulted in significant damage to the waterway banks and riparian vegetation (see **Plate 6**). Based on extensive site observations by Emerge Associates botanists, vegetation along the Manjedal Brook was found to be in a “Degraded” to “Completely Degraded” condition, and in a large portion of the waterway consists of only a single row of native trees over pasture grass (see **Plate 7**). This is consistent with the outcomes of the *Spring Flora and Vegetation Survey* (Emerge Associates 2017).

Based on the requirements of the Western Australian Planning Commission (WAPC) *Schedule of Modifications* (WAPC 2021), a foreshore reserve of 50 m on either side of the waterway is proposed and the foreshore encompasses the existing ecological and hydrological values of the Manjedal Brook, and provides an appropriate buffer between the waterway and adjacent development.



Plate 6: Degraded riparian vegetation over pasture grass within Manjedal Brook



Plate 7: Manjedal Brook, degraded by extensive cattle grazing in and around the waterway

2.5.3 Wetlands

Based on the DBCA Geomorphic Wetland series mapping (DBCA 2022), the majority of the site is mapped as Multiple Use wetlands (MUW), with areas of Conservation Category wetlands (CCW) in both the south-east and south of the site, as shown in **Figure 11**. Areas of CCW in the south of the site (UFI 14945 and UFI 15446) are associated with Manjedal Brook, while a large circular CCW (UFI 7835) is located in the south-eastern corner of the site, as shown in **Plate 8** below. This CCW (UFI 7835) is a seasonally inundated basin or 'sumpland' wetland which supports a large area of remnant vegetation consisting mainly of *Melaleuca preissiana*, *Melaleuca rhaphiophylla* and planted Eucalypt species over *Baumea articulata*, *Lepidosperma longitudinale* and *Juncus pallidus,* in generally 'Very Good' condition (Emerge Associates 2017).

Due to the significant historic disturbance of Manjedal Brook through extensive livestock grazing and weed invasion, UFI 14945 and UFI 15446 are no longer considered representative of the current conservation status, and support very limited remaining riparian vegetation.



Plate 8: CCW (UFI 7835) located in the south-eastern portion of the site

2.5.4 Public Drinking Water Source Areas

Public Drinking Water Source Areas (PDWSAs) are surface water catchments or groundwater recharge areas that have been identified as drinking water sources, proclaimed as water reserves by the DWER (DoW 2009b), and protected by government legislation. PDWSAs provide the majority of Western Australia's drinking water supplies and can be vulnerable to contamination from a range of

land uses and water based activities (DoW 2009a) therefore consideration needs to be given to the intended land use and associated activities to ensure that they are appropriate in meeting the water protection quality objectives of the area.

The site does not fall with a declared PDWSA.

2.6 Health and amenity

2.6.1 Mosquitos

In the context of southwest Western Australia, mosquitos are known to constitute a potential risk to human health as a vector for serious diseases such as Ross River Virus, Barmah Forest Virus and Murray River Encephalitis (DoH 2010). Apart from acting as disease vectors, when present in sufficiently high numbers, biting female mosquitoes can also cause nuisance to the public and reduce the ability of residents to enjoy outdoor living areas. Similarly, non-biting Chironomid midges can also cause nuisance to residents of areas adjacent to wetland areas when present in large numbers by accumulating under eaves and entering the home.

The site contains wetland areas that are permanently or seasonally inundated which provide suitable breeding habitat for mosquitos. The flight range of adult mosquitoes is five kilometres; as a result, there is some potential for future homeowners within the site to be adversely affected.

2.7 Heritage

2.7.1 Indigenous heritage

Based on a review of the Department of Planning, Lands and Heritage (DPLH) 'Aboriginal Heritage Places' online database (DPLH 2023) there is two registered Indigenous heritage sits mapped within the site in the south-east, and several Other Heritage Places mapped throughout the site, as shown in **Figure 12**. The details for the registered heritage sites and other heritage places are as follows:

Table 3: Registered Indigenous heritage sites within or in close proximity to the site

SITE ID	DESCRIPTION
Registered sites	
3648	Soldiers Road, Mundijong – Artefacts/Scatter
37116	Soldiers Road, Mundijong – Modified Tree
Other Heritage Places	
32591	MJ-01 – Artefacts/Scatter, Arch Deposit
32615	MJ-04 – Artefacts/Scatter, Arch Deposit
32616	MJ-03 – Artefacts/Scatter, Arch Deposit
32619	MJ-02 – Artefacts/Scatter, Arch Deposit

Peet Ltd has engaged the services of ethnography and heritage consultant, Ethnosciences to provide additional advice in relation to the heritage and cultural values of the site. Ethnosciences conducted two separate archaeological investigations of the site in 2012 and 2014, in consultation with

representatives of the relevant traditional owners and Aboriginal elders, in order to understand the extent of the heritage values of the site. These investigations identified a number of values within the site, generally aligning in location with the 'other heritage places' identified within the AHIS dataset, while Ethnosciences (TCHM 2014) also identified that the registered site (ID No. 3648) was potentially incorrectly mapped, concluding that the values were more likely to occur north of this location, directly adjacent to the western boundary of the Conservation Category Wetland.

An application was made under Section 18 of the *Aboriginal Heritage Act 1972* (AHA) on 12 December 2019 and consent granted by the Minister for Aboriginal Affairs on 26 April 2020 (subject to conditions). Archaeological sites identified as meeting the requirements of section 5 of the in the AHA and proposed to be disturbed through development of the subject land are outlined in the Aboriginal Archaeological Assessment prepared by Thomson Cultural Heritage Management (April 2014) .

Furthermore, an Aboriginal Heritage Management Plan shall be prepared and implemented prior to subdivision.

2.7.2 Non-Indigenous heritage

A desktop search of the Australian Heritage Database (DCCEEW 2022), the State Heritage Office database (Heritage Council WA 2022) and the Shire of Serpentine Jarrahdale's local municipal heritage list indicated there are no registered heritage sites within or in close proximity to the site.

2.8 Land use considerations

2.8.1 Existing and historic land uses

The site was historically cleared and used for rural purposes; predominantly livestock grazing as part of dairy farm operations. A Preliminary Site Investigation (PSI) was undertaken for the site (Aurora Environmental 2014a) which identified several sources of potential contamination associated with the historic agricultural land uses across the site, primarily within Lot 2 and Lot 11. This is addressed within the EAMS (Emerge Associates 2023c) prepared for the site.

2.8.2 Surrounding land uses

The site is bound by "Urban" zoned land to the east and south, with a Railway reserve associated with the existing railway line adjacent to the eastern and northern site boundaries, and a "Primary Regional Road" reserve immediately west of the site, associated with the future Tonkin Highway extension. Landholdings further west of the site are currently zoned for "Rural" land uses, and are intended for future industrial land uses under the West Mundijong Industrial Area District Structure Plan (SoSJ 2022).

Landholdings east of the site are currently undergoing separate residential subdivision processes in line with the endorsed Whitby Local Structure Plan (Roberts Day 2012) and will form an urban district centre and residential neighbourhood along with the site, in accordance with the Mundijong DSP.

2.8.2.1 Freight railway line

The site is bordered by a freight railway line to the east, as shown in **Figure 2**. Noise emissions and vibrations from this transport corridor have the potential to impact upon the future urban land use of the site.

Potential mitigation strategies for development within the site include an acoustic barrier/wall, and/or architectural treatments to new buildings in the vicinity of the railway line. These mitigation options can be used to meet "Noise Target" levels for residential development (as outlined in the WAPC's *State Planning Policy 5.4 Road and Rail Noise* (SPP 5.4) (WAPC 2019).

2.8.2.2 Tonkin Highway extension

The site is bordered by a "Primary Regional Road" reservation, associated with the future Tonkin Highway extension, to the west, as shown in **Figure 2**. Noise emissions from this transport corridor will have the potential to impact upon urban land uses within the site. Construction is expected to commence in 2025 with target completion in late 2027, subject to regulatory approvals.

2.9 Natural hazards

2.9.1 Flooding

Based on detailed flood modelling undertaken for Manjedal Brook in the south of the site (Wave International 2016; RPS 2023) flood levels for Manjedal Brook have been modelled to be fully contained within 50 m flow width of the waterway. This will be accommodated by the foreshore reserve of 50 m on either side of the waterway, proposed to encompass the existing ecological and hydrological values of the Manjedal Brook, and provide an appropriate buffer between the waterway and adjacent development.

2.9.2 Bushfire hazard

The site has been identified as a "Bushfire Prone Area" under the state-wide *Map of Bushfire Prone Areas* (OBRM 2021) as mapped by the Office of Bushfire Risk Management (OBRM), and shown in **Figure 13**. The identification of a site within an area declared as bushfire prone necessitates further assessment of the determined bushfire risk affecting the site in accordance with *Australian Standard 3959:2018 Construction of buildings in bushfire prone areas* (AS 3959) (Standards Australia 2018), and the satisfactory compliance of the proposal with the policy measures described in *State Planning Policy 3.7 Planning in Bushfire Prone Areas* (SPP 3.7) (WAPC 2015) and the *Guidelines for Planning in Bushfire Prone Areas Version 1.4* (the Guidelines) (DPLH & WAPC 2021).The Bushfire Management Plan (BMP) aims to address bushfire management issues within the LSP and through this, minimise the impact of bushfires within and surrounding the site, thereby reducing the threat to life, property and the environment.

A bushfire management plan (BMP) has been prepared (Emerge Associates 2023b) to meet the requirements of SPP 3.7 to identify bushfire risk and the bushfire protection measures that will make the land suitable for its intended purpose. As part of this, a Bushfire Attack Level (BAL) assessment involving the classification and condition of vegetation within 150 m of the site has been undertaken.

The permanent bushfire hazard features which are relevant for the site include remnant vegetation within Bush Forever Site 350 adjacent to the eastern site boundary, and areas of remnant vegetation to be permanently retained within Manjedal Brook and CCW areas (and associated buffers) in the southern portion of the site. The bushfire hazard assessment is outlined in detail within the BMP (Emerge Associates 2023b).

3 Relevant Legislation, Policy and Guidelines

In considering the environmental values and attributes within the site, and providing for future management of these values, it is necessary to consider the legislation, policies and guidelines which ultimately guide the required and expected management outcomes from a federal, state and local government perspective. Below, **Table 4** and **Table 5** consider the relevant legislation, policies and guidelines and how these apply to the site.

Table 4: Federal and state legislation relevant to the site

LEGISLATION	DESCRIPTION	RELEVANCE TO SITE
Federal		
Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act)	The EPBC Act is a Federal environmental legal framework which aims to protect and manage nationally and internationally significant flora, fauna, ecological communities and heritage places. Under the Act, a person must not take an action that has, will have or is likely to have a significant impact on any Matter of National Environmental Significance (MNES) without approval from the Australian Government Minister for the Environment (the Minister) (DoE 2013). An action is described as a project, a development, an undertaking, an activity or a series of activities, or an alteration of any of these things. The MNES considered under the EPBC Act are: • Listed threatened species and ecological communities. • Migratory species (protected under international agreements). • Wetlands of international importance. • Commonwealth marine areas. • The Great Barrier Reef Marine Park. • World heritage properties. • National heritage places. • Nuclear actions. • A water resource, in relation to coal seam gas development and large coal mining development. Under the EPBC Act, a significant impact is determined by the sensitivity, value and quality of the environment which is to be impacted and the intensity, duration, magnitude and geographic extent of the impacts (DoE 2013). If a proposed action is deemed to have a significant impact, this action should be referred to the Minister.	Suitable foraging habitat species and potential roosting habitat for Black Cockatoos was identified within the site, however is not considered to be locally or regionally significant. Furthermore, no existing or potential habitat was identified for any of the other threatened fauna species within the site. Management of fauna is discussed further in **Section 5.2**.

Table 4: Federal and state legislation relevant to the site (continued)

LEGISLATION	DESCRIPTION	RELEVANCE TO SITE
State		
Aboriginal Heritage Act 1972 (AH Act) / Aboriginal Cultural Heritage Act 2021 (ACH Act)	The ACH Act provides a framework for the recognition, protection, conservation and preservation of Aboriginal cultural heritage. The specifics of the implementation of the ACH Act are still under design with Aboriginal people (and while this occurs, the requirements of the AH Act and Section 18 approval will apply), however will include a due diligence process, and working with Aboriginal parties to manage identified values appropriately, and will depend upon the type of activity and the associated tier of impact.	As outlined previously, an application was made under Section 18 of the *Aboriginal Heritage Act 1972* (AHA) on 12 December 2019 and consent granted by the Minister for Aboriginal Affairs on 26 April 2020 (subject to conditions). Archaeological sites identified as meeting the requirements of section 5 of the in the AHA and proposed to be disturbed through development of the subject land are outlined in the Aboriginal Archaeological Assessment prepared by Thomson Cultural Heritage Management (April 2014). This Section 18 approval will be valid under the new *Aboriginal Cultural Heritage Act 2021* as part of transition provisions, and values will be managed in accordance with all relevant requirements. An Aboriginal Heritage Management Plan shall be prepared and implemented as part of the subdivision process, when ground disturbance will occur.
Environmental Protection Act 1986 (EP Act)	The EP Act aims to protect and enhance the environment through the prevention and control of pollution and environmental harm. Under the EP Act, the EPA is responsible for assessing the impacts of projects, proposals, town planning schemes and scheme amendments on the environment and providing advice to the Minister for Environment. This advice is guided by policy and guidance documents prepared by the EPA.	The MRS amendment for the site was referred to the Environmental Protection Authority (EPA), which determined that the proposed amendment was environmentally acceptable subject to several recommendations relating to the retention of regionally significant wetland values. Wetland values identified within the site, while of conservation significance, are not considered regionally significant under the EPA's advice. The management of wetland values within the site is discussed further in **Section 5**.

Table 4: Federal and state legislation relevant to the site (continued)

LEGISLATION	DESCRIPTION	RELEVANCE TO SITE
State (continued)		
Biodiversity Conservation Act 2016 (BC Act)	In Western Australia flora and fauna species may be classed as 'threatened' under the *Biodiversity Conservation Act 2016* (BC Act). It is an offence to 'take' or 'disturb' threatened flora or fauna without Ministerial approval. TECs are also listed within Western Australia under the BC Act and the BC regulations. Their significance is also acknowledged through other state environmental approval processes such as 'environmental impact assessment' pursuant to Part IV of the *Environmental Protection Act 1986* (EP Act) and the *Environmental Protection (Clearing of Native Vegetation) Regulations 2004*.	No significant habitat for any conservation significant flora or fauna species was found to occur within the site. The retention of existing vegetation and proposed planting and/or enhancement of native vegetation within the site will contribute and improve the overall extent of flora and fauna habitat within the site. Management of these values is discussed further in **Section 5**.
Environmental Protection (Noise) Regulations 1997	The *Environmental Protection (Noise) Regulations 1997* provide a basis for determining acceptable noise levels in relation to land use. The regulations assign acceptable noise levels which are allowed to be received at a premise at a particular time of day or night. The highest levels of noise that can be received are set differently depending on the type of premise receiving the noise. These can be noise-sensitive premises such as residences, commercial premises such as shops and offices, and industrial premises. For noise-sensitive premises the assigned levels are calculated by looking at land use zonings within radiuses of 100 m and 450 m from the noise receiver. Assigned levels for noise-sensitive premises also vary depending on the time of day. Low levels of noise must occur at night, with allowable noise levels being higher during the evening and highest during the day. Allowing noise emissions to exceed the set levels at the noise receiver is an offence under Section 3 of the EP Act.	Potential noise impacts and management of these impacts are considered within the EAMS (Emerge Associates 2023c). Therefore, no further consideration on the management of noise impacts is provided in this strategy.
State Planning Policy No. 2.1 Peel-Harvey Coastal Plain Catchment (SPP 2.1) (WAPC 2003)	SPP 2.1 was developed to ensure that land use changes within the Peel-Harvey Estuary System that are likely to cause environmental damage are brought under planning control and are prevented (Department of Planning 2003). Generally the policy states that any development, including the construction of buildings should aim to: • Reduce the nutrient load discharging into the Peel-Harvey Estuary system. • Encourage the retention and rehabilitation of existing remnant vegetation. • Minimise the impact to the environment of changes in land use. • Prevent land uses that result in excessive nutrient export into the drainage system. SPP 2.1 is related to the consideration and application of the *Environmental Protection Peel Inlet – Harvey Estuary Policy 1992*.	The site is located within the Peel-Harvey Catchment. The aims of SPP 2.1 have been considered as part of the LWMS and addendum (Wave International 2016; RPS 2023) and this ILMS.

Table 4: Federal and state legislation relevant to the site (continued)

LEGISLATION	DESCRIPTION	RELEVANCE TO SITE
State (continued)		
State Planning Policy No. 2.9 Water Resources (SPP 2.9) (WAPC 2006b)	SPP 2.9 aims to ensure the protection and appropriate management of water resources (in line with state guidelines) is included within the planning framework. The broad aims of this policy are to: • Protect, conserve and enhance water resources. • Assist in ensuring the availability of suitable water resources to maintain essential requirements for human and other biological life and to maintain or improve the quality and quantity of water resources. • Promote and assist in the management and sustainable use of water resources. As a part of implementing this policy, the *Better Urban Water Management (WAPC 2008)* framework was developed. This framework provides detail on how water resources should be considered at each stage of planning by identifying the various actions and investigations required with regard to regional and local planning strategies, town planning schemes, structure plans, subdivisions, strata subdivision and development applications (WAPC 2008).	This policy is considered within the LWMS and addendum (Wave International 2016; RPS 2023), which outlines how surface water and groundwater will be managed within the site.
State Planning Policy No. 3.4 Natural Hazards and Disasters (SPP 3.4) (WAPC 2006c)	SPP 3.4 was prepared to ensure that mitigation measures for potential natural hazards are integrated into the process of land use planning. Hazards considered under this policy include, floods, severe storms, erosion, and bushfires. The objectives of the policy are to: • Include planning for natural disasters as a fundamental element in the preparation of all statutory and non-statutory planning documents, specifically town planning schemes and amendments, and local planning strategies. Through the use of these planning instruments, minimise the adverse impacts of natural disasters on communities, the economy and the environment.	The potential for flooding to occur within the site from Manjedal Brook has been considered in detail within the LWMS and addendum (Wave International 2016; RPS 2023). Overall there is no significant flood risk within the site and can be managed through the provision of fill and implementation of the LWMS. Bushfire risk is considered further below.

Table 5: State and local policies and guidelines relevant to the site

POLICY	DESCRIPTION	RELEVANCE TO SITE
State (continued)		
State Planning Policy No. 3.7 Planning for Bushfire Management (SPP 3.7) *(WAPC and DFES 2021)*	SPP 3.7 aims to assist in reducing the risk of bushfire to people, property and infrastructure by taking a risk minimisation approach to development proposed in bushfire-prone areas. The policy is intended to inform and guide decision makers, referral authorities and proponents to achieve acceptable bushfire protection outcomes, including detail on the expectations at the different stages of planning.	Classified vegetation within and surrounding the site poses bushfire hazard for future residential development within the site. The management of bushfire risk within the site is considered further in the BMP (Emerge Associates 2023b). Areas of public open space within the site will be managed as 'low threat' and is considered further in **Section 5**.
State Planning Policy No. 5.4 Road and Rail Noise (SPP 5.4) (WAPC 2019)	SPP 5.4 recognises that excessive noise has the potential to affect the health and amenity of a community as a whole, as well as the wellbeing of individuals. The policy aims to: • Protect individuals from unreasonable levels of transport noise by establishing a standardised set of criteria to be used in the assessment of proposals. • Protect major transport corridors and freight operations from incompatible urban encroachment. • Encourage best practice design and construction standards for new development proposals and new or redeveloped transport infrastructure proposals. The policy is applicable to development adjacent to or in proximity to road and rail transport corridors that produce noise emissions that could potentially impact future sensitive land uses, such as residential development.	An existing railway line lies adjacent to the eastern and north site boundary, while the future Tonkin Highway extension road reserve is located adjacent to the western boundary of the site. Noise impacts from the existing and future adjacent land uses on the proposed future residential land use within the site can be suitably managed and is considered further in the EAMS (Emerge Associates 2023c).
Environmental Protection Peel Inlet – Harvey Estuary Policy 1992	This policy sets out environmental quality objectives for the Peel Inlet – Harvey Estuary which aim to rehabilitate the estuary and protect it from further degradation. The objectives focus on limiting the total phosphorus flowing into the estuary from its major tributaries, being the Serpentine River, Murray River and Harvey River. These objectives are to be achieved and maintained through: • The implementation of the planning policy by local authorities through Town Planning Schemes, and by the WAPC through the MRS. • Appropriate land management by landholders and management authorities. Local authorities and WAPC ensuring that decisions and actions are compatible with the achievement and maintenance of the objectives.	The site is located within the Peel-Harvey Catchment, with surface water flows from the site to eventually join the Serpentine-River. The aims of this policy have been considered as part of the LWMS and addendum (Wave International 2016; RPS 2023) as well as this ILMS.

Table 5: State and local policies and guidelines relevant to the site (continued).

POLICY	DESCRIPTION	RELEVANCE TO SITE
Local		
Local Planning Policy 2.4 – Water Sensitive Urban Design Guidelines (LPP 2.4) (SoSJ 2018a)	This policy aims to enhance the beneficial use of watercourses and wetlands within the Shire of Serpentine Jarrahdale, ensure water sensitive design best management practices are implemented, improve water quality and develop a network of multiple use corridors. The policy applies to rezonings, structure plans, detailed area plans, subdivisions and development proposals. The key principles of this policy are: • Catchment based approach to stormwater management with water resource management addressed within each catchment. • Stormwater retention, use and treatment to occur at source or as high in the catchment as possible, including the 'treatment train approach'. • Protect property from flooding and damage.	This policy is considered within the LWMS and addendum (Wave International 2016; RPS 2023) for the site which outlines how surface water and groundwater will be managed.
Local Planning Policy 2.7: Bio-Diversity Planning Policy (LPP 2.7) (SoSJ 2018b)	*LPP 2.7* aligns with the Shire of Serpentine Jarrahdale's *Local Biodiversity Strategy* (Ironbark Environmental 2009). This policy recognises that the Swan Coastal Plain has been significantly cleared as a part of historical land uses and details the Shire of Serpentine Jarrahdale's commitment to the conservation of biodiversity and the restoration of the environment. *LPP 2.7* aims to: • Contribute towards biodiversity conservation goals and targets outlined in the *Local Biodiversity Strategy*. • Protect natural areas and maintain the values and ecosystem services of these areas in the long-term. • Ensure natural areas are not negatively impacted by development. • Ensure the protection, restoration or management of natural areas, or the revegetation of other areas to increase fauna habitat.	Remnant vegetation occurring in the southern portion of the site, associated with Manjedal Brook and areas of CCW, will be retained.
Local Planning Policy No.4.16 Tree Retention and Planting (LPP 4.16)	*LPP 4.16* aims to preserve and enhance the Shire's landscape potential through tree preservation and landscaping measures. The key principle is to protect and maintain significant trees, provide guidance when the Shire will support tree removal and require replacement planting, enhance the overall landscape and increase canopy coverage in the urban landscape.	Retention of mature trees where possible within the subdivision area and planting for replacement of trees removed using local native flora species will be carried out within the streetscapes (where possible) as part of the development, as outlined in **Section 5.4**.
Local Planning Policy No. 4.18 Street Trees (LPP 4.18) (SoSJ 2018c)	*LPP 4.18* aims to promote 'leafy streetscapes' in new developments within the Shire of Serpentine Jarrahdale, through street tree planting and protecting remnant trees in road reserves.	Planting using local native flora species will be carried out within the streetscapes (where possible) as part of the development, as outlined in **Section 5.4**.

Table 5: State and local environmental guidelines relevant to the site.

GUIDELINES	DESCRIPTION	RELEVANCE TO SITE
State		
Environmental Protection Authority Guidance Statement No. 33 Environmental Guidance for Planning and Development (EPA 2008)	The purpose of EPA *Guidance Statement No.33* is to outline the significance of environmental factors and provide the key definitions associated with the environmental factors. This document is primarily targeted at ensuring environmental factors are considered in line with the EPA's principals and objectives and within the planning framework. In particular, EPA *Guidance Statement No.33* aims to: • Provide an overview to environmental protection processes and information. • Describe the referral and environmental impact assessment process and process under Part IV of the EP Act. • Provide the EPA's position and advice on a range of environmental factors, outlining how to protect, conserve and enhance the environmental values. This document represents the primary guidance tool for ensuring environmental values within and surrounding potential developments are identified, managed appropriately, and enhanced where possible.	The site has been historically utilised for agricultural land uses, specifically cattle grazing and dairy farm operations. It has been historically cleared and remnant vegetation is limited to Manjedal Brook and areas of CCW in the south of the site. The rest of the site is made up of scattered paddock trees over pasture grass. Retention of native vegetation within the site is addressed further in **Section 5**.
Better Urban Water Management (WAPC 2008)	*Better Urban Water Management* is a framework created as a whole of government approach by the Department of Planning which aims to integrate land-use planning and water management. This framework outlines the specific actions required with regard to water management at the different stages of planning. The different actions are outlined below: • A District Water Management Strategy is to be prepared in support of a District Structure Plan, local planning strategy or region scheme amendment. • A Local Water Management Strategy is to be prepared in support of a Local Structure Plan or TPS amendment. • Urban Water Management Plans are to be prepared at the subdivision stage. There is an emphasis within this framework on the application of water sensitive urban design to effectively and efficiently manage the way in which water within an urban context is utilised. This framework has been developed to minimise the impact of urbanisation on the natural water cycle.	A District Water Management Strategy (DWMS) has been prepared for the Mundijong DSP area (GHD 2010). The DWMS details the water management objectives and design criteria that future development should aim to meet. A LWMS and addendum (Wave International 2016; RPS 2023) has been prepared for the site in accordance with this framework.

Table 5: State and local environmental guidelines relevant to the site (continued).

GUIDELINES	DESCRIPTION	RELEVANCE TO SITE
State (continued)		
State Planning Policy 2.8 - Bushland policy for the Perth Metropolitan Region (WAPC 2010)	Bush Forever identifies a range of sites for retention which contain regionally significant bushland and associated wetlands. Bushland is described as "*land on which there is vegetation which is either a remainder of the natural vegetation of the land or, if altered, is still representative of the structure and floristics of the natural vegetation, and provides the necessary habitat for fauna*". Specifically Bush Forever aims to protect comprehensive representations of all original ecological communities by targeting a minimum of 10 per cent of each vegetation complex for protection. The criteria utilised to select regionally significant areas of bushland for retention include: • Representative of ecological communities. • Areas with highly diverse flora, and/or fauna, and/or communities. • Areas containing rare or threatened communities or species. • Maintaining ecological systems or natural processes. • Scientific or evolutionary importance. • Protection of wetland, streamline and estuarine fringing vegetation and coastal vegetation. • Criteria not relevant to the selection of regionally significant bushland, but important such as landscape or historical values.	Bush Forever Site 350 occurs immediately east of the site.
A Guide to Managing and Restoring Wetland in Western Australia (DEC 2013)	This guide, developed by the former Department of Environment and Conservation (DEC), provides information about the nature of Western Australia's wetlands, and practical guidance on how to manage and restore wetlands for nature conservation. The guide is aimed at anyone intending to manage a wetland, including landowners, land managers, community members and consultants. The guide includes chapters on: • Planning for wetland management. • Understanding wetlands. • Managing wetlands. • Monitoring wetlands. • Protecting wetlands.	The site contains four Multiple Use Wetlands and three Conservation Category Wetlands.

Table 5: State and local environmental guidelines relevant to the site (continued).

GUIDELINES	DESCRIPTION	RELEVANCE TO SITE
State (continued)		
Guidelines Checklist for preparing a Wetland Management Plan (DEC 2008)	The aim of this guideline is to provide a checklist for practitioners to utilise, to ensure that management under such a plan will maintain, if not improve the values of a wetland. A summary of information generally required is outlined below: • Summary of management commitments including the overall intent of the plan, objectives, strategies to achieve the objectives, timing and priorities in enacting these strategies and the performance criteria which provide measurable targets to indicate effectiveness of the management plan. • Detail on existing environment describing the natural environment and values currently present. • Cultural and social value/use detailing the indigenous and non-indigenous heritage and community-use/appreciation of the wetland. This may include existing management, access, facilities and community group involvement. • Potential impacts/threats to the wetland values, attributes and functions during and post construction and development. • Management and monitoring commitments pre, during and post construction and development. • Implementation and review to detail how the management actions will be enacted, and whether they have been successful and/or adapt the plan to achieve objectives. This may include funding mechanisms, handover arrangements and a schedule for implementation of actions.	The site contains four Multiple Use Wetlands and three Conservation Category Wetlands.

Table 5: State and local environmental guidelines relevant to the site (continued).

GUIDELINES	DESCRIPTION	RELEVANCE TO SITE
Local		
Local Biodiversity Strategy (SoSJ 2019)	The Shire of Serpentine Jarrahdale has prepared a *Local Biodiversity Strategy (SoSJ 2019)* with the aim of this strategy being to protect local areas of bushland, wetlands and vegetated waterways. The strategy identifies the areas considered to contain remnant vegetation, termed 'Local Natural Areas', and outlines potential mechanisms for retention given that much of the identified remaining vegetation is within private-owned land. Local Natural Areas are natural areas that exist outside of Bush Forever Sites and DPaW managed estate and regional parks. The four primary goals of the strategy are to: • Prevent further loss of Local Natural Areas. • Protect and manage a portion of each basic type of vegetation and ecosystem typical to the area. • Protect specific ecological features and processes including rare species, Threatened Ecological Communities, wetland vegetation and ecological linkages. • Manage and restore Local Natural Areas and revegetate new areas to increase habitat.	Although, there are no Local Natural Areas within the site, the principles of the policy apply to the Conservation Category Wetlands in the south of the site and Bush Forever Site 350 east of the site.

4 Landscape Design Principles

4.1 Taylor Road, Mundijong Local Structure Plan (TBB 2023)

A LSP has been prepared for the site by TBB and is provided in **Appendix A**. The LSP design incorporates the inputs from a multi-disciplinary project team, and the outcomes from various technical studies. The LSP provides the sequential level of land use planning detail associated with implementing the Mundijong DSP.

The environmental planning principles outlined within the Mundijong DSP and to be considered as a part of LSP are that:

- The natural environment will be protected, repaired, enhanced and respected within the natural context;
- Urban development will promote green power initiatives;
- The total water cycle will be sustainably repaired, maintained and enhanced;
- Feasible water cycle management approaches will be promoted; and
- Existing landform must be respected and maintained and be utilised to enhance the built form.

The LSP area includes a total land area of approximately 199 ha and the proposed land uses include:

- Residential lots of varying density, to provide a range of lot sizes and lifestyle options
- Two primary school sites
- A neighbourhood centre
- Public road reserves
- Areas of public open space, incorporating appropriate drainage basins
- Remnant waterway and wetland areas with the accommodation of a foreshore reserve and wetland buffer areas
- A 60 m wide service corridor to the west of the site.

Within the LSP, the environmental values of the site (outlined in **Section 2**) have been considered as part of the design process through a variety of mechanisms. These include the retention of significant vegetation, and provision of a wetland buffer and drainage basins. The most significant spatial responses within the LSP, used to address the environmental values include:

- Retention of Manjedal Brook within a 50 m foreshore reserve, which will incorporate remnant vegetation and proposed revegetation and rehabilitation works, public open space amenities and drainage basins.
- Retention of the CCW in the south-east of the site, with a 50 m wetland buffer, incorporated into public open space and conservation reserve. The wetland buffer will incorporate remnant vegetation and proposed revegetation and rehabilitation works, public open space amenities and drainage basins.
- Design of public open space areas to retain remnant trees where possible, while providing an appropriate drainage function.
- Aligning areas of public open space with the natural pre-development drainage flows across the site.

4.2 Landscape Master Plan

4.2.1 Landscape principles

The landscape strategy behind public open space development is to provide a readily useable, aesthetic and liveable environment to potential residents from day one. Landscaped open space areas shall incorporate features and facilities to both encourage residential growth and to provide public, aesthetic and site character building amenities to residents. Landscape works shall contain and maximise both aesthetic and functional uses where possible. Preliminary concept plans for key areas of public open space and interfaces with residential development and environmental assets within the site have been prepared by Emerge Associates, and are provided in **Appendix B**. Further detailed landscape design will be undertaken as part of future subdivision and development approval stages.

Acknowledging that previous land uses within the site have removed the majority of remnant vegetation, part of the successful delivery of aesthetic and functional public open space area within the development will be the retention of remnant trees where possible in accordance with proposed civil engineering design levels. The retention of remnant trees will assist in establishing the site's Sense of Place and reinforcing Mundijong's rural setting, which will also be reinforced through the landscape materials palette to be finalised as part of future subdivision and development.

The preliminary planting palette is provided in **Appendix C**, and will be finalised as part of future detailed landscape design and in consultation with the Shire of Serpentine Jarrahdale. This planting palette will be used in the conservation areas, amenity areas of the public open space and streetscape hierarchies discussed below.

4.2.2 Management areas

This section provides a broad description of the 'management areas' within the site and generally respond to a particular environmental value or the form of development. These management areas will be further refined through future detailed landscape planning and design, as part of future subdivision and development approval. The management areas are shown in **Figure 14**.

4.2.2.1 Multiple use corridors

Multiple use corridors are those areas of public open space that have been purposely designed to larger paddock trees (where possible) and to align with existing agricultural drainage lines through the site in an integrated landscape design approach with usable informal passive and active public open space. The existing drain lines provide a district wide drainage function (as identified in the Mundijong DSP) which needs to be maintained through the development of the site. The provision of these linear public open space areas will connect into the greater subdivision road reserves to allow for a legible cycle and pedestrian network through the development. These parks will be overlooked by adjacent residents, in accordance with Liveable Neighbourhood guidelines and best practice 'Designing Out Crime' (WAPC 2006a).

Remnant native vegetation is limited throughout the majority of the site, given the disturbance resulting from historic agricultural land uses. Large existing trees may be retained where possible within the multiple use corridors.

Multiple use corridors will be designed and landscaped to incorporate the conveyance of overland drainage flows whilst also designed to accept major and minor stormwater drainage events in an attractive landscape setting. These open space areas will contain the swales and overland flow path

that will be created, contoured and stabilised where necessary to provide a multiple use drainage/landscaped response. An example of this treatment is shown in **Plate 9** and **Plate 10** below.



Plate 9: Indicative multiple use corridor landscape response



Plate 10: Indicative edging treatment between landscape interfaces

To facilitate multiple uses, it is proposed that 63% annual exceedance probability (AEP) and 10% AEP stormwater events will be contained within landscaped drainage channels within the multiple use corridors and the 1% AEP stormwater event contained within the adjacent drainage basins. The drainage channels will typically be planted with side slopes no greater than 1:3 or grassed areas with

maximum side slopes of 1:6 grade to allow for ongoing maintenance activities and safe egress in the event of a large stormwater event.

All outlet structures into public open space areas will incorporate stabilised water entry points, smooth and even grading of contours and mass planting of suitable native water tolerant tree and shrub species for maintenance minimisation.

All associated landscape infrastructure such as picnic shelters, playgrounds, footpaths and the like will be constructed above the 20% AEP stormwater flood levels.

Pedestrian crossings over the drainage channels will be incorporated into the overall footpath network which will be constructed of timber or composite decking products as agreed with the Shire of Serpentine Jarrahdale. Balustrading will be provided where the fall heights exceed the requirements of the Building Code of Australia (typically 900mm in height)

Edge treatment to the swales will include planted garden beds with mowing kerbs and / or hard edge treatments as a maintenance edge between adjoining turf areas within the open space. Hard edge interfaces will include either one of the following:

- Limestone retaining wall
- Concrete mowing kerb
- Informal granite rockwork

The multiple use corridors will incorporate dual use and pedestrian path systems with built in vehicular crossing and access points for maintenance purposes. Dual use and pedestrian systems shall provide smooth and easy access to all features of the open space and link accordingly into residential and other areas adjacent as part of a greenbelt system across the development. Disability access will be given a high priority and will be designed in accordance with relevant Australian Standards.

4.2.2.2 Neighbourhood parks

Neighbourhood parks are large open space areas which generally act as a ‘destination park’ either along the multiple use corridors or in their own right. Neighbourhood parks will link to the adjoining residential streets and to the overall network of footpaths, providing ease of access and legibility. Disability access will be given a high priority in all neighbourhood parks and will be designed in accordance with the relevant Australian Standards where practicable.

Neighbourhood parks will offer a range of recreation and community facilities. These areas will provide both informal active and passive recreation functions, including but not limited to picnic shelters, BBQs, playground facilities and park furniture. The parkland shall consist of open grassed spaces bounded and defined by both feature avenue trees and native tree groupings (see **Plate 11**).

Shrub plantings are planned to strategic areas to provide spatial definition and colour where required. Shrub planting shall primarily consist of lower growing species to enable clear vision and security through passive surveillance. It is proposed that the shrubs will consist of native species, with consideration and adherence to Waterwise principles.

Drainage areas may be catered for within the neighbourhood parks. Where these are included, the drainage basins will be landscaped, for both recreational and amenity functions to the same principles outlined in **Section 4.2.2.1**.



Plate 11: Indicative neighbourhood park amenity facilities

4.2.2.3 Local sport open space

The local sport open space refers to the open public space adjacent south of the northern primary school site. This area will serve a dual function, as a sport playing field for primary school use, and broader community sport and recreation needs outside school hours. Appropriate space should be provided for:

- Formal playing fields;
- Athletics infrastructure (e.g. throwing circles, jump pits);
- Buffers to roads and other infrastructure;
- Unstructured recreation areas;
- Pavilions, carparks and other sporting infrastructure (e.g. cricket nets, batting cages, baseball back nets etc.);
- Retention of native vegetation in 'good' or better condition, where possible; and
- Significant tree retention, where possible.

The specifics will be determined as part of future detailed design, in consultation with the Shire and Department of Education.

4.2.2.4 Pocket parks

Pocket parks are small parcels of POS areas (approximately < 5000 m^2) primarily serving an amenity and recreational function, in addition serving as a stormwater drainage redirection in to Manjedal Brook and the CCW. The pocket parks serve to create connectivity between the Manjedal Brook foreshore reserve and the CCW buffer area to the general residential built out area, incorporating walking paths, significant trees and vegetation.

4.2.2.5 Drainage basins

Drainage basins refers to those portions of the open space areas allocated for drainage and stormwater treatment within the site. These areas will accommodate bio-retention areas and flood storage areas which will be used to ensure that pre-development surface water and groundwater quality and surface water peak flow rates across the site are maintained post-development in accordance with the LWMS and addendum (Wave International 2016; RPS 2023).

Runoff from storm events will be directed into outlet basins located within the open space areas. These basins will be located in a manner which considers the environmental values of the area and generally avoid further clearing of native vegetation wherever possible. Generally these will include:

- Bio-retention areas – vegetated swales and/or basins designed to retain the 1 exceedance per year (EY) - 1 hour event rainfall events and to strip nutrients.
- Flood storage areas – detention basins to ensure that post-development stormwater flows are equivalent to pre-development flows, and may include vegetated, turfed, or other treatments.

4.2.2.6 Conservation Category Wetland buffer

As outlined in **Section 2.4.3**, there are three Conservation Category Wetlands located in the south and south-east of the site; UFI 14945 and UFI 15446 are associated with Manjedal Brook in the south of the site, and UFI 7835 occurs in the south-eastern portion of the site, as shown in **Figure 11**. This management area refers purely to the CCW in the south-east of the site (UFI 7835) and its buffer area. The remaining CCW areas are addressed as part of the Manjedal Brook foreshore reserve, outlined in **Section 4.2.2.7**.

A 50 m buffer from the mapped CCW has been accommodated within the LSP layout to UFI 7835 to provide an appropriate separation between the mapped wetland values and the development area, as shown in **Appendix A**.

There is limited remnant vegetation within the CCW buffer area, which is in a 'Completely Degraded' to 'Degraded' condition. To enhance the condition of the vegetation and protect these areas from current and potential future impacts from adjacent land uses, partial revegetation will be undertaken within the buffer areas. The revegetation will consist of local native flora species and those wetland and dryland species considered suitable for revegetation, and will be undertaken in a way that considers future bushfire implications on the adjacent development area. No formal management of fuel loads in this areas has been assumed for bushfire purposes.

Passive surveillance will be provided to the buffer area through the road network which provides a hard boundary to the wetland and buffer area. Interpretative signage will be located along the footpath and boardwalk network informing the community and users of the waterway, highlighting local flora and fauna values (see **Plate 12** and **Plate 13** below for an indicative cross-section for how these interfaces will work).

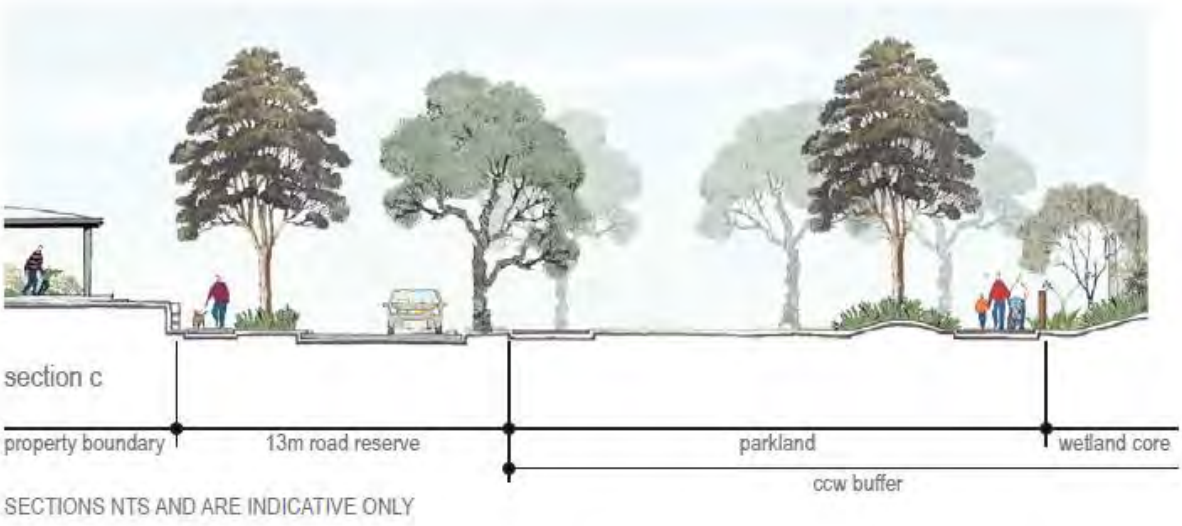


Plate 12: Indicative CCW buffer cross section

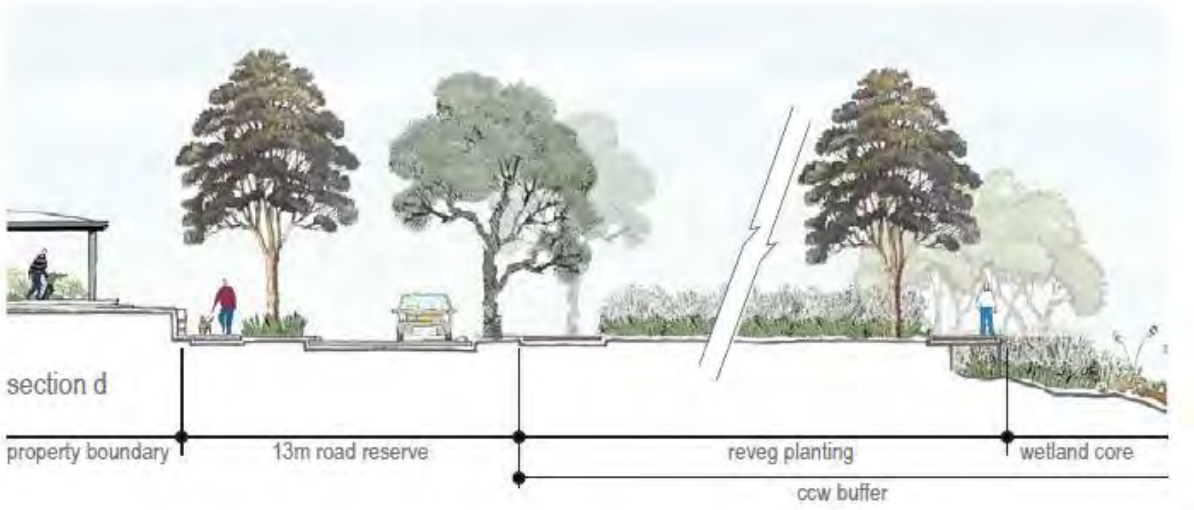


Plate 13: Indicative CCW buffer cross section

The natural hydrology of the wetland will be protected and maintained through the implementation of the LWMS and addendum (Wave International 2016; RPS 2023) prepared for the site and subsequent preparation and implementation of an Urban Water Management Plan (UWMP) at the subdivision and development stage.

4.2.2.7 Manjedal Brook foreshore reserve

Due to the significant historic disturbance of Manjedal Brook through extensive livestock grazing and weed invasion, CCWs UFI 14945 and UFI 15446 are no longer considered representative of the current conservation status, and support very limited remaining riparian vegetation.

A 50 m foreshore reserve has been provided on either side of the existing Manjedal Brook waterway channel (as shown in the structure plan, including land outside the site), and is considered appropriate to encompass the existing ecological and hydrological values of the Manjedal Brook, and provide an appropriate buffer between the waterway and adjacent development. The extent of development in relation to the buffer will be determined at the more detailed subdivision design stage.

Limited remnant vegetation occurs within the Manjedal Brook foreshore reserve, and is comprised mainly of *Corymbia calophylla*, *Melaleuca preissiana* and *Melaleuca rhaphiophylla* trees over pasture grasses. Due to the extent of disturbance from cattle grazing within the waterway, vegetation associated with Manjedal Brook is considered to be in a “Degraded” to “Completely Degraded” condition, and therefore no longer considered representative of its mapped conservation status. To enhance the condition of the vegetation in the area and protect these areas from current and potential future impacts from adjacent land uses, revegetation will be undertaken within the foreshore reserve, consisting of local native flora species where appropriate, and those wetland and dryland species considered suitable for revegetation. No formal management of fuel loads in this areas has been assumed for bushfire purposes.

Passive surveillance will be provided to the foreshore reserve through the design of the proposed road network, with a combination of road and open space interfacing with the majority of the foreshore reserve. Where lots interface directly with the foreshore reserve, a hard interface in the form or a footpath and passive fencing will be provided.

The natural hydrology of the waterway will be protected and maintained through the implementation of the LWMS and addendum (Wave International 2016; RPS 2023) prepared for the site and subsequent preparation and implementation of an Urban Water Management Plan (UWMP) at the subdivision and development stage.

4.2.2.8 Bush Forever interface

The Bush Forever interface is designed to protect the flora and fauna values within Bush Forever Site 350, and to satisfy the requirements within the *Guidelines for Planning in Bushfire Prone Areas* (DPLH & WAPC 2021), reducing the vulnerability of future development to bushfire risk.

The proposed development interfaces with Bush Forever Site 350 in the eastern portion of the site. The CCW buffer and Manjedal Brook foreshore reserve provides separation and buffering between future development and Bush Forever Site 350 along the majority of this interface, as shown in **Figure 14.**

Potential future treatments for this interface may include (but are not limited to):

- A road interface or trafficable access track may be provided between Bush Forever Site 350 and future development in the north-east of the site, where the CCW buffer is not located.
- Conservation fencing may be utilised along this interface between development and Bush Forever Site 350.
- Drainage infrastructure will not be placed within or immediately adjacent to Bush Forever Site 350.

This list will be further refined as part of future detailed planning and design.

4.2.2.9 Subdivision area

The 'subdivision area' refers to all remaining areas of the development, excluding the management areas outlined above. This includes the internal road network and lots, and in particular streetscaping. Streetscaping will be applied throughout the subdivision area with the aim to maintain and improve viewscapes. In all cases landscape works will incorporate tree planting in accordance with *LPP 4:16 Tree Retention and Planting* and the accepted traffic standards, and will aim to retain existing mature trees where possible. Species planted within streetscapes will be in accordance with *LPP 4:16 Tree Retention and Planting* or as agreed with the Shire.

Streetscapes throughout the development shall incorporate a variety of treatments in response to the road hierarchy system. In all cases landscape works shall incorporate tree planting in accordance with accepted traffic standards on the standard street tree alignment in relation to the service utility corridor. Treatments may include soft works such as street trees, hedge planting and groundcovers.

The retention of existing trees where possible will enhance the project's landscape theme, and the trees will serve an important visual buffer and amenity function in reinforcing the rural character of Mundijong (see **Plate 14**).



Plate 14: Example of retained mature trees in median strips

5 Management Elements

This section outlines the management measures applicable to the various management areas within the site, described in **Section 4**. These management measures have been termed 'management elements', as one or more of the elements may be applicable to any particular management area. These management elements outline the principles and practices which will be required as part of future development to achieve the federal, state and local objectives.

Preliminary landscape concept plans have been provided in **Appendix B**.

5.1 Conservation Category Wetland buffer management

Four Multiple Use Wetlands occur within the site. These do not require specific management but measures will be taken to accommodate the hydrological characteristics of the area in line with the LWMS and addendum (Wave International 2016; RPS 2023).

CCWs occur in the southern extent of the site. This section addresses the management of UFI 7835 and its buffer, in the south-east of the site. The management of wetlands associated with Manjedal Brook is addressed separately as part of the Manjedal Brook foreshore reserve management, outlined in **Section 5.2**.

CCWs are afforded protection through various state policies (EPA 2004; WAPC 2006b) as they typically have high conservation value for both natural and human use. There is a general presumption that a 50 m buffer will be provided between any development and a CCW boundary. The majority of this 50 m buffer has been accommodated in the LSP, in the south-east of the site, with the remainder of the buffer accommodated within the road and rail reserve and Bush Forever Site 350 adjacent to the eastern boundary of the site. The vegetation in the wetland buffer is currently in a 'Completely Degraded' condition and is comprised of cleared paddocks with limited native vegetation remaining.

Management of the CCW and its associated buffer in the south-eastern portion of the site will focus on the maintenance of hydrological processes and functions associated with the wetlands, and the enhancement of native vegetation within the buffer, to minimise the potential impacts that may occur as a result of the future development.

Within the CCW buffer area, the management measures may include:

- Maintaining natural hydrological regimes, through the implementation of the LWMS and addendum (Wave International 2016; RPS 2023) and subsequent preparation and implementation of an Urban Water Management Plan (UWMP) at future subdivision stages.
- Delineate the CCW buffer boundaries using construction fencing prior to clearing for development. This will ensure that no clearing is conducted inadvertently within the wetland buffer.
- Undertake revegetation within the wetland buffer with local native species (preferably fire and dieback-resistant species), in consultation with the Shire of Serpentine Jarrahdale.
- Incorporate drainage infrastructure (where required under the LWMS and addendum) and undertake planting in consultation with the Shire of Serpentine Jarrahdale and DBCA.
- Incorporate passive recreation opportunities such as open space areas, walking trails and information nodes relating to the environmental and Indigenous heritage values of the area.

- Install permeable fencing along the CCW core boundary to enable passive surveillance of bushland from within the development, while restricting access to the wetland core.

It is expected that the above measures will be implemented at the subdivision and development stages, when clearing, civil construction and revegetation occurs. A summary of the management actions for the wetland buffer has been provided in **Table 6** below. These measures will be further refined as part of future detailed subdivision and development planning and design.

Table 6: Summary of management actions for Conservation Category Wetland buffer at appropriate stages of development

LOCAL STRUCTURE PLAN	SUBDIVISION/DEVELOPMENT	ONGOING
• Provision of a 50 m buffer based on location of the Conservation Category Wetland. • Preparation of LWMS and addendum which includes appropriate water management requirements for Multiple Use Wetlands and Conservation Category Wetlands.	• Prepare Landscape Management Plan, which may include: o Weed removal program. o Revegetation including: • Planting of wetland and dryland species. • Monitoring. • Replanting based on success criteria. • Delineation of wetland buffer with construction fencing prior to site works. • Implementation of approved Urban Water Management Plan.	• Maintenance of fencing (where required). • Maintenance of public access facilities (where required). • Monitoring condition of vegetation and replanting when necessary. • Weed control if necessary.

5.2 Manjedal Brook foreshore reserve management

Manjedal Brook traverses the southern extent of the site, as shown in **Figure 11**, and flows in an east to west direction. Areas of CCW (UFI 14945 and UFI 15446) are associated with Manjedal Brook, and have been subject to significant historic disturbance through extensive livestock grazing and weed invasion.

While Manjedal Brook has a defined channel through the site, extensive disturbance through historic agricultural land uses and cattle grazing has resulted in significant damage to the waterway banks and riparian vegetation is in a “Degraded” to “Completely Degraded” condition.

As outlined in the LWMS and addendum (Wave International 2016; RPS 2023) prepared for the site, flood levels for the Manjedal Brook have been modelled to be fully contained within 30 m flow width of the waterway. However, following consultation with the WAPC, a 50 m foreshore reserve on either side of the waterway has been proposed and is considered appropriate to encompass the existing ecological and hydrological values of the Manjedal Brook, and provide an appropriate buffer between the waterway and adjacent development.

The management of the Manjedal Brook foreshore reserve will focus on rehabilitation, stabilisation and revegetation works to restore the existing brook, with local native species, to provide a stable waterway and a variety of fauna habitats. This may involve the removal of some vegetation, as vegetation such as **Watsonia meriana var. bulbillifera*, **Gomphocarpus fruticosus* and introduced grass species are currently present within the Manjedal Brook foreshore reserve area.

Passive recreation opportunities within the Manjedal Brook foreshore reserve will include dual-use footpaths, boardwalks and shelters, which will link in with the wider open space network. Interpretative signage will be located along the footpath and boardwalk network informing the community and users of the waterway, highlighting local flora and fauna values.

In some locations within the open space areas adjacent to the Manjedal Brook foreshore reserve, discrete bio-filtration and detention basins will be included. These basins will be landscaped for both recreational and amenity purposes, to provide ease of maintenance and to maintain the current predevelopment flows into the brook, particularly the incorporation for requirements from the 1% AEP events. These areas are outlined further in the LWMS and addendum (Wave International 2016; RPS 2023).

The natural hydrology of the waterway will be protected and maintained through the implementation of the LWMS and addendum (Wave International 2016; RPS 2023) prepared for the site and subsequent preparation and implementation of an Urban Water Management Plan (UWMP) at the subdivision and development stage.

A summary of the management actions for the Manjedal Brook foreshore reserve has been provided in **Table 7** below. These measures will be further refined as part of future detailed subdivision and development planning and design.

Table 7: Summary of management actions for Manjedal Brook foreshore reserve at appropriate stages of development

LOCAL STRUCTURE PLAN	SUBDIVISION/DEVELOPMENT	ONGOING

• Provision of a 50 m foreshore reserve based on the existing waterway.
• Preparation of LWMS which includes appropriate water management requirements for Manjedal Brook.
	• Prepare Landscape Management Plan, to include:
	o Weed removal program.
	o Revegetation including:
	  • Planting of wetland and dryland species.
	  • Monitoring.
	  • Replanting based on success criteria.
	• Delineation of foreshore reserve with construction fencing prior to site works.
	• Implementation of approved Urban Water Management Plan.
		• Maintenance of fencing (where required).
		• Maintenance of public access facilities (where required).
		• Monitoring condition of vegetation and replanting when necessary.
		• Weed control if necessary.

5.3 Planting within conservation areas

Revegetation may be carried out within the CCW buffer and Manjedal Brook foreshore reserve. Vegetation in these conservation areas is currently in a “Degraded” to “Completely Degraded” condition, consisting predominantly of cleared paddocks. Any revegetation will be largely aimed at re-establishing native vegetation to create habitat for native fauna, improve water quality and protect existing vegetation and environmental values (Greening Australia 2003). A revegetation program should aim to maximise the diversity of plant species and structure (ground, middle and overstorey).

Revegetation works within the conservation areas should take into consideration the bushfire hazard associated with the increase in fuel loads in proximity to development, and should be undertaken in such a way as to manage the impact on adjacent dwellings. This will be determined as part of future

detailed landscape design, in consultation with an appropriate bushfire consultant and the Shire of Serpentine Jarrahdale.

Revegetation can involve a range of techniques, which vary depending on the scale of work, the availability of resources and the site conditions. The broad techniques applicable to revegetation within the site have been outlined below:

- Direct seeding involves the sowing of treated seeds directly onto an area to achieve germination and establishment. This technique can be undertaken by machine or hand depending upon the scale of revegetation. Local provenance seed (sourced from within 50 km of the revegetation site) is preferred for revegetation, and when not available, seed is to be obtained from locations as close to the planting site as possible.
- Planting of seedlings involves the utilisation of seedlings grown by a nursery or re-vegetation specialist to establish areas quickly. As with direct seeding, this technique can be undertaken by hand or machine. Seedlings should be obtained from accredited nurseries to ensure disease free and high standard products.

A revegetation program involves a number of steps and considerations which are outlined below:

- Planning to determine the scale of revegetation required.
- Preparation of the ground, which includes:
  - Weed control to reduce competition on seeds/seedlings.
  - Soil preparation to produce loose, well drained and aerated soil appropriate for plant establishment.
- Pest animal management, in which the exclusion of animals is undertaken to prevent grazing during establishment and may include fencing and plant guards, or more intensive management of rabbits and insects (such as snails, slugs, ants, grasshoppers and mites).
- Seeds and seedlings, which depending on the revegetation technique to be employed, may include seed collection, cleaning and ordering and/or propagation.
- Revegetation program using techniques outlined above. The specifics of the revegetation program will be determined during the subdivision and development stages. Planting is generally carried out between May and September.
- Maintenance, which includes replacing and removing plant guards, management of pests and watering, when required.
- Monitoring to determine success of revegetation and whether further planting is required. The monitoring and evaluation process, and success criteria are outlined in **Appendix D**.

Revegetation in the CCW buffer and foreshore reserve should also consider bushfire management requirements. The species used should be low growing and, where possible, fire resistant in order to maintain a low fuel load, however the BMP assumes no ongoing management of fuel loads, to provide a conservative assessment of bushfire risk. An indicative list of local native flora species that may be utilised for planting within conservation areas is provided in **Appendix C**. The list contains flora species which occur in the Guildford soil complex of the Pinjarra Plain, and details whether each species is fire or dieback-resistant. The list is based on the Shire of Serpentine Jarrahdale *Low flammability local native species (SoSJ 2010)* , and the Landcare Serpentine Jarrahdale Inc. *Local native species list for Landscape projects in the Mid Swan Coastal Plain (Landcare Serpentine-Jarrahdale Inc 2017)*.

The principles and objectives outlined within this management element will be undertaken as part of subdivision and development, and will require ongoing management. The management actions have

been summarised in **Table 8** below. These measures will be further refined as part of future detailed subdivision and development planning and design.

Table 8: Summary of management actions for planting within conservation areas at appropriate stages of development

LOCAL STRUCTURE PLAN	SUBDIVISION/DEVELOPMENT	ONGOING
• Delineate preliminary areas within conservation areas requiring revegetation.	• Prepare Landscape Management Plan. • Undertake revegetation program, including steps outlined above. o Preparation of the soil. o Weed control. o Pest animal management, including fencing and plant guards, or more intensive management of rabbits and insects. o Collection, cleaning and ordering and/or propagation of plant species. o Revegetation program, through direct seeding and/or planting.	• Undertake monitoring and evaluation, see **Appendix D**. • Undertake maintenance measures as required, including fencing and plant guards, weeding, pest management, and replanting.

5.4 Planting within public open space

Planting within public open space areas will apply to multiple use corridors, neighbourhood parks, local sport open space, pocket parks and drainage basins, as well as throughout the subdivision area within streetscapes. Planting in these areas will generally follow the principles outlined below:

- Local native species to be planted throughout the development. Species used will be determined through consultation with the Shire of Serpentine Jarrahdale.
- Groundcover planting to occur within medians, planters and areas requiring clear views.
- Planting in drainage basins should be at a density of three plants per square metre and include a mixture of low to mid-growing plants, or a mixture of vegetation and turf for areas also used for recreation.
- Erosion control measures such as rock pitching and bubble-up pits should be used in addition to planting within drainage basins to assist in managing erosion.
- Basic monitoring to determine success of planting and whether further planting is required.
- Long-term irrigation and maintenance of open space areas, where required.

Planting for streetscapes should be in line with *LPP 4:16 Tree Retention and Planting*. Planting within open space areas should use species listed within **Appendix C** or as agreed with the Shire. Monitoring of the planting success should be undertaken in the form of visual inspection and comparison using the criteria outlined in **Appendix D**. Depending on the outcomes of this monitoring, further planting may be required.

The principles outlined in this management element will largely be accommodated during the subdivision and development stage, when civil construction and landscaping occurs. A summary of the management actions is provided in **Table 9** below. These measures will be further refined as part of future detailed subdivision and development planning and design.

Table 9: Summary of management actions for planting within open space areas at appropriate stages of development

LOCAL STRUCTURE PLAN	SUBDIVISION/DEVELOPMENT	ONGOING
• Delineate drainage basins within areas of public open space. • Delineate those areas of public open space requiring planting. • Preparation of preliminary landscape concept plans.	• Prepare Landscape Management Plan. • Prepare detailed landscape designs. • Undertake development of drainage basins, planting and irrigation.	• Complete monitoring and evaluation of planting success. • Maintenance of landscaped area, including replanting. To be undertaken by the proponent for the first two years and then Shire of Serpentine Jarrahdale thereafter.

5.5 Bush Forever Site interface

Management measures for the Bush Forever Site interface have been guided by *Bush Forever Site Implementation Guidelines Practice Note 5: Bushland-sensitive Design Criteria for Urban Development (WPCC 2000)* and may include:

- Provision of conservation fencing along the boundary of Bush Forever Site 350.
- Provision of public open space/conservation area interface with Bush Forever Site 350, as in the south-eastern portion of the site.
- Where possible, incorporate a hard edge into the remaining interface between bushland and development in the form of a road. This will assist in minimising invasion of weeds and the dumping of rubbish into the areas of bushland.
- Where a hard road interface is not provided, a trafficable access track should be installed. This track will be used as a means of providing access to emergency services personnel in the case of a bushfire.
- Manage construction works adjacent to the Bush Forever Site to ensure no impact on existing trees between the site and Soldiers Road.
- Restrict placement of drainage infrastructure within or immediately adjacent to the Bush Forever Site.
- Manage potential run off of pollutants and nutrients into the Bush Forever Site through the implementation of the LWMS and subsequent UWMP.

These management strategies will be further refined and implemented as part of future detailed design and development stage, when clearing and civil construction occurs. Management measures associated with the Bush Forever Site interface management are summarised in **Table 10** below. These measures will be further refined as part of future detailed subdivision and development planning and design.

Table 10: Summary of management actions for Bush Forever Site interface at appropriate stages of development

LOCAL STRUCTURE PLAN	SUBDIVISION/DEVELOPMENT	ONGOING
• Preparation of a LWMS which includes measures for managing stormwater runoff. • Restrict drainage design within and immediately adjacent to Bush Forever Site 350.	• Installation of conservation fencing at Bush Forever Site 350 boundary. • Managed construction works adjacent to the Bush Forever Site 350. • Managed construction of road or access track adjacent to Bush Forever Site 350. • Implementation of approved UWMP.	• Maintenance of conservation fencing (where required). • Maintenance of access track (if required).

5.6 Fauna management

Native fauna are an integral part of the State's rich biodiversity and they play an essential role in maintaining ecosystem balance. Generally, native fauna are best protected through the retention and protection of large areas of intact vegetation and through the provision of ecological linkages (WALGA and PBP 2009).

Manjedal Brook foreshore reserve and the CCW and buffer in the south-east of the site contain the majority of fauna habitat values within the site, and are proposed to be retained as part of future development. Scattered paddock trees may provide opportunistic habitat for mobile species, and will be retained where possible within areas of public open space, where engineering and site works permit.

Given the extent of quality fauna habitat reserved within Bush Forever sites north-east of the site, vegetation within the site is not considered to support significant fauna habitat values.

Managing impacts on fauna species will largely occur during the construction and development of the site. Management measures may include:

- Scattered trees and areas of vegetation intended for clearing should be inspected immediately prior to clearing for the presence of fauna species, to limit injury and death.
- If necessary, translocate any fauna found prior to clearing, based on liaison with DBCA.
- Logs, branches and dead trees that are cleared to be relocated to other remnant vegetation or revegetated areas as fauna refuge/habitat.
- If sick, injured or orphaned native wildlife are found during construction or ongoing industrial operations call the DBCA Wildcare Helpline ((08) 9474 9055). The Helpline can also provide advice on snakes and contact numbers for volunteer reptile removers if required.

A summary of the management actions for the protection of fauna is provided in **Table 11** below. These measures will be further refined as part of future detailed subdivision and development planning and design.

Table 11: Summary of management actions for fauna at appropriate stages of development

LOCAL STRUCTURE PLAN	SUBDIVISION/DEVELOPMENT	ONGOING
• Survey of site to determine fauna habitat values and species present. • Provision for retention of areas of high fauna habitat value (Manjedal Brook, and CCW and buffer areas).	• Inspection for presence of fauna in vegetation to be cleared. • Translocate species (if found and necessary). • If sick, injured or orphaned native wildlife are found during construction call DBCA Wildcare Helpline. • Stockpile and use logs, branches and dead trees within drainage basins and CCW buffer.	Nil.

5.7 Disease (Dieback) management

Dieback refers to the introduced plant disease caused by *Phytophthora cinnamomi*, a water mould which requires moist conditions for its survival, reproduction and dispersal. Dieback attacks the roots of plants causing them to rot, which weakens or kills the plant by limiting uptake of water and nutrients. It is recognised as a threat within the Shire of Serpentine Jarrahdale, however, its presence on the site has not been confirmed.

Dieback can be transported either by the movement of spores through free water or by the movement of infected soil or plant material. As such, construction activities such as road building or earthworks can contribute significantly to the spread of dieback. Construction management will be important in managing potential dieback spread within the site.

Although a dieback assessment has not been conducted within the site, mitigation measures are proposed to minimise the risk of dieback being introduced to the site if it is not already present, and to prevent the disease from spreading within the site or to another site if it is present. The management measures may include:

- Vehicles and machinery should be free of soil when arriving or leaving the construction site, or wash-down areas should be provided for vehicles that require cleaning (Dieback Working Group Inc 2021).
- Schedule activities that involve soil disturbance (e.g. Construction of drains and roads) for low rainfall months (November to March) when the soil is dry.
- Install signage at access gates to ensure there is no vehicle access into the CCWs or buffer areas. If a vehicle must enter, ensure that it is clean on entry and stays on the access tracks.
- Use dieback-resistant species, where possible, for planting in wetland buffer areas.
- Where possible, use fill certified as being pathogen free.
- Where possible, stockpile topsoil and return it to the site in preference to importing fill.
- Manage runoff through the implementation of the LWMS and subsequent UWMP/s.

The management measures outlined above will mainly apply at the subdivision and development stage when the majority of ground disturbing works will occur. Management measures associated with dieback are summarised in **Table 12**. These measures will be further refined as part of future detailed subdivision and development planning and design.

Table 12: Summary of management actions for dieback at appropriate stages of development

LOCAL STRUCTURE PLAN	SUBDIVISION/DEVELOPMENT	ONGOING
• Preparation of LWMS which includes measures for managing stormwater.	• Any works proposed within risk areas include considerations outlined above and within *'Dieback Working Group Inc. – Best Practice Guidelines for Management of Phytophthora Dieback in the Basic Raw Materials Industries (Dieback Working Group Inc 2021)* as a part of construction management. • Civil construction should be undertaken from November to March, where possible. • Installation of signage at access gates. • Planting of dieback-resistant species in Conservation Category Wetland buffers. • Implementation of approved UWMP.	• Monitor the Conservation Category Wetland buffers for signs of dieback.

5.8 Indigenous heritage management

Acknowledging the presence of Aboriginal heritage values within the local and regional context is a key consideration of the proposed development of the site. An Aboriginal Heritage Management Plan will be prepared to support ongoing development of the site, and may include actions such as:

- Ensure all development is compliant with the requirements of the relevant legislation.
- Maintain and enhance the Aboriginal heritage values of the site, through:
  - Identification and flagging of known heritage values.
  - Incorporation of heritage values within the urban design.
- Involve Aboriginal community representatives in the management of heritage values.
- Identify Aboriginal heritage interpretation or education opportunities.

It is envisaged that the implementation of these principles through actions set out in **Table 13** below will allow for an increased connection between the Aboriginal heritage values of the site and the future community, providing a wider knowledge of Aboriginal culture, and will be undertaken in accordance with the Section 18 approval and in collaboration with Aboriginal community representatives.

Management measures associated with Indigenous heritage are summarised in **Table 13** below. These measures will be further refined as part of future detailed subdivision and development planning and design.

Table 13: Summary of management actions for Indigenous heritage at appropriate stages of development

LOCAL STRUCTURE PLAN	SUBDIVISION/DEVELOPMENT	ONGOING
• Undertake a heritage assessment and undertake consultation with relevant Indigenous representatives.	• Implement Section 18 approval • Prepare and implement Aboriginal Heritage Management Plan.	• Implement Aboriginal Heritage Management Plan.

5.9 Bushfire hazard management

The site is located within a 'bushfire prone area' under the state-wide Map of Bush Fire Prone Areas prepared by the Office of Bushfire Risk Management (OBRM) (2021). In order to address this requirement, a Bushfire Management Plan (BMP) has been prepared (Emerge Associates 2023b) to support the LSP. Bushfire hazards have been identified in association with the Manjedal Brook foreshore reserve and the CCW and buffer area in the south-eastern portion of the site remnant vegetation within Bush Forever Site 350 immediately east of the site, and existing grassland vegetation outside the site.

As outlined, the BMP assumes no fuel load management is required within the conservation areas within the site. The remaining public open space areas are assumed to be managed to achieve low threat and will not be a bushfire hazard to future residents. This will be determined as part of future detailed landscape design, in consultation with an appropriate bushfire consultant and the Shire of Serpentine Jarrahdale.

The management measures listed below are intended to reduce the impacts of bushfire on life, property and the environment, and may include the provision of:

- A minimum of two vehicular access ways into the site (and each subdivision stage) at all times allowing access by emergency service vehicles from public roads, if required.
- Reticulated or non-reticulated water supply, together with fire hydrants, within the development, in accordance with the specifications of the Water Corporation and DFES.
- Either a bitumen road or trafficable access track along the interfaces between the revegetated conservation areas.
- An appropriate Asset Protection Zone (APZ) where required, to the below standards:
    - Provide a separation between lots and classified vegetation to widths outlined in the BMP (Emerge Associates 2023b) or as part of future detailed bushfire assessment/s. The should achieve low threat and can include non-flammable features such as irrigated landscapes, gardens, driveways, roads and maintained grassland areas.
    - Maintain low fuel loads within the APZ by maintaining vegetation in line with the Guidelines. This includes but is not limited to, planting fire-resistant flora species and ensuring tree crowns do not overhang buildings.
    - Ensure that the APZ is located outside of CCW areas (as shown in **Appendix A**) so that management measures do not impact on the vegetation values of these areas. APZs may fall within the wetland buffer areas where landscaped and maintained to the appropriate standards in perpetuity. Road reserves can form APZs as these areas will be landscaped and managed in a low fuel state through the Shire of Serpentine Jarrahdale's roadside maintenance program.
- Increased construction standards (where required) of dwellings in accordance with AS 3959, as outlined in the BMP (Emerge Associates 2023b).

The management measures above will be further refined and implemented at the subdivision and development stages with some ongoing maintenance in the future. Management measures are summarised in **Table 14** below. These measures will be further refined as part of future detailed subdivision and development planning and design.

Table 14: Summary of management actions for bushfire management at appropriate stages of development

LOCAL STRUCTURE PLAN	SUBDIVISION/DEVELOPMENT	ONGOING
• Preparation of a BMP	• Undertake further detailed bushfire assessment in accordance with the relevant bushfire policies and guidelines. • Construction of dwellings to increased standards (where required) in accordance with the BAL ratings determined as per AS 3959 . • Provision of an APZ where required and to the standards outlined in the BMP. • Provision of road or trafficable access tracks adjacent to CCW buffer areas.	• Maintenance of firebreaks and/or access ways. • Maintenance of fire hydrants and access to fire hydrants. • Maintain property to achieve requirements with APZ.

5.10 Construction management

Construction management can include a range of strategies to be implemented as part of construction within the development, including site preparation, civil works and individual lot works. Construction management generally includes:

- Site based training and communication (site induction).
- Roles and responsibilities of the project team and contractors.
- Documentation and records.
- Reporting systems for safety/hazard incidents.
- Site management and mitigation measures and procedures.
- Incident planning including fuel spill and emergency response procedures, corrective actions and contingency plans.

The purpose of this management element is to outline the practices that will need to be implemented as a part of construction within the site to avoid impacting on environmental values.

The broad objectives for construction management are:

- To minimise the impact of construction personnel and activities on the existing environmental values.
- To avoid or manage adverse impacts from construction activities on flora and fauna species, ecological communities and fauna habitat.
- To ensure that fauna are not caused undue stress or death due to construction activities.
- To maintain the integrity, ecological functions and environmental values of soil and landform where possible.
- To prevent the introduction and/or spread of disease and invasive weed species within the site or into adjacent Bush Forever Sites and the CCW.
- To minimise the generation of wastes and discharge into the environment and manage wastes and sediment so they do not cause pollution.
- To minimise the occurrence of erosion, particularly within the CCW buffer.
- To prevent fire occurring as a result of construction activities.

Actions to be implemented to meet the objectives for construction management include:

- Construction management will form part of the construction contract for all parties operating on the site.
- Ensure all members of the management team and contractors participate in a site induction prior to commencement of works. This induction should clearly outline the environmental values of the site and how to prevent impacting these values and should also incorporate information on incident reporting.
- Identify the chain of responsibility for incident reporting and procedures for recording areas of non-compliance and corrective actions.
- Establish an appropriate site inspection routine to ensure all environmental management measures are being carried out
- All paddock trees and remnant vegetation to be cleared must be inspected for potential fauna species. Report any fauna injured or killed during the construction and/or clearing process.
- All conservation areas are to be clearly demarcated (with tape and temporary fencing) to prevent unauthorised clearing incidents and/or access. This includes Bush Forever Site 350 and the CCW buffer.
- Temporary fencing must be sufficient to also protect areas of vegetation and wetland from potential sediment and erosion impacts.
- Clearly demarcate vehicle access routes to be used during construction to prevent unauthorised off-track use or unapproved vehicle traffic.

A summary of the management strategies applicable to each stage of development and construction is provided in **Table 15** below. These measures will be further refined as part of future detailed subdivision and development planning and design.

Table 15: Summary of management actions for construction at appropriate stages of development

LOCAL STRUCTURE PLAN	SUBDIVISION/DEVELOPMENT	ONGOING
N/A	• Prepare Landscape Management Plan, to include construction management. • Demarcate vegetation for retention (if any) with tape and temporary fencing. • Demarcate vehicle access routes and provide traffic management. • Prepare and present site induction, outlining the sites environmental values, to all staff and contractors. • Conduct regular site inspections.	Nil.

6 Implementation of the Management Strategy

6.1 Future approval and implementation process

The approval process has been summarised in **Plate 15**. The Shire of Serpentine Jarrahdale, with the WAPC, will be the key approval agencies for the LSP and subdivision approval process. It will be important that the landowner liaises with the Shire of Serpentine Jarrahdale and various agencies during the development of the *Landscape Management Plans* for each subdivision area, as outlined in **Section 6.2** below.

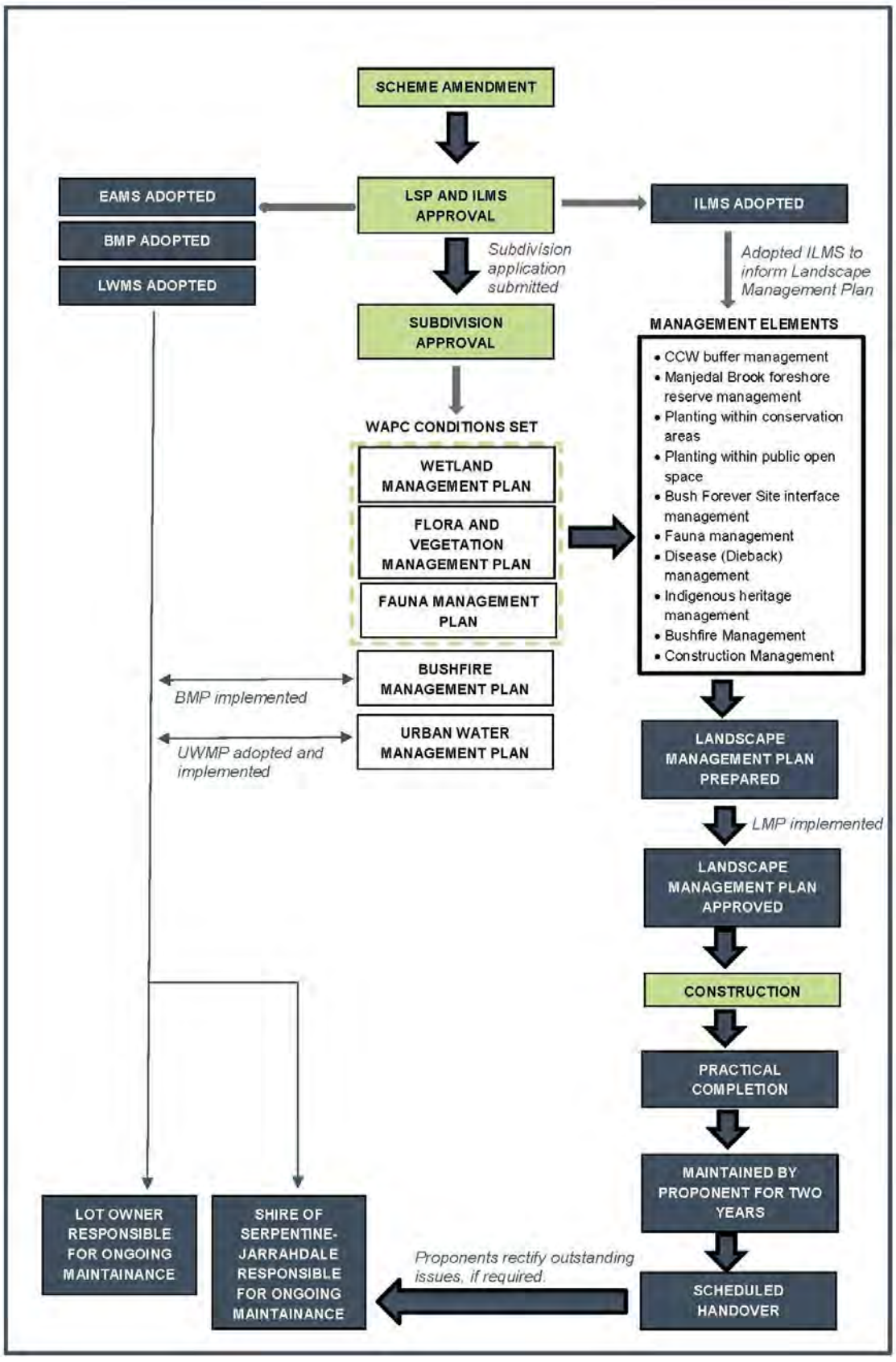


Plate 15: Approval and Implementation Process

6.2 Subdivision

Following the approval of this *Integrated Landscape Management Strategy* at the LSP, a *Landscape Management Plan* will be prepared for each subdivision area. Each *Landscape Management Plan* will provide detail on the implementation of the management elements applicable to the management areas within the specific subdivision area and could be in the form of detailed construction and/or landscape drawings. This will include the identification of specific environmental values found within each subdivision stage and outlining how these values would be protected and managed as part of construction of the project, as well as outlining the principles/requirements that will inform detailed landscape design (undertaken as a separate process, as outlined further in **Section 6.3**).

Table 16 below provides a summary of the management areas, the management elements applicable to each, the expected stage of development at which these will be undertaken and who will be responsible.

Table 16: Implementation of management strategies, appropriate stage and responsible authority

MANAGEMENT AREA	MANAGEMENT ELEMENT	IMPLEMENTATION STAGE	RESPONSIBILITY
Multiple use corridors	Planting in public open space	Subdivision	• Proponent
		Ongoing	• Proponent • Shire of Serpentine Jarrahdale
	Fauna management	Subdivision	• Proponent
	Dieback management	Subdivision	• Proponent
	Bushfire hazard management	Subdivision	• Proponent
		Development Application	• Proponent
		Ongoing	• Proponent • Shire of Serpentine Jarrahdale
	Construction Management	Subdivision	• Proponent
Neighbourhood parks, local sport open space, and pocket parks	Planting in public open space	Subdivision	• Proponent
		Ongoing	• Proponent • Shire of Serpentine Jarrahdale
	Fauna management	Subdivision	• Proponent
	Dieback management	Subdivision	• Proponent
	Bushfire hazard management	Subdivision	• Proponent
		Development Application	• Proponent
		Ongoing	• Proponent • Shire of Serpentine Jarrahdale
	Construction Management	Subdivision	• Proponent

Table 17: Implementation of management strategies, appropriate stage and responsible authority (continued)

MANAGEMENT AREA	MANAGEMENT ELEMENT	IMPLEMENTATION STAGE	RESPONSIBILITY
Drainage basins	Planting in public open space	Subdivision	• Proponent
		Ongoing	• Proponent • Shire of Serpentine Jarrahdale
	Bush Forever interface management	Subdivision	• Proponent
		Ongoing	• Proponent • Shire of Serpentine Jarrahdale
	Fauna Management	Subdivision	• Proponent
	Dieback Management	Subdivision	• Proponent
	Bushfire hazard management	Subdivision	• Proponent
		Development Application	• Proponent
		Ongoing	• Proponent • Shire of Serpentine Jarrahdale
	Construction Management	Subdivision	• Proponent
Manjedal Brook foreshore reserve	Planting in conservation areas	Subdivision	• Proponent
		Ongoing	• Proponent • Shire of Serpentine Jarrahdale
	Bush Forever interface management	Subdivision	• Proponent
		Ongoing	• Proponent • Shire of Serpentine Jarrahdale
	Fauna management	Subdivision	• Proponent
	Dieback management	Subdivision	• Proponent
	Indigenous heritage management	Subdivision	• Proponent
		Ongoing	• Proponent • Shire of Serpentine Jarrahdale
	Bushfire hazard management	Subdivision	• Proponent
		Development Application	• Proponent
		Ongoing	• Proponent • Shire of Serpentine Jarrahdale
	Construction Management	Subdivision	• Proponent

Table 17: Implementation of management strategies, appropriate stage and responsible authority (continued)

MANAGEMENT AREA	MANAGEMENT ELEMENT	IMPLEMENTATION STAGE	RESPONSIBILITY
Conservation Category Wetland Buffer	Planting in conservation areas	Subdivision	• Proponent
		Ongoing	• Proponent • Shire of Serpentine Jarrahdale
	Bush Forever interface management	Subdivision	• Proponent
		Ongoing	• Proponent • Shire of Serpentine Jarrahdale
	Dieback Management	Subdivision	• Proponent
	Indigenous heritage management	Subdivision	• Proponent
		Ongoing	• Proponent • Shire of Serpentine Jarrahdale
	Bushfire Management	Subdivision	• Proponent
		Development Application	• Proponent
		Ongoing	• Proponent • Shire of Serpentine Jarrahdale
	Construction Management	Subdivision	• Proponent
Management area	Management Element	implementation stage	• responsibility
Subdivision Area	Planting in public open space	Subdivision	• Proponent
		Ongoing	• Proponent • Shire of Serpentine Jarrahdale
	Bush Forever interface management	Subdivision	• Proponent
		Ongoing	• Proponent • Shire of Serpentine Jarrahdale
	Fauna Management	Subdivision	• Proponent
	Indigenous heritage management	Subdivision	• Proponent
		Ongoing	• Proponent • Shire of Serpentine Jarrahdale
	Bushfire Management	Subdivision	• Proponent
		Development Application	• Proponent
		Ongoing	• Proponent • Shire of Serpentine Jarrahdale
	Construction Management	Subdivision	• Proponent

6.3 Detailed landscape design and implementation

As part of the subdivision process, detailed landscape design for the site will be undertaken for the management areas identified in **Section 4.2.2**. The detailed landscape design process will be undertaken following subdivision approval and generally follows the completion of bulk earthworks and civil construction. The detailed landscape design process will address the landscape design, implementation and on-going maintenance of landscape elements within the site. It will be in accordance with the management considerations outlined within this ILMS and the Shire of Serpentine Jarrahdale's *LPP 4:16 Tree Retention and Planting,* and will generally include:

- Details of the type and area associated with ground treatment including soft landscape (trees, grass, mulch etc.) and hard landscape (i.e. paving, pathways, parking, pitching etc.).
- Location of facilities and play elements.
- Planting palette, location of proposed planting, size of planting and density of plant species.
- Design and location of bio-retention swales and flood storage areas.
- Irrigation design and detail, including volume required and source.
- Completion criteria.
- Ongoing maintenance requirements.
- Cost schedule to inform any bank guarantees and/or bonds (if required).

6.4 Contract (developer) maintenance

The industry accepted standard Developer funded and managed landscape and irrigation maintenance period is typically two summers as outlined in Liveable Neighbourhoods. Following this period, the landscape and irrigation maintenance will be handed over to the Serpentine Jarrahdale Shire to manage, unless otherwise negotiated.

Typically the first year is an establishment period, followed by a second year of consolidation. Irrigation requirements are to be scheduled to be wound back during this period to a point of almost self-sufficiency at the time of handover to the Council.

As part of the ongoing approval process, every public open space landscape and irrigation design will be submitted to and approved by the Serpentine Jarrahdale Shire prior to construction commencing.

The Landscape Design will incorporate recreation and environmental requirements, whilst focusing on maintenance minimisation principles and techniques. The developer is committed to working with the local authority to deliver outcomes in this process to reflect best practice throughout the development.

6.5 Practical completion and handover

Practical completion relates to the completion of landscaping construction works for the management areas in accordance with the *Landscape Management Plan* (or similar) approved by the Shire of Serpentine Jarrahdale for each relevant subdivision area. These areas will be inspected by the Shire of Serpentine Jarrahdale and the maintenance period will commence following approval with the relevant criteria. Scheduled handover of these areas will generally occur after the two year maintenance period is complete and the Shire of Serpentine Jarrahdale is satisfied the areas have been maintained suitably. These areas will be managed and maintained by the Shire of Serpentine Jarrahdale in the long-term.

7 Summary and Conclusion

Emerge Associates was engaged by the Peet Mundijong Syndicate Ltd to provide a comprehensive strategy for the management of the environmental attributes and values within the proposed Taylor Road, Mundijong LSP area (referred to as “the site”).

The site is approximately 199 hectares (ha) in size, located in the Shire of Serpentine Jarrahdale, approximately 37 km south-east of the Perth Central Business District (CBD). The site is bound by Bishop Road to the north and east, Manjedal Brook and Scott Road to the south, and rural landholdings to the west.

The environmental attributes and values identified within the site have been outlined in **Section 2** and include:

- The majority of the site was historically cleared for agricultural purposes, primarily cattle grazing.
- Based on a flora and vegetation survey undertaken in 2017, there are no Threatened Flora (TF) or Priority Flora (PF) species, Threatened Ecological Communities (TECs) or Priority Ecological Communities (PECs) present within the site.
- Vegetation within the site is generally in “Completely Degraded” or “Degraded” condition (based upon the flora and vegetation survey (Emerge Associates 2017)). A small portion of vegetation in the south-east of the site, associated with an area of CCW, is considered to range from “Good - degraded” to “Excellent – very good” condition. This vegetation may also provide habitat for fauna species, including black cockatoos, but is not considered significant.
- Bush Forever Site 350 occurs immediately east of the site, within the Soldiers Road and railway reserve. This Bush Forever Site is known to support significant flora and vegetation values. There are no Bush Forever sites within the site.
- ESAs extend into the east of the site, associated with the flora and vegetation values known to occur within Bush Forever Site 350.
- Manjedal Brook runs through the south of the site. This creekline conveys surface flows through the site to the west, and joins with Cardup Brook and eventually the Serpentine River west of the site.
- The majority of the site is covered by MUWs, and there are three CCWs in the south of the site, two of which are associated with Manjedal Brook.
- An existing railway line occurs adjacent to the northern and eastern site boundary, while a Primary Regional Road reserve associated with the Tonkin Highway extension and Water Corporation service corridor lies adjacent to the western boundary of the site. These existing and future adjacent land uses will pose acoustic and potential vibration implications to residential development within the site.
- Vegetation associated with Manjedal Brook and the CCWs, as well as that surrounding the site presents a permanent bushfire hazard to residential development.

A Local Structure Plan (LSP) has been prepared for the site which has provided for the retention of Manjedal Brook and areas of CCW in the south of the site, with the provision of appropriate foreshore and buffer, and drainage reserves for the maintenance of pre-development surface water and groundwater conditions.

Based on the LSP design, a number of 'management areas' have been identified which will guide the application of various 'management elements' across the site. The 'management areas' are listed below and are detailed in **Section 4** of this strategy:

- Multiple use corridors
- Neighbourhood parks
- Drainage basins
- Local sport open space
- Manjedal Brook foreshore reserve
- Pocket parks
- Conservation Category Wetland buffer
- Subdivision area.

In order to provide for the management of the environmental values within the site, this strategy has outlined a number of 'management elements' which provide for the different types of management that are required to be applied within the 'management areas' as part of subdivision and ongoing maintenance. These 'management elements' are based on the environmental values and landscape principles outlined for the site, as well as federal, state and local expectations (based on legislation, policy and guidelines) and will form a key basis for guiding management requirements, including planting and revegetation, weed and disease, fauna and construction requirements.

A *Landscape Management Plan* (or similar detailed provided as part of detailed design drawings), in addressing the principles outlined in this strategy, replaces the requirement for various separate management plans and instead will provide a comprehensive plan which addresses all landscape management aspects. The management areas present within a subdivision area will influence the management elements that will need to be addressed in a *Landscape Management Plan*.

The implementation of a *Landscape Management Plan* and the maintenance of the management areas will be the responsibility of the developers, or where appropriate, the Shire of Serpentine Jarrahdale. As part of the subdivision process, it is expected that the developer, following practical completion will maintain the relevant management areas for two years before handing over to the Shire of Serpentine Jarrahdale.

This ILMS is expected to guide the preparation of a *Landscape Management Plan* at the subdivision stage, which will include detailed management measures and practical completion criteria based on the management areas located within each subdivision area.

8 References

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9 Glossary

AEP	Annual Exceedance Probability
BMP	Bushfire Management Plan
BAL	Bushfire Attack Level
DPLH	Department Planning, Lands and Heritage
DWER	Department of Water and Environmental Regulation
DBCA	Department of Biodiversity and Conservation
DSP	District Structure Plan
DWMS	District Water Management Strategy
EAMS	Environmental Assessment and Management Strategy
LSP	Local Structure Plan
LPS	Local Planning Scheme
LWMS	Local Water Management Strategy
MRS	Metropolitan Region Scheme
TPS	Town Planning Scheme
UWMP	Urban Water Management Plan
WAPC	Western Australian Planning Commission

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Figure 11: Hydrology and Geomorphic Wetlands

Figure 12: Indigenous Heritage Values

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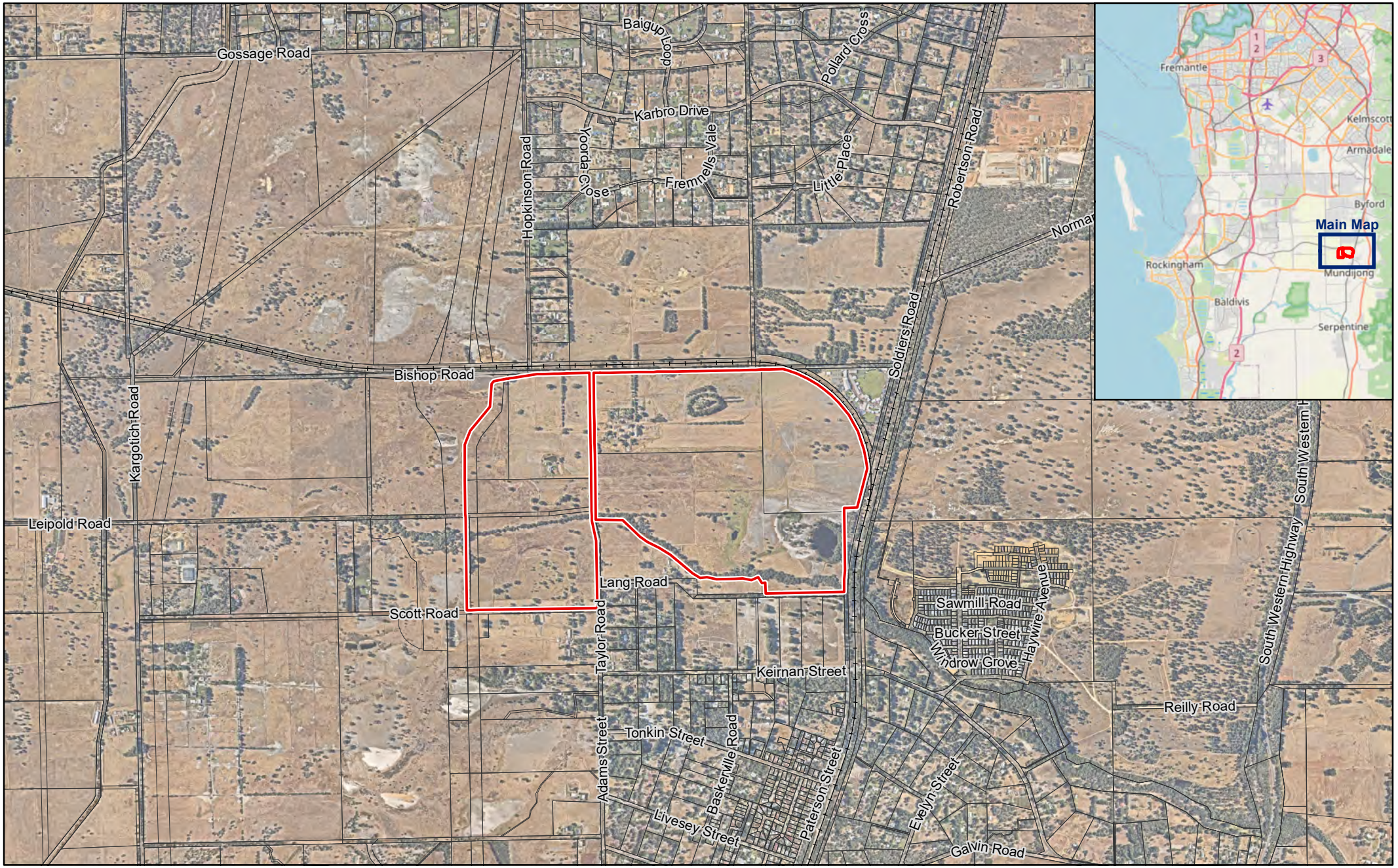


Figure 1: Location Plan

Project:	Integrated Landscape and Management Strategy Taylor Road, Mundijong
Client:	Peet Mundijong Syndicate Ltd

Legend

- Site boundary
- Cadastral boundary
- Railway

Plan Number: EP15-036(03)--F71			
Drawn:	WJC	Date:	17/04/2023
Approved:	KK	Date:	04/05/2023
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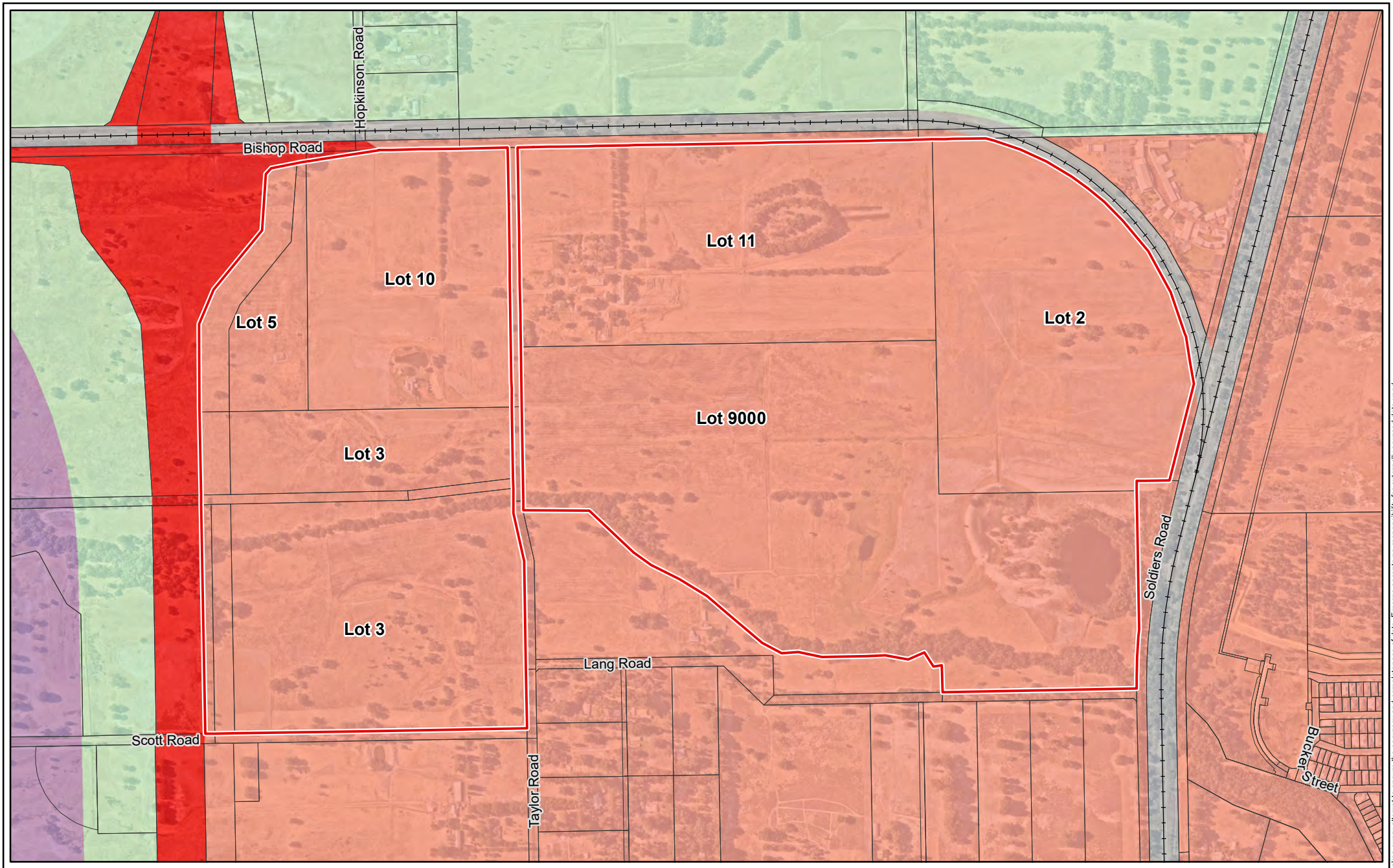


Figure 2: Site and Nearby Land Uses

Project:	Integrated Landscape and Management Strategy Taylor Road, Mundijong
Client:	Peet Mundijong Syndicate Ltd

Legend

- Site boundary
- Cadastral boundary
- Railway

Region Schemes (DPLH 2023)

- Industrial
- Primary regional roads

- Railways
- Rural
- Urban

Plan Number: EP15-036(03)--F72			
Drawn:	WJC	Date:	17/04/2023
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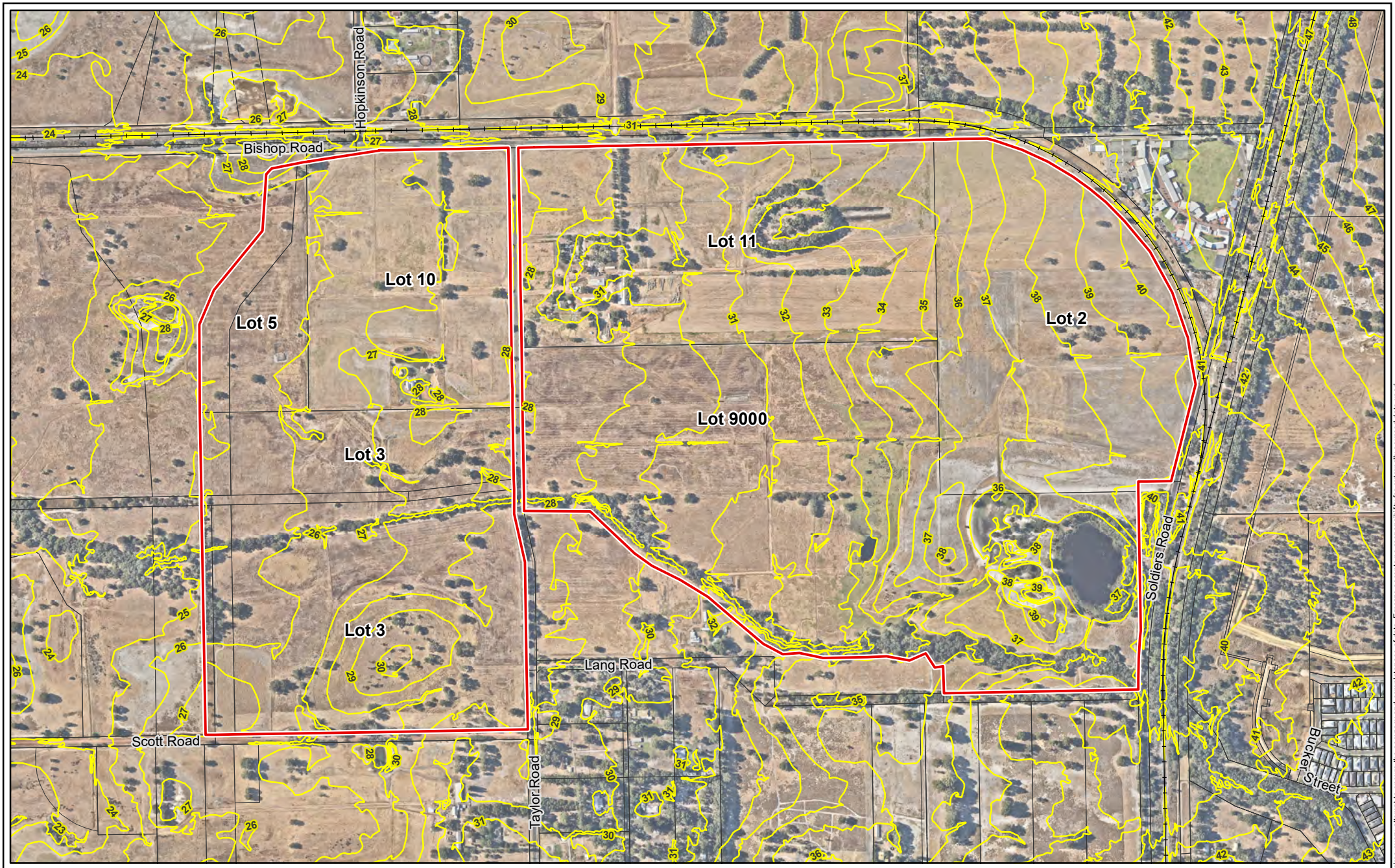


Figure 3: Topography

Project:	Integrated Landscape and Management Strategy Taylor Road, Mundijong
Client:	Peet Mundijong Syndicate Ltd

Legend

- Site boundary
- Cadastral boundary
- Railway
- Elevation contour (DWER)

Plan Number: EP15-036(03)--F73			
Drawn:	WJC	Date:	17/04/2023
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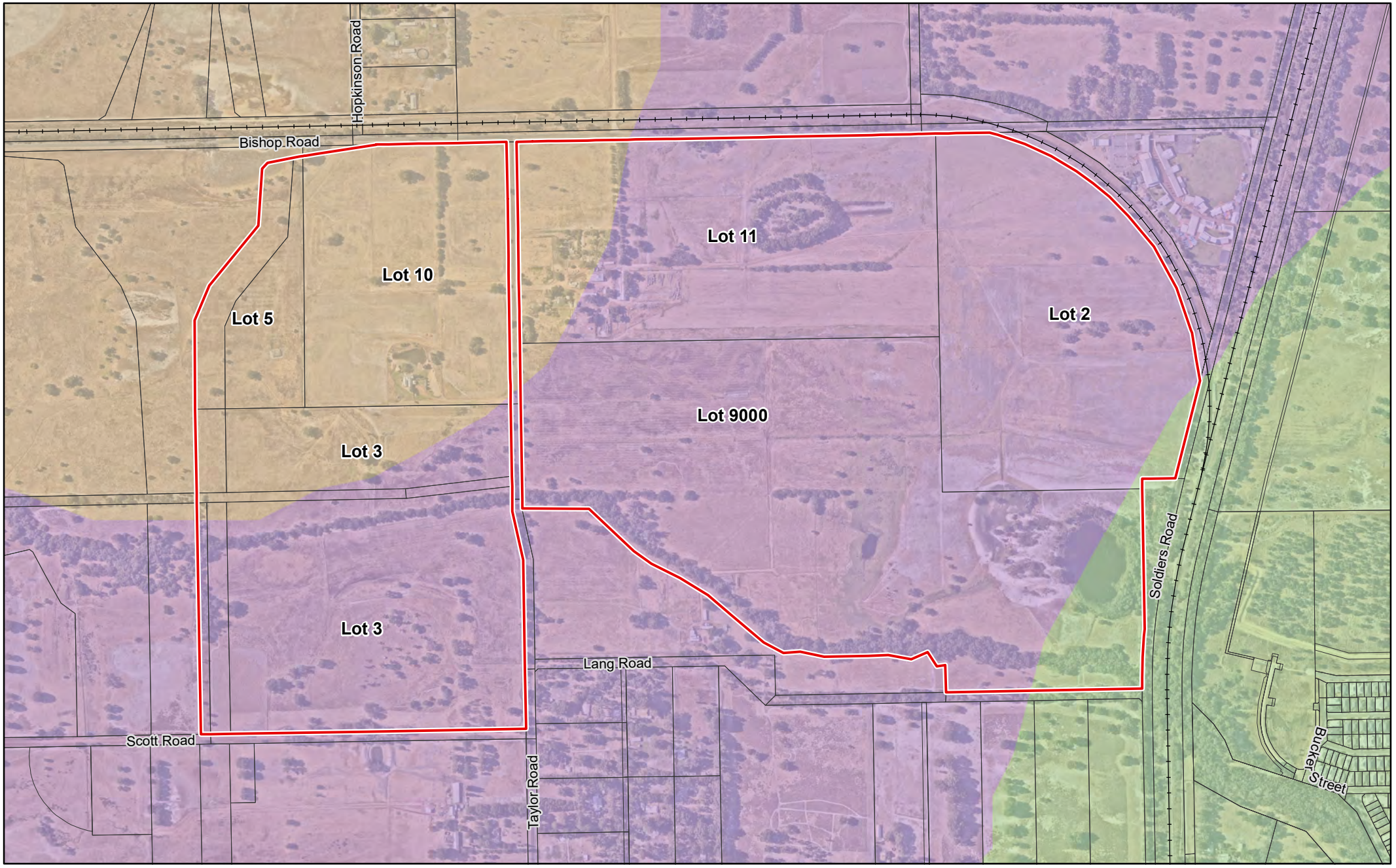


Figure 4: Landforms

Project:	Integrated Landscape and Management Strategy Taylor Road, Mundijong
Client:	Peet Mundijong Syndicate Ltd

Legend

- Site boundary
- Cadastral boundary
- Railway

Landforms (Churchward and McArthur)

- Beermullah
- Forrestfield
- Guildford

Plan Number: EP15-036(03)--F74			
Drawn:	WJC	Date:	17/04/2023
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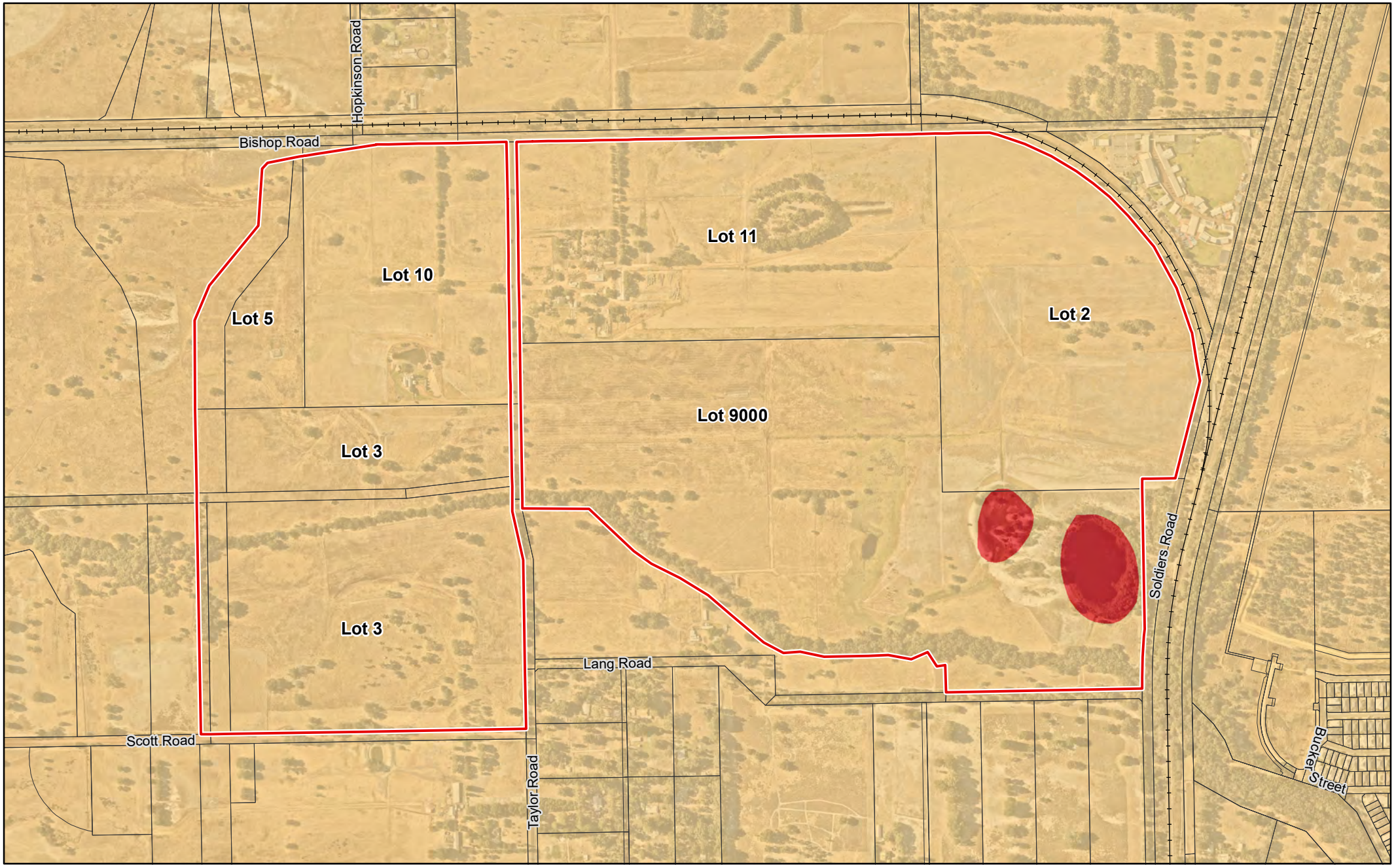


Figure 5: Acid Sulfate Soils

Project:	Integrated Landscape and Management Strategy Taylor Road, Mundijong
Client:	Peet Mundijong Syndicate Ltd

Legend

- Site boundary
- Cadastral boundary
- Railway

Acid Sulfate Soils (DWER)

- High to moderate risk
- Moderate to low risk

Plan Number: EP15-036(03)--F75

Drawn:	WJC	Date:	17/04/2023
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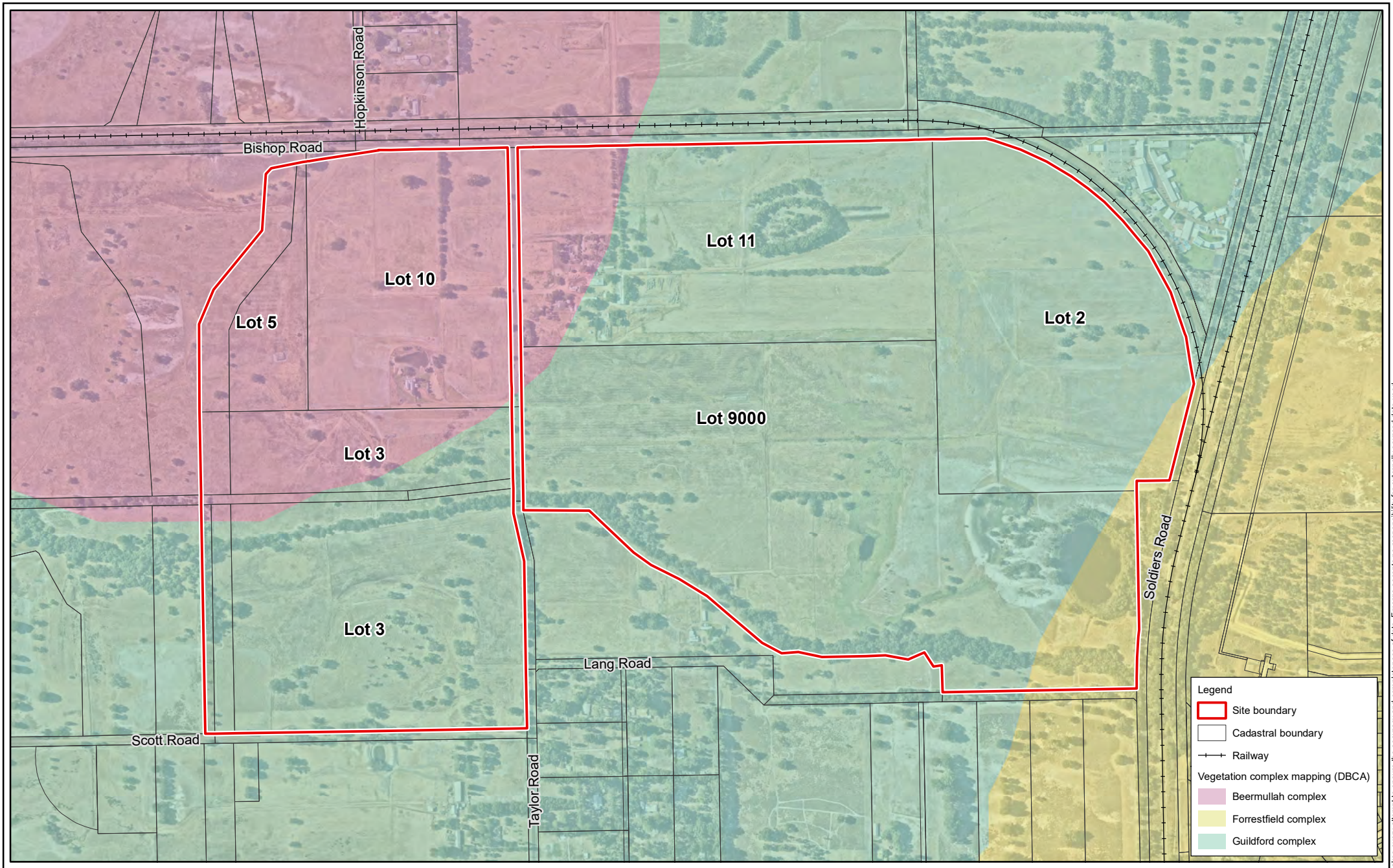


Figure 6:	**Regional Vegetation Complex Mapping**
Project:	Integrated Landscape and Management Strategy Taylor Road, Mundijong
Client:	Peet Mundijong Syndicate Ltd

Plan Number: EP15-036(03)--F76			
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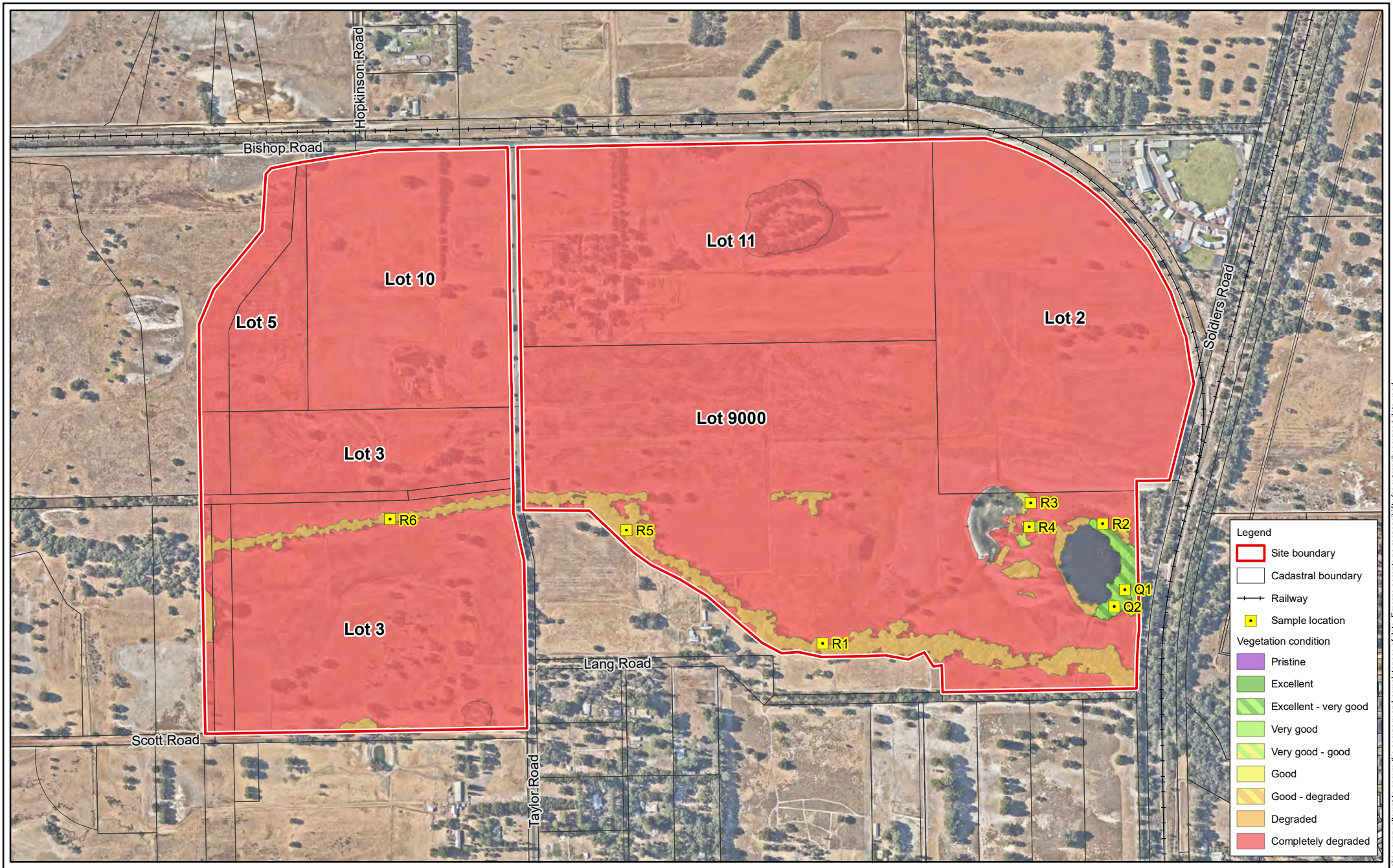


Figure 7: Vegetation Condition

Project:	Integrated Landscape and Management Strategy Taylor Road, Mundijong
Client:	Peet Mundijong Syndicate Ltd

Sourced: Emerge Associates (2017) *Spring Flora and Vegetation Survey - Taylor Road, Mundijong* (EP15-036(07)--008 RAO)

Plan Number: EP15-036(03)--F77

Drawn:	WJC	Date:	19/04/2023
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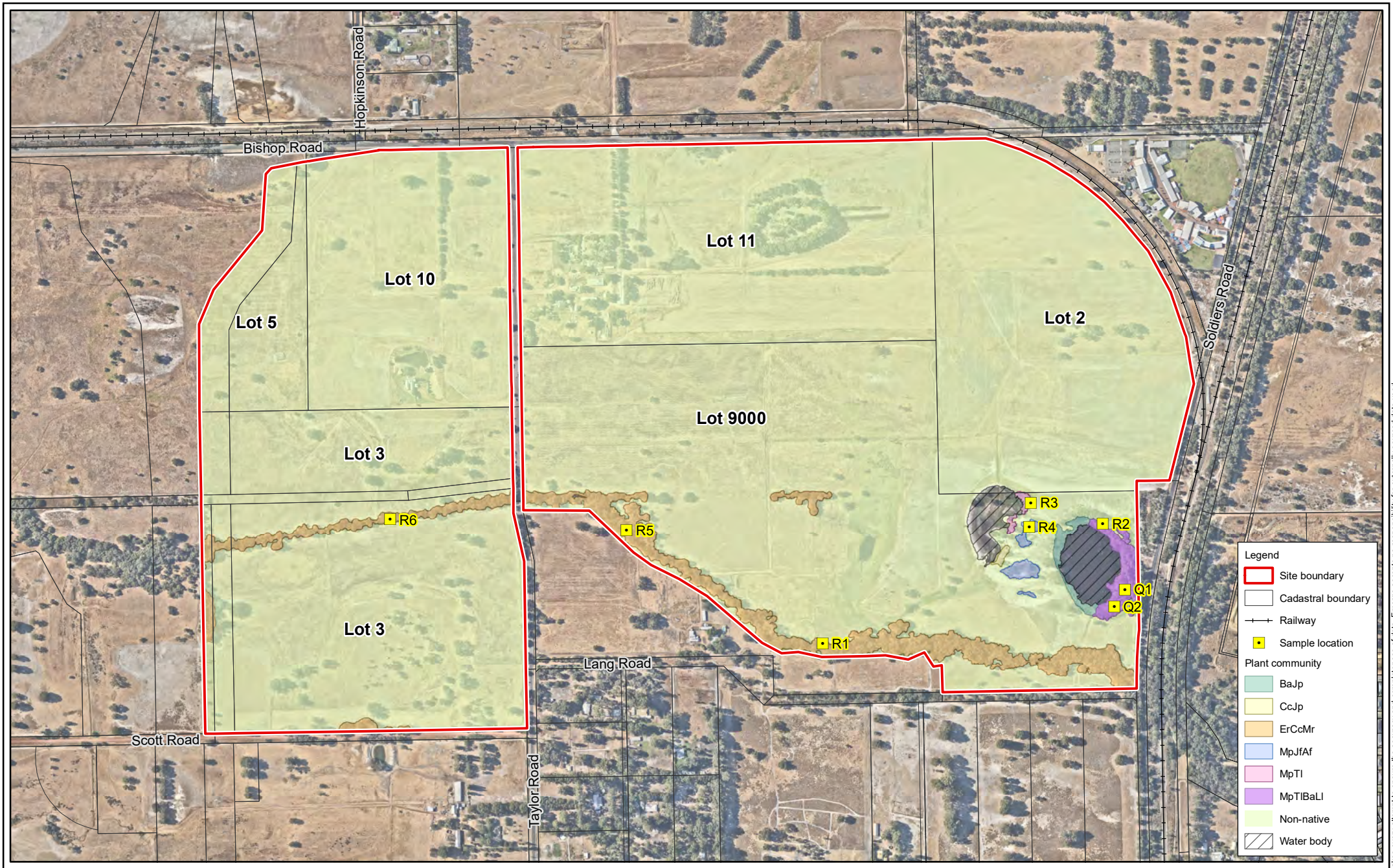


Figure 8: Plant Communities

Project: Integrated Landscape and Management Strategy
Taylor Road, Mundijong

Client: Peet Mundijong Syndicate Ltd

Sourced: Emerge Associates (2017) *Spring Flora and Vegetation Survey - Taylor Road, Mundijong* (EP15-036(07)--008 RAO)

Plan Number: EP15-036(03)--F78

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Approved:	KK	Date:	04/05/2023
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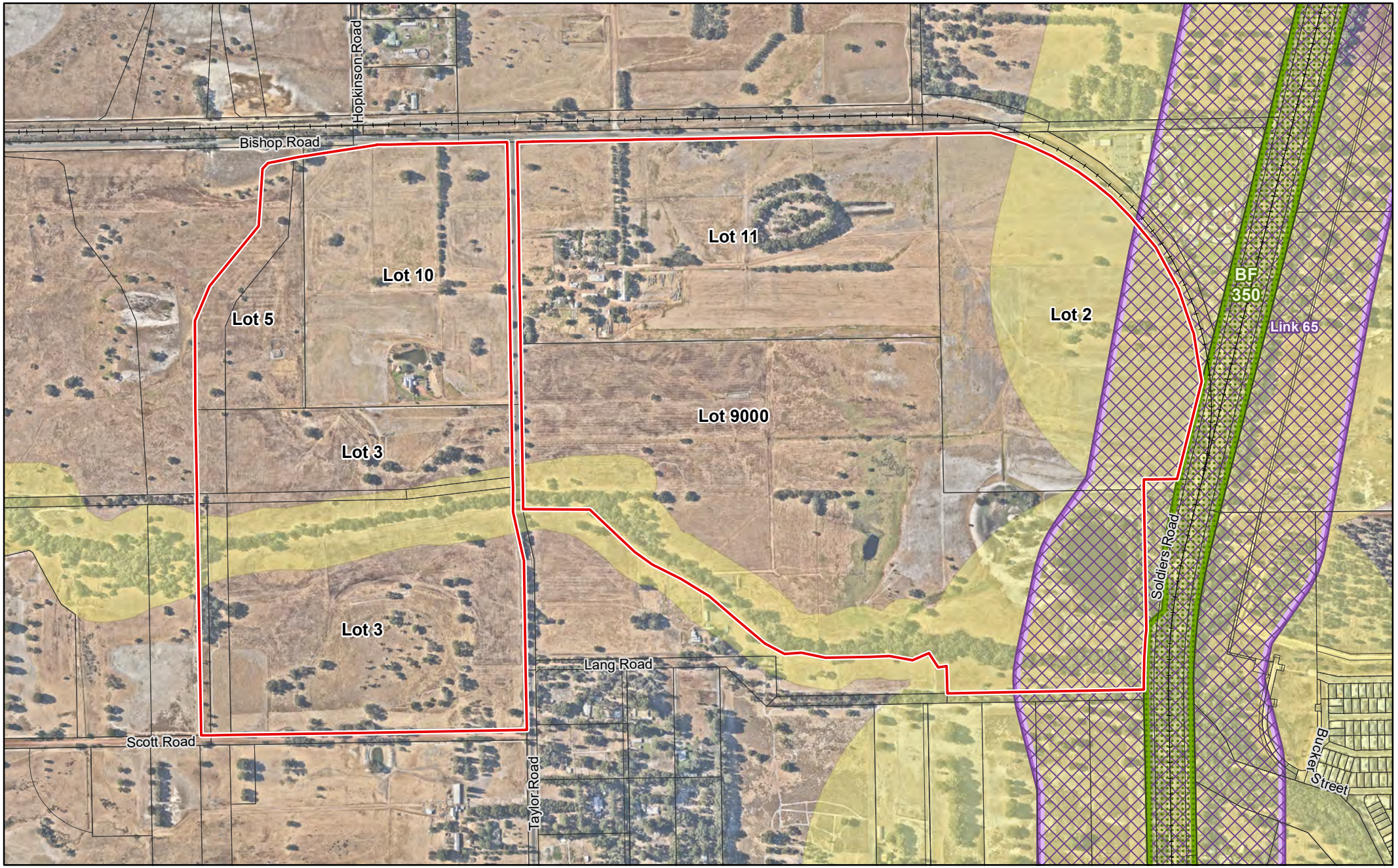


Figure 9: Bush Forever, ESAs and Ecological Linkages

Project:	Integrated Landscape and Management Strategy Taylor Road, Mundijong
Client:	Peet Mundijong Syndicate Ltd

Legend

- Site boundary
- Cadastral boundary
- Railway
- Bush forever
- Environmentally sensitive area
- Biodiversity linkage

Plan Number: EP15-036(03)--F79			
Drawn:	WJC	Date:	17/04/2023
Approved:	KK	Date:	04/05/2023
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0 100 200 400 Metres

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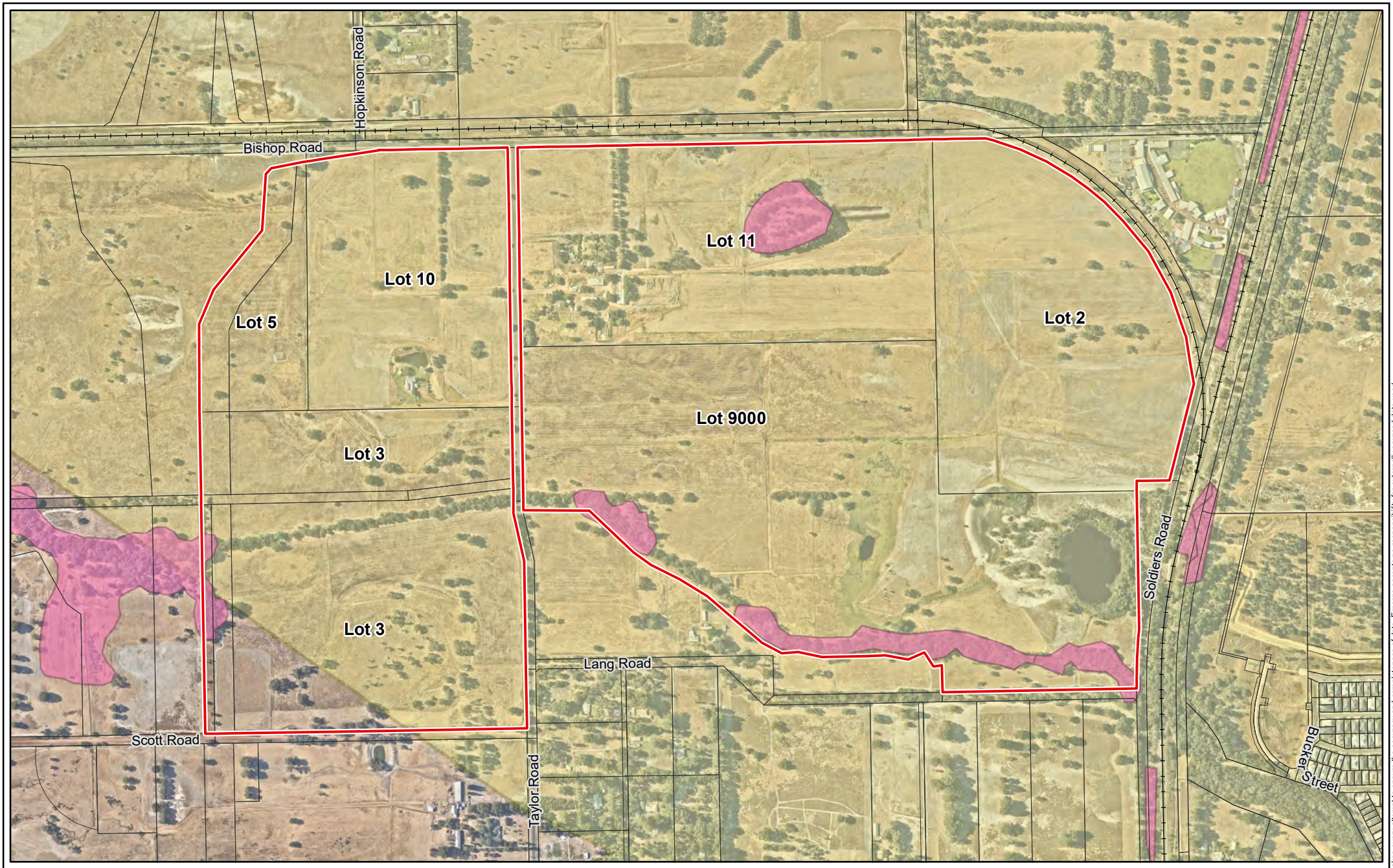


Figure 10: Potential Black Cockatoo Habitat

Project:	Integrated Landscape and Management Strategy Taylor Road, Mundijong
Client:	Peet Mundijong Syndicate Ltd

Legend

- Site boundary
- Cadastral boundary
- Railway
- Potential black cockatoo foraging habitat (DEC)
- Unconfirmed breeding areas within 6km (DEC)

Plan Number: EP15-036(03)--F80			
Drawn:	WJC	Date:	17/04/2023
Approved:	KK	Date:	04/05/2023
Checked:	SAM	Scale:	1:10,000@A4

0 100 200 400 Metres

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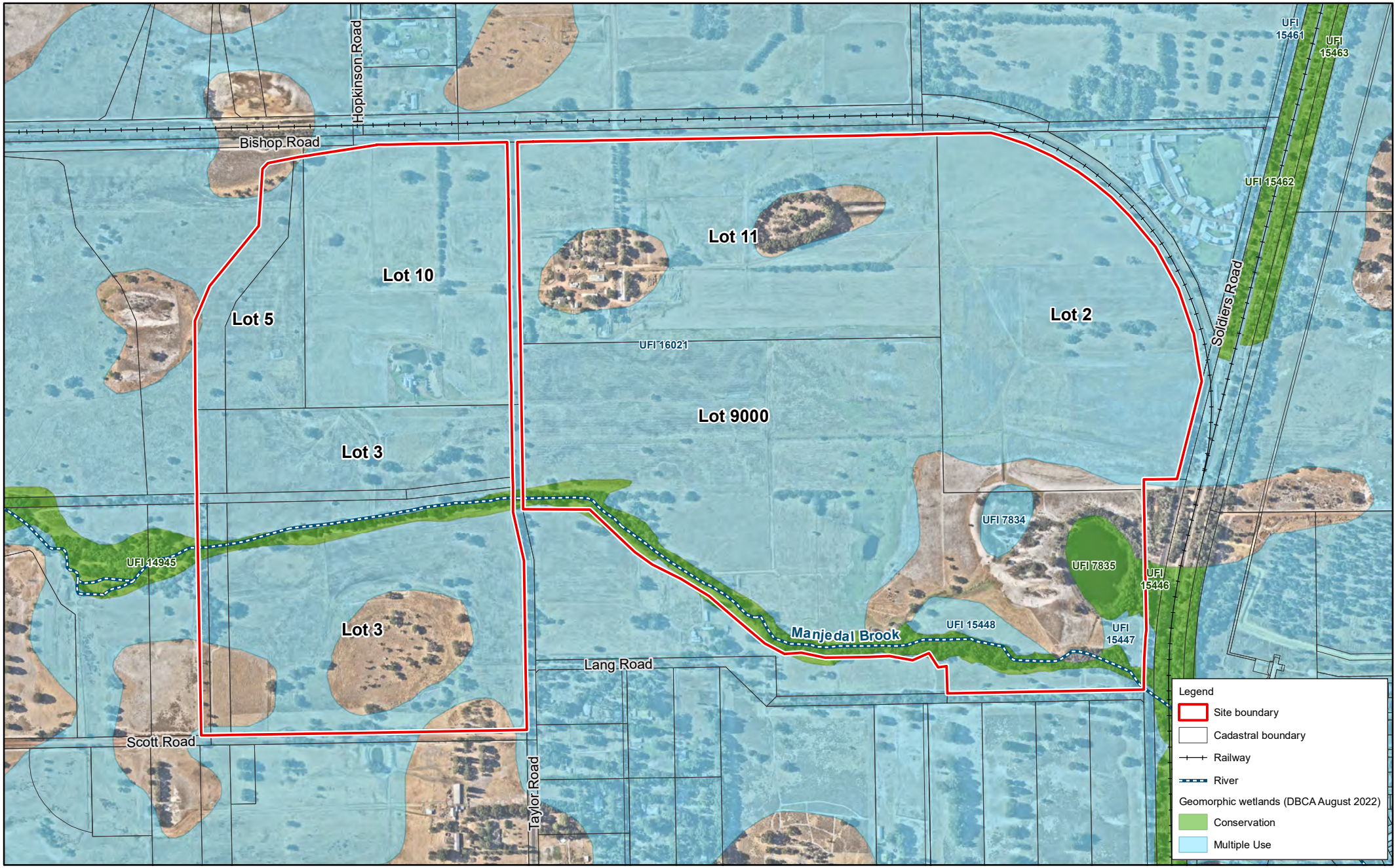


Figure 11: Hydrology and Geomorphic Wetlands

Project:	Integrated Landscape and Management Strategy Taylor Road, Mundijong
Client:	Peet Mundijong Syndicate Ltd

Plan Number: EP15-036(03)--F81

Drawn:	WJC	Date:	17/04/2023
Approved:	KK	Date:	04/05/2023
Checked:	SAM	Scale:	1:10,000@A4

0 100 200 400 Metres

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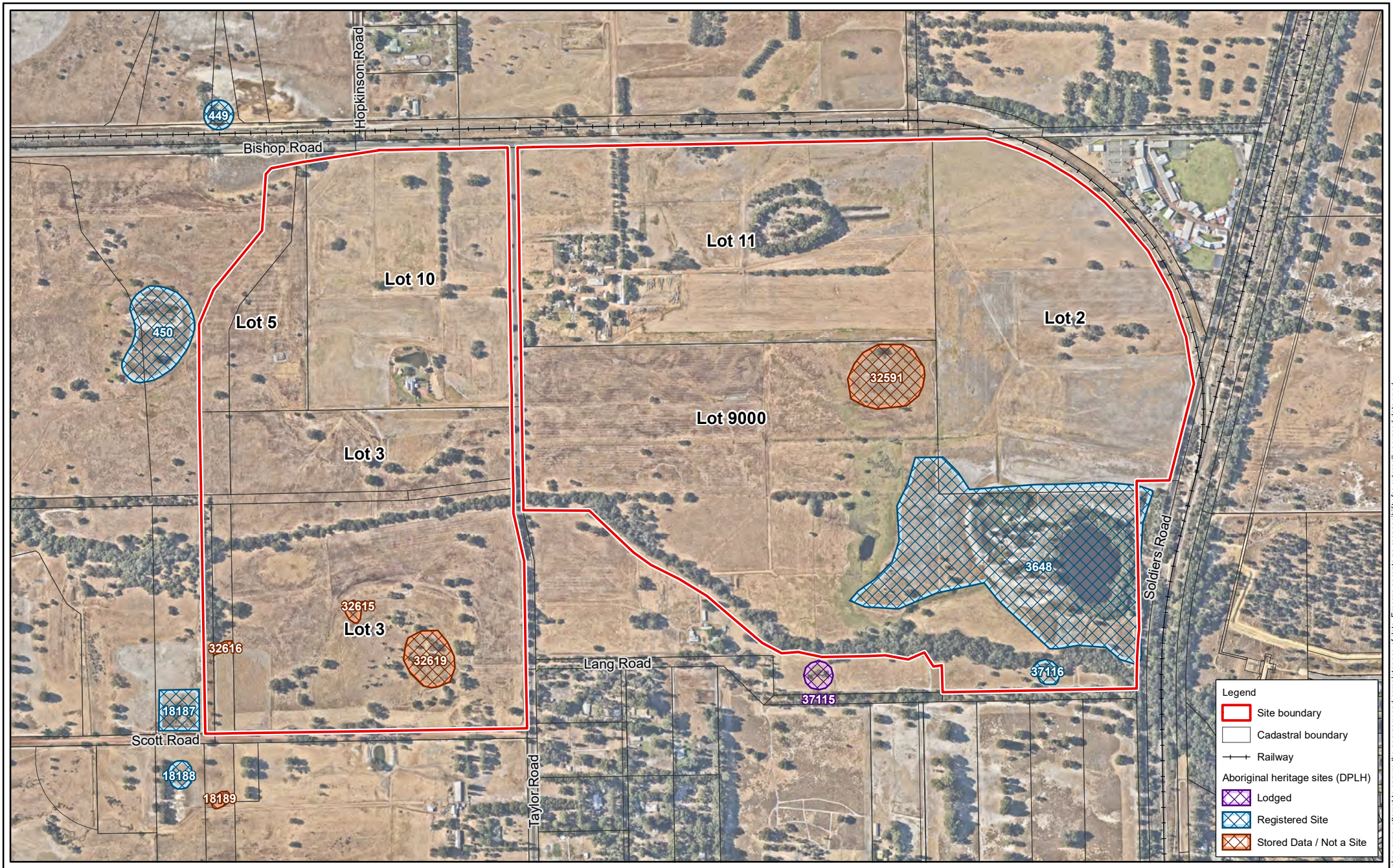


Figure 12: Indigenous Heritage Values

Project:	Integrated Landscape and Management Strategy Taylor Road, Mundijong
Client:	Peet Mundijong Syndicate Ltd

Plan Number: EP15-036(03)--F82

Drawn:	WJC	Date:	17/04/2023
Approved:	KK	Date:	04/05/2023
Checked:	SAM	Scale:	1:10,000@A4

0 100 200 400 Metres

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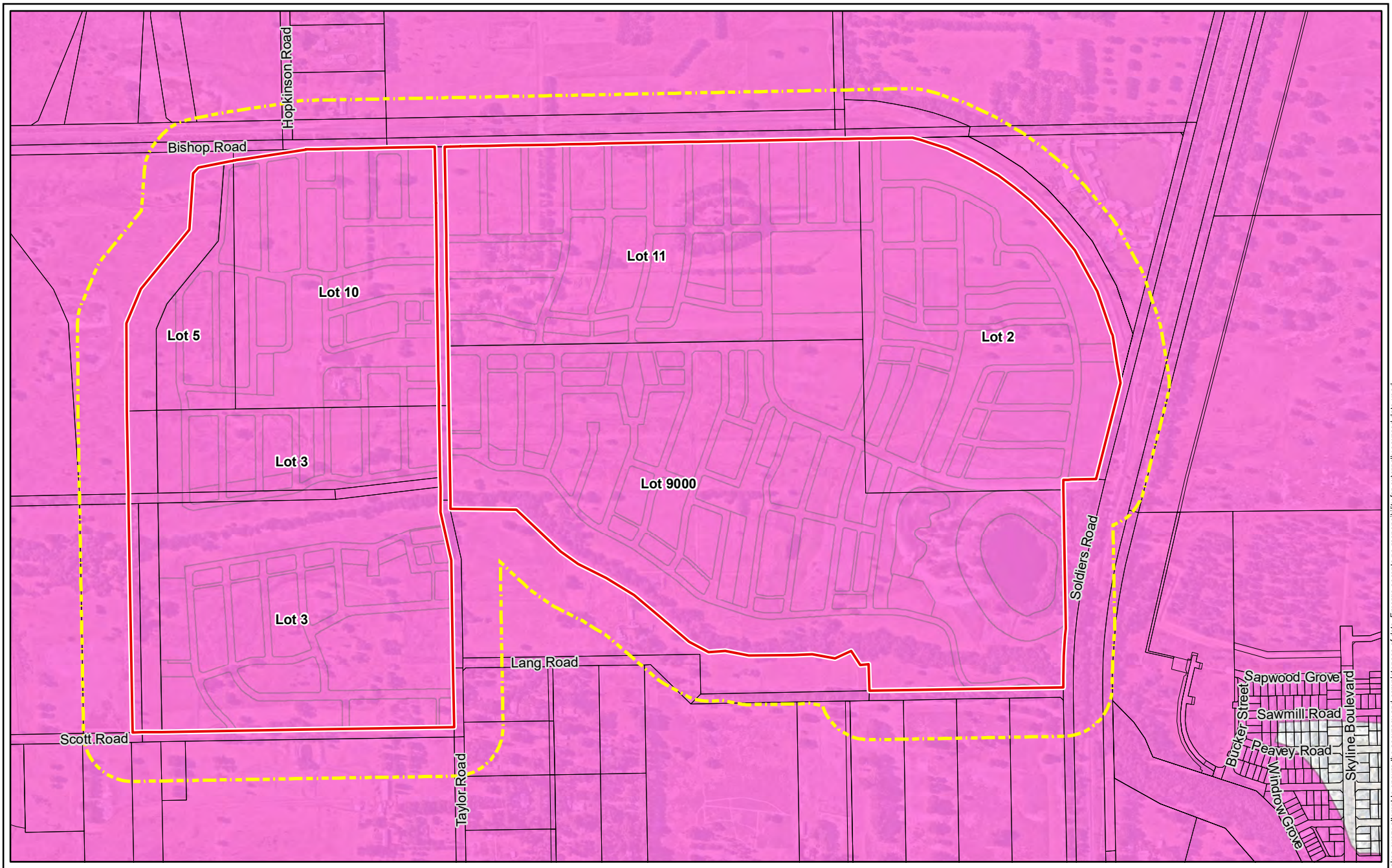


Figure 13: Map of Bushfire Prone Areas

Project:	Integrated Landscape and Management Strategy Taylor Road, Mundijong
Client:	Peet Mundijong Syndicate Ltd

Legend

- Site Boundary
- Assessment boundary
- Cadastral boundary
- LSP
- Bush Fire Prone Areas (OBRM 2021)

Plan Number: EP15-036(03)--F83			
Drawn:	WJC	Date:	17/04/2023
Approved:	KK	Date:	04/05/2023
Checked:	SAM	Scale:	1:10,000@A4

0 100 200 400 Metres

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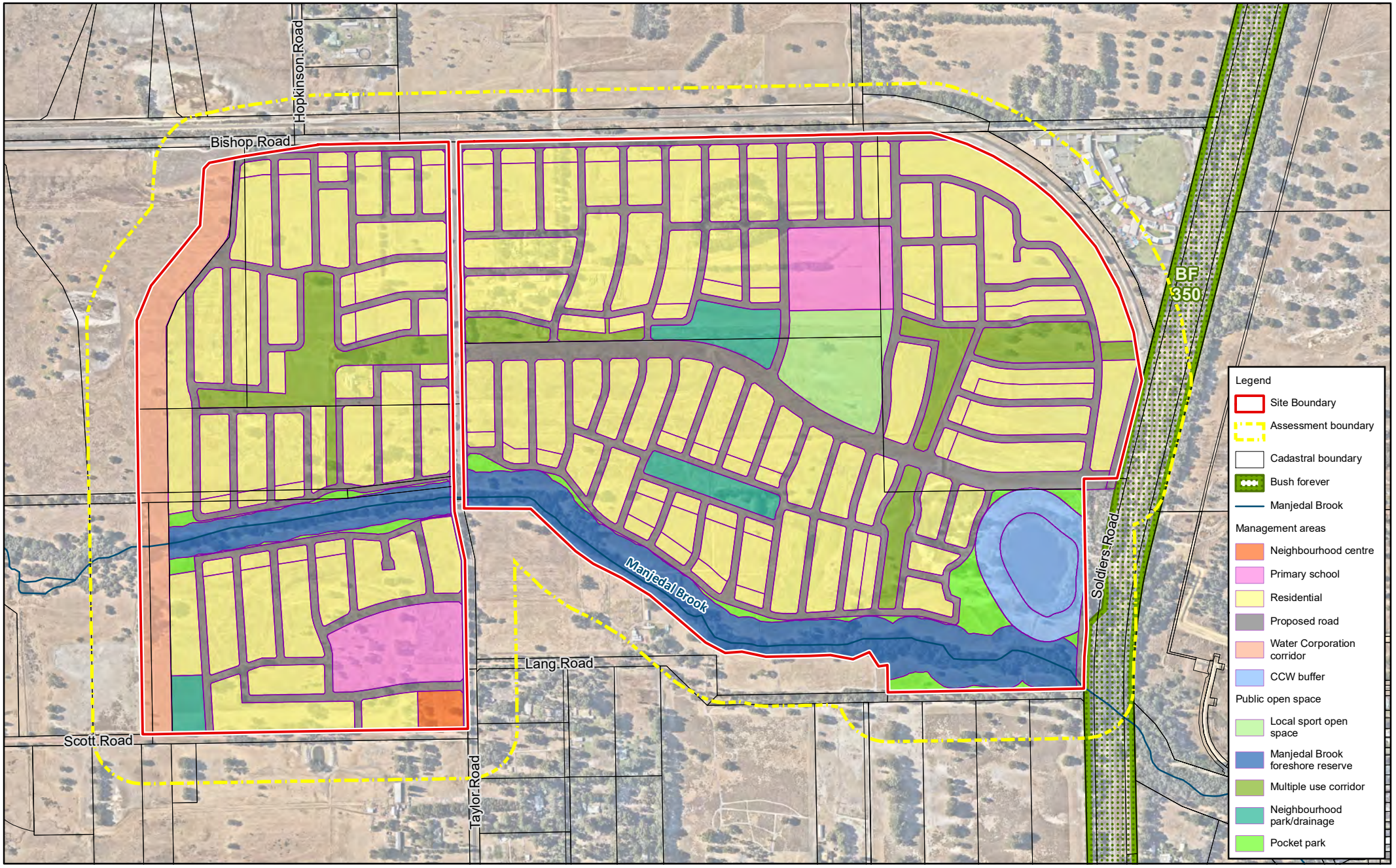


Figure 14: Management Areas

Project:	Integrated Landscape and Management Strategy Taylor Road, Mundijong
Client:	Peet Mundijong Syndicate Ltd

Plan Number: EP15-036(03)--F84			
Drawn:	WJC	Date:	01/05/2023
Approved:	KK	Date:	04/05/2023
Checked:	SAM	Scale:	1:10,000@A4

0 100 200 400 Metres

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APPENDIX A

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TAYLOR ROAD, MUNDIJONG LOCAL STRUCTURE PLAN

Legend

- STRUCTURE PLAN BOUNDARY
- RESIDENTIAL (R10)
- RESIDENTIAL (R25-40)
- RESIDENTIAL (R40-60)
- NC — CENTRE - NEIGHBOURHOOD
- PUBLIC OPEN SPACE AND DRAINAGE
- ENVIRONMENTAL CONSERVATION
- PUBLIC PURPOSES
  Denoted as:
  IS - Infrastructure Services
  E(PS) - Education, Primary School
  E(HS) - Education, High School
- PRIMARY REGIONAL ROAD
- INTEGRATOR ARTERIAL
- NEIGHBOURHOOD CONNECTOR
- AREA SUBJECT TO FUTURE INVESTIGATION (FREIGHT RAIL REALIGNMENT)

Notes

1. The location of local roads, public open space, civic and community sites and neighbourhood centre sites are indiciative only and subject to refinement at subdivision stage.
2. Area subject to future investigation to consider appropriate planning responses for the proposed freight rail realignment. and does not constitute a Structure Plan pursuant to the *Planning and Development (Local Planning Scheme) Regulations 2015 Schedule 2 - Deemed provisions* until such time as a subsequent Structure Plan amendment has been lodged and assessed to the satisfaction of the WAPC.
3. The Structure Plan provides for an at-grade connection to Whitby Town Centre and identifies this area as also subject to further investigation for a grade-separated railway crossing.



Structure Plan

TAYLOR & BISHOP ROAD, MUNDIJONG

A Peet Limited Project

DRAFT

scale: 1:7000@A3
0 50 100m

plan: 06/066/043H
date: 11/03/2024
aerial: n/a

Taylor Burrell Barnett Town Planning & Design
Level 7, 160 St Georges Terrace, Perth WA 6000
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p: (08) 9226 4276

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ALL AREAS AND DIMENSIONS DISPLAYED ARE SUBJECT TO DETAIL SURVEY.

APPENDIX B

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LANDSCAPE MASTERPLAN (EMERGE ASSOCIATES 2023)

BISHOP ROAD, MUNDIJONG
LANDSCAPE MASTERPLAN

DWG **MJ01-01**
REV **D**
DATE **APRIL-23**

0 30 60 90 120 130 m

SCALE **1 : 6000 @ A3**

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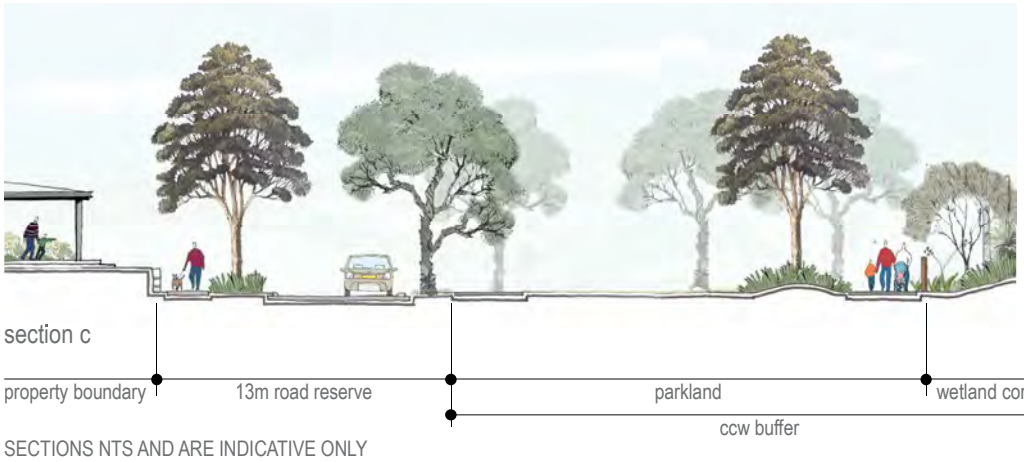
U:\CURRENT PROJECTS\Peet Bishop Road\(MJ-01) Drawings\(MJ-01) Concept Plans, Scans and Graphics\Landscape\Overall Project Plans\LSP- POS Concepts\2023 Mundijong Masterplan Inlay.indd

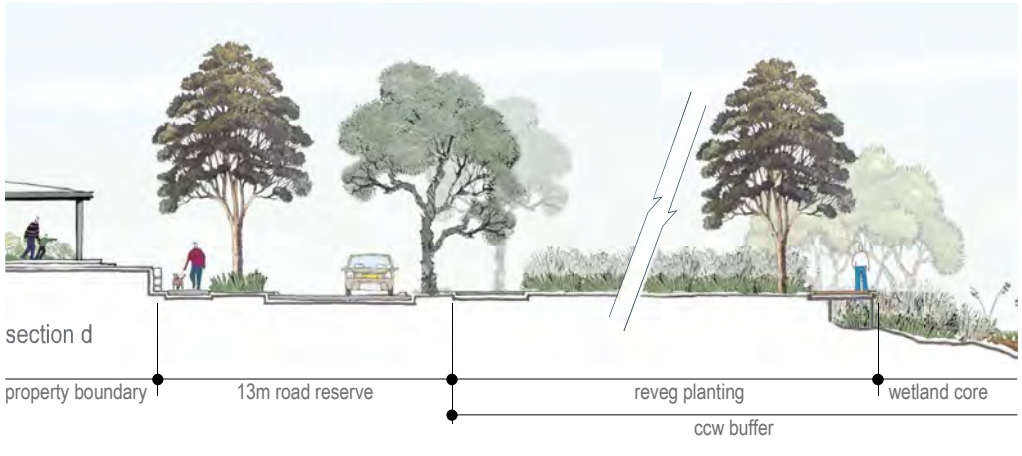












SECTIONS NTS AND ARE INDICATIVE ONLY

BISHOP ROAD, MUNDIJONG
WETLAND POS

DWG MJ01-02
REV D
DATE APRIL-23
0 5 10 15 20 25 m
SCALE 1 : 1000 @ A3

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SECTIONS NTS AND ARE INDICATIVE ONLY

BISHOP ROAD, MUNDIJONG

MANJEDAL BROOK INTERFACE POS

DWG **MJ01-03**
REV **D**
DATE **APRIL-23**
0 5 10 15 20 25 m
SCALE **1 : 1000 @ A3**

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BISHOP ROAD, MUNDIJONG

WETLAND CONNECTION POS CONCEPT

DWG MJ01-04
REV D
DATE APRIL-23
SCALE 1 : 1000 @ A3

0 5 10 15 20 25 m

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BISHOP ROAD, MUNDIJONG

EAST - WEST POS CONCEPT

DWG **MJ01-05**
REV **D**
DATE **APRIL-23**
SCALE **1 : 1000 @ A3**

0 5 10 15 20 25 m

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APPENDIX C

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INDICATIVE PLANTING PALETTE

Appendix C: Planting Palette

The Planting Palette is provided in **Table 1** below, and outlines the flora species that may be planted within the open space treatments of the Taylor Road, Mundijong Local Structure Plan. This has been prepared to guide planting within the various open space treatments across the site and includes local native flora species, in addition to exotic species which will be used in some feature locations, streetscapes and open space areas.

Listed flora species generally align with the known species composition of regional vegetation complexes identified within the site, including the Beermullah, Guildford and Forrestfield complexes (Heddle 1980). Within **Table 1**, the plant species have been categorised based on a number of different attributes, including form (plant shape and structure), height, dieback resistance and their general suitability for planting in each open space treatment.

- Management Area, based on ILMS – NP=Neighbourhood Parks, MUC=Multiple Use Corridors, PP = Pocket Parks, LSOP = Local sport open space, MB=Manjedal Brook (foreshore reserve), CCW=Conservation Category Wetland buffer, BF=Bush Forever interface, SA=Subdivision Area and D=Drainage treatments within public open space.

1. Listed as 'Low flammability in Shire of Serpentine-Jarrahdale *Keeping it Local* guide.
2. *Flammability rating* – based on Shire of Serpentine-Jarrahdale *Indicative List of Low Flammability Plants* (2010). 1 = relatively low flammability and may be suitable for planting within BPZ, 2=Medium flammability and may be suitable for planting more than 5m from buildings, 3=relatively high flammability.
3. Listed as 'Dieback resistant' within Shire of Serpentine-Jarrahdale *Keeping It Local* guide and/or Lullfitz Nursery website.

The Planting Palette was compiled using the following information sources:

- APACE, 2015, *APACE WA – Online Nursery*, Available at <http://www.apacewa.org.au/nursery> [Accessed April 2023].
- Garvey J., Hunn S., Gregory K., Hollick P. and Hooper-Worrell T. (2017) *Keeping It Local: Local native species list for Landcare projects in the Mid Swan Coastal Plain*, Shire of Serpentine Jarrahdale, Mundijong.
- Powell R. and Emberson J. (1996) *Growing Locals: Gardening with Local Plants in Perth*, WA Naturalists Club (Inc.), Perth.
- Western Australian Herbarium (2014) *FloraBase – the Western Australian Flora*, Department of Parks and Wildlife, Perth, Available at <http://florabase.dpaw.wa.gov.au/> [Accessed April 2023].

It should be noted that the Planting Palette represents only a guide to landscaping, and planting across the site is not limited to the species listed in **Table 1**.

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Table 1: List of plant species for use within management areas

SPECIES NAME	FORM	HEIGHT	LISTED IN KEEPING IT LOCAL	MANAGEMENT AREAS[1]	LOW FLAMMABILITY[2] AND/OR RATING[3]	DIEBACK RESISTANT[4]
Acacia alata	Shrub	2.1 m	Y	MB, CCW, D	Y - 2	Y
Acacia dentifera	Shrub	0.6-3 m	Y	NP	Y - 2	Y
Acacia lasiocarpa	Shrub	0.15-1.5(2.5) m	Y	NP, D	Y - 2	Y
Acacia lateriticola	Shrub - erect or spreading	0.4-1.5 m	Y	NP, SA	Y - 2	Y
Acacia nervosa	Shrub - erect or spreading	0.2-0.5 m	Y	NP, SA	Y - 2	Y
Acacia pulchella	Shrub	3 m	Y	NP, MB, CCW, D	Y - 2	Y
Acacia saligna	Shrub or Tree	6(-9) m	Y	MB, CCW, D	2	Y
Acacia sessilis	Shrub - diffuse	0.3-1(1.5)m	Y	NP, SA	Y - 2	Y
Acacia stenoptera	Shrub - sprawling	0.2-0.7 m	Y	SA, NP, LSOS, PP	Y - 2	Y
Acacia willdenowiana	Shrub	0.6 m	Y	D, MB, NP, SA, LSOS, PP	Y - 2	Y
Adenanthos meisneri	Shrub	0.2-1.5 m	Y	NP, SA, LSOS, PP	Y - 2	
Agonis flexuosa	Tree	8 m	Y	SA, NP, LSOS, PP		Y
Agrostocrinum scabrum	Forb	to 1.7 m	Y	D, CCW, MB, NP, LSOS, PP	Y - 1	

Table 1: List of plant species for use within management areas (continued)

SPECIES NAME	FORM	HEIGHT	LISTED IN KEEPING IT LOCAL	MANAGEMENT AREAS[1]	LOW FLAMMABILITY[2] AND/OR RATING[3]	DIEBACK RESISTANT[4]
Allocasuarina fraseriana	Tree	15 m	Y	SA, MUC, NP, LSOS, PP	3	Y
Allocasuarina huegeliana	Tree	4-10 m	Y	SA, MUC, NP, LSOS, PP	3	Y
Allocasuarina humilis	Shrub	0.2-2 m	Y	NP, LSOS, PP		Y
Amphipogon turbinatus	Grass	0.2-0.8 m	Y	SA, NP, D, LSOS, PP		
Anigozanthos humilis	Forb	0.1-1 m	Y	D, SA, NP, LSOS, PP	Y - 1	Y
Anigozanthos manglesii	Forb	0.2-1.1 m	Y	SA, NP, LSOS, PP	Y - 1	Y
Anigozanthos viridis	Forb	0.05-0.85 m	Y	NP, SA, D, LSOS, PP	Y - 1	
Astartea scoparia (previously Astartea aff. fascicularis)	Shrub	1.8 m	Y	MB, CCW, D, NP, LSOS, PP		Y
Austrostipa elegantissima	Grass	0.35-2 (3) m	Y	NP, LSOS, PP		
Austrostipa tenuifolia	Grass	1.2 m	N			
Babingtonia camphorosmae (previously Baeckea camphorosmae)	Shrub	0.3 m	Y	SA, NP, D, LSOS, PP		Y
Banksia armata	Shrub	3 m	N	NP, LSOS, PP	2	
Banksia attenuata	Tree	10 m	Y	NP, MUC, SA, LSOS, PP	Y -2	
Banksia dallanneyi	Shrub	to 3 m	Y	NP, LSOS, PP	Y	
Banksia grandis	Tree	1.5-10 m	Y	SA, NP, MUC, LSOS, PP	Y -2	
Banksia ilicifolia	Tree/shrub	to 12 m	Y	NP, SA, LSOS, PP	Y -2	
Banksia littoralis	Tree/shrub	1.5-12 m	Y	D	Y -2	

Table 1: List of plant species for use within management areas (continued)

SPECIES NAME	FORM	HEIGHT	LISTED IN KEEPING IT LOCAL	MANAGEMENT AREAS[1]	LOW FLAMMABILITY[2] AND/OR RATING[3]	DIEBACK RESISTANT[4]
Banksia menziesii	Tree	7 m	Y	NP, MUC, SA, LSOS, PP	Y -2	
Banksia nivea	Shrub	1.5 m	Y	NP, SA, LSOS, PP	Y -2	
Banksia sessilis	Shrub/ small tree	8 m	Y	NP, LSOS, PP	2	
Baumea articulata	Sedge	2.6 m	Y	MB, CCW, D	Y	
Beaufortia purpurea	Shrub	0.3-1.5 m	Y	NP, LSOS, PP		
Billardiera fraseri (was Pronaya)	Climber		N		Y - 1	
Billardiera fusiformis	Climbing shrub		N	SA, NP, LSOS, PP	1	
Billardiera heterophylla	Climbing shrub	2 m (long)	Y	MUC, NP, LSOS, PP	Y - 1	
Bossiaea aquifolium	Shrub or tree	0.6-8 m	Y	NP, LSOS, PP	Y -2	
Bossiaea eriocarpa	Shrub	1 m	Y	NP, SA, LSOS, PP	Y -1	
Bossiaea ornata	Shrub - erect	0.15-1 m	Y	NP, SA, LSOS, PP	Y -1	
Burchardia congesta (Previously B. umbellata)	Forb	0.8 m	Y	NP, SA, LSOS, PP	Y -1	Y
Caesia micrantha	Forb	0.6 m	N		Y -1	
Calothamnus lateralis	Shrub - erect and slender	0.4-1.5(2.5)m	Y	D, CCW, MB		Y
Calothamnus quadrifidus	Shrub	0.9-2 m	Y	NP, LSOS, PP		Y
Calytrix angulata	Shrub	0.2-1 m	Y	NP, SA, LSOS, PP		
Casuarina obesa	Tree	10 m	Y	SA, NP, LSOS, PP	Y - 3	Y
Centrolepis drummondiana	Forb	0.12 m	N			

Table 1: List of plant species for use within management areas (continued)

SPECIES NAME	FORM	HEIGHT	LISTED IN KEEPING IT LOCAL	MANAGEMENT AREAS[1]	LOW FLAMMABILITY[2] AND/OR RATING[3]	DIEBACK RESISTANT[4]
Chamaescilla corymbosa	Forb	0.2 m	Y	NP, MUC, LSOS, PP	Y	Y
Conospermum stoechadis	Shrub	0.3-2 m	Y	NP, LSOS, PP	Y - 2	
Conostylis aculeata	Forb	0.06-0.5 m	Y	NP, SA, LSOS, PP	Y -1	Y
Conostylis setosa	Forb	0.3 m	N		Y -1	Y
Corymbia calophylla	Tree	40 m	Y	NP, MUC, LSOS, PP	3	Y
Corymbia ficifolia	Tree	10 m	N	SA, NP, LSOS, PP		
Dampiera linearis	Forb	0.6 m	Y	NP, SA, LSOS, PP	Y - 1	Y
Dasypogon bromeliifolius	Forb	1 m	Y	NP, LSOS, PP	Y - 2	
Daviesia decurrens	Shrub	to 1 m	Y	NP, SA, LSOS, PP	Y - 1	
Daviesia divaricata	Shrub	3 m	N	NP, LSOS, PP		
Daviesia triflora	Shrub	0.25-0.6 m	Y		Y - 1	
Desmocladus fasciculatus	Rush	0.3 m	N		Y - 2	
Dianella revoluta	Forb	0.3-1.5 m	Y	NP, SA, LSOS, PP	Y - 1	
Drosera erythrorhiza	Forb	0.12 m	N			
Eremaea pauciflora	Shrub	4 m	Y	NP, D, LSOS, PP		
Eucalyptus lane-poolei	Mallee or Tree	12 m	Y	SA, NP, MUC, LSOS, PP	Y - 3	Y
Eucalyptus laeliae	Tree	6 m	Y	SA, NP, MUC, LSOS, PP	Y – 3	Y
Eucalyptus marginata	Tree	40 m	Y	SA, NP, MUC, LSOS, PP	Y - 3	
Eucalyptus rudis	Tree	20 m	Y	MB, CCW, D	Y - 3	Y

Table 1: List of plant species for use within management areas (continued)

SPECIES NAME	FORM	HEIGHT	LISTED IN KEEPING IT LOCAL	MANAGEMENT AREAS[1]	LOW FLAMMABILITY[2] AND/OR RATING[3]	DIEBACK RESISTANT[4]
Eucalyptus torquata	Tree	4 m	N	SA, NP, LSOS, PP		
Eucalyptus wandoo	Tree	3-25 m	Y	SA, NP, MUC, LSOS, PP	Y - 3	Y
Gastrolobium capitatum (prev. Nemcia capitatum)	Shrub - prostrate to low	to 1 m	Y	SA, NP, LSOS, PP	Y - 1	
Gastrolobium spinosum	Shrub - low to erect	to 3.5 m	Y	NP, LSOS, PP	Y - 2	
Gompholobium knightianum	Shrub	0.5 m	Y	SA, NP, BF, LSOS, PP	Y - 1	
Gompholobium marginatum	Shrub	0.4 m	Y	SA, NP, LSOS, PP	Y - 1	
Gompholobium tomentosum	Shrub - erect	0.3-1 m	Y	SA, NP, LSOS, PP	Y - 1	Y
Grevillea bipinnatifida	Shrub	0.2-1 m	Y	SA, NP, LSOS, PP	Y - 2	
Grevillea obtusifolia	Shrub	0.2-2 m	Y	NP, MB, D, LSOS, PP	Y - 2	Y
Grevillea pilulifera	Shrub	0.2-1 m	Y	NP, SA, LSOS, PP	Y - 2	
Grevillea vestita	Shrub	0.5-3 (4.5) m	Y	NP, LSOS, PP	Y - 2	
Grevillea wilsonii	Shrub	0.4-1 (1.3 m)	Y	NP, SA, LSOS, PP	Y - 2	
Haemodorum spicatum	Forb	2 m	N	NP, LSOS, PP	Y - 1	
Hakea ceratophylla	Shrub	0.5-2 m	Y	NP, LSOS, PP	Y - 2	
Hakea incrassata	Shrub	0.35-1.5 m	Y	NP, SA, LSOS, PP	Y - 2	
Hakea lissocarpha	Shrub	1.5 (3m)	Y	MB, CCW, D	Y - 2	Y
Hakea prostrata	Shrub	1-3 m	Y	NP, LSOS, PP	Y - 2	
Hakea ruscifolia	Shrub	0.5-3 m	Y	NP, LSOS, PP	Y - 2	
Hakea spathulata	Shrub	3 m	N			

Table 1: List of plant species for use within management areas (continued)

SPECIES NAME	FORM	HEIGHT	LISTED IN KEEPING IT LOCAL	MANAGEMENT AREAS[1]	LOW FLAMMABILITY[2] AND/OR RATING[3]	DIEBACK RESISTANT[4]
Hakea stenocarpa	Shrub	0.3-1(2) m	Y	NP, LSOS, PP	Y - 2	
Hakea sulcata	Shrub	0.4-2 m	Y	NP, LSOS, PP	Y - 2	
Hakea trifurcata	Shrub	1.5-3 m	Y	NP, LSOS, PP	Y - 2	
Hakea varia	Shrub	3 m (4 m)	Y	MB, CCW, D	Y - 2	
Hardenbergia comptoniana	Climber		Y	MB, CCW, D	Y - 1	Y
Hemiandra pungens	Shrub - prostrate to erect	0.05-1 m	Y	NP, SA, LSOS, PP	Y - 1	Y
Hibbertia commutata	Shrub - erect or sprawling	0.1-0.6(1) m	N	NP, SA, LSOS, PP	Y - 1	
Hibbertia huegelii	Shrub - erect-spreading	0.1-0.6(1.5)m	Y	NP, SA, LSOS, PP	Y - 1	
Hibbertia hypericoides	Shrub	0.2-1(1.5)m	Y	NP, SA, LSOS, PP	Y - 1	
Hibbertia racemosa	Shrub	0.1-0.75 m	Y	NP, SA, LSOS, PP	Y - 1	Y
Hibbertia stellaris	Shrub	0.15-1.5 m	Y	MB, D	Y - 1	
Hibbertia vaginata	Shrub	0.2-0.75 m	Y	NP, SA, LSOS, PP	Y - 1	
Hovea trisperma	Shrub - straggly to ascending	0.1-0.7 m	Y	NP, SA, LSOS, PP	Y - 1	Y
Hybanthus calycinus	Forb	0.1-0.6 m	Y	NP, SA, LSOS, PP	Y - 1	
Hypocalymma angustifolium	Shrub	1.5 m	Y	MB, CCW, D		Y
Hypocalymma robustum	Shrub	0.4-1(1.5) m	Y	NP, SA, LSOS, PP		
Jacaranda mimosifolia	Tree	10 m	N	SA		

Table 1: List of plant species for use within management areas (continued)

SPECIES NAME	FORM	HEIGHT	LISTED IN KEEPING IT LOCAL	MANAGEMENT AREAS[1]	LOW FLAMMABILITY[2] AND/OR RATING[3]	DIEBACK RESISTANT[4]
Jacksonia furcellata	Shrub	0.4-4(6) m	Y	NP, LSOS, PP	Y - 2	
Jacksonia sternbergiana	Shrub/ Tree	1.5-5 m	Y	MB, CCW, D	Y - 2	
Juncus pallidus	Sedge	2 m	Y	MB, CCW, D	Y - 2	Y
Kennedia coccinea	Climber	-	Y	NP, SA, LSOS, PP	Y - 2	Y
Kennedia prostrata	Forb/ prostrate shrub	prostrate	Y	NP, MUC, MB, CCW, D, LSOS, PP	Y - 2	Y
Kunzea glabrescens (previously K. ericifolia)	Shrub	4 m	Y	D, MB		
Kunzea micrantha	Shrub	1.5 m	Y	D, MB		
Kunzea recurva	Shrub	2 m	Y	D, MB		
Labichea lanceolata	Shrub	3 m	N			
Lechenaultia biloba	Shrub	1 m	Y	NP, SA, LSOS, PP	Y - 1	Y
Lepidosperma leptostachyum	Sedge	1 m	N	D, MB, CCW	2	
Lepidosperma longitudinale	Sedge	2 m	Y	MB, CCW, D	Y - 2	
Lepidosperma pubisquameum	Sedge	0.4 m	N			
Lepidosperma tetraquetrum	Sedge	2-3 m	Y		Y - 2	Y
Leptospermum erubescens	Shrub	1-3 m	N	NP, LSOS, PP		
Lepyrodia glauca	Sedge	1.5 m	N	Rehab, drainage	2	
Leucopogon capitellatus	Shrub	0.2-1 m	Y	NP, SA, LSOS, PP	Y - 1	
Levenhookia pusilla	Forb	0.1 m	N	NP, LSOS, PP	Y - 1	

Table 1: List of plant species for use within management areas (continued)

SPECIES NAME	FORM	HEIGHT	LISTED IN KEEPING IT LOCAL	MANAGEMENT AREAS[1]	LOW FLAMMABILITY[2] AND/OR RATING[3]	DIEBACK RESISTANT[4]
Lobelia anceps(previously L. alata)	Forb	to 1.2 m	Y	D, SA, NP, LSOS, PP	Y - 1	
Macrozamia riedlei	Tree - cycad	0.5-3 m	Y	NP, LSOS, PP	Y - 2	
Meeboldina cana	Rush	0.35-1.2 m	Y	MB, D	Y - 2	
Melaleuca cuticularis	Tree	7 m	Y	MB, CCW, D, SA		Y
Melaleuca lateritia	Shrub	2.5 m	Y	MB, CCW, D		Y
Melaleuca preissiana	Shrub or tree	2-9 m	Y	MB, CCW, D, SA	3	Y
Melaleuca rhaphiophylla	Shrub or Tree	10 m	Y	MB, CCW, D, SA	3	Y
Melaleuca scabra	Shrub	0.2-1.5 (2) m	Y	NP, LSOS, PP		Y
Melaleuca systena	Shrub	0.5-2(3) m	Y	NP, LSOS, PP		Y
Melaleuca trichophylla	Shrub	0.15-1 m	Y	NP, SA, LSOS, PP		Y
Melaleuca viminea	Shrub or tree	0.6-5 m	Y	NP, D, MB, LSOS, PP		Y
Mesomelaena pseudostygia	Sedge	1 m	N		2	
Mesomelaena tetragona	Sedge	0.8 m	N		2	
Microlaena stipoides	Grass	0.75 m	Y	D, MB		
Monotaxis grandiflora subsp. grandiflora	Shrub	0.15 m	N		1	
Neurachne alopecuroidea	Grass	0.5(0.8) m	N			
Nuytsia floribunda	Tree	10 m	Y	NP, MUC, LSOS, PP	Y - 2	Y
Patersonia occidentalis	Forb	to 1.5 m	Y	NP, SA, LSOS, PP	Y - 1	Y

Table 1: List of plant species for use within management areas (continued)

SPECIES NAME	FORM	HEIGHT	LISTED IN KEEPING IT LOCAL	MANAGEMENT AREAS[1]	LOW FLAMMABILITY[2] AND/OR RATING[3]	DIEBACK RESISTANT[4]
Pericalymma ellipticum	Shrub	to 3 m	Y	NP, D, MB, LSOS, PP		
Persoonia elliptica	Shrub/Tree	8 m	N	NP, MUC, LSOS, PP		
Petrophile linearis	Shrub - erect	0.2-1 m	Y	NP, SA, LSOS, PP	Y - 2	
Petrophile macrostachya	Shrub	0.3-1.2 m	N		2	
Philotheca spicata	Shrub	0.6 m	Y	NP, SA, LSOS, PP		
Phlebocarya ciliata	Forb	0.2-0.6 m	Y	D, MB	Y - 1	Y
Phyllanthus calycinus	Shrub	0.2-1.2 m	Y	NP, SA, LSOS, PP	Y - 1	Y
Quinetia urvillei	Forb	0.2 m	N		Y - 1	
Regelia ciliata	Shrub	0.5-2 m	Y	D, MB		
Rhytidosperma caespitosum	Grass	0.3 m	N			
Sapium sebiferum	Tree	10 m	N	SA		
Scaevola calliptera	Forb	0.1-0.4 m	Y	NP, SA, LSOS, PP	Y - 1	
Schoenus latitans	Sedge	0.04 m	N			
Scholtzia involucrata	Shrub	1.5 m	Y	NP, LSOS, PP		
Sowerbaea laxiflora	Forb	0.15-0.45	Y	NP, SA, LSOS, PP	Y - 1	
Stirlingia latifolia	Shrub	0.2-1.5 m	Y	NP, SA, LSOS, PP	Y - 1	
Stylidium brunonianum	Forb	0.7 m	N			
Stylidium carnosum	Forb	1 m	N			

Table 1: List of plant species for use within management areas (continued)

SPECIES NAME	FORM	HEIGHT	LISTED IN KEEPING IT LOCAL	MANAGEMENT AREAS[1]	LOW FLAMMABILITY[2] AND/OR RATING[3]	DIEBACK RESISTANT[4]
Stylidium dichotomum	Forb	0.4 m	N			
Taxandria linearifolia (previously Agonis linearifolia)	Tree or shrub	5 m	Y	CCW, MB, D		
Thysanotus dichotomus	Forb	1 m	Y	NP, SA, LSOS, PP	Y - 1	Y
Thysanotus multiflorus	Forb	0.5 m	Y	NP, SA, LSOS, PP	Y - 1	
Thysanotus tenellus	Forb	0.3 m	N		1	
Thysanotus thyrsoideus	Forb	0.35 m	N		1	
Trichocline spathulata	Forb	1 m	N		1	
Verticordia acerosa	Shrub	0.2-1 m	Y	NP, SA, LSOS, PP		
Verticordia densiflora	Shrub	0.25-2 m	Y	NP, LSOS, PP		
Verticordia huegelii	Shrub	0.05-1.4 m	Y	NP, SA, D, LSOS, PP		
Verticordia plumosa	Shrub	0.2-1.5 m	Y	NP, SA, D, LSOS, PP		
Viminaria juncea	Shrub	1-4 m	Y	MB, D	Y - 2	Y
Xanthorrhoea gracilis	Shrub	2 m	Y	NP, LSOS, PP		
Xanthorrhoea preissii	Shrub	5 m	Y	NP, MUC, LSOS, PP		
Xylomelum occidentale	Tree	8 m	Y	NP, MUC, SA, LSOS, PP	Y - 2	

APPENDIX D

emerge ASSOCIATES
Integrated Science & Design

OUTLINE OF MONITORING AND EVALUATION REQUIREMENTS

Outline of Monitoring and Evaluation

The purpose of vegetation monitoring is to provide information about the success of revegetation within the conservation areas, and to adjust the way in which the rehabilitation is undertaken if the outcomes of the current methods are not satisfactory in returning natural biodiversity to the area.

Vegetation monitoring will involve setting up permanent monitoring quadrats within the conservation areas identified within the ILMS. In addition to monitoring quadrats, control-monitoring plots will be established within nearby undisturbed/natural vegetation to provide a mechanism for comparison.

The quadrats should be established in autumn before rehabilitation work begins and the initial data recorded. The second round of monitoring should be undertaken in the spring of that year, followed by two more monitoring periods in the autumn and spring of the following year. The information gathered from the monitoring will indicate the success of the revegetation and whether further planting or management is required.

The number of the monitoring quadrats within the conservation area will be dependent on the area, but will need to cover 4% of the area to provide adequate data. All quadrats must be the same dimensions so that comparison between plots and across data can be made, a 5 x 5 metre monitoring quadrats is recommended where possible. Specific monitoring will include a visual inspection and a visual representation (e.g. photograph).

Once the quadrats have been established the following data should be recorded for each plot:

- Quadrat Number.
- Location.
- Dimensions of the area.
- Visual representation e.g. photograph, from a set point.
- List of all vascular plants present.
- Number of individuals of each native plant species.
- Number of individuals of each exotic plant species.
- After root stock have been planted, record species and number of root stock.
- After seed have been sown, record species and densities sown.
- To determine the success of the monitoring, the following completion criteria should be achieved by the final spring monitoring period:
    - Root stock are healthy in appearance, diverse with no mass losses or species dominance.
    - The average seedling height has increased between assessments.
    - More than 75% of tube stock (from original and replacement plants) plants are alive.
    - Weed presence is minimal and not inhibiting native plant survival and growth.

These expectations are for a period of normal weather conditions and limited access to the site. Temporary signage will be erected around the revegetation areas to alert the community and contractors of the revegetation underway.

As the Conservation Category Wetland buffer and Manjedal Brook foreshore reserve areas are in ‘Completely Degraded’ condition, preparation of the area and ongoing maintenance will need to address weed control, infill planting and the integrity of protection features such as windbreaks, fences and stakes to ensure success.

Appendix H

Transport Report

PEET MUNDIJONG SYNDICATE PTY LTD

TAYLOR ROAD, MUNDIJONG

STRUCTURE PLAN TRAFFIC REPORT

February 2016

PO BOX Z5578

Perth WA 6831

0413 607 779 Mobile

Issued on	122February 2016	Amendments	Date
Version	V4	V2 report updated V3 Yield adjusted	21-01-16 08-02-16
Reference	648	V4 plans updated	22-02-16

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1.0 EXECUTIVE SUMMARY

Riley Consulting has been commissioned by the Peet Mundijong Syndicate Pty Ltd to consider the traffic and transport impacts of developing land at Taylor Road, Mundijong. The development proposes infill residential dwellings to the south of Bishop Road bounded by the future Tonkin Highway and Soldiers Road. The key findings of the traffic overview are:

- The traffic assessment undertaken for the structure planning of the subject land has used a Saturn model to distribute traffic demands to the surrounding road network. The model includes traffic generated within the Whitby-Mundijong district structure plan to ensure adjacent development traffic movements are fully considered.

- The development of the subject land has already been included in the traffic planning undertaken for the Whitby-Mundijong district structure plan. The Saturn traffic model forecast demands do not significantly affect the current planning outcomes of the Whitby-Mundijong district structure plan.

- Access to the subject land can be achieved from Taylor Road, Bishop Road and Soldiers Road.

- Structure planning of land to the south of the subject land identified that the intersection of Taylor Road / Mundijong Road may need to be upgraded to a roundabout. The need for this upgrading will be subject to the construction of the Tonkin Highway and whether Bishop Road has access to the Tonkin Highway.

- The road hierarchy developed for the subject land is cognisant of the road network planning for the Whitby-Mundijong district structure plan at of 2014. A minimum road reservation of 20 metres is suggested for neighbourhood connectors, 16 metres for higher order access streets and 15 metres for lower order access streets.

- All access streets have low daily traffic volumes and are considered appropriate for on-street cycling. A principal shared path is indicated in the Whitby-Mundijong district structure plan adjacent to the future Tonkin Highway, but the proposed service corridor may compromise access. This matter needs to be addressed once regional planning has determined the accessibility over the service corridor.

RECOMMENDATIONS

The location of the district centre shown in the Whitby structure plan area is expected to exacerbate traffic issues at level crossings accessing Patterson Road / Soldiers Road. Such matters are outside of the subject land.

Revised road network planning in the Mundijong-Whitby District Structure Plan places extraneous traffic through the Mundijong north residential precinct. Connectivity of the link between Patterson Road and the Tonkin Highway interchange is circuitous.

Access to Bishop Road may need to be reviewed depending on the outcomes of District Structure Plan amendments. Access in accordance with *Liveable Neighbourhoods* principles is recommended.

Primary schools should not be located adjacent to higher order roads (roads carrying more than 7,000vpd). A review of local schools will be required if current District Structure Plan amendments are approved.

2.0 THE SITE AND SURROUNDING ROAD NETWORK

Mundijong is located approximately 40 kilometres south east of Perth. The area falls within the Shire of Serpentine - Jarrahdale and is accessed from the South Western Highway and Mundijong Road. Figure 1 shows the location of the subject land. Roads of importance are discussed below.

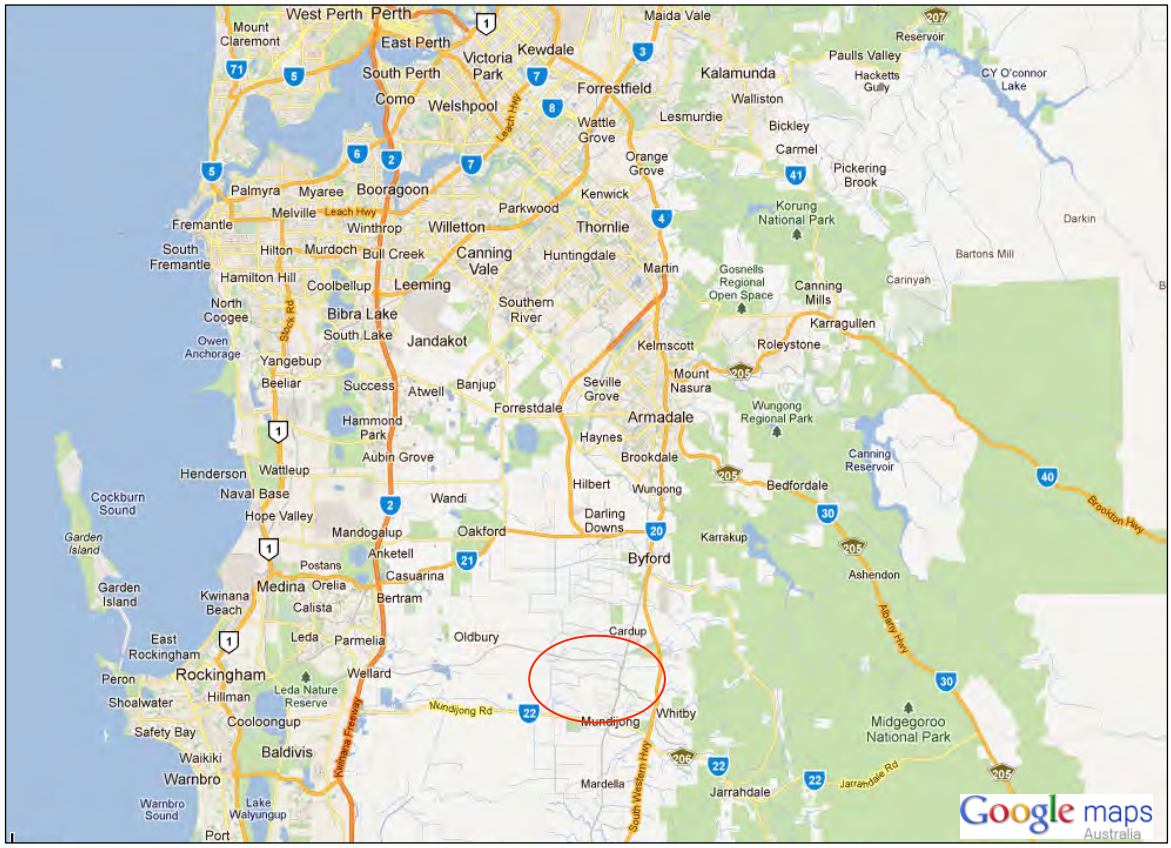


Figure 1 **Site Location** (Site area indicative)

South Western Highway

The South Western Highway is a primary regional road under the control of Main Roads Western Australia (MRWA). It provides a major traffic and freight route between Pinjarra to the south and the eastern industrial areas of Perth (Kewdale and the airport etc.). It also provides connectivity at a regional level to the Tonkin Highway and Albany Highway.


Photograph 1 South Western Highway

Photograph 1 shows the view looking north along the South Western Highway to Watkins Road (Mundijong Road).

The South Western Highway is generally constructed as a rural standard single lane road with 2 traffic lanes. A northbound overtaking lane exists at the intersection of Watkins Road, which will make egress from Watkins Road difficult and potentially dangerous during busy periods. A right turn deceleration lane is provided on the highway for southbound traffic. The South Western Highway has a posted speed limit of 90kph adjacent to the locality of Mundijong.

Current traffic data provided by MRWA indicates 5,777 vehicle movements per day (17.6% HGV) to the south of Reilly Road (June 2015). The peak hours show 420 vehicles in the morning and 520 in the evening. Further south, traffic flows are higher with MRWA data indicating 6,004vpd south of Watkins Road in 2010. It is noted that at the same located the daily flow was 10.054vpd in 2009.

Watkins Road – Mundijong Road

Watkins Road is the continuation of Mundijong Road to the east of the Perth – Bunbury rail line. It is constructed as a single carriageway road with 2 traffic lanes. A standard 7.2 metre carriageway is provided. Photograph 2 shows Watkins Road looking towards Mundijong. Photograph 3 shows Mundijong Road west of the town looking to the west.



Photograph 2 Watkins Road


Photograph 3 Mundijong Road

Traffic data provided by MRWA indicates 2,400 vehicle movements per day on Watkins Road to the west of the South Western Highway (2008/09). The current level of traffic movements at this location supports the current provision of yield control to Watkins Road.

A controlled level crossing is provided at the railway line. A 60kph posted limit applies through the town site area. To the west, about 200m west of Patterson Street, an 80kph posted limit applies. Approximately 50 metres west of Adonis Street a 100kph posted limit applies.

Traffic data sourced for Mundijong Road shows:

- 3,280vpd west of Patterson Street (2013)
- 4,592vpd east of King Road (2015)
- 3,946vpd east of the Kwinana Freeway (2013)

Overall it can be seen that Watkins Road and Mundijong Road are operating well within their derived operational capacity and will experience very good Levels of Service.

Patterson Street / Soldiers Road

Patterson Street is the main street to the Mundijong town site and is constructed with a wide 9 metre carriageway (approximate) in a 20 metre road reservation. Photograph 4 shows Patterson Street at Mundijong town centre. Patterson Street links Mundijong Road to Abernethy Road in Byford. It is classified as a district distributor type A road in the MRWA *Functional Road Hierarchy.* Historical traffic data from MRWA (2004/05) indicates 2,200 vehicle movements per day. It is unlikely that this daily volume has changed significantly.



Photograph 4 Patterson Street

Bishop Road

Bishop Road provides an east-west connection between Kargotich Road and Soldiers Road. It is classified as a local distributor road in the Main Roads *Functional Road Hierarchy* with a functional Class of Significant Urban Local Road. It is located to the south of the freight rail line and to the northern side of the Mundijong structure plan area. A road reservation of 20 metres is provided. Photograph 5 shows the view looking along Bishop Road.



Photograph 5 Bishop Road

No traffic data is available, although it can be expected that current volumes are well below 500 vehicles per day. Close to the intersection of Soldiers Road is a school that can be expected to increase traffic flows at the eastern end. However, such increases would only affect school pick-up / drop-off periods typically between 08:15 – 09:00 and then 14:30 to 15:30.

Kargotich Road

Kargotich Road is classified as a district distributor type B road in the MRWA *Functional Road Hierarchy*. It provides a currently important north-south connection between Mundijong Road and Thomas Road. However, construction of the future Tonkin Highway will attract the majority of traffic using this road.

Traffic data from MRWA indicates 1,730 vehicle movements per day to the north of Bishop Road and 2,387vpd south of Orton Road (2012).

Taylor Road / Adams Street

Classified as local distributor roads, Taylor Road and Adams Street provide a convenient north-south link between Richardson Street and Bishop Road. Photograph 6 shows the view looking north along Taylor Road close to Lang Road.



Photograph 6 Taylor Road

The current sealed width of Taylor Road / Adams Street is about 6 metres (approximately) and may require additional width to cater for significant increases in traffic demand. A road reservation of 20 metres is provided. There is an existing bridge over Manjedal Brook approximately 400 metres south of Bishop Road.

At Bishop Road a left-right stagger leads to Hopkinson Road, which is classified as a district distributor type B road. Hopkinson Road provides a convenient link to the south of Armadale and may be attractive to commuter traffic. However, the development of the Tonkin Highway will negate Hopkinson Road as a desirable route.

Livesey Street and Tonkin Street

These two streets are existing east-west connections between Patterson Street and Adams Street. Constructed with standard 7.2 metre wide carriageways, these streets are rural residential in nature.

Cockram Street

Cockram Street is a local access street that links Adonis Street through to Patterson Street. It is bounded by larger residential lots and provides access to local sporting facilities. It is

constructed with a standard 7.2 metre wide carriageway (approximate). Present day traffic movements would be expected to be less than 500 vehicles per day. West of Butcher Street a standard 20 metre wide road reservation is provided.

Adonis Street

Adonis Street is a local access street that links Richardson Street to Mundijong Road. It is bounded by larger lots and provides access to about 8 properties south of Cockram Street. It is constructed with a standard 7.2 metre wide carriageway (approximate). Present day traffic movements would be expected to be less than 500 vehicles per day.

Kiernan Street

Kiernan Street is a local access street providing an east-west connection between Patterson Street and Taylor Road. Photograph 7 shows the view along Kiernan Street.



Photograph 7 Keirnan Street

No traffic data is available for Kiernan Street, but based on current levels of development accessed from this link, a daily flow of less than 500 vehicles would be expected.

Tonkin Highway

To the west of the subject land, an existing road reservation is set aside for the construction of the future Tonkin Highway. At present the construction of the Tonkin Highway is not in the MRWA 4-year programme. It can be expected to be required at the time when daily volumes on the South Western Highway reach about 15,000vpd. At this point a poor Level of Service will exist for regional movements and widening would be warranted. However, the construction of the Tonkin Highway would negate the need to widen the South Western Highway.

Appendix A shows the current MRWA / DPI planning for the Tonkin Highway adjacent to Mundijong. As part of the highway proposal, a re-alignment of Mundijong Road to provide a connection to Jarrahdale Road has been indicated.

Current traffic volumes on the Tonkin Highway north of Thomas Road are 14,642 (2013). It would be expected that the future extension would carry about 9,000vpd on opening.

Mundijong – Whitby District Structure Plan

A district structure plan has already been prepared for the Whitby – Mundijong locality and is provided on the Shire of Serpentine – Jarrahdale website. Traffic forecasts have been provided and are attached as Appendix B. At the time of updating this report in February 2016 changes to the District Structure Plan have been suggested. However, details provided indicate the proposed road network changes would be unworkable. These changes cannot therefore, be considered in this report.

As a result of the traffic forecasting for the district, the following works can be expected:

- Mundijong Road – Forecast flow of 12,000vpd. Single lane road would operate but with increased delay in peak periods. If railway crossings removed, the volume increases to 16,000vpd. Therefore assume road reservation of 30 metres for future duplication to be required.
- Taylor Road / Adams Street – Forecast flow of 5,000vpd. Therefore assume road reservation of 20 metres for neighbourhood connector to be required.

Figure 2 shows the indicative structure plan.

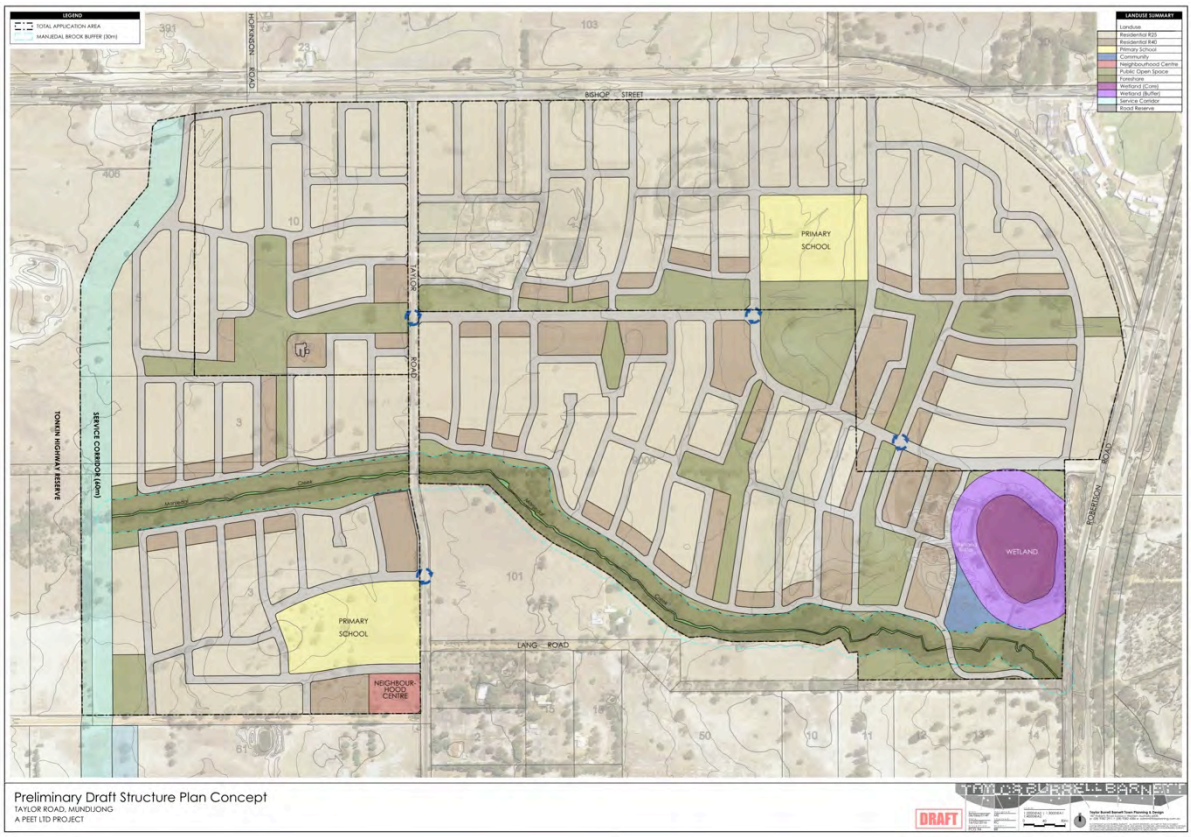


Figure 2 **Indicative Structure Plan Concept** (refer to planner for detail)

3.0 TRAFFIC GENERATION AND DISTRIBUTION

The development of residential land at Mundijong will provide for the growing population forecast for Perth and the south eastern rural areas.

Reference to trip generation source documents suggest that the trip generation of a typical household can vary from 5 trips to 11 trips per day. Traffic analysis of similar development to the north of Mundijong identified a residential trip rate of 8 trips per dwelling per day, which is slightly higher than the Perth metropolitan average rate of 7 trips per day. The trip rate is based on typical R20 density, which is attractive to families.

It is understood that other developments have indicated a higher density level of development in Mundijong that may be expected to generate a lower average rate per household. However, the use of 8 trips per dwelling will provide a robust assessment of the road network and provide flexibility for future planning to meet consumer demands.

The concept plan indicates a yield of about 3,000 residential lots and on the basis of 8 trips per lot the site can be expected to generate (3,000 x 8) 24,000 vehicle movements per day.

The subject site is expected to generate 24,000 trips per day.

The subject land will provide two primary schools, which will retain traffic within the developable area.

Distribution

Table 1 shows the distribution assumptions by trip purpose used to assign traffic onto the external road network. The distribution used is as per previous assumptions for land to the south. The traffic generation and distribution has been used to prepare a matrix for the Saturn traffic model.

Table 1 Composition of Residential Trips

Purpose of trips	% of Total	North Tonkin	North SW Highway	East	South – SW Highway	South - Freeway	West Rockingham / Freeway north
Home Based – Work	29%	30%	8%	2%	10%	10%	40%
Home Based – Education	Assigned by school						
Home Based – Other	36%	15%	5%	5%	10%	15%	50%
Home Based – Evening	21%	30%	10%	0%	0%	10%	50%
Non-Home Based	14%	50%	5%	0%	3%	7%	35%

Traffic Modelling

The development of the subject land will need to be considered in regard to development within the Whitby-Mundijong district structure plan area as indicated in Appendix C. A traffic model has been created using Saturn to assign traffic to the future road network. The model uses the trip generation and distribution assumptions discussed above applied to the district structure plan area. The modelled area is indicated in Appendix D.

The following assumptions have been made with regard to traffic accessing the surrounding road network. The speeds are the estimated journey time speeds including movement delays at intersections etc. - they may not match the free-flow posted speed.

- New residential roads operate with a speed of 40kph and 30kph.
- Neighbourhood connectors operate at 50kph.
- Mundijong Road operates at 60kph between Tonkin Highway and the rail crossing, then 70kph.
- Tonkin Highway / Mundijong Road re-alignment operates at 80kph (long term)
- South Western Highway 110kph
- Freeway and Tonkin Highway 100kph
- Bishop Road operates at 60kph
- Soldiers Road operates at 60kph and 70kph north of Bishops Road

Trips to schools are based on the Education Department's assessment of 0.35 pupils per household. 30% of home based other trips are assigned to localised shopping (Whitby district centre and Mundijong town centre).

4.0 DEVELOPMENT TRAFFIC IMPACTS

The development of the subject land is anticipated to generate about 24,000 trips per day, which is higher than expectations of previous studies. Table 2 shows the anticipated road network impacts to the district structure planning based on the revised traffic forecasts (refer to Appendix B for DSP forecasts). The traffic model prepared to consider the subject land includes all local development and infill development expectations within Mundijong. The modelling also includes expectations of the development of Whitby and connection through to Bishop Road

Table 2 Changes to District Structure Plan Forecasts

Road	DSP	Forecast	Comment
Watkins Road at Mundijong	5,000	6,100	In line with DSP
Mundijong Road west of Patterson	13,000	8,500	In line with DSP
Mundijong Road east of Tonkin	12,000	18,000	**Higher than DSP**
South Western Highway	12,000	13,350	In line with DSP
Patterson St at Mundijong	11,000	10,380	In line with DSP
Soldiers Rd	13,000	13,850	In line with DSP
Taylor Rd S Bishop	7,000	6,150	In line with DSP
Taylor Road S Scott	5,000	5,600	In line with DSP
Bishop Road at Tonkin	14,000	21,450	**Higher than DSP**
Bishop Road at Soldiers	1,4000	12,700	In line with DSP
Tonkin Highway	18,000	19,500	In line with DSP

Table 2 shows that the development of the subject site generally retains traffic forecasts to levels identified in the district structure plan. There are some external roads that are shown to carry a greater traffic demand that are discussed below:

Mundijong Road east of Tonkin Highway

The revised modelling indicates a greater attraction to Mundijong Road to access the Tonkin Highway and locations to the west accessed from Mundijong Road (Rockingham etc.). This is most likely due to different modelling of the Tonkin Highway. Plans provided by

MRWA indicate Mundijong Road to be a four lane divided road at this location, and the increase in traffic will not affect the planning of this road.

Bishop Road

The forecast traffic demands on Bishop Road are subject to full movement being provided to the Tonkin Highway and access to Whitby over the existing freight rail line. The DSP forecast of 14,000vpd would suggest that planning for a four lane divided road would be identified in the district structure plan. The revised forecast is within the capacity of a four lane divided road. The forecast traffic demands indicate that an integrator street type B is an appropriate classification and a road reservation of 25.2m to 29.2 metres should be provided.

At present the road reservation of Bishop Road is 20 metres and Liveable Neighbourhoods would suggest an increase of 5.2 metres – 9.2 metres. The need to widen Bishop Road will occur as a result of the re-alignment of the existing freight rail line and the provision of access between Whitby and Bishop Road. Prior to this occurrence, the traffic demands on Bishop Road will be from local traffic and are unlikely to be greater than 7,000vpd (modelling indicates that without Whitby a neighbourhood connector is sufficient).

Bishop Road will require widening after the freight rail line is relocated

To the north of Bishop Road there is an existing freight rail reservation which will become redundant once the freight rail is relocated. After the relocation of the freight rail line ample land will be available to widen Bishop Road to provide a four lane divided road between Whitby and the Tonkin Highway. It is considered that the existing 20 metre road reservation will be sufficient to cater for the development of the subject land.

Tonkin Highway

Tonkin Highway will be constructed as four lane divided freeway and the change in forecast traffic demands will retain Level of Service A.

It is concluded that the revised traffic forecasts do not change road network planning identified in the district structure plan.

Impacts to Existing Land Uses

The Serpentine-Jarrahdale Grammar School is located to the north of the subjects land to the corner of Soldiers Road and Bishop Road. The development of the subject land will

result in greater traffic demands to surrounding road and may impact the intersection of Soldiers Road / Bishop Road. A right turn lane treatment may be required for this intersection.

Longer term planning of the district may see grade separation of the freight rail line at this location that will significantly impact local traffic movements.

5.0 ACCESS

The subject land is bounded by Bishop Road, Soldiers Road and also has access to Taylor Road. Access is reviewed in regard to typical intersection capacity constraints set out by Austroads, reproduced below. Based on the upper levels of flow indicated by Austroads, Table 3 assesses the expected intersection treatments. The forecast volumes used are based on the district level modelling and include the development of Whitby etc. Initial access to existing roads would be made using simple priority tee intersections until traffic demands required some form of upgrading.

Table 5.5 — Typical Limits of Intersection Capacity (vph)

(Four way intersection with equal demand for all movements

Approach Width	Type of Control		
	No signals [a]	Round-about[b]	Signals[c].
1 lane	1500	2600	1500
2 lanes	1500	4560	3000
3 lanes	1500	6000	4500
4 lanes	1500	na.	6000

Notes:
(a) Based on practical absorption capacities of unsignalised intersections.
(b) Based on gap acceptance criteria.
(c) Based on four split phases (120s cycle).

Table 3 External Access Operation

Location	Major Road	Minor Road	Peak Hourly Flow	Type
A	Bishop Road*	Access St	2,145	Roundabout
B	Bishop Road	Taylor Road	1,825	Roundabout
C	Bishop Road	Access St	1,424	Priority
D	Bishop Road	Access St	1,366	Priority
E	Bishop Road	Neighbourhood	1,435	Priority
F	Bishop Road	Access St	1,392	Priority
G	Soldiers Road	Neighbourhood	1,532	Roundabout
H	Soldiers Road	Neighbourhood	1,460	Priority
J	Taylor Road	Access St	780	Priority

*Subject to access controls

Figure 3 shows the expected long-term intersection control requirements for the subject land access. Note that intersections adjacent to school sites should be reviewed at the time of subdivision.

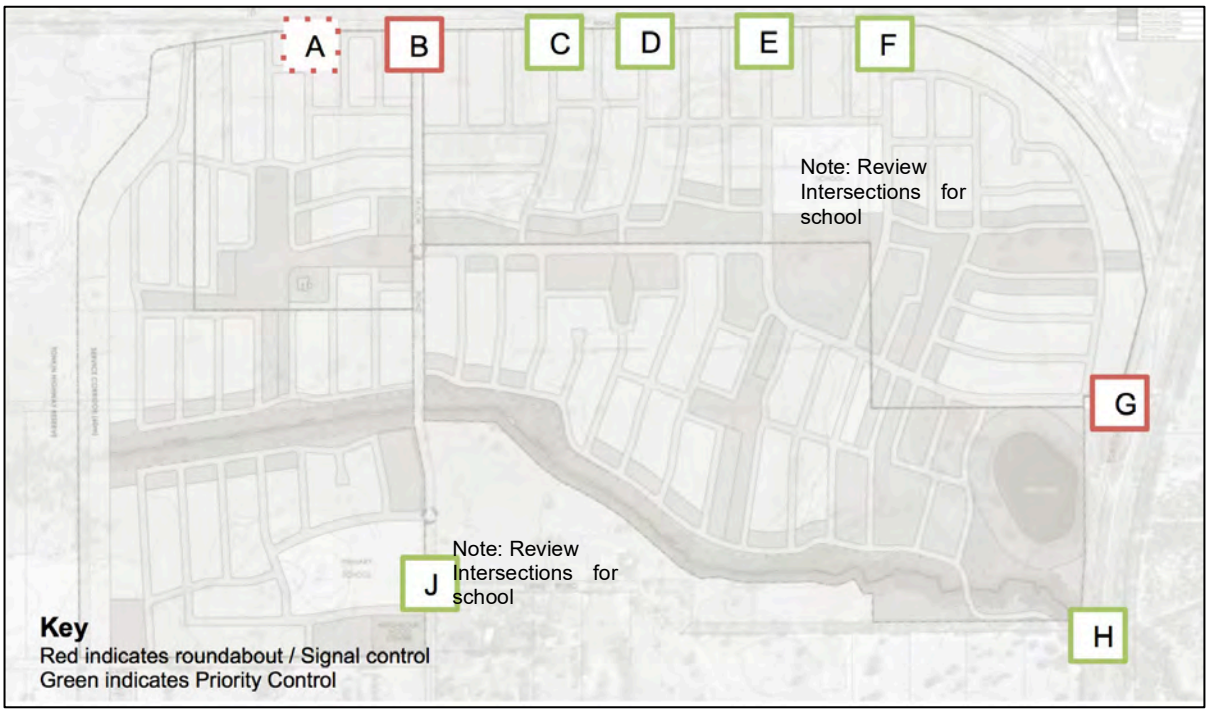


Figure 3 Long Term External Intersection Control Requirements

Intersection A needs to be reviewed as the constructyion of the Tonkin Higway may restrict this access to left-in / lefyt-out.

Access to Bishop Road

Access to Bishop Road will need to accord with the intersection spacing requirements set out in *Liveable Neighbourhoods*. Based on integrator A standard, intersection spacing will be 130m (junctions on same side of street). Direct lot access would not be permitted, although service lanes maybe used. This matter needs to be considered in more detail at the time of subdivision.

6.0 THE INTERNAL ROAD NETWORK

The forecast traffic flows provide a basis to develop an internal road hierarchy. Table 5 reproduces the advice on road types recommended by *Liveable Neighbourhoods.* The road hierarchy considers those streets that have a connective function and assigns an appropriate classification based on volume and continuity of movement.

The traffic model has been used to determine the anticipated daily traffic flows on local streets. Appendix E shows the modelled forecast flows based on the *Liveable Neighbourhoods* road classification volumes. The forecasts assume full development of the Mundijong and Whitby localities.

Figure 9 shows the suggested road hierarchy for the subject land and identifies all streets operating with daily traffic flows greater than 1,000vpd (higher order access streets and above).

Table 5 *Liveable Neighbourhoods* Road Hierarchy

Indicative Traffic Flow*	Classification	Street Characteristics	Typical Reserve Width
<300vpd	Laneway	Laneways may incorporate some services and can provide rubbish collection access. Laneways usually contain some studio units over garages for surveillance. Lane may be widened in parts to create mews courts.	Pavement - 6.0m to 6.4m
< 1,000vpd	Lower order Access Street (D)	Access street D is for short, low volume and low parking demand streets. In addition, a comprehensively designed variant with 3.5 m travel lane with indented parking is also specified for very low volume short streets. Indicative pavement 5.5m to 6m	14.2m
1,000vpd to 3,000vpd	Higher order Access Streets (A – C)	The most typical and most common residential street will be Access street C – Yield street. Indicative pavement 7m to 7.5m	15.4m to 16m
	B	Access street B is a wider undivided street for situations with increased parking and/or traffic demand. Indicative pavement 9.7m.	16.5m to 18m
	A	Access street A is a wider avenue for situations with increased parking and/or traffic demand with median suited to incorporation of a drainage swale. Indicative pavement 2 x 3.5 (or 2 x 3.6 under some conditions) plus indented parking.	20m to 24m

3,000vpd to 7,000vpd	Neighbourhood Connector B	A two-lane undivided street for lower volume neighbourhood connectors. Typically can accommodate buses, will have at least one shared path and above 3000 vehicles per day separate on- street bike lane.	19.4m
	Neighbourhood Connector A	A two-lane divided street used for higher neighbourhood connector volumes, or for character, storm water infiltration swales or safety. These are often special streets and their design needs to have particular regard to context, function and adjacent land uses.	24.4m
7,000vpd - 15,000vpd	Integrator B (Two lanes, outside centres)	Integrators through centres typically will have at least one clear travel lane in each direction, and parking and/or maneuvering lane. Volumes above 15,000 vehicles per day need detailed design to manage traffic at intersections, facilitate bus movement and deal with parking and access.	25.2m to 29.2m

* Function of streets needs to be considered as well as traffic volume.

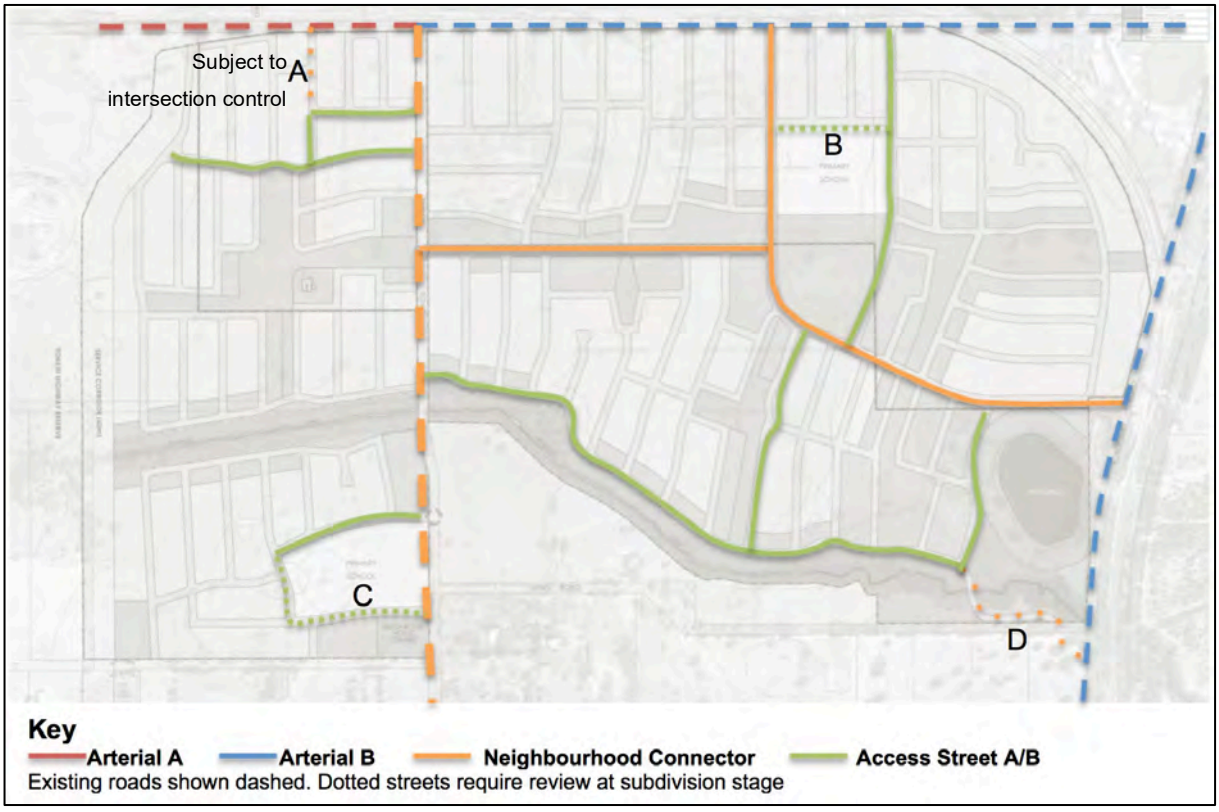


Figure 9 **Road Hierarchy** (All streests are residential access streets unless indicated)

Street shown dotted in Figure 9 should be reviewed closer to the time of subdivision. Road A connecting to Bishop Road may be restricted to left-in / left-out at the time of the Tonkin Highway construction This will reduce the traffic demand on this link. Roads B and C are adjacent to proposed primary schools and a wider reservation may be required to provide

on-street parking. Road D linking to Soldiers Road is shown to operate as a neighbourhood connector. However, with no residential frontage, a significantly reduced road reservation would be appropriate.

The following section provides guidance on the suggested hierarchy with regard to reserves and cross-sections. The cross-sections indicated are the minimum widths recommended for the various street types. The philosophy of providing constrained streets is to encourage a slower speed environment. However, wider reservation widths may be used to suit the character of the development and increase the opportunity for landscaping and frontage activity.

Neighbourhood Connectors

Liveable Neighbourhoods provides the following comment on neighbourhood connectors:

Neighbourhood connectors link neighbourhoods and towns, are carefully designed to calm traffic, limit noise and facilitate pedestrian use. They have frequent local street connections. They should not attract substantial long distance through traffic, but provide for safe and convenient local travel to and from arterial routes, usually at signal controlled intersections.

Roads shown blue in Figure 9 are considered as neighbourhood connectors as they provide the primary access to the structure plan area. Daily traffic flows on these roads are well within the 7,000 vehicles per day recommended. These streets can be provided with a standard 7.2m carriageway, which is suited to bus movements. A footpath to both sides of the street is required, although one side may be designated as a shared path. Figure 10 shows a suitable cross-section with localised widening at intersections.

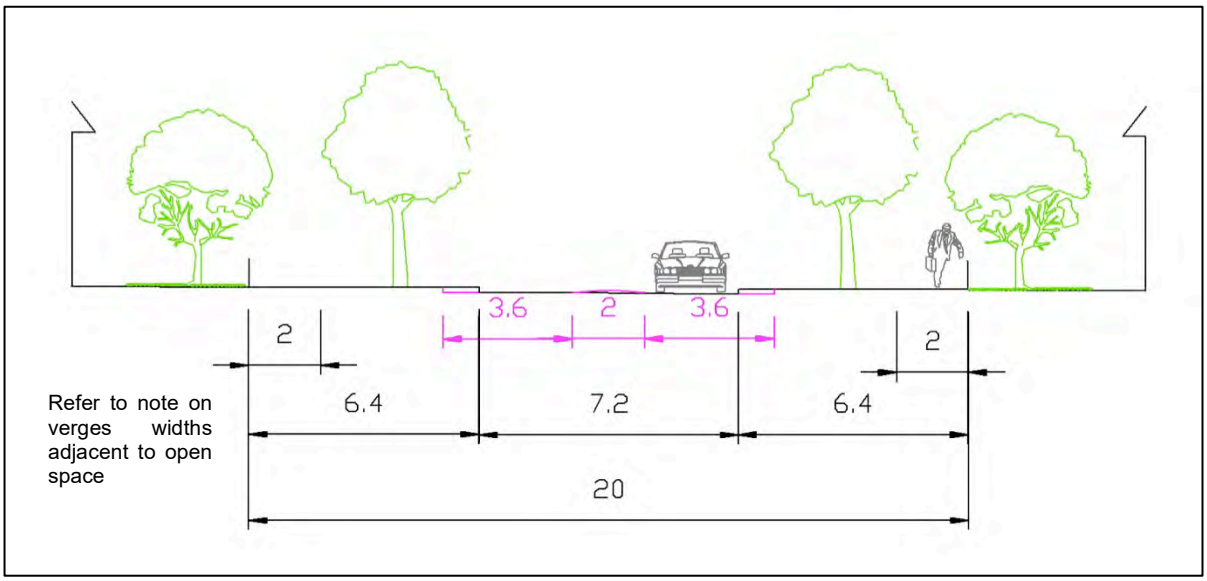


Figure 10 Neighbourhood Connector 20 metre Road Reservation

At intersections, median islands of 2.0m would be desirable to provide safer pedestrian crossing points and to highlight the intersection. A residual verge width of 5.4m can be provided where such medians are provided. The adjacent kerbs will need to be over-runnable. If barrier kerbs are to be used, the lane width should be widened to 4.1 metres, leaving a residual verge of 4.9 metres.

A minimum 20.0m cross-section is recommended for neighbourhood connectors

Higher Order Access Streets

Access streets carrying between 1,000vpd to 3,000vpd are considered to be higher order access streets and a slightly wider road reservation is suitable. Roads shown green in Figure 9 are considered as higher order access streets. Figure 11 shows a typical cross-section for a 16.0m wide road reservation providing a 6.0m carriageway and two 5.0m verges.

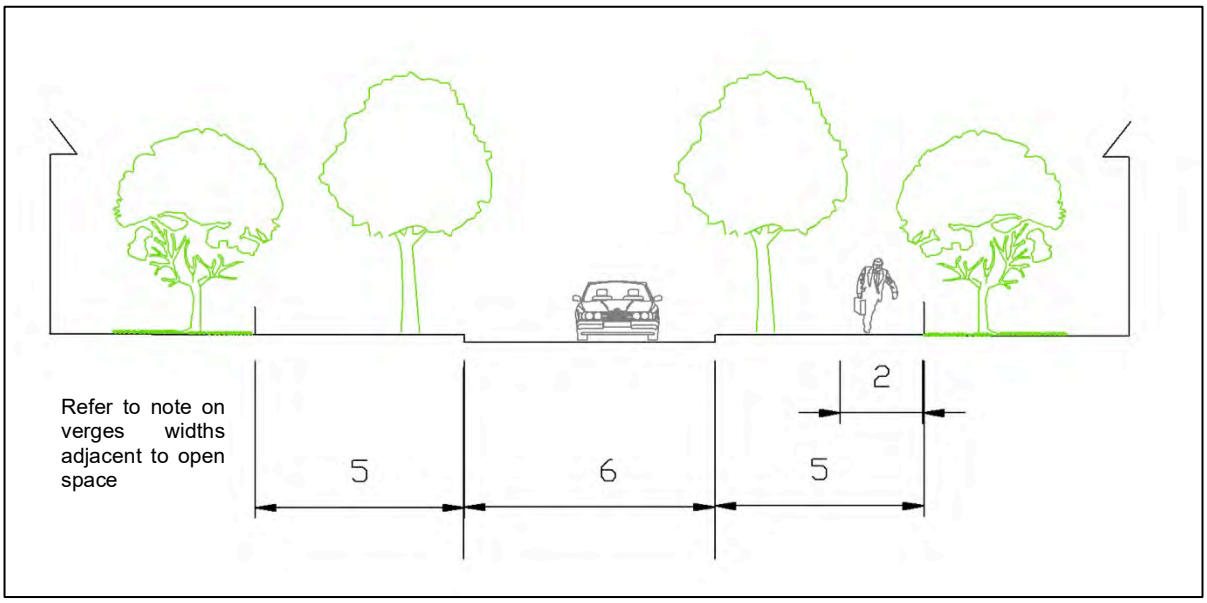


Figure 11 Higher Order Access Street 16 metre Road Reservation

Liveable Neighbourhoods suggests that these streets would be considered as "typical residential streets" (LN notation as access street C) and a carriageway width of 7.0 metres within a 15.4m – 16.0m road reservation is appropriate. However, the 7.0m wide carriageway is not supported in low density residential areas, as it will tend to encourage a higher traffic speed. A 6.0m carriageway is preferred to encourage a 40kph target speed and enables occasional on-street parking. A wider carriageway is only recommended where buses or large vehicles are expected.

In higher density areas, the provision of parking embayments is a preferred treatment, rather than an increased carriageway width.

It should be noted that from a road network capacity basis, a 6m wide carriageway could accommodate two-way traffic flows up to 1,100 vehicles per hour (indicatively 11,000vpd), but as a residential street should be restricted to less than 3,000vpd to maintain appropriate residential amenity. A wider carriageway is not required from a traffic movement perspective.

A minimum 16.0m cross-section is recommended for higher order access streets.

Lower Order Access Streets

Where daily traffic volumes are shown to be less than 1,000 vehicles per day, *Liveable Neighbourhoods* suggests that a reduced road reservation is acceptable. A carriageway width of 5.0m to 5.6m is suggested within a 14.2m road reservation. Figure 12 shows a

typical cross-section of a lower order access street with a 6.0m wide carriageway in a 15.0m road reservation. The road reservation can accommodate parking embayments.

A minimum 15.0m cross-section is recommended for lower order access streets

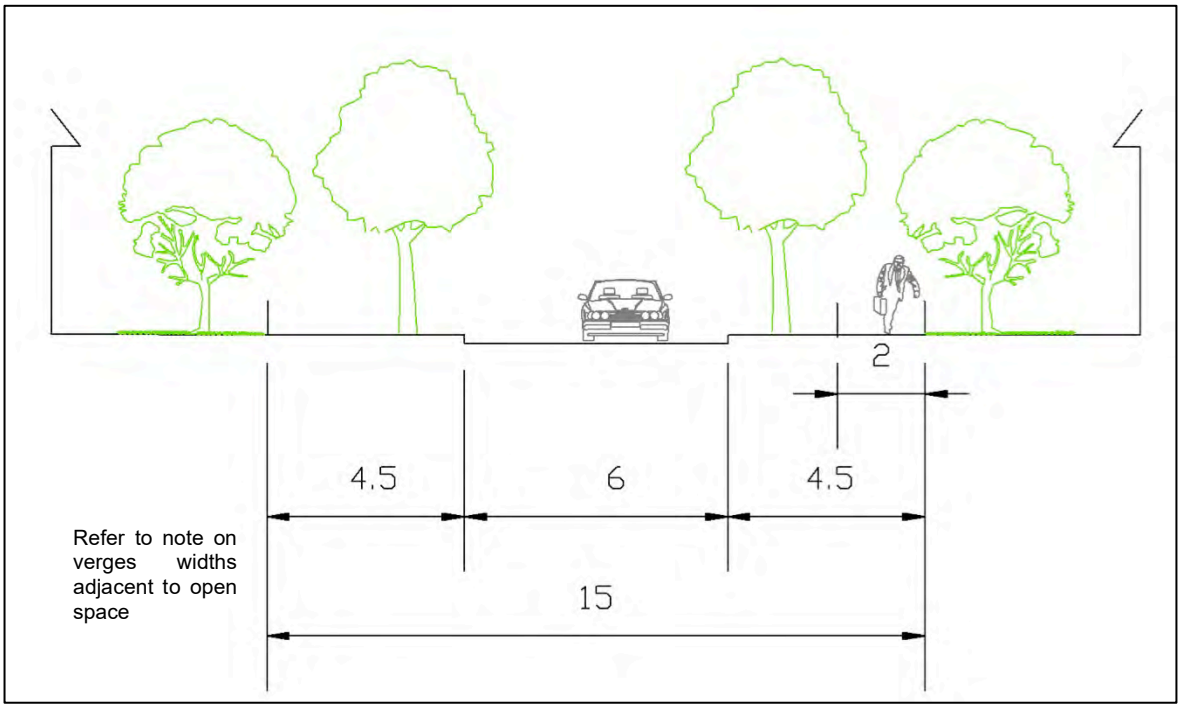


Figure 12 Access Street 15 Metre Road Reservation

Roads Adjacent to Open Space

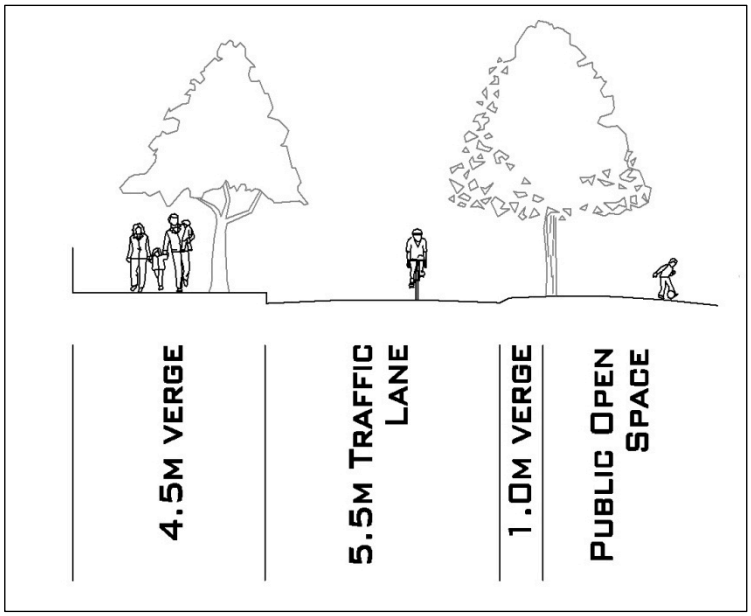


Figure 13 Roads Adjacent to POS

Where the road reservation abuts POS, bushland, golf courses etc., there is limited need to provide a verge. The verge may be reduced where parking and/or services are not required and should be considered at the time of subdivision. A minimum verge of 1.0m is advised by current road planning standards to accommodate street furniture. Footpaths do not need to be adjacent to the road where POS

is provided, but must be provided in a safe and appropriate manner. Figure 13 shows an example of a reduced road reservation adjacent to open space.

Roads Adjacent to Schools

The subject land shows two primary schools will be provided. To provide for future on street parking an 18 metre road reservation is recommended to be used on all roads fronting a school. The reservation allows ample width to provide embayed parking and a dual use path to the school side and a footpath to the opposite side.

7.0 TRAFFIC MANAGEMENT

The detail of any traffic management should be considered at the time of subdivision.

Four-way Intersections

Within the structure plan area daily traffic volumes are shown to be low and the use of four-way intersections is appropriate. Figure 14 shows an extract from Liveable Neighbourhoods on the preferred treatment of four-way intersections.

Liveable Neighbourhoods suggests that four-way intersections are an appropriate treatment at the meeting of two access streets and where daily flows through the intersection are less than 2,000vpd. Approach legs should be limited to a maximum length of 160 metres with some form of speed reducing feature where the length is greater than 80 metres.

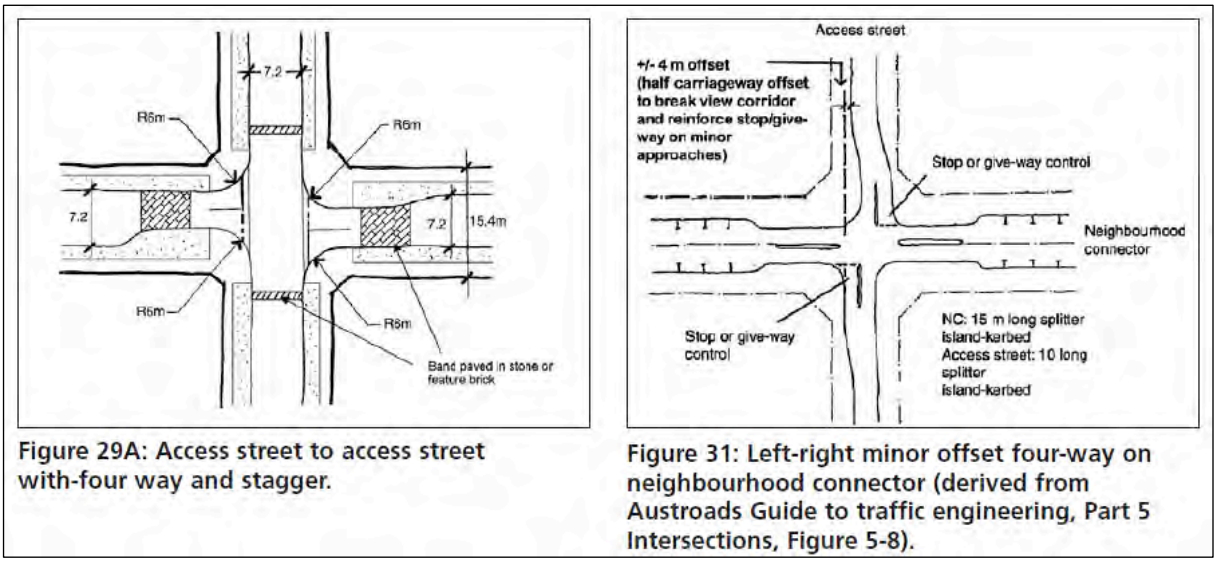


Figure 29A: Access street to access street with-four way and stagger.

Figure 31: Left-right minor offset four-way on neighbourhood connector (derived from Austroads Guide to traffic engineering, Part 5 Intersections, Figure 5-8).

Figure 14 Liveable Neighbourhoods Four-way Intersections

Access streets meeting neighbourhood connectors and some arterial streets are considered acceptable, but will generally require a treatment as indicated in Figure 14. In these instances *Liveable Neighbourhoods* would require a maximum of 4,000vpd passing through the intersection with a maximum combined flow of 1,000vpd on the minor legs.

Introducing four-way priority intersections on arterial streets is not recommended.

Figure 15 shows the traffic management treatments and requirements for the subject land.

Local Intersection Design

To reduce the opportunity for speeding it is recommended that corner radii advised by *Liveable Neighbourhoods* be used within the subdivision. The recommended radii are:

- 6.0 metres - access street / access street intersections
- 9.0 metres - access street / neighbourhood connector

Where larger vehicles are expected, such as buses accessing the school, larger radii may be required and should be considered at subdivision stage. It should be noted that adjacent to the proposed school, the minimum 6.0m radii is preferable to ensure side road traffic enters the major road at 90^0 to improve visibility to pedestrians. The tighter radii will also ensure traffic cannot enter or depart the side road at speed.

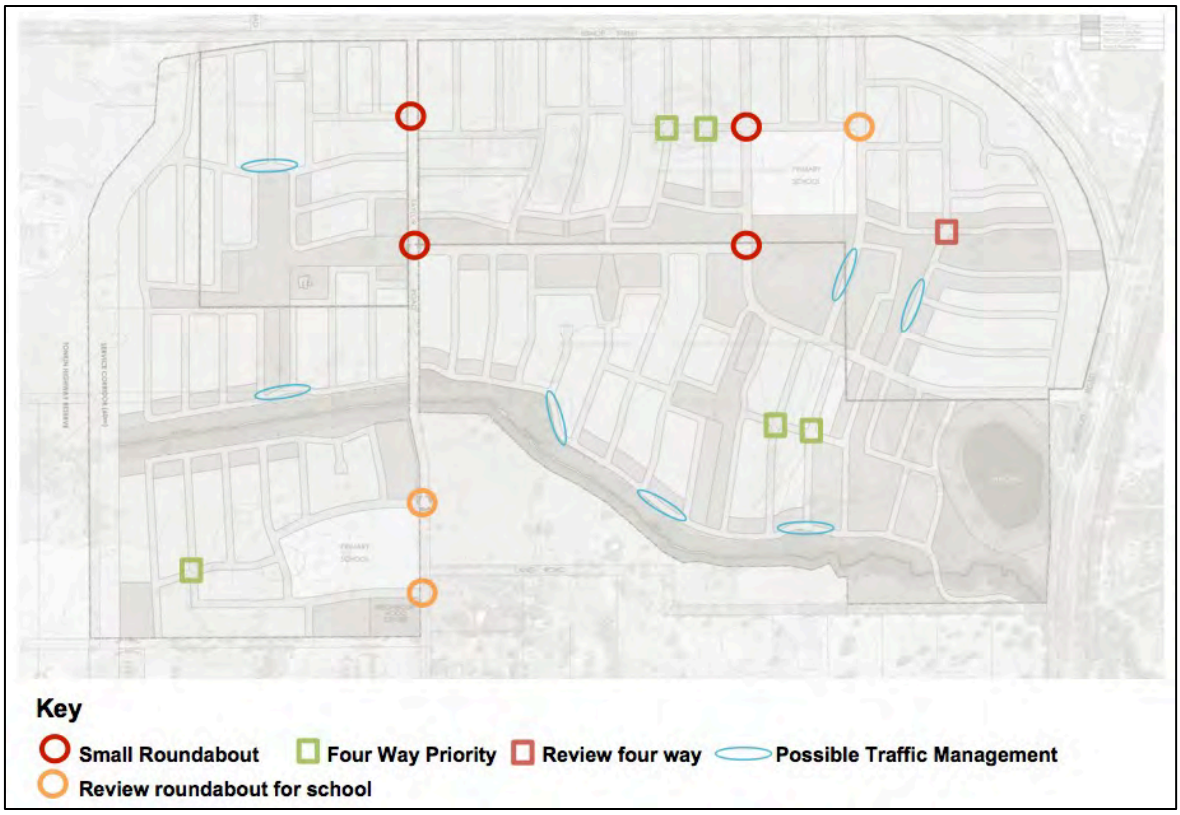


Figure 15 Internal Traffic Management and Intersection Control Requirements

8.0 IMPACT OF DISTRICT STRUCTURE PLAN AMENDMENT

In January 2016 the Shire of Serpentine-Jarrahdale advertised an amendment to the Whitby-Mundijong District Structure Plan (DSP). The amendment seeks to address issues of railway level crossings that were not considered at the time of drafting the DSP. The DSP did not investigate the impacts of level crossings and their resulting traffic impacts to land uses. As a result, the Whitby district centre is shown adjacent to the rail corridor and opportunities for grade separation of the rail corridor have been compromised.

The revised DSP is indicated in Figure 16 and identifies a district level road passing through the subject site. Soldiers Road is shown to be disconnected south of Bishop Road and a circuitous northern access road to Norman Road / Soldiers Road is shown for the Whitby locality. As a result of the proposed road network amendments, traffic flows passing through the residential area of Mundijong are shown to significantly increase.

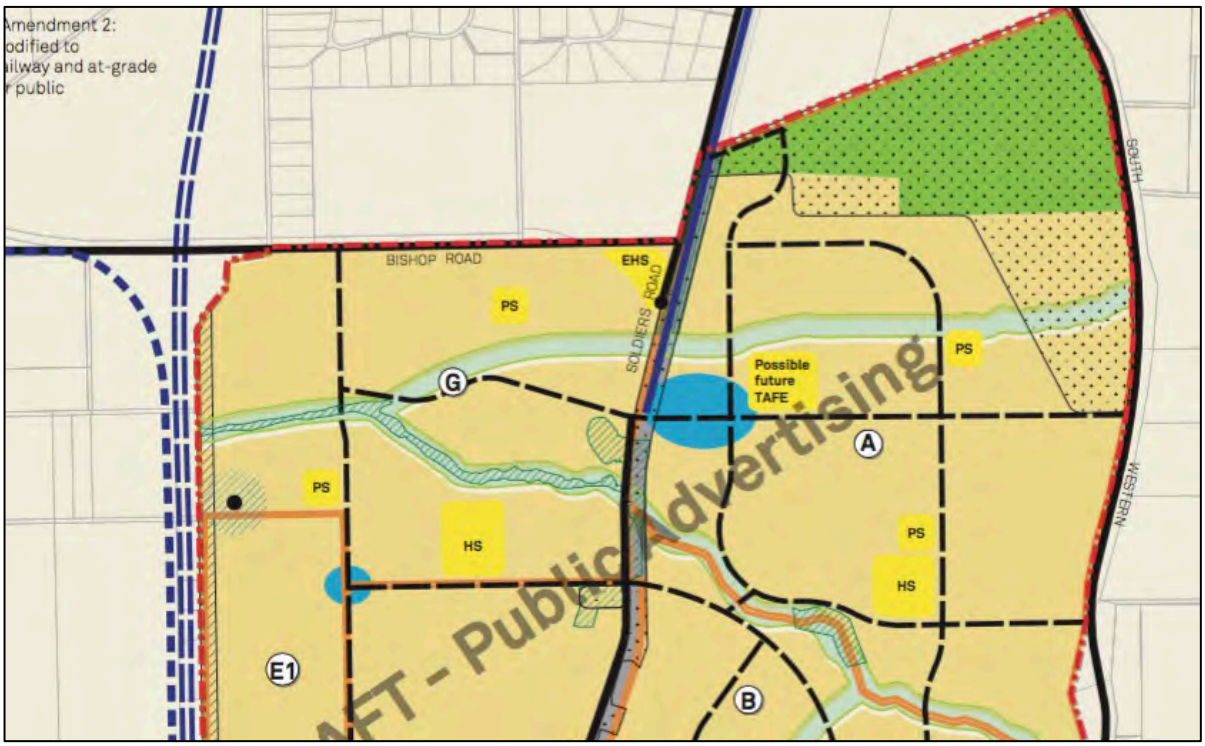


Figure 16 DSP Amendment

In Figure 16 the east-west connection shown in precinct G does not accord with the structure plan shown at Figure 2 and provides a circuitous route to Whitby via the residential precinct of Mundijong north (noting that Soldiers Road south of Bishop Road is closed). Traffic forecasts provided in support of the amended DSP suggest demands in excess of 10,000vpd resulting in a need for arterial type streets. Conversely Bishop Road, the current

arterial street, is shown to operate as an access street (flows less than 3,000vpd). The amended DSP is not supported on the grounds that it fails to address the impacts of the freight rail line and it places extraneous traffic through the Taylor Road residential precinct, contrary to the principles of *Liveable Neighbourhoods*.

Mitigating Measures

The local structure plan shown in Figure 2 can be amended to address the traffic issues resulting from the proposed DSP amendment. Figure 17 shows 2 alternative options to manage traffic through the residential precinct. The two options are notated as the blue route and the orange route and are discussed below.

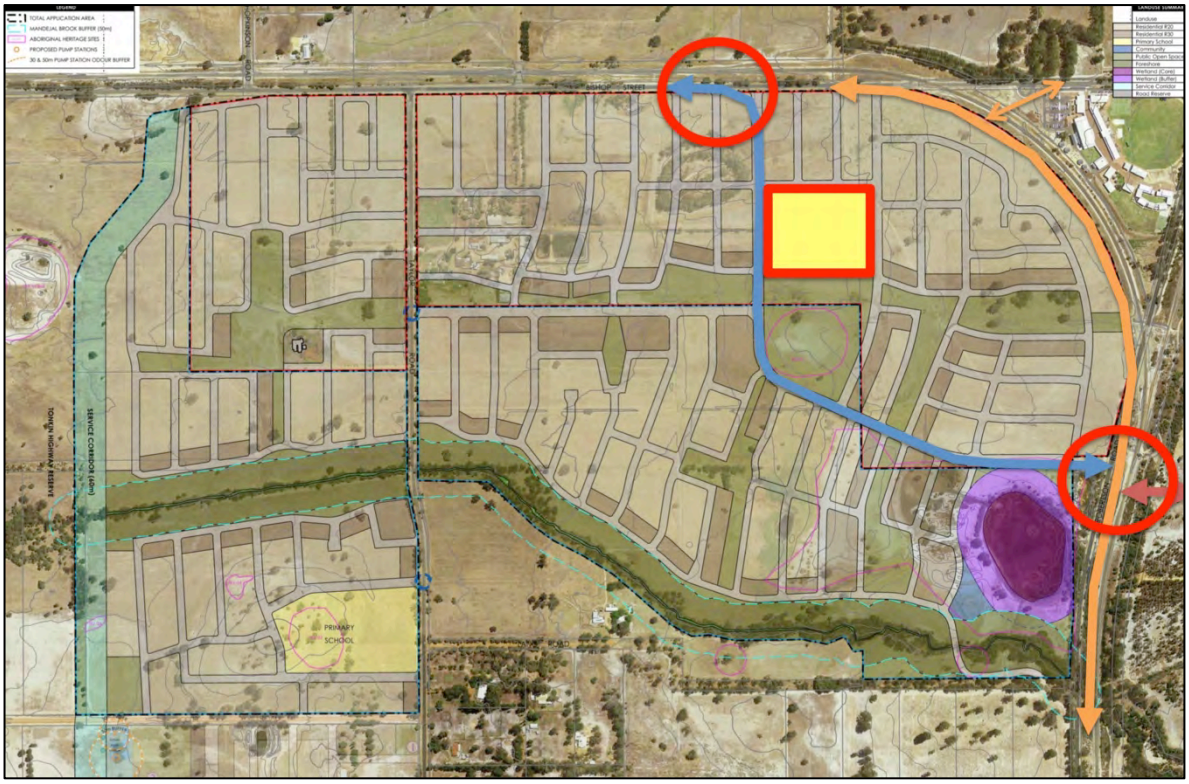


Figure 17 Future Mitigation Measures (Plan is indicative)

It is noted that the amended DSP seeks to provide direct connectivity east-west between Whitby and Mundijong over the level crossing with Soldiers Road north of this intersection closed.

Orange Route

The Orange Route option would provide a new road adjacent to the freight rail line to link Patterson Road through to Bishop Road. An offset four way intersection to Patterson Road

would be recommended to maintain north-south connectivity (major road). The rail crossing would be located on a side road and can be easier controlled.
Access to Serpentine-Jarrahdale grammar school and Soldiers Road north can be maintained by relocating the Bishop Road level crossing as indicated in Figure 17.

Blue Route

The blue route maintains the proposed road network and upgrades the link between Patterson Road and Bishop Road to provide a wider road reservation and higher order boulevard. Direct lot access would be removed and intersections would be reduced. The location of the primary school would need to be reviewed, as the location of a primary school adjacent to an arterial type street is not recommended.

The connection to Bishop Road will require reprioritisation under Austroads, which will affect lots adjacent to the intersection.

9.0 PEDESTRIANS, CYCLISTS AND PUBLIC TRANSPORT

The structure plan provides for two primary schools within a pleasant walking distance for the majority of households. Adjacent to the school and on identified walking routes, it is desirable to provide a footpath to both sides of the street. A shard path linking the schools is also very desirable.

Current planning guidelines suggest that all streets should be provided with a footpath wherever possible. Where traffic flows exceed 1,000 vehicles per day, a footpath to both sides of the road should be provided. Figure 16 shows those streets where a footpath is required to both sides. However, a footpath and a shared path may be used in these locations.

Cycling

Cycling would be safe on the majority of local streets where traffic flows are less than 1,000 vehicles per day. On the neighbourhood connectors shared paths should be provided to provide a safe alternative to on-road cycling (if not provided). A principal shared path is indicated in the district structure plan adjacent to the future Tonkin Highway. It is desirable to provide linkages to this path, although the future service corridor may preclude such access.

Public Transport

Mundijong already has a rail station on the Perth to Bunbury line, utilised by the Australind service, which does stop. However, this is a twice a day service with scheduled departure times that make commuting to Perth CBD awkward.

Armadale is about 21 kilometres to the north of Mundijong, where the metro rail line service to the CBD currently terminates. There is discussion of the service being extended to Byford, although this is a very long-term proposal. The Perth – Mandurah line can be accessed at Wellard, Rockingham and Safety Bay. These stations are probably closer than Armadale to the north and have been developed as park and ride stations. It can be expected that commuters to Perth will be split 60/40 to the Perth – Mandurah line.

There are 2 bus services passing through the locality, routes 252 and 253. The services connect to Armadale railway station. The district structure plan sets out to provide a bus route along Taylor Road / Soldiers Road that would terminate to the north side of Mundijong Road. Figure 16 shows the proposed bus route.

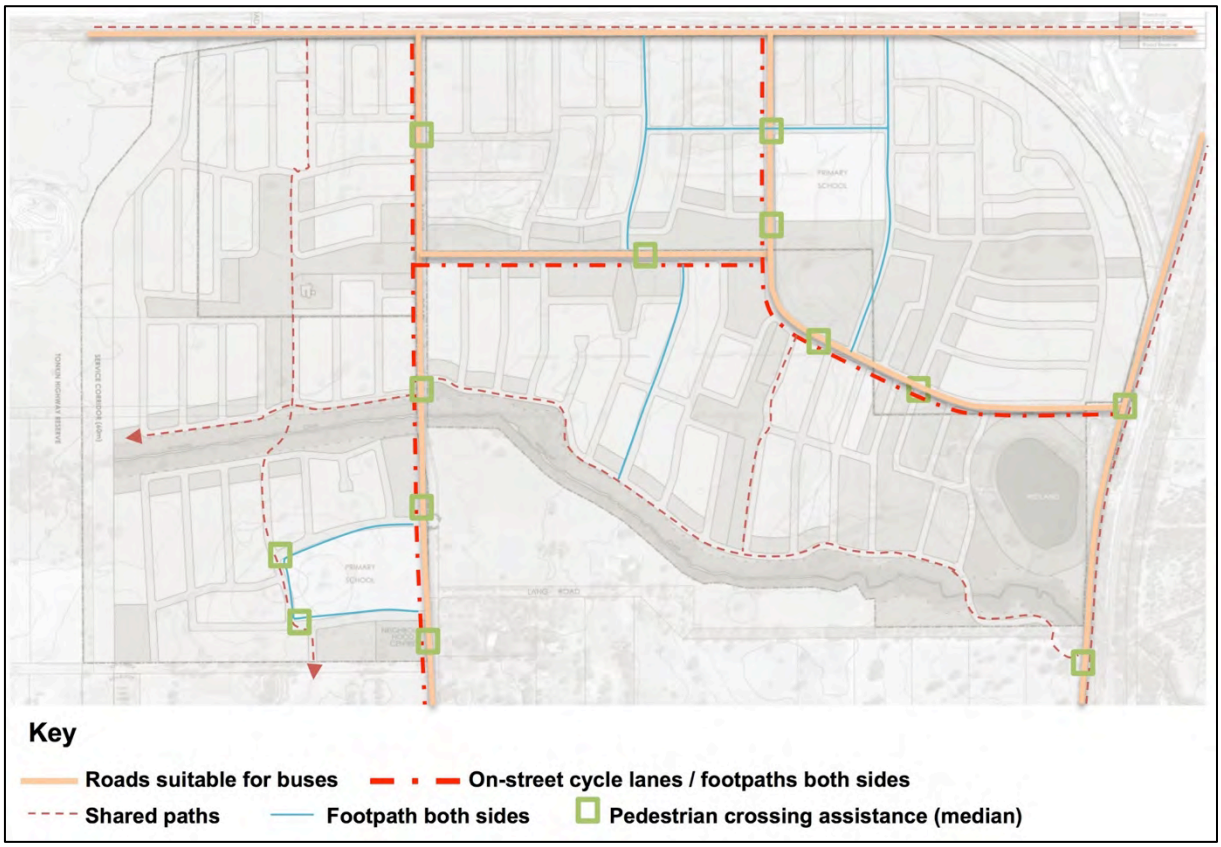
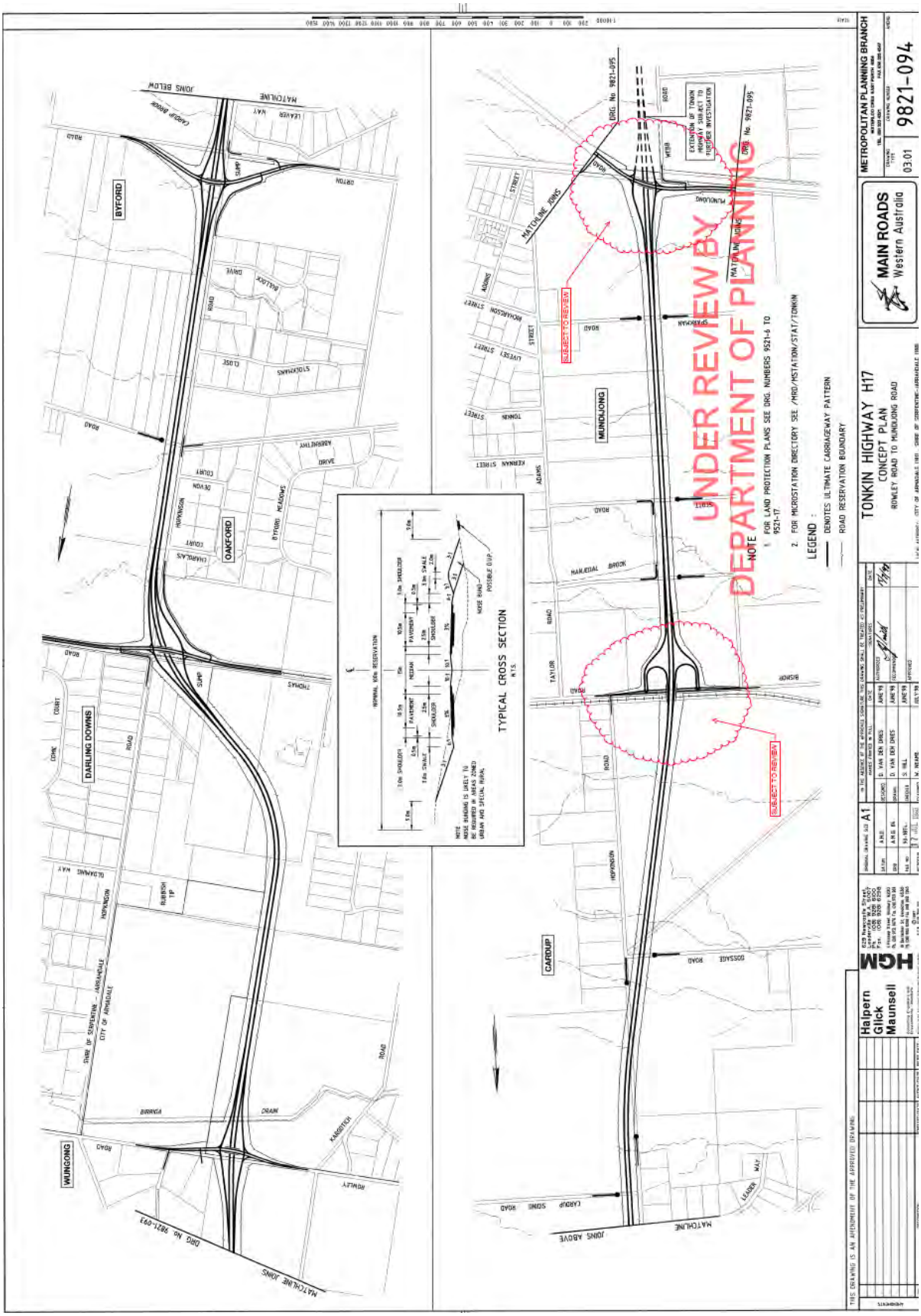
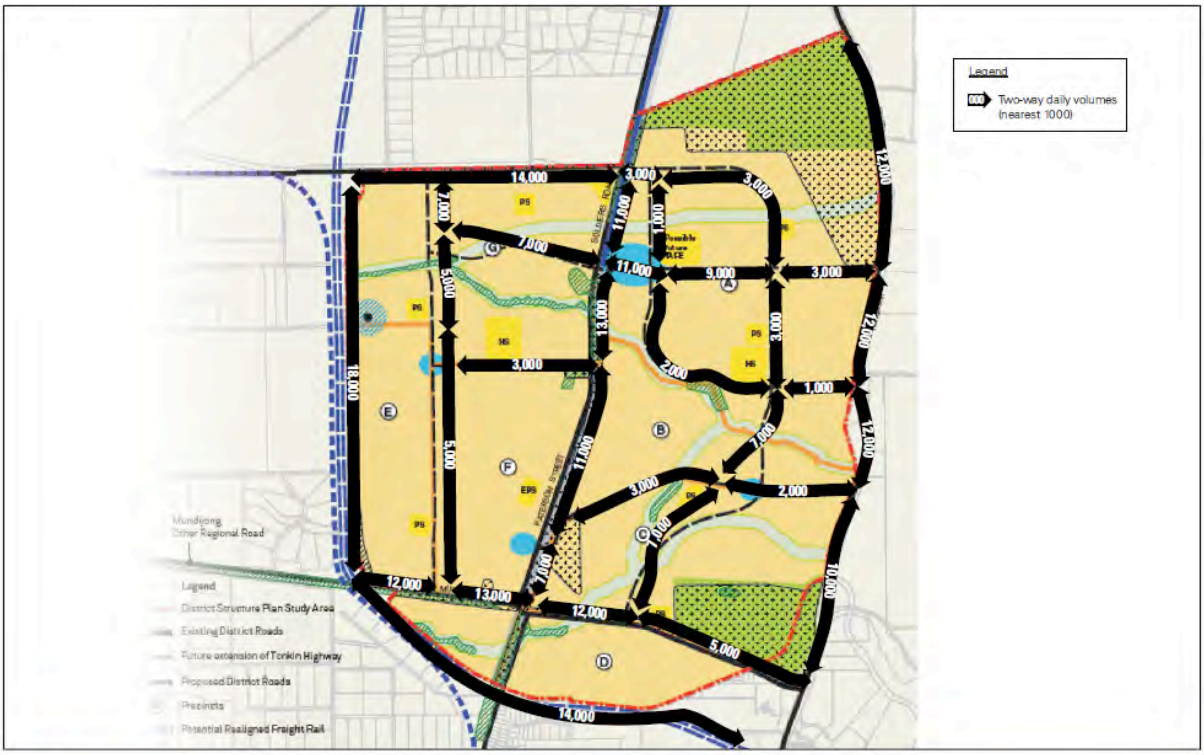


Figure 16 Footpaths, Cycle Paths and Bus Routes (base plan indicative)

APPENDIX A Tonkin Highway Concept Plan



APPENDIX B Whitby – Mundijong District Structure Plan Traffic Forecasts



Cardno Eppell Olsen

Mundijong - Whitby District Structure Plan - Forecast Traffic Volumes 2029 - Base Network

Figure 1 | Job Number: CEP02036 | 04 | 05 | 2010

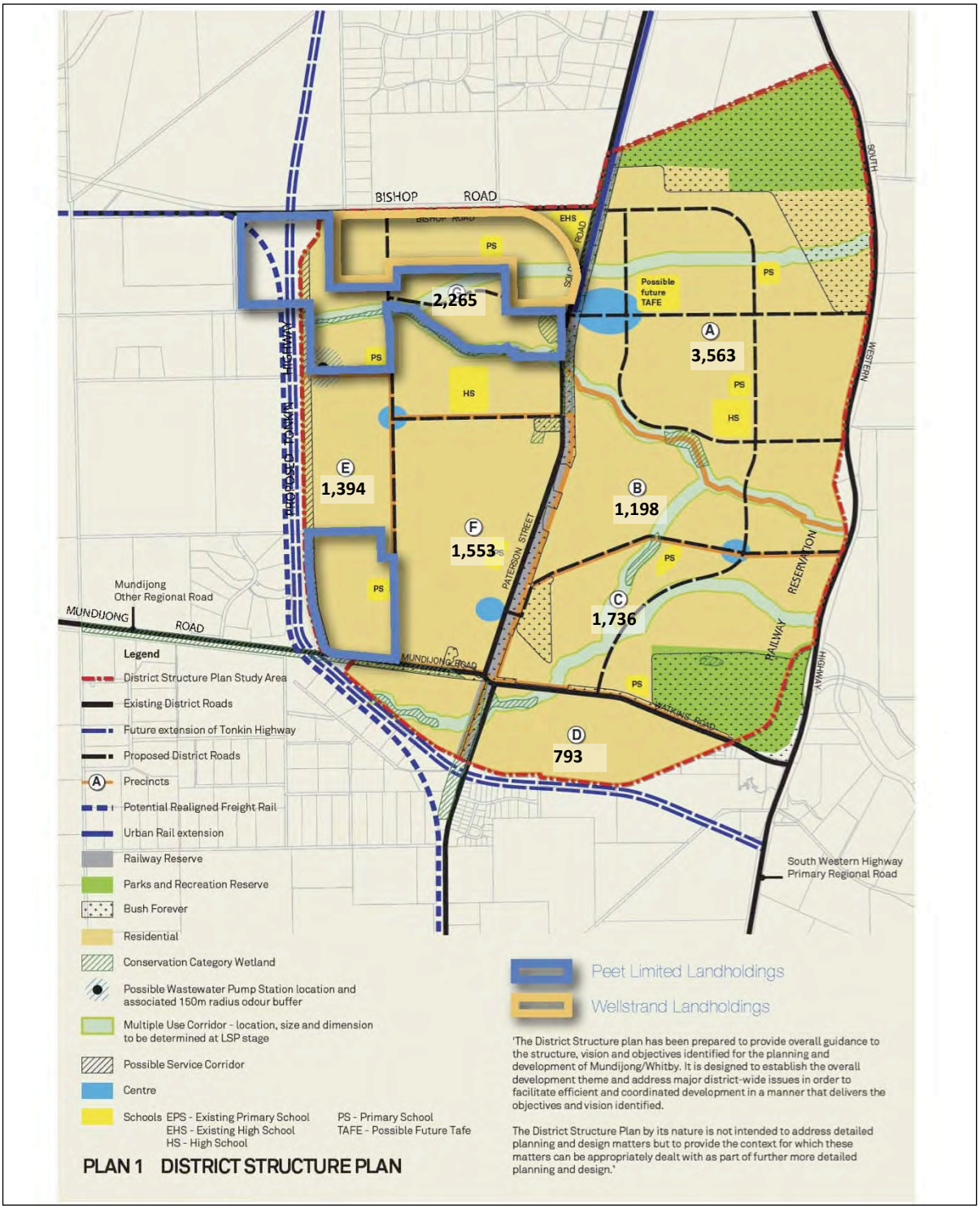


Cardno Eppell Olsen

Mundijong - Whitby District Structure Plan - Forecast Traffic Volumes 2029 - Option A With Removed Railway Crossings

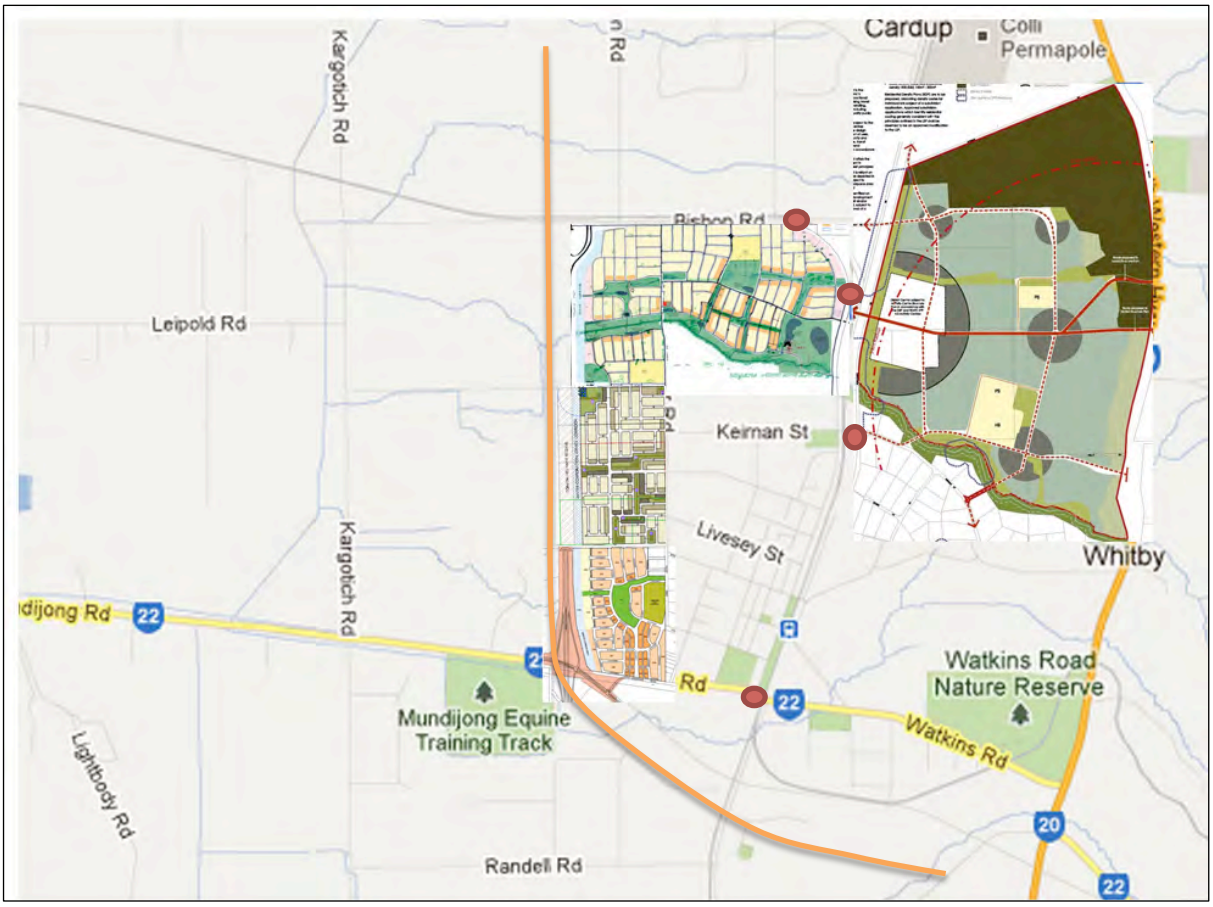
Figure 1 | Job Number: CEP02036 | 04 | 05 | 2010

APPENDIX C Whitby - Mundijong District Structure Plan



Expected dwelling yields

APPENDIX D Traffic Model Area



Mundijong Modelled area and Rail Crossings

APPENDIX E Model Outputs



Roads 1,000-3,000vpd



Roads 3,000 – 7,000vpd



Roads greater than 7,000vpd

PEET MUNDIJONG SYNDICATE PTY LTD

TAYLOR ROAD, MUNDIJONG

STRUCTURE PLAN TRAFFIC REPORT

Updated July 2022

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Issued on 23 April 2024 Version V5A Reference 648	Amendments V2 report updated V3 Yield adjusted V4 plans updated V5 DPLH updates V5 A edits Final	Date 21-01-16 08-02-16 22-02-16 15-6-22 4-7-22

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1.0 EXECUTIVE SUMMARY

Riley Consulting has been commissioned by the Peet Mundijong Syndicate Pty Ltd to consider the traffic and transport impacts of developing land at Taylor Road, Mundijong. The development proposes infill residential dwellings to the south of Bishop Road bounded by the future Tonkin Highway and Soldiers Road. A structure plan traffic report was prepared in 2016 and this version provides amendments to reflect the schedule of modifications required by the WAPC. The traffic modelling prepared by Riley Consulting in 2016 has not been updated to reflect changes to lot yields, only amended to reflect the changed road network through the subject land, due to the high level of uncertainty relating to district road planning and modelling by the Shire, DPLH and Main Roads WA. The data used to inform this traffic report deemed appropriate. The key findings of the traffic overview are:

- The traffic assessment undertaken for the structure planning of the subject land has used a Saturn model to distribute traffic demands to the surrounding road network. The model includes traffic generated within the Whitby-Mundijong district structure plan to ensure adjacent development traffic movements are fully considered.
- The development of the subject land has already been included in the traffic planning undertaken for the Whitby-Mundijong district structure plan. The Saturn traffic model forecast demands do not significantly affect the current planning outcomes of the Whitby-Mundijong district structure plan.
- Access to the subject land can be achieved from Taylor Road, Bishop Road and Soldiers Road.
- The road hierarchy developed for the subject land is cognisant of the road network planning identified by DPLH for the Whitby-Mundijong district structure plan. A minimum road reservation of 36.5 metres is dictated for the east-west link from the Whitby rail crossing to Bishop Road. Road reservation widths for key arterial roads are also consistent with the Shire of Serpentine-Jarrahdale Mundijong-Whitby Development Contribution Plan.
- All access streets have low daily traffic volumes and are considered appropriate for on-street cycling. A principal shared path is indicated in the Whitby-Mundijong district structure plan adjacent to the future Tonkin Highway, but the proposed service corridor may compromise access. This matter needs to be addressed once regional planning has determined the accessibility over the service corridor.

2.0 THE SITE AND SURROUNDING ROAD NETWORK

Mundijong is located approximately 40 kilometres south east of Perth. The area falls within the Shire of Serpentine – Jarrahdale and is accessed from the South Western Highway and Mundijong Road. Figure 1 shows the location of the subject land. Roads of importance are discussed below. Note that traffic flow data shown is from 2016 and may be lower than currently recorded in 2022.

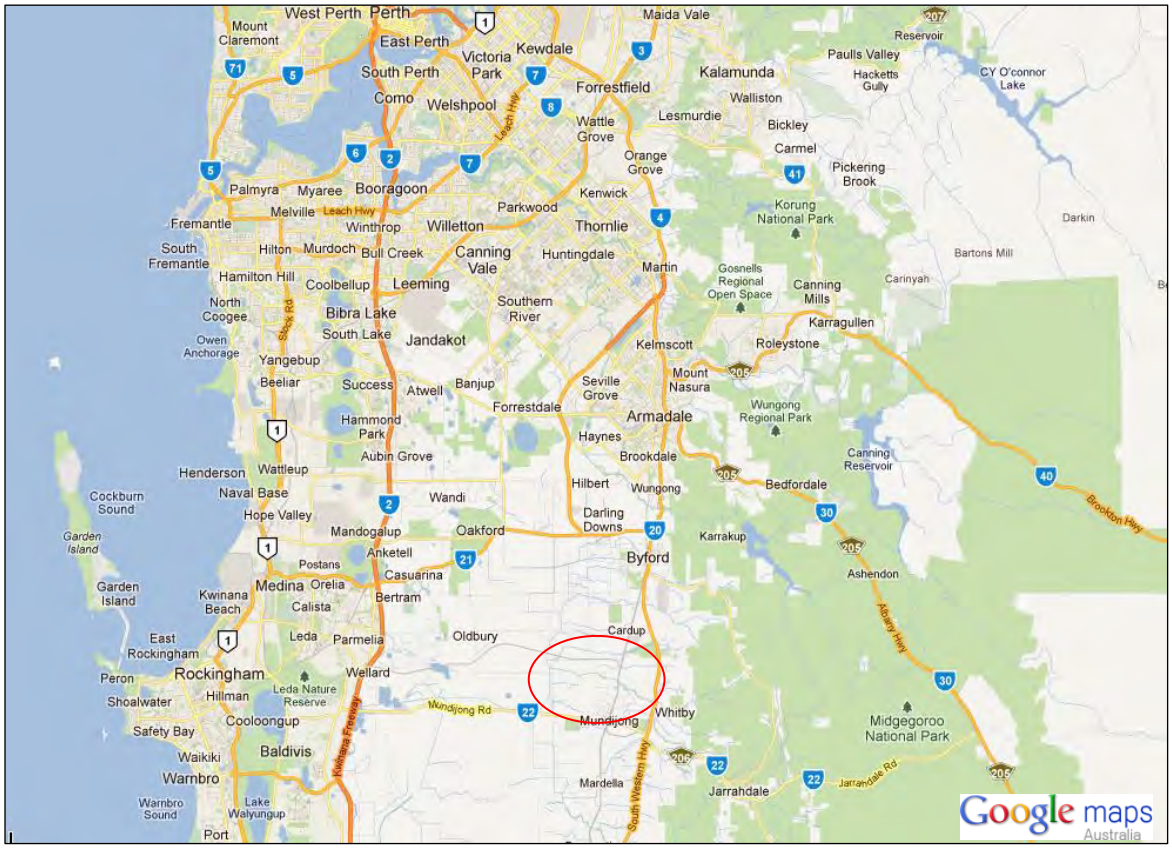


Figure 1 Site Location (Site area indicative)

South Western Highway

The South Western Highway is a primary regional road under the control of Main Roads Western Australia (MRWA). It provides a major traffic and freight route between Pinjarra to the south and the eastern industrial areas of Perth (Kewdale and the airport etc.). It also provides connectivity at a regional level to the Tonkin Highway and Albany Highway.



Photograph 1 South Western Highway

Photograph 1 shows the view looking north along the South Western Highway to Watkins Road (Mundijong Road).

The South Western Highway is generally constructed as a rural standard single lane road with 2 traffic lanes. A northbound overtaking lane exists at the intersection of Watkins Road, which will make egress from Watkins Road difficult and potentially dangerous during busy periods. A right turn deceleration lane is provided on the highway for southbound traffic. The South Western Highway has a posted speed limit of 90kph adjacent to the locality of Mundijong.

Current traffic data provided by MRWA indicates 5,777 vehicle movements per day (17.6% HGV) to the south of Reilly Road (June 2015). The peak hours show 420 vehicles in the morning and 520 in the evening. Further south, traffic flows are higher with MRWA data indicating 6,004vpd south of Watkins Road in 2010. It is noted that at the same located the daily flow was 10.054vpd in 2009.

Watkins Road – Mundijong Road

Watkins Road is the continuation of Mundijong Road to the east of the Perth – Bunbury rail line. It is constructed as a single carriageway road with 2 traffic lanes. A standard 7.2 metre carriageway is provided. Photograph 2 shows Watkins Road looking towards Mundijong. Photograph 3 shows Mundijong Road west of the town looking to the west.



Photograph 2 Watkins Road


Photograph 3 Mundijong Road

Traffic data provided by MRWA indicates 2,400 vehicle movements per day on Watkins Road to the west of the South Western Highway (2008/09). The current level of traffic movements at this location supports the current provision of yield control to Watkins Road.

A controlled level crossing is provided at the railway line. A 60kph posted limit applies through the town site area. To the west, about 200m west of Patterson Street, an 80kph posted limit applies. Approximately 50 metres west of Adonis Street a 100kph posted limit applies.

Traffic data sourced for Mundijong Road shows:

- 3,280vpd west of Patterson Street (2013)
- 4,592vpd east of King Road (2015)
- 3,946vpd east of the Kwinana Freeway (2013)

Overall it can be seen that Watkins Road and Mundijong Road are operating well within their derived operational capacity and will experience very good Levels of Service.

Patterson Street / Soldiers Road

Patterson Street is the main street to the Mundijong town site and is constructed with a wide 9 metre carriageway (approximate) in a 20 metre road reservation. Photograph 4 shows Patterson Street at Mundijong town centre. Patterson Street links Mundijong Road to Abernethy Road in Byford. It is classified as a district distributor type A road in the MRWA *Functional Road Hierarchy.* Historical traffic data from MRWA (2004/05) indicates 2,200 vehicle movements per day. It is unlikely that this daily volume has changed significantly.



Photograph 4 Patterson Street

Bishop Road

Bishop Road provides an east-west connection between Kargotich Road and Soldiers Road. It is classified as a district distributor road under the Mundijong-Whitby DSP and in the Main Roads *Functional Road Hierarchy* with a functional Class of Significant Urban Local Road. It is located to the south of the freight rail line and to the northern side of the Mundijong structure plan area. A road reservation of 20 metres is provided. Photograph 5 shows the view looking along Bishop Road.



Photograph 5 Bishop Road

No traffic data is available, although it can be expected that current volumes are well below 500 vehicles per day. Close to the intersection of Soldiers Road is a school that can be expected to increase traffic flows at the eastern end. However, such increases would only affect school pick-up / drop-off periods typically between 08:15 – 09:00 and then 14:30 to 15:30.

Kargotich Road

Kargotich Road is classified as a district distributor type B road in the MRWA *Functional Road Hierarchy*. It provides a currently important north-south connection between Mundijong Road and Thomas Road. However, construction of the future Tonkin Highway will attract the majority of traffic using this road.

Traffic data from MRWA indicates 1,730 vehicle movements per day to the north of Bishop Road and 2,387vpd south of Orton Road (2012).

Taylor Road / Adams Street

Classified as district distributor roads under the Mundijong-Whitby DSP, Taylor Road and Adams Street provide a convenient north-south link between Richardson Street and Bishop Road. Photograph 6 shows the view looking north along Taylor Road close to Lang Road.



Photograph 6 Taylor Road

The current sealed width of Taylor Road / Adams Street is about 6 metres (approximately) and may require additional width to cater for significant increases in traffic demand. A road reservation of 20 metres is provided. There is an existing bridge over Manjedal Brook approximately 400 metres south of Bishop Road.

At Bishop Road a left-right stagger leads to Hopkinson Road, which is classified as a district distributor type B road. Hopkinson Road provides a convenient link to the south of Armadale and may be attractive to commuter traffic. However, the development of the Tonkin Highway will negate Hopkinson Road as a desirable route.

Livesey Street and Tonkin Street

These two streets are existing east-west connections between Patterson Street and Adams Street. Constructed with standard 7.2 metre wide carriageways, these streets are rural residential in nature.

Cockram Street

Cockram Street is a local access street that links Adonis Street through to Patterson Street. It is bounded by larger residential lots and provides access to local sporting facilities. It is constructed with a standard 7.2 metre wide carriageway (approximate). Present day traffic movements would be expected to be less than 500 vehicles per day. West of Butcher Street a standard 20 metre wide road reservation is provided.

Adonis Street

Adonis Street is a local access street that links Richardson Street to Mundijong Road. It is bounded by larger lots and provides access to about 8 properties south of Cockram Street. It is constructed with a standard 7.2 metre wide carriageway (approximate). Present day traffic movements would be expected to be less than 500 vehicles per day.

Kiernan Street

Kiernan Street is a local access street providing an east-west connection between Patterson Street and Taylor Road. Photograph 7 shows the view along Kiernan Street.



Photograph 7 Keirnan Street

No traffic data is available for Kiernan Street, but based on current levels of development accessed from this link, a daily flow of less than 500 vehicles would be expected.

Tonkin Highway

To the west of the subject land, an existing road reservation is set aside for the construction of the future Tonkin Highway. At present the construction of the Tonkin Highway is not in the MRWA 4-year programme but planning is well commenced. Appendix A shows the current MRWA planning for the Tonkin Highway adjacent to Mundijong. As part of the highway

proposal, a re-alignment of Mundijong Road to provide a connection to Jarrahdale Road is shown.

Mundijong – Whitby District Structure Plan

A district structure plan has already been prepared for the Whitby – Mundijong locality and is provided on the Shire of Serpentine – Jarrahdale website. Traffic forecasts have been provided and are attached as Appendix B (Cardno 2020). Since the original structure planning in 2010 the Shire has progressed an update to the 2010 DSP. The traffic modelling undertaken for the 2020 DSP by Carndo has been factored into the update of this traffic report (refer Table 2).

Figure 2 shows the indicative structure plan.



Figure 2 Indicative Structure Plan Concept (refer to planner for detail)

3.0 TRAFFIC GENERATION AND DISTRIBUTION

The development of residential land at Mundijong will provide for the growing population forecast for Perth and the south eastern rural areas.

Reference to trip generation source documents suggest that the trip generation of a typical household can vary from 5 trips to 11 trips per day. Traffic analysis of similar development to the north of Mundijong identified a residential trip rate of 8 trips per dwelling per day, which is slightly higher than the Perth metropolitan average rate of 7 trips per day. The trip rate is based on typical R20 density, which is attractive to families.

It is understood that other developments have indicated a higher density level of development in Mundijong that may be expected to generate a lower average rate per household. However, the use of 8 trips per dwelling will provide a robust assessment of the road network and provide flexibility for future planning to meet consumer demands.

The concept plan indicates a yield of about 3,000 residential lots and on the basis of 8 trips per lot the site can be expected to generate (3,000 x 8) 24,000 vehicle movements per day.

The subject site is expected to generate in the order of 24,000 trips per day.

The subject land will provide two primary schools, which will retain traffic within the developable area.

Distribution

Table 1 shows the distribution assumptions by trip purpose used to assign traffic onto the external road network. The distribution used is as per previous assumptions for land to the south. The traffic generation and distribution has been used to prepare a matrix for the Saturn traffic model.

Table 1 Composition of Residential Trips

Purpose of trips	% of Total	North Tonkin	North SW Highway	East	South – SW Highway	South - Freeway	West Rockingham / Freeway north
Home Based – Work	29%	30%	8%	2%	10%	10%	40%
Home Based – Education	Assigned by school						
Home Based – Other	36%	15%	5%	5%	10%	15%	50%
Home Based – Evening	21%	30%	10%	0%	0%	10%	50%
Non-Home Based	14%	50%	5%	0%	3%	7%	35%

Traffic Modelling

The development of the subject land will need to be considered in regard to development within the Whitby-Mundijong district structure plan area as indicated in Appendix C. A traffic model was created by Riley Consulting (2016) using the Saturn package to assign traffic to the revised road network. The model uses the trip generation and distribution assumptions discussed above applied to the district structure plan area. The modelled area is indicated in Appendix D. The Riley Consulting model has been amended to reflect the changed road network.

The following assumptions have been made with regard to traffic accessing the surrounding road network. The speeds are the estimated journey time speeds including movement delays at intersections etc. - they may not match the free-flow posted speed.

- New residential roads operate with a speed of 40kph and 30kph.
- Neighbourhood connectors operate at 50kph.
- East-west Whitby link operates at 60kph
- Mundijong Road operates at 60kph between Tonkin Highway and the rail crossing, then 70kph.
- Tonkin Highway / Mundijong Road re-alignment operates at 80kph (long term)
- South Western Highway 110kph
- Freeway and Tonkin Highway 100kph
- Bishop Road operates at 60kph
- Soldiers Road operates at 60kph and 70kph north of Bishops Road

Trips to schools are based on the Education Department's assessment of 0.35 pupils per household. 30% of home based other trips are assigned to localised shopping (Whitby district centre and Mundijong town centre).

4.0 DEVELOPMENT TRAFFIC IMPACTS

The development of the subject land is anticipated to generate about 24,000 trips per day, which is higher than expectations of previous studies. Table 2 shows the anticipated road network impacts to the district structure planning based on the revised traffic forecasts (The traffic model prepared by Riley Consulting to consider the subject land includes all local development and infill development expectations within the district (as far as known). The modelling also includes expectations of the development of Whitby and connection through to Bishop Road

Table 2 Changes to District Structure Plan Forecasts

Road	DSP 2010	Cardno 2020	RC 2022
Watkins Road at Mundijong	5,000	4,200	5,980
Mundijong Road W Patterson	13,000	12,381	11,510
Mundijong Road east of Tonkin	12,000	7,000	22,221
South Western Highway	12,000	18,270	14,590
Patterson St at Mundijong	11,000	2,810	7,270
Soldiers Rd	13,000	3,420	4,380
Taylor Rd S Bishop	7,000	5,962	17,580
Taylor Road S Scott	5,000	1,740	6,390
Bishop Road at Tonkin	14,000	7,010	23,410
Bishop Road at Soldiers	1,4000	3,590	3,190
Tonkin Highway	18,000	15,650	19,420
E-W Whitby Link mid	7,000	2,200	15,790
E-W Whitby Link @ Whitby	-	-	21,850

Table 2 shows that the Riley Consulting modelling of the subject site generally retains traffic forecasts to levels identified in the district structure plan. There are some external roads that are shown to carry a greater traffic demands that are discussed below:

Bishop Road

The forecast traffic demands on Bishop Road are subject to full movement being provided to the Tonkin Highway and more direct access to Whitby. The forecast of 24,000vpd would suggest that planning for a four-lane divided road would be identified in the district structure plan. The revised forecast is within the capacity of a four lane divided road. The forecast traffic demands indicate that an integrator street type A is an appropriate classification for

the western portion between Tonkin Highway and Taylor Road and a road reservation of 31.2m – 53.6m is identified by Libeable Neighbourhoods. It is noted that a 35.6 metre reservation is to be provided as per the WAPC's Schedule of Modifications. The eastern portion between Taylor Road and Soldiers Road and a road reservation of 30m is required.

Soldiers Road

The forecast traffic demands to Soldiers Road are similar in the Cardno 2020 and the Riley Consulting modelling at less than 5,000vpd. A single carriageway two lane road within the current road reservation would be considered appropriate for the forecast demands.

It is concluded that the revised traffic forecasts do not change road network planning identified in the district structure plan.

Impacts to Existing Land Uses

The Serpentine-Jarrahdale Grammar School is located to the north of the subject land to the corner of Soldiers Road and Bishop Road. The development of the subject land is unlikely to result in greater traffic demands to roads accessing the school.

5.0 ACCESS

The subject land is bounded by Bishop Road, Soldiers Road and also has access to Taylor Road. Access is reviewed in regard to typical intersection capacity constraints set out by Austroads, reproduced below. Based on the upper levels of flow indicated by Austroads, Table 3 assesses the expected intersection treatments. The forecast volumes used are based on the district level modelling and include the development of Whitby etc. Initial access to existing roads would be made using simple priority tee intersections until traffic demands required some form of upgrading.

Table 5.5 — Typical Limits of Intersection Capacity (vph)

(Four way intersection with equal demand for all movements

Approach Width	Type of Control		
	No signals [a]	Round-about[b]	Signals[c].
1 lane	1500	2600	1500
2 lanes	1500	4560	3000
3 lanes	1500	6000	4500
4 lanes	1500	na.	6000

Notes:
(a) Based on practical absorption capacities of unsignalised intersections.
(b) Based on gap acceptance criteria.
(c) Based on four split phases (120s cycle).

Table 3 External Access Operation

Location	Major Road	Minor Road	Type
A	Bishop Road*	Access St	Left in / left out
B	Bishop Road	Taylor Road	Re-align – Bishop Road east to yield
C	Bishop Road	Access St's	Priority
D	Soldiers Road	E-W Link	Grade separation at rail line

*Subject to access controls

Figure 3 shows the expected long-term intersection control requirements for the subject land access. Note that intersections adjacent to school sites should be reviewed at the time of subdivision.

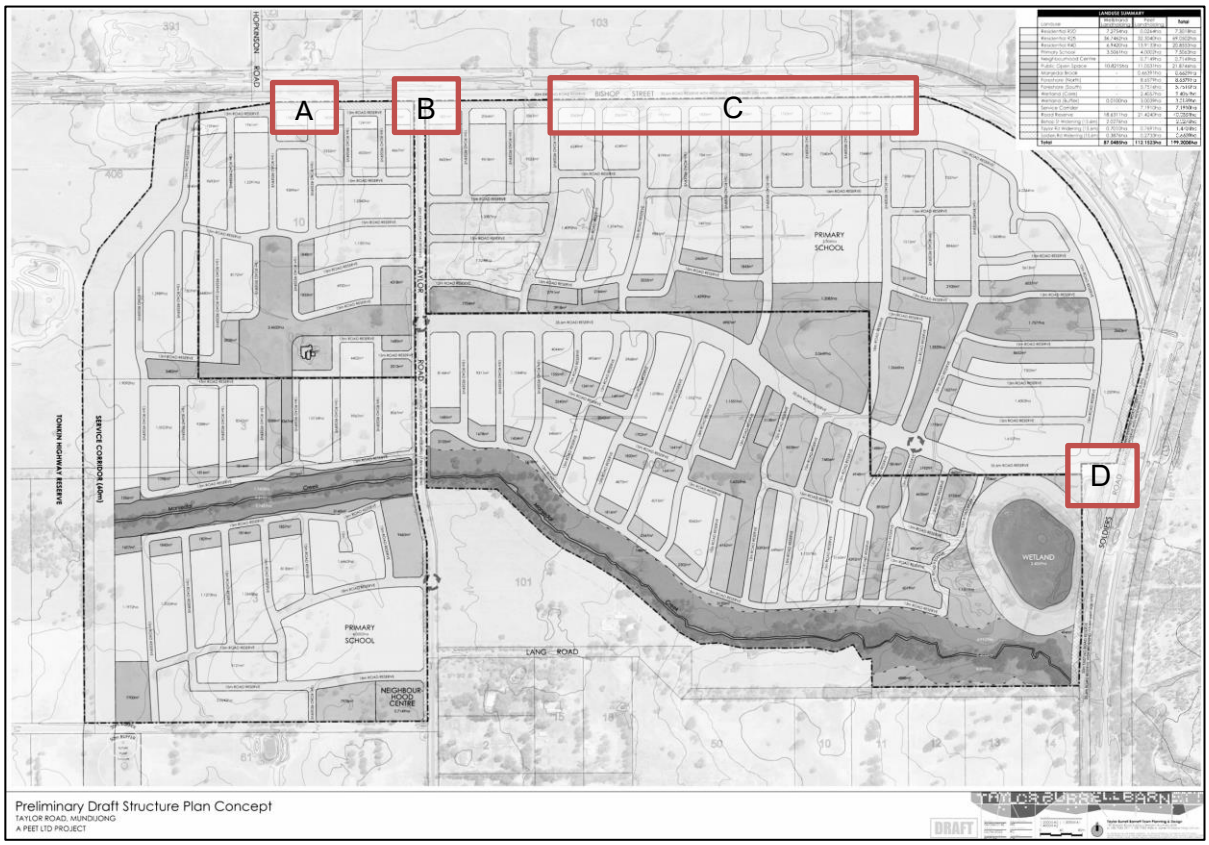


Figure 3 Long Term External Intersection Control Requirements

Access to Bishop Road

To the west of Taylor Road, access to Bishop Road will need to accord with the intersection spacing requirements set out in *Liveable Neighbourhoods*. Based on integrator A standard for the western portion between Tonkin Highway and Taylor Road, intersection spacing will be 130m (junctions on same side of street). Direct lot access would not be permitted, although service lanes maybe used. This matter needs to be considered in more detail at the time of subdivision. Access A maybe restricted to left-in / left out. Access B at Taylor Road need to be reviewed as Austroads would dictate the alignment of Bishop Road should be to Taylor Road, being the dominant demand.

East of Taylor Road the forecast demands to Bishop Road suggest classification as a neighbourhood connector and side road access streets can operate under yield (give way) conditions.

Soldiers Road / East-West Link

Intersection D will need to be designed to accommodate any proposed grade separation of the rail line for the central Whitby connector road. It is noted that the intersection of the Town Centre Distributor Road and Soldiers Road, as well as the land acquisition and

construction of grade-separated rail crossing is included with the scope of items in the Mundijong Urban DCP (Amendment 209) and accordingly will be delivered by the DCP.

6.0 THE INTERNAL ROAD NETWORK

The forecast traffic flows provide a basis to develop an internal road hierarchy. Table 5 identifies the road reservations proposed for the structure plan area. The reservations are based on advice set out in *Liveable* Neighbourhoods and as required by the WAPC's Schedule of Modifications. The road hierarchy considers those streets that have a connective function and assigns an appropriate classification based on volume and continuity of movement.

The traffic model has been used to determine the anticipated daily traffic flows on local streets. Appendix E shows the modelled forecast flows based on the *Liveable Neighbourhoods* road classification volumes. The forecasts assume full development of the Mundijong and Whitby localities.

Figure 4 shows the suggested road hierarchy for the subject land. Table 5 shows the road reservation requirements.

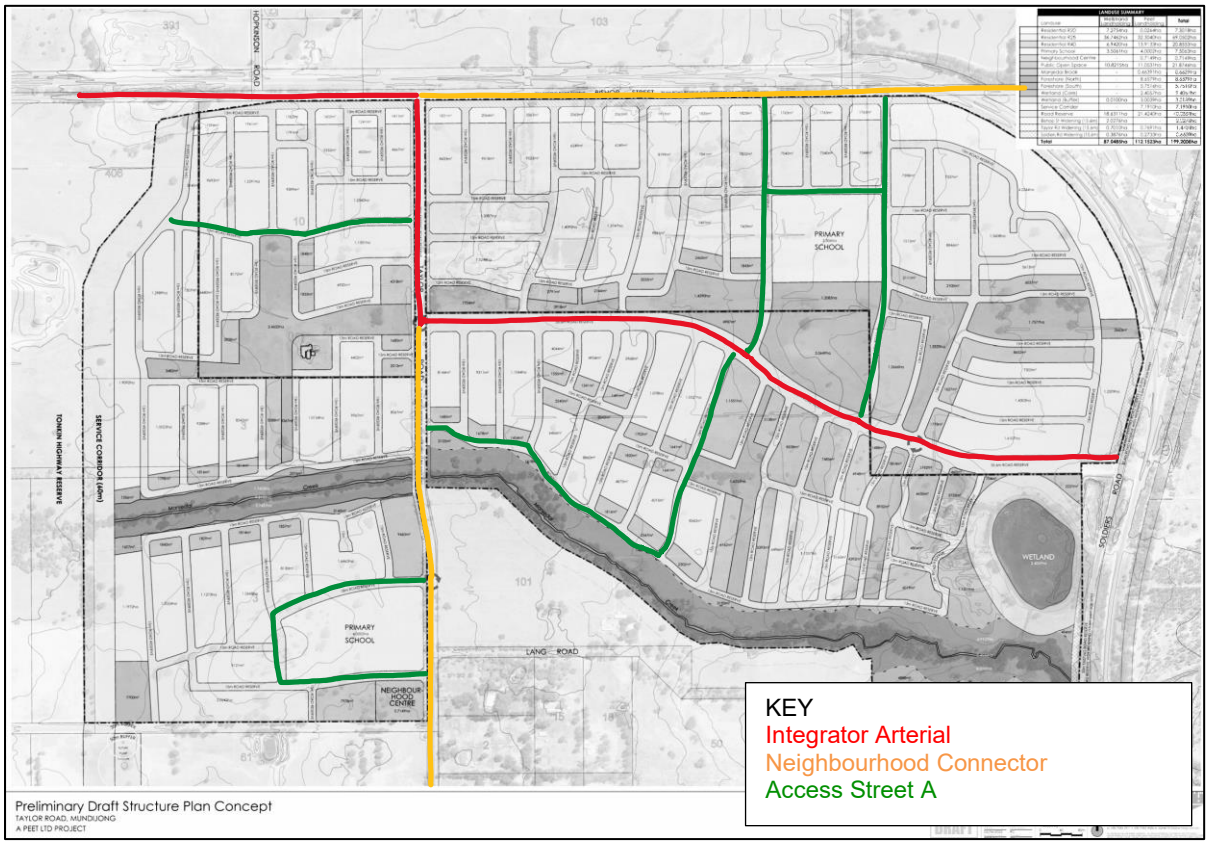


Figure 4 **Road Hierarchy** (All streets are residential access streets unless indicated)

Table 5 *Liveable Neighbourhoods* Road Hierarchy

Indicative Traffic Flow	Classification	Street Characteristics	Reserve Width
<300vpd	Laneway	Laneways may incorporate some services and can provide rubbish collection access. Laneways usually contain some studio units over garages for surveillance. Lane may be widened in parts to create mews courts.	Pavement - 6.0m
< 1,000vpd	Lower order Access Street (D)	Access street D is for short, low volume and low parking demand streets. In addition, a comprehensively designed variant with 3.5 m travel lane with indented parking is also specified for very low volume short streets. Indicative pavement 5.5m to 6m	15m
1,000vpd to 3,000vpd	Higher order Access Streets (A – C)	The most typical and most common residential street will be Access street C – Yield street. Indicative pavement 7m to 7.5m. Note adjacent to Schools 18m is required.	Typical range 15m to 17.2m
	B	Access street B is a wider undivided street for situations with increased parking and/or traffic demand. Indicative pavement 9.7m.	Up to 20.1m
	A	Access street A is a wider avenue for situations with increased parking and/or traffic demand with median suited to incorporation of a drainage swale. Indicative pavement 2 x 3.5 (or 2 x 3.6 under some conditions) plus indented parking.	20m to 24m
3,000vpd to 7,000vpd	Neighbourhood Connector B	A two-lane undivided street for lower volume neighbourhood connectors. Typically can accommodate buses, will have at least one shared path and above 3000 vehicles per day separate on- street bike lane.	20+m
	Neighbourhood Connector A	A two-lane divided street used for higher neighbourhood connector volumes, or for character, storm water infiltration swales or safety. These are often special streets and their design needs to have particular regard to context, function and adjacent land uses.	27.6m*
7,000vpd - 15,000vpd	Integrator (Two lanes, outside centres)	Integrators through centres typically will have at least one clear travel lane in each direction, and parking and/or maneuvering lane. Volumes above 15,000 vehicles per day need detailed design to manage traffic at intersections, facilitate bus movement and deal with parking and access.	28.2m to 31.2m WAPC require 35.6m

Note: Function of streets needs to be considered as well as traffic volume.

*Eastern portion of Bishop Road between Taylor Road and Soldiers Road and southern portion of Taylor Road from E-W Link, to be widened to 30m road reservation as required by the WAPC Schedule of Modifications.

The following section provides guidance on the suggested hierarchy and required hierarchy as per the WAPC Schedule of Modifications with regard to reserves and cross-sections. The

cross-sections indicated are the minimum widths recommended for the various street types. The philosophy of providing constrained streets is to encourage a slower speed environment. However, wider reservation widths may be used to suit the character of the development and increase the opportunity for landscaping and frontage activity.

Integrator Arterials

Liveable Neighbourhoods provides the following comment on integrator arterial roads:

> *Integrator arterials form a finer grain of routes than the primary distributors, with frequent connections to local streets. Low percentage of trucks. Usually bus routes. On-street bike lanes and separate dual-use paths are usually required.*

East-West Link

The modelling shows that the east-west road through the Mundijong Peet landholding will experience traffic demands of 13,000vpd to 16,000vpd. Under Liveable Neighbourhoods the forecast traffic demands would require the link to be classified as an integrator type A road (10,000vpd-25,000vpd) with a road reservation of 31.2 metres. It is noted that a road reservation of 35.6 metres is required by the WAPC Schedule of Modifications.

A 6 metre median is recommended for this link to provide for right turn lanes and the ability for side road traffic to shelter when turning right. Pavements of 5 metres would be suited to this road to provide a standard traffic lane and an on-street cycle lane of 1.5 metres. Residual verges of 7.6 metres would be provided and allow for future duplication of the traffic lanes if deemed appropriate. With ultimate pavements of 8.5 metres for each direction (7 metre traffic lane plus 1.5 metre cycle lane), the verges would be reduced to 4.1 metres. If standard verge configurations are deemed to be required (5.1 metres) at full development a further 2 metres would be required to the road reservation, or a reservation of 33.1 metres. It is noted that a road reservation of 35.6 metres is required by WAPC Schedule of Modifications.

As a result of choosing the residential east-west connection through Mundijong as the main connection between Whitby and the Tonkin Highway, Austroads recommends that where a turning movement is greater than the through movement, the intersection should be re-aligned. It is evident therefore that the two intersections on Taylor Road at Bishop Road and the east west connection will need to be redesign in accordance with Austroads. A minimum curve radius of 210 metres for re-alignment of these two intersections will be required (refer current design guides).

Austroads requires that should a future dual carriageway be provided along the link between Whitby and Tonkin Highway it should be designed to at least an 80kph design standard (70kph posted speed). It is strongly recommended that a 90kph design standard is used as it can be expected that the link will operate at a higher speed if provided with four lanes. Whilst a lower limit may be applied (70kph) the design of the road alignment should be forgiving of vehicles using higher speeds.

Neighbourhood Connectors

Liveable Neighbourhoods provides the following comment on neighbourhood connectors:

> *Neighbourhood connectors link neighbourhoods and towns, are carefully designed to calm traffic, limit noise and facilitate pedestrian use. They have frequent local street connections. They should not attract substantial long distance through traffic, but provide for safe and convenient local travel to and from arterial routes, usually at signal controlled intersections.*

Roads shown orange in Figure 4 are considered as neighbourhood connectors as they provide the primary access to the structure plan area. Daily traffic flows on these roads are well within the 7,000 vehicles per day recommended. These streets can be provided with a standard 7.2m carriageway, which is suited to bus movements. A footpath to both sides of the street is required, although one side may be designated as a shared path. Figure 5 shows a suitable cross-section within a 20 metre reservation. Localised widening at intersections may be required to provide medians.

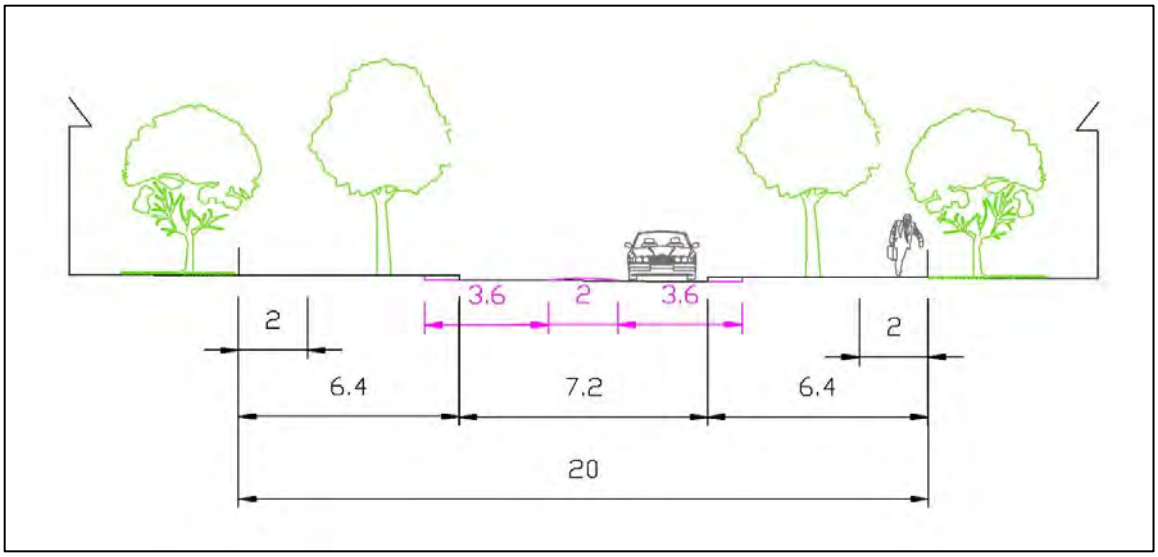


Figure 5 LN Neighbourhood Connector

At intersections, median islands of 2.0m would be desirable to provide safer pedestrian crossing points and to highlight the intersection. A residual verge width of 5.4m can be provided where such medians are provided. The adjacent kerbs will need to be over-runnable. If barrier kerbs are to be used, the lane width should be widened to 4.1 metres, leaving a residual verge of 4.9 metres. The eastern portion of Bishop Road and southern portion of Taylor Road classified as 'neighbourhood connectors' will feature a 30m road reservation through the subject land is required by regional and district road planning.

Access Streets

Access streets carrying between 1,000vpd to 3,000vpd are considered to be the normal street cross section used in the local area. All roads unmarked in Figure 9 are considered as access streets. Figure 6 shows a typical cross-section for a 15.0m wide road reservation providing a 6.0m carriageway and two 4.5m verges.

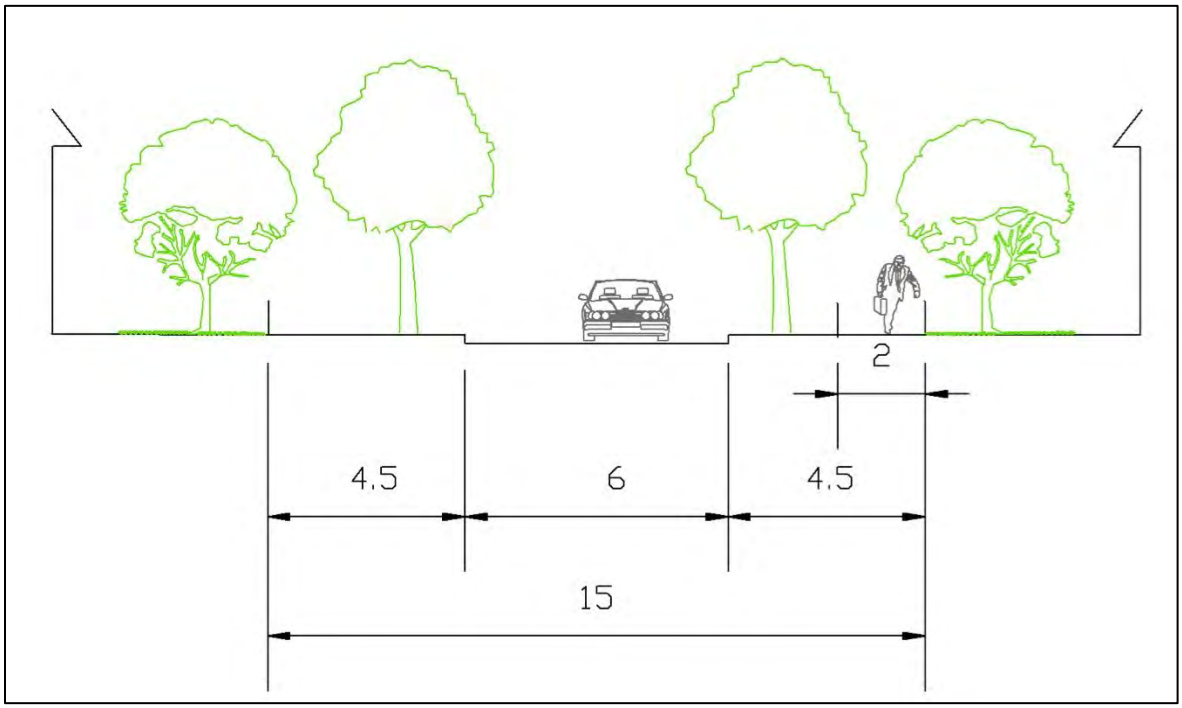


Figure 6 Access Street

Liveable Neighbourhoods suggests that these streets would be considered as "typical residential streets" (LN notation as access street C). A carriageway width of 6.0 metres is shown as a 7.0m wide carriageway will tend to encourage a higher traffic speed. A 6.0m carriageway is preferred to encourage a 40kph target speed and enables occasional on-street parking. A wider carriageway is only recommended where buses or large vehicles are expected. In higher density areas, the provision of parking embayments is a preferred treatment, rather than an increased carriageway width.

It should be noted that from a road network capacity basis, a 6m wide carriageway could accommodate two-way traffic flows up to 1,100 vehicles per hour (indicatively 11,000vpd), but as a residential street should be restricted to less than 3,000vpd to maintain appropriate residential amenity. A wider carriageway is not required from a traffic movement perspective however, may be used to provide route continuity.

Roads Adjacent to Open Space

Where the road reservation abuts POS, bushland, golf courses etc., there is limited need to provide a verge. The verge may be reduced where parking and/or services are not required and should be considered at the time of subdivision. A minimum verge of 1.0m is advised by current road planning standards to accommodate street furniture. Footpaths do not need to be adjacent to the road where POS is provided, but must be provided in a safe and appropriate manner.

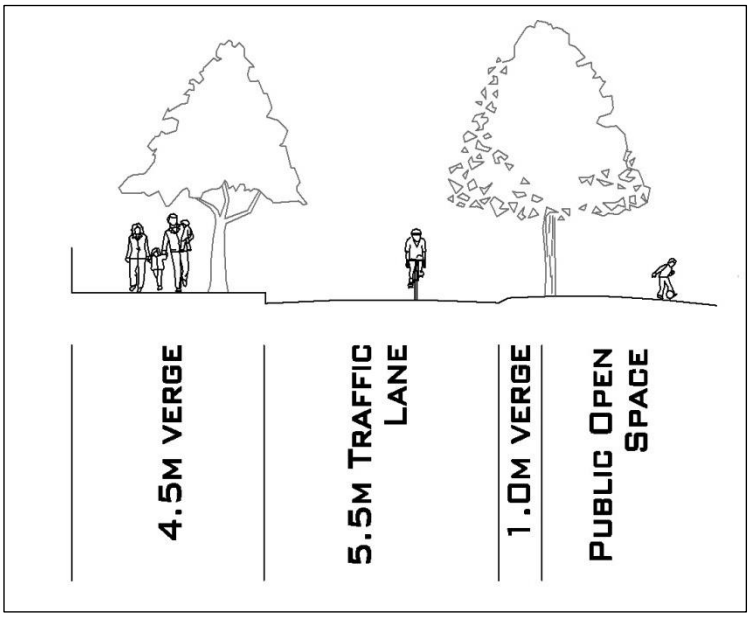


Figure 7 POS Roads

Roads Adjacent to Schools

The subject land shows two primary schools will be provided. To provide for future on street parking an 18 metre road reservation is required to be used on all roads fronting a school. The reservation allows ample width to provide embayed parking and a dual use path to the school side and a footpath to the opposite side.

7.0 TRAFFIC MANAGEMENT

The detail of any traffic management should be considered at the time of subdivision.

Four-way Intersections

Within the structure plan area daily traffic volumes are shown to be low and the use of four-way intersections is appropriate. Figure 8 shows an extract from Liveable Neighbourhoods on the preferred treatment of four-way intersections.

Liveable Neighbourhoods suggests that four-way intersections are an appropriate treatment at the meeting of two access streets and where daily flows through the intersection are less than 2,000vpd. Approach legs should be limited to a maximum length of 160 metres with some form of speed reducing feature where the length is greater than 80 metres.

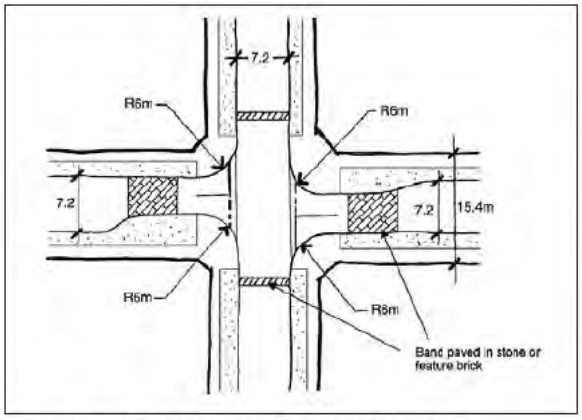


Figure 29A: Access street to access street with-four way and stagger.

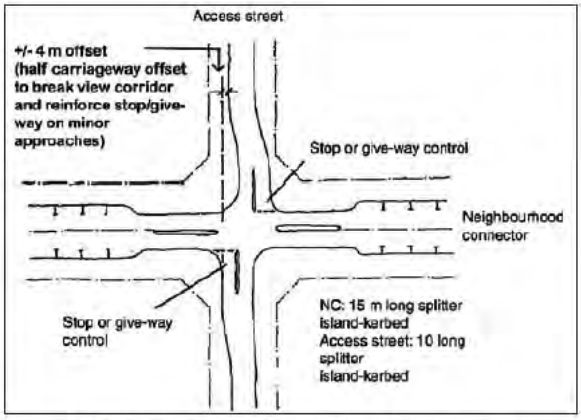


Figure 31: Left-right minor offset four-way on neighbourhood connector (derived from Austroads Guide to traffic engineering, Part 5 Intersections, Figure 5-8).

Figure 8 Liveable Neighbourhoods Four-way Intersections

Access streets meeting neighbourhood connectors and some arterial streets are considered acceptable, but will generally require a treatment as indicated in Figure 14. In these instances *Liveable Neighbourhoods* would require a maximum of 4,000vpd passing through the intersection with a maximum combined flow of 1,000vpd on the minor legs.

Introducing four-way priority intersections on arterial streets is not recommended.

Figure 9 shows the traffic management treatments and requirements for the subject land.

Note intersections at locations A and B need to be reviewed in regard to Austroads guidelines on major road traffic flow and intersection alignments.

Local Intersection Design

To reduce the opportunity for speeding it is recommended that corner radii advised by *Liveable Neighbourhoods* be used within the subdivision. The recommended radii are:

- 6.0 metres - access street / access street intersections
- 9.0 metres - access street / neighbourhood connector

Where larger vehicles are expected, such as buses accessing the school, larger radii may be required and should be considered at subdivision stage. It should be noted that adjacent to the proposed school, the minimum 6.0m radii is preferable to ensure side road traffic enters the major road at 90^0 to improve visibility to pedestrians. The tighter radii will also ensure traffic cannot enter or depart the side road at speed.

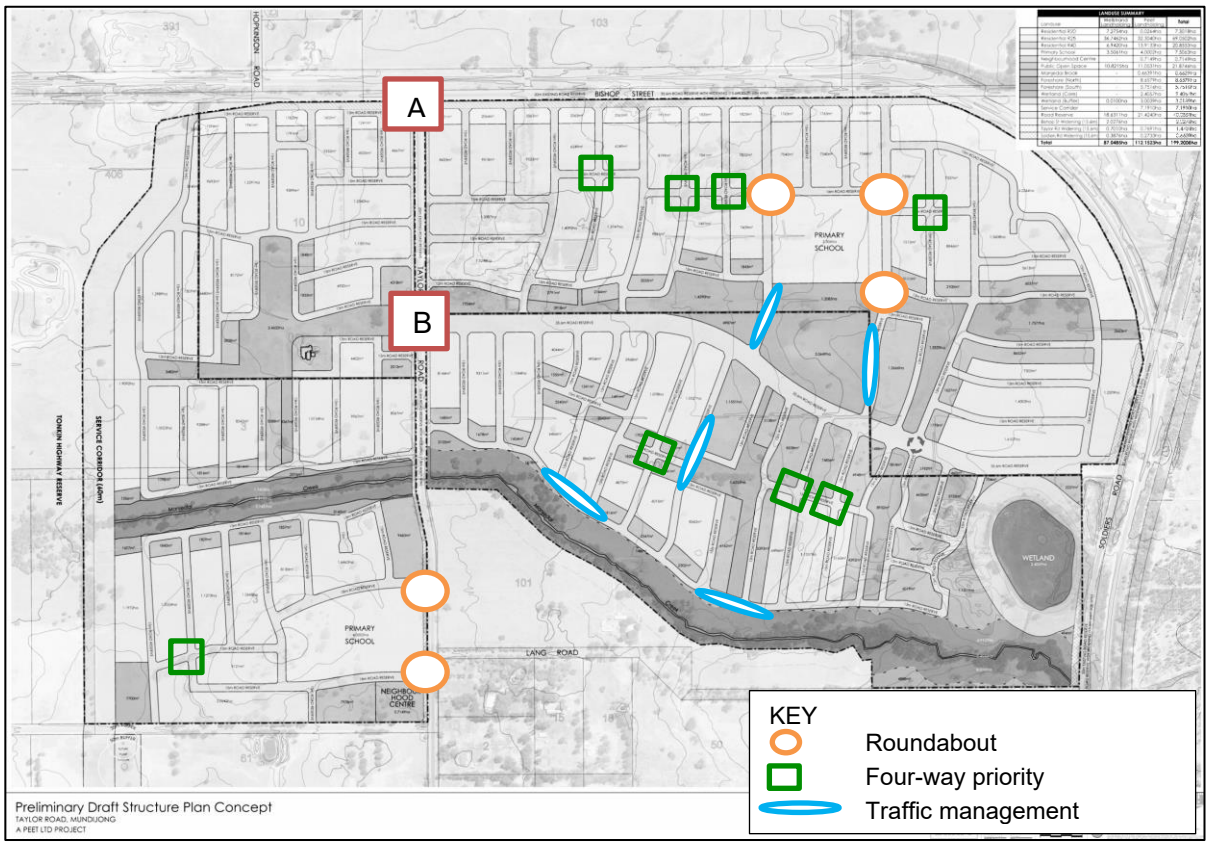


Figure 9 Internal Traffic Management and Intersection Control Requirements

8.0 PEDESTRIANS, CYCLISTS AND PUBLIC TRANSPORT

The structure plan provides for two primary schools within a pleasant walking distance for the majority of households. Adjacent to the school and on identified walking routes, it is desirable to provide a footpath to both sides of the street. A shard path linking the schools is also very desirable.

Current planning guidelines suggest that all streets should be provided with a footpath wherever possible. Where traffic flows exceed 1,000 vehicles per day, a footpath to both sides of the road should be provided. However, a footpath and a shared path may be used in these locations.

Cycling

Cycling would be safe on the majority of local streets where traffic flows are less than 1,000 vehicles per day. On the neighbourhood connectors shared paths should be provided to provide a safe alternative to on-road cycling (if not provided). A principal shared path is indicated in the district structure plan adjacent to the future Tonkin Highway. It is desirable to provide linkages to this path, although the future service corridor may preclude such access.

Public Transport

Mundijong already has a rail station on the Perth to Bunbury line, utilised by the Australind service, which does stop. However, this is a twice a day service with scheduled departure times that make commuting to Perth CBD awkward.

Armadale is about 21 kilometres to the north of Mundijong, where the metro rail line service to the CBD currently terminates. There is discussion of the service being extended to Byford, although this is a very long-term proposal. The Perth – Mandurah line can be accessed at Wellard, Rockingham and Safety Bay. These stations are probably closer than Armadale to the north and have been developed as park and ride stations. It can be expected that commuters to Perth will be split 60/40 to the Perth – Mandurah line.

There are 2 bus services passing through the locality, routes 252 and 253. The services connect to Armadale railway station. The district structure plan sets out to provide a bus route along Taylor Road / Soldiers Road that would terminate to the north side of Mundijong Road. Figure 10 shows the proposed bus route.

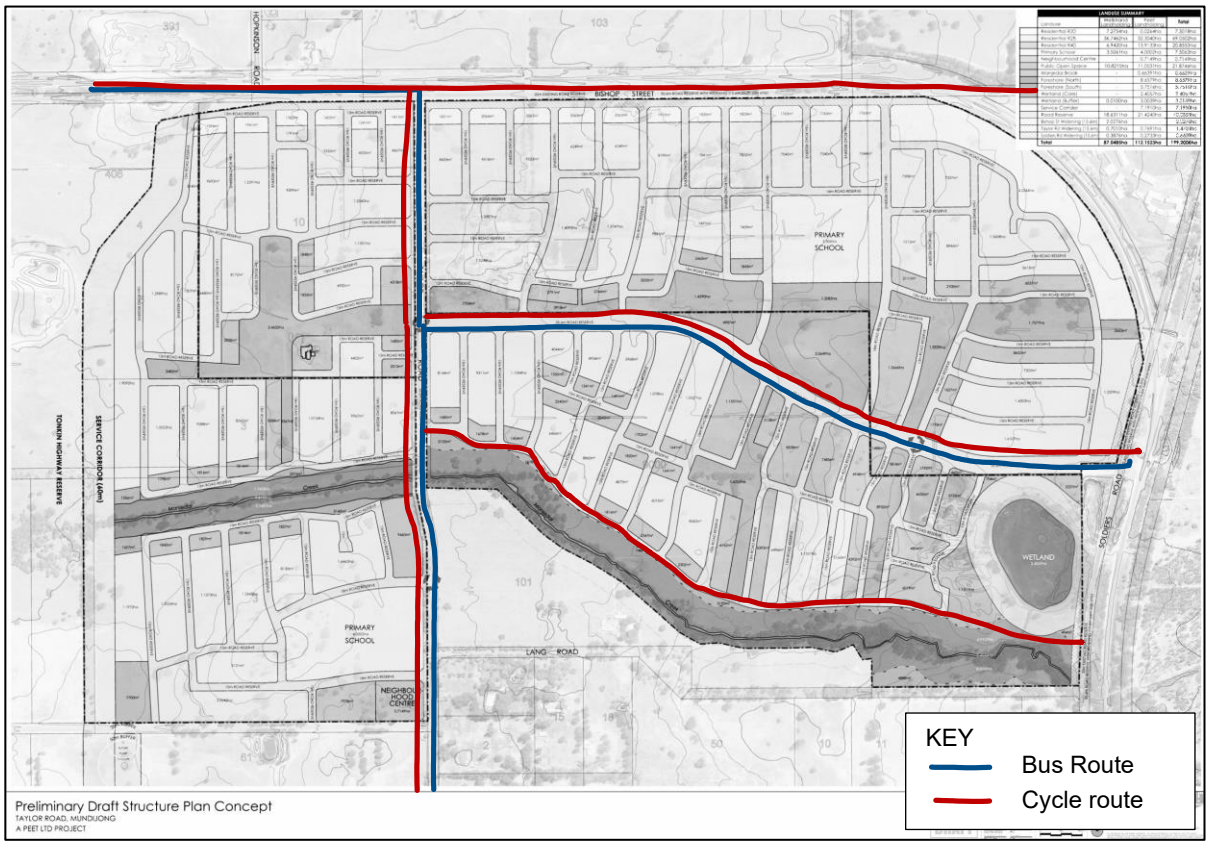


Figure 10 Cycle and Bus Routes (base plan indicative)

APPENDIX A Tonkin Highway Concept Plan

JUNE 2021

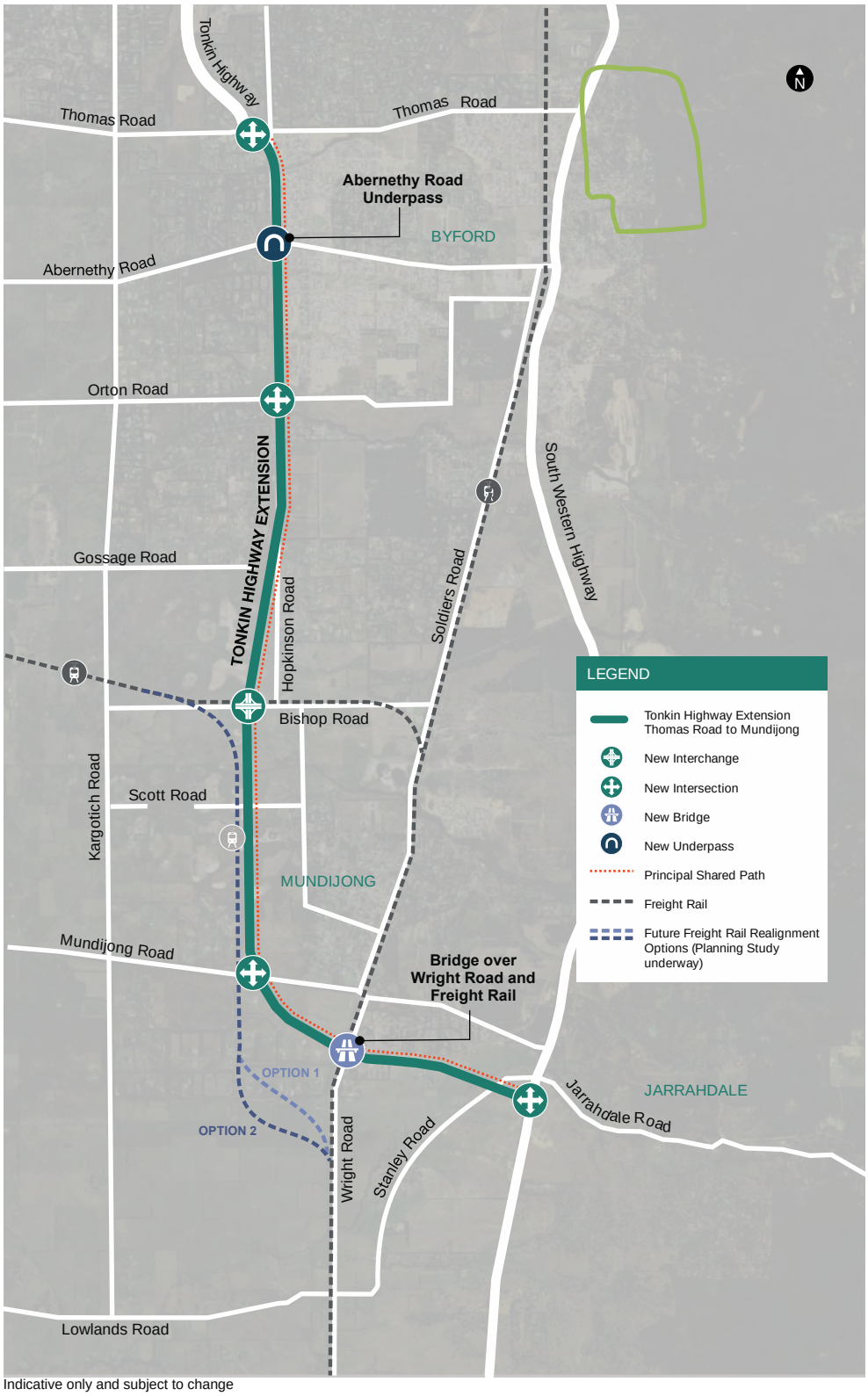
TONKIN HIGHWAY EXTENSION

THOMAS ROAD TO SOUTH WESTERN HIGHWAY

Australian Government

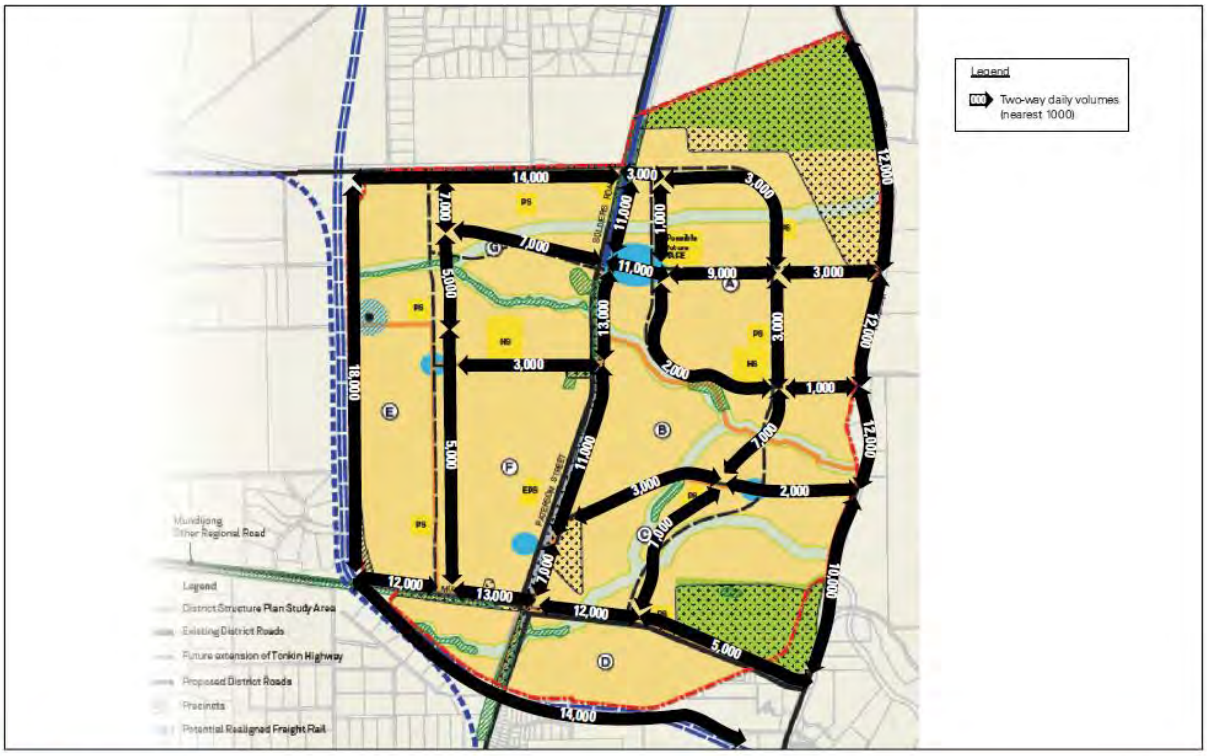
BUILDING OUR FUTURE

mainroads WESTERN AUSTRALIA



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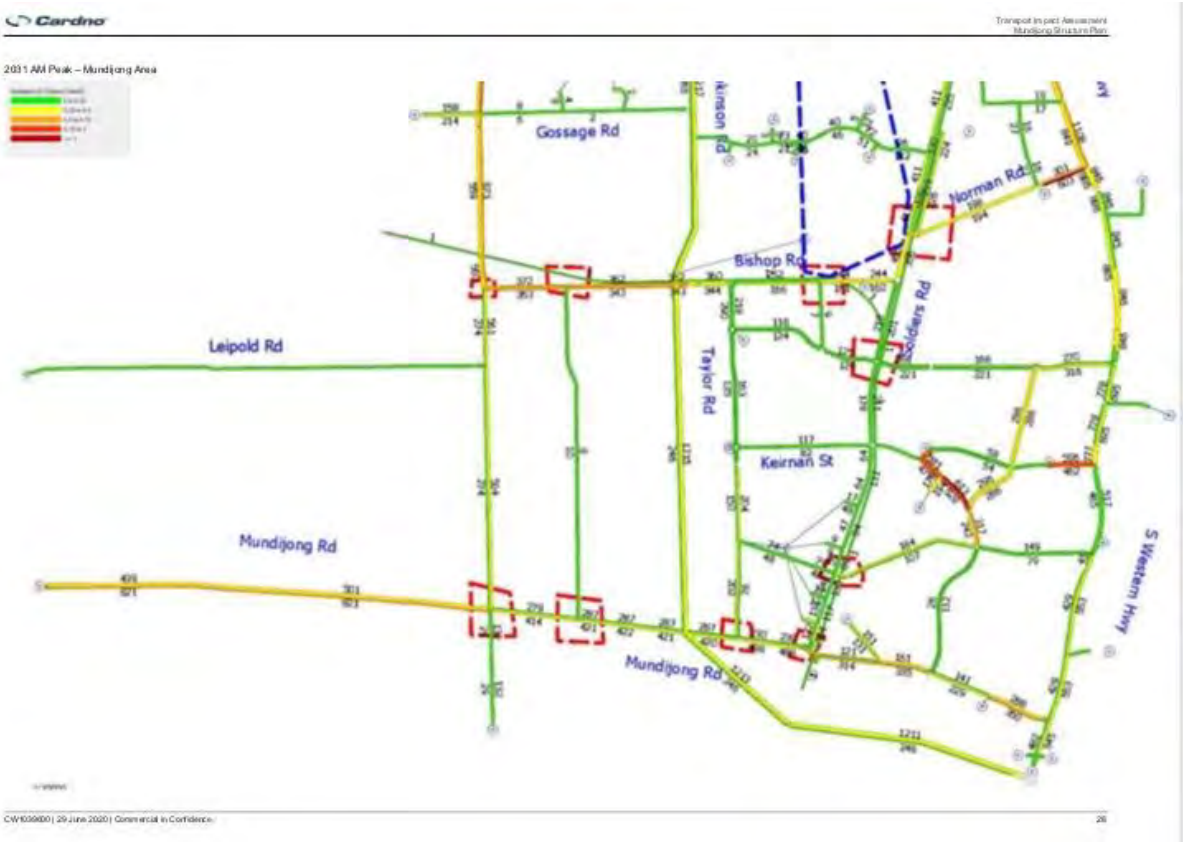
APPENDIX B Whitby – Cardno Mundijong DSP Traffic Forecasts 2010



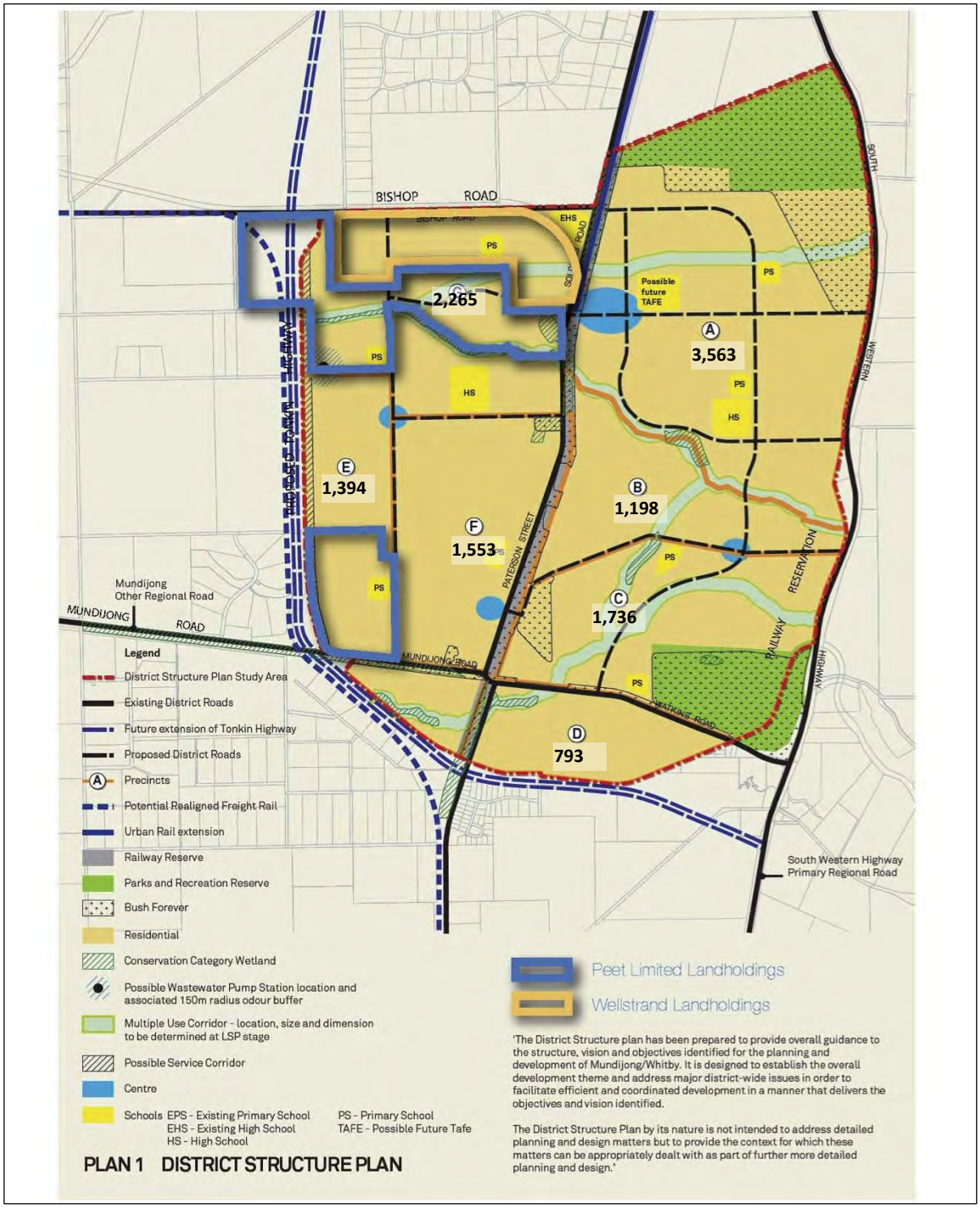


Cardno Mundijong DSP Traffic Forecasts 2020



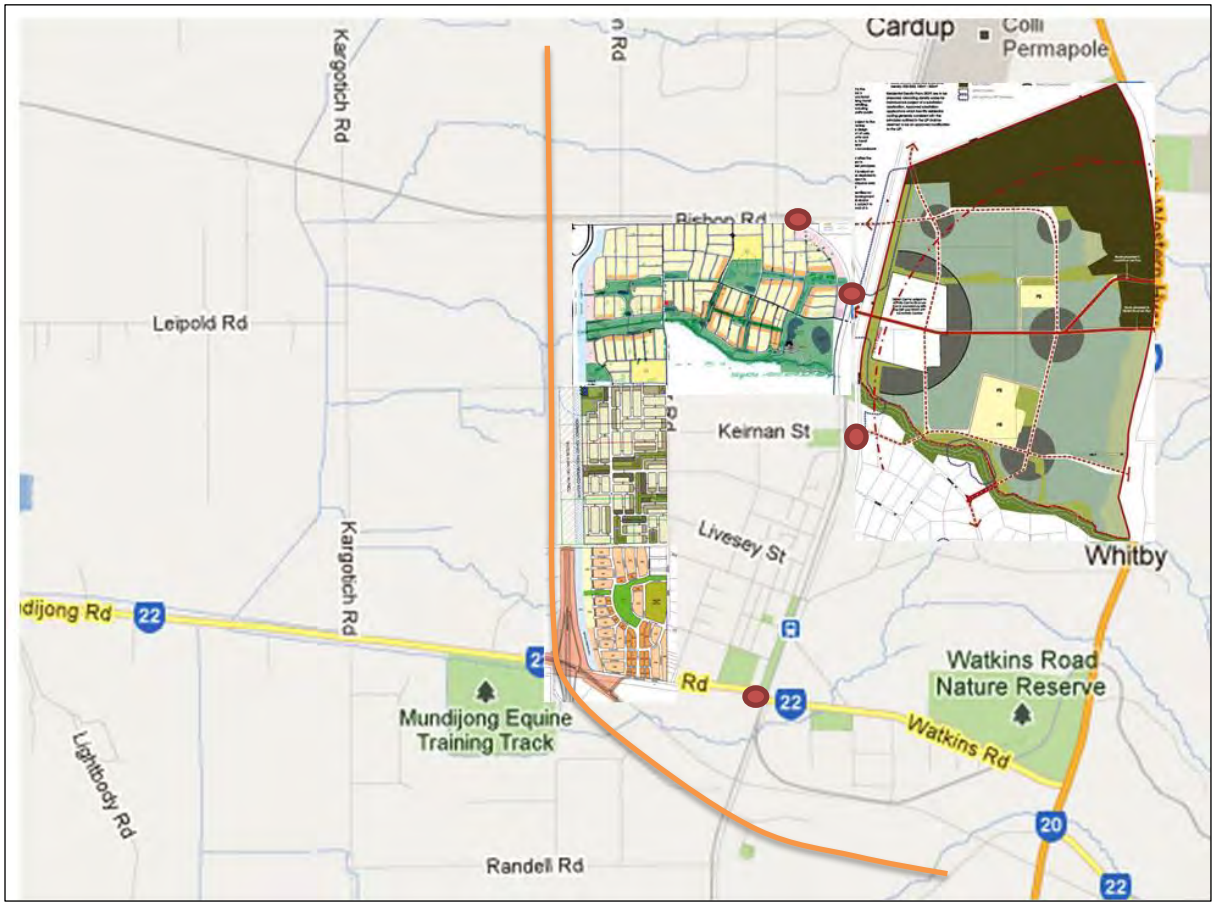


APPENDIX C Whitby - Mundijong District Structure Plan



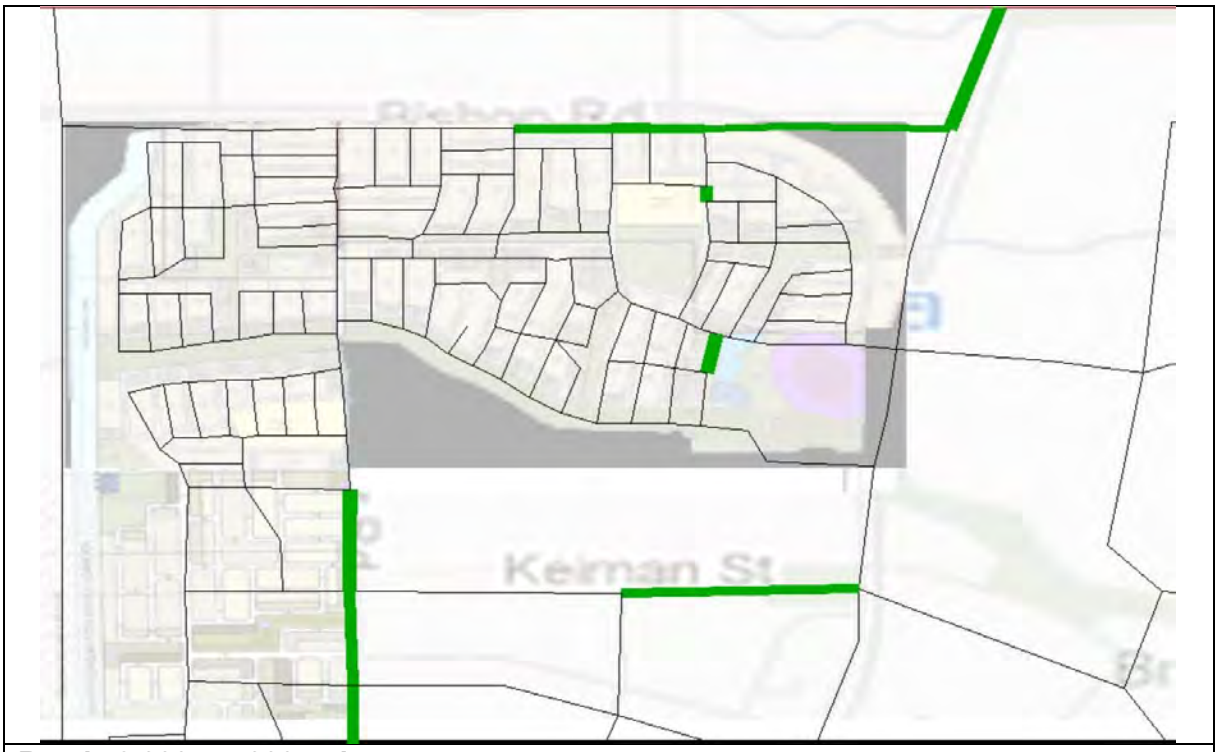
Expected dwelling yields

APPENDIX D Traffic Model Area

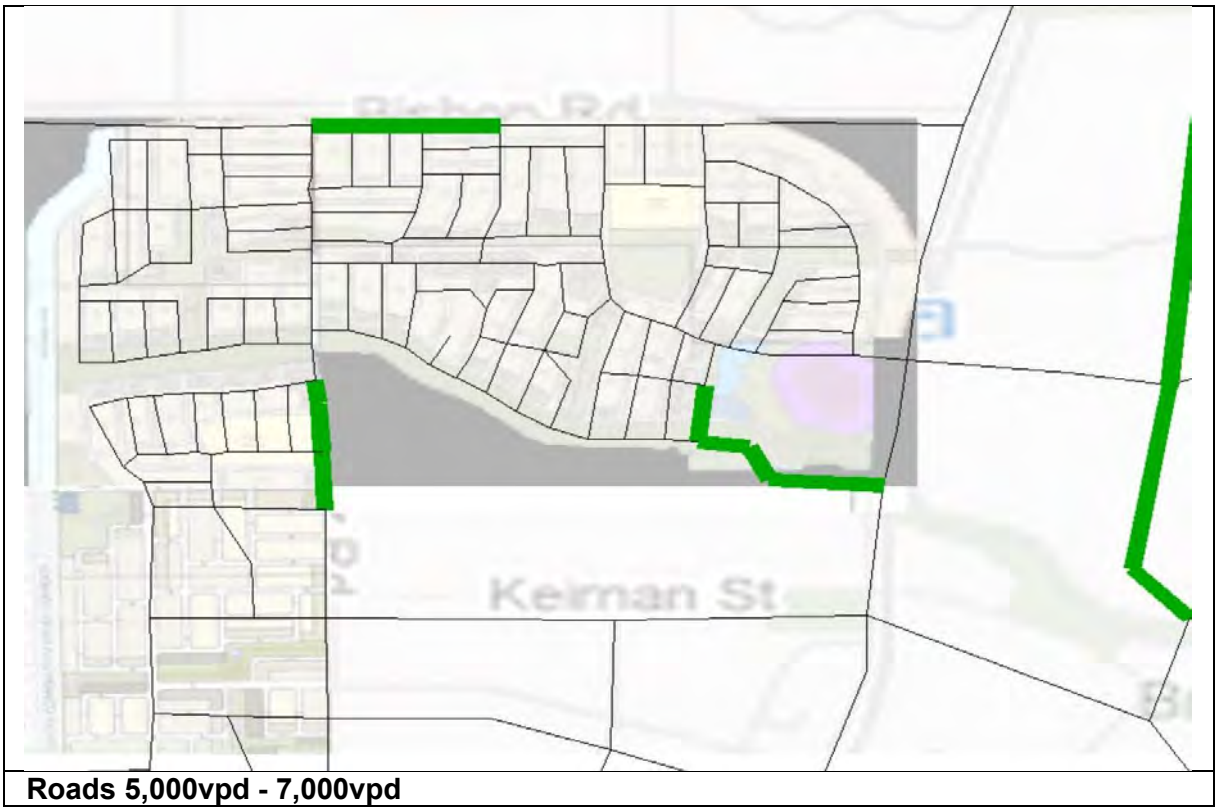


Mundijong Modelled area and Rail Crossings

APPENDIX E Model Outputs



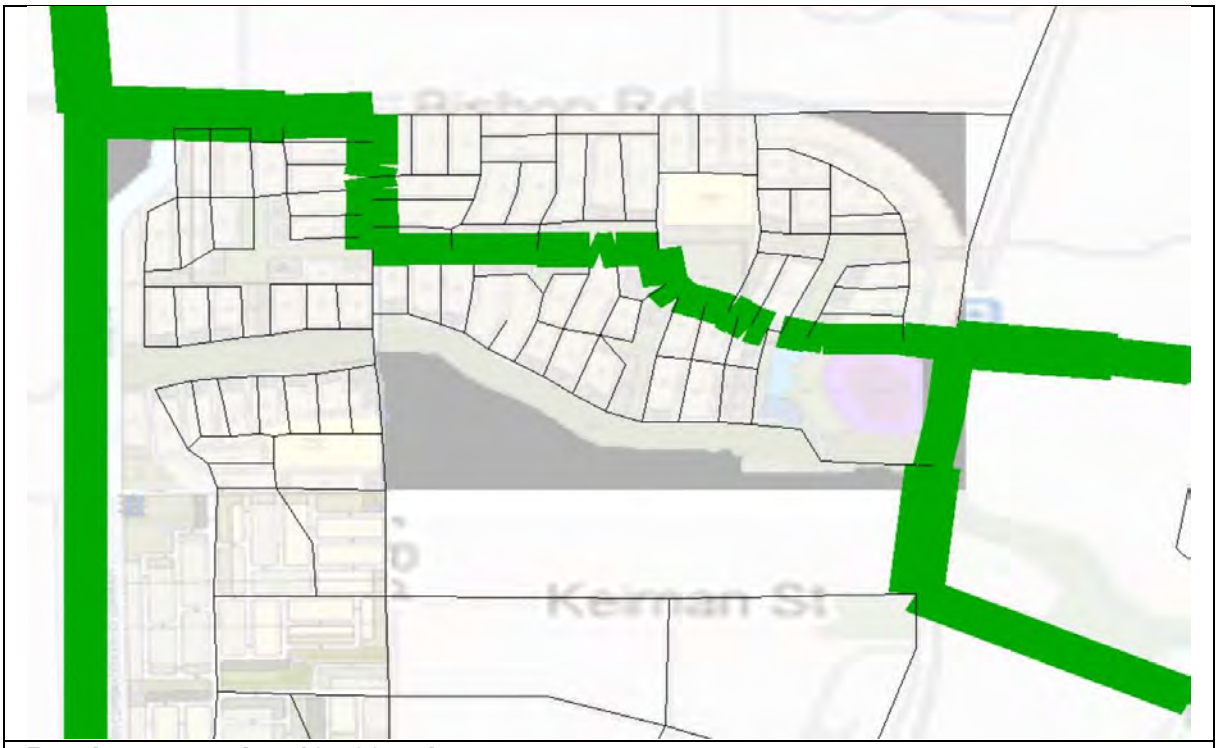
Roads 3,000 – 5,000vpd



Roads 5,000vpd - 7,000vpd



Roads 7,000vpd – 9,000vpd



Roads greater than13,500vpd

Appendix I

Infrastructure Servicing Report

wave international

DETERMINE • DESIGN • DELIVER





Mundijong Precinct G1
Infrastructure Servicing Report

Peet Ltd
February 2015

engineering project management environment

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wave international
DETERMINE · DESIGN · DELIVER

MUNDIJONG PRECINCT G1

INFRASTRUCTURE SERVICING REPORT

Project Brief

Job Number	2680
Doc Number	2680-30-RPT-CI-24001
Project	Mundijong Precinct G1 Infrastructure Servicing Report
Client	Peet Ltd
Client Contact	Charlie Kennett
Client Address	Level 7, 200 St Georges Terrace PERTH, WA 6000

Document Status

Rev	Date	Description	By	Signed
A	May 2014	Draft	PK	
B	February 2015	Issued to Client	LC	

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Appendix A – Preliminary Infrastructure Services Layouts.....A

1 EXECUTIVE SUMMARY

Wave International was commissioned by Peet Ltd to prepare an infrastructure investigation and servicing report for a 199 hectare landholding within the Mundijong/Whitby District Structure Plan (DSP) area. This area is delineated as Precinct G1 in the DSP. The Local Structure Plan area is approximately 40km south of the Perth CBD, and 3km north-west of the Mundijong Town Centre.

The key findings of the infrastructure Investigation are:

- All infrastructure required to support the future development of Precinct G1 is either in place or can be economically constructed to provide a service at the time of subdivision. No material infrastructure constraints were identified.
- The greater Mundijong area has historically had no Water Corporation sewer infrastructure. The Water Corporation planning for the area has been completed and the future sewer infrastructure requirements have been identified. Water Corporation has budgeted for the key capital infrastructure to service this LSP in their 5 year capital investment programme.
- Land requirements for the major wastewater pumstation has been identified outside this LSP area and the Water Corporation is currently in the process of acquiring the land. There are no odour buffer impacts on this LSP.
- Water Infrastructure capable of supporting the LSP's development has been partially constructed and the remaining distribution main sections are included in the Water Corporations 5 year Capital Investment Programme. Reticulation mains to connect the LSP area to the distribution mains can be constructed in existing road reserves.
- Existing overhead High Voltage powerlines are located close to the site and can supply the future development of the LSP area. Sufficient capacity exists in the existing HV network.
- Existing high pressure gas mains are located on the northern boundary of the LSP area and can supply the future development of the site.
- The site is well serviced by existing roads and the required road upgrading and reserve widening has been identified through a separate LSP traffic study.

2 RECOMMENDATIONS

The following recommendations are made in respect of the LSP.

- There are no specific land requirements that need to be set aside in the LSP for the future provision of sewer, water and power headworks infrastructure.
- Provision for future road reserve widening along Bishop Road, Soldiers Road and Taylor Road be made in the LSP design in accordance with the Riley Consulting traffic report.
- The relevant service authorities and local government be contacted during future subdivision applications in accordance with standard subdivision processes

3 INTRODUCTION

3.1 Background

The Site is bounded by Bishop Road to the north, proposed Tonkin Highway to the west, Scott Road and Manjedal Brook to the south and Soldiers Road to the east. Refer Figure 1.1 for site location in relation to the surrounding areas.

The Site is approximately 199 hectares and is shown in Figure 1.2. The proposed Local Structure Plan (LSP) has a potential to develop approximately 2270 residential lots.

This infrastructure servicing report is prepared in support of the LSP submission.

3.2 Proposed Land Use

The Lots 2, 10, 11, 98, 405 and 9000 Taylor Road in Mundijong (Site) will be developed predominantly for residential purposes with supportive land uses such as primary schools, public open space, foreshore reserve (Manjedal Brook), possible neighbourhood activity centre and associated community infrastructure.

Based on the local structure concept plan by Taylor Burrell Barnett (Dated 02/12/2015), the lot yield will comprise of approximately 2300 lots, depending on the layout adopted during future subdivision applications.

An indication of dwelling yield as follows:

- R20 standard traditional – approximately 1,800No with an average lot size of 450sqm (82.7 hectares)
- R30 medium density – approximately 500No with an average lot size of 300sqm (14.6 hectares)

The concept plan also makes provision for the following:

- 2No primary schools (7.6 hectares)
- Public open space (23.1 hectares)
- Wetland and foreshore reserves, including a community area (18.1 hectares)

4 SEWER

4.1 Existing Infrastructure

Currently there is no sewer reticulation network in the greater Mundijong area. The Whitby development to the east of this LSP area has recently installed a gravity sewer system and Waste Water Pump Station that will discharge into the existing Byford Gravity sewer system. This system is located in a different gravity sewer catchment and is therefore not able to provide any service to this LSP area.

4.2 Water Corporation Planning

The Water Corporation has a long term plan to construct a permanent Type 1000 sewer pump station (Byford Main Pumpstation) on the southern side of Scott Road (south-west corner of the Site) to service the greater Mundijong/Byford/Armadale area. The discharge from the Byford Main Pumpstation will be the proposed East Rockingham Waste Water Treatment Plant via a pressure main along a service corridor (located on the western side of the Site) and Mundijong Road. This pumpstation will be developed as multiple Type 350 and Type 500 units located on two separate sites, east and west of the proposed Tonkin Highway, and will be developed to the ultimate capacity over several decades.

As an interim measure to service the immediate Mundijong gravity sewer catchment, a Type 90 interim sewer pump station will be constructed at Scott Road and pump sewage approximately 8km northwards to an existing pump station (PS086-02) off Hopkinson Road in Byford, with an approximately 20 l/s available capacity.

The availability of the 20 l/s capacity for the Site will be subject to ongoing monitoring which will only be available on a staged basis and dependent on the progressive upgrades of the Byford pump station.

The Water Corporation's planning currently shows upstream sub-catchments discharging through the Site, therefore oversized pipes are shown running through the development area. Depending on the timing of the development, Water Corporation may allow the development to be designed without receiving any external catchments. As a minimum, provision must be made for the future elimination of the existing Type 10 WWPS located at the Whitby development

At the time of producing this report the Water Corporation were in the process of acquiring the land for the proposed Byford Main pump station and the location of the Type 90 interim pumpstation is therefore fixed for the purposes of this LSP. There is no odour buffer encroachment north of Scott Road into this LSP area.

The proposed sewer infrastructure requirements for the Site are shown in Figure 3.1.

5 WATER

5.1 Existing Infrastructure

The main water supply to Mundijong is currently supplied off the Serpentine Trunk Main on Summerfield Road 5.5km south of Mundijong Road. This water main consists of 150mm and 300mm dia pipes.

The Water Corporation is in the process of providing an interim upgrade of the water supply which consists of upgrading the water mains between Summerfield Road and Mundijong Road from 150mm dia to 400mm dia and this is expected to be operational in 2016.

5.2 Water Corporation Planning

The long term water supply proposed for Mundijong consists of three systems as follows:

- Construction of several distribution and reticulation mains that connect at Mundijong Road. Initially this will be served from the Serpentine Trunk Main. This system can be discussed as follows:
  - A 500mm dia distribution main will be connected to the interim upgraded system at Mundijong Road following a route northbound along Paterson Street. This Distribution main reduces in size at the intersection of Paterson Street and Richardson Street. It branches off into a -
    - 375mm dia distribution main following a western route along Richardson Street.
    - 300mm dia distribution main continuing northwards along Paterson Street.
    - 300mm dia distribution main following an eastwards route along Kiernan Street.
  - The 375mm dia distribution main in Richardson Street reduces to a 250mm dia reticulation main at the corner of Richardson Street and Adams Street. The 250mm dia reticulation main continues north along Adams Street/Taylor Road, through the Site, to Bishop Road.
  - The 300mm dia to Paterson Street/Soldiers Road continues northwards to the Site where it reduces to a 250mm dia reticulation main. At Bishop Street, the 250mm dia reticulation main branches off to a 200mm dia reticulation main following Bishop Street and a 100mm dia reticulation main as it continues along Soldiers Road.
  - The 300mm dia distribution main in Evelyn Street/Galvin Road will provide a connection to the future pump station that will service a high level water tank, which is discussed below.
- High level water tank located east of the Site. This will be constructed to supply the higher region of Mundijong where the pressures become too low to provide a supply from the distribution infrastructure discussed above.
- Regional reservoir located south east of the Site. This future reservoir will be connected to the interim upgrade between Summerfield road and Mundijong Road via a 600mm dia distribution main.

At the date of producing this report only the 500mm Paterson Road main and the 300mm Kiernan Street water main were included in the Water Corporations 5 year Capital Investment Program (CIP), therefore all remaining infrastructure required to serve the Site will be funded by the Developer. This may change in future as the CIP works are reviewed annually to prioritise infrastructure according to development progress and Water Corporation priorities.

Given the above, and based on a meeting with the Water Corporation, the water supply for this LSP area Site can be obtained from constructing a 250mm dia reticulation main from Mundijong Road along the following route.

- Northwards along Paterson Street to Cockram Street.
- Westwards along Cockram Street to the future Adams Street Extension.
- Northwards on Adams Street and continuing north along Taylor Road to the Site.
- Note: This route will provide a 250mm dia reticulation main to the Cockram Street Development in Mundijong, which is also a Peet Ltd Development.

It should be noted that this 250mm dia reticulation main will only have the capacity to serve approximately 400 lots. Once the 250mm dia reticulation main has reached its capacity, additional works will be required to upgrade the water supply system with additional water mains to form a loop main. This will be confirmed by the Water Corporation at detail design stage.

The proposed water infrastructure requirements for the Site are shown in Figure 4.1.

6 ROADS AND TRAFFIC

6.1 Existing Road Infrastructure

The subject land is bounded by Bishop Road to the north, Soldiers Road to the east, Scott Road and Manjedal Brook to the south and Tonkin Highway to the west.

The existing road infrastructure is described in more detail below.

- **Bishop Road** – Bishop Road is located to the north of the Site and provides a link between Kargotich Road (western side) and Soldiers Road (eastern side) of the Site. Bishop Road is a sealed rural road within a 20m wide road reserve. A railway line is located to the immediate north of the road reserve.
- **Proposed Tonkin Highway** – Proposed Tonkin Highway is proposed to be located to the west of the Site. There is no direct link between the Site and the Highway, however, land has been allocated for an intersection from the Tonkin Highway to Bishop Road. The proposed Highway is separated from the Site by a 60m Water Corporation service corridor.
- **Scott Road** – Scott Road is located to the south of the Site and provides connection between Kargotich Road (western side) and Taylor Road (eastern side). Scott Road is an unsealed rural access road with a 20m wide road reserve. This access road provides access to several rural properties.
- **Taylor Road**- Taylor Road runs through the Site between Bishop Road (northern side) and southwards where it changes name to Adams Street. Taylor Road is a sealed rural road within a 20m wide road reserve.
- **Soldiers Road** – Soldiers Road is located to the east of the Site and provides a major north to south link between Byford and Mundijong. Bishop Road intersects with Soldiers Road to the north and the Manjedal Brook to the south. Soldiers Road is a sealed rural road within a 20m wide road reserve. A railway line is located to the immediate east of the road reserve.

6.2 Proposed New Road and Upgrade

A detailed Structure Plan traffic report has been prepared by Riley Consulting in support of the proposed LSP and details the traffic background and treatments required for future subdivision applications. A summary of the proposed road upgrading, based on the report recommendations, is provided below.

- Bishop Street – The road is currently a sealed 7.5m (western side) to 6.0m (eastern side) two lane rural road within a 20.0m wide road reserve. The DSP forecasted traffic volumes for 2029 is up to 14,000 vehicles per day. In accordance with 'Liveable Neighbourhoods' Bishop Street should become an Integrator B, requiring a road reserve width of 29.2m comprising of two lanes (5.0m which includes a 1.5m cycle lane), central median (6.0m) and parking (2.5m).

  A recent DSP scheme amendment has proposed to close Soldiers Road south of the freight rail crossing and to route the Bishop Road traffic through this LSP area. There are various traffic scenario that could eventuate should this be adopted and is addressed in the Riley Consulting report. The DSP scheme amendment has nit yet been adopted at the time of writing this report.
- Soldiers Road – The road is currently a sealed 7.0m two lane rural road within a 20.0m wide road reserve. The DSP forecasted traffic volumes for 2029 is up to 13,000 vehicles per day. In accordance with 'Liveable Neighbourhoods' Soldiers Road should become an 'Integrator B, requiring a reserve width of 29.2m requiring two lanes (5.0m which includes a 1.5m cycle lane), central median (6.0m) and parking (2.5m).

The ultimate configuration of Soldiers Road will be subject to the proposed DSP amendment and the traffic treatment to reconnect Bishop Road into Soldiers Road south of the freight railway.

- Taylor Road - The road is currently a sealed 6.8m two lane rural road within a 20.0m wide road reserve. The DPS forecasted traffic volumes for 2029 is up to 7,000 vehicles per day. In accordance with 'Liveable Neighbourhoods' Taylor Road should become an 'Neighbourhood Connector A', requiring a reserve width of 24.4m requiring two vehicle lanes (3.5m) with cycle lanes (1.5m) and parking (2.1m).

The funding for the road upgrading of the above road is likely to be funded through a Developer Contribution Scheme (DCS) currently in progress by the Shire of Serpentine Jarrahdale.

7 SURFACE WATER MANAGEMENT

7.1 District and Local Water Management

The Taylor Road development falls within the area covered by the Mundijong Whitby District Structure Plan District Water Management Strategy (DWMS), which was prepared by GHD (2010). The DWMS addresses broad-scale stormwater management measures over an 1,800ha area which extends from the future Tonkin Highway reserve to South Western Highway.

A Local Water Management Strategy has been prepared by Wave International to further define surface water and groundwater management design concepts at the Site. The following paragraphs summarise the main outcomes of the DWMS and LWMS.

7.2 Flood Management Strategy

7.2.1 Flood Conveyance

Stormwater runoff from upstream landholdings flows via overland flow across the Site from east to west. This flow, along with runoff from the Site will be managed within several multiple-use corridors on the Site and the foreshore reserve.

Stormwater will be managed to ensure that post-development flow rates are within pre-development levels and that dwellings are protected from flooding in major storm events.

7.3 Local Stormwater Management

7.3.1 Lot Runoff

Lot runoff will be managed through the use of soak-well systems to retain and infiltrate roof runoff within individual lots.

Subsoil drainage will be installed within road reserves to promote infiltration and improve the efficiency of soak-wells.

Future lot owners may also opt to install rainwater tanks, which will also act to retain lot runoff on-Site.

7.3.2 Road Runoff

A conventional piped network will be designed to manage road runoff, with 'leaky' side entry/gully pits located to suit appropriate spread rates and pit spacing. The level of service for the side entry/gully pits and the pipe network will be dependent on the road hierarchy.

Road runoff from minor storm events (up to 1 year ARI) will be retained and treated within roadside rain gardens and bio-retention systems in public open space areas to ensure water quality objectives are met.

7.3.3 Post Development Flows and Storage

To ensure that downstream landholdings are not adversely impacted by development in upstream catchments, each development must ensure that peak post-development flow rates generated by runoff

from the development area do not exceed pre-development levels. This is achieved through the use of detention storage areas spread throughout the development.

On-line and Off-line storage areas will be provided within public open space to attenuate peak flows, and will discharge to the foreshore reserve open via swale drains through the multiple use corridors.

8 POWER

8.1 Existing High Voltage

The existing Western Power distribution infrastructure in the vicinity of the Site comprises of several three phase 22kV high voltage (HV) aerial feeder lines, which are supplied from the existing Byford Zone Substation. These are present in the following locations.

- Bishop Road – The three phase overhead power line crosses Bishop Road from the east side of Hopkinson Street, this aerial line runs eastwards along the southern side of Bishop Road where it terminates prior to the intersection with Soldiers Road to serve the Serpentine Jarrahdale Grammar School.
- Taylor Road – A three phase overhead power line connects from the Bishop Road system and runs southwards on the eastern side of Taylor Road. This overhead line runs the full length of Taylor Road and Adams Street to serve the residential area to the southern side of the Site.
- Scott Road - A three phase overhead power line connects from the Taylor Road overhead lines and runs westwards before connecting to the Kargotich Road overhead power lines.
- Robertson Road –An underground HV cable runs along the eastern side of Robertson road from the Byford sub-station to Kiernan Street.

The existing HV lines can be seen in Figure 6.1.

8.2 Estimated Load

The proposed structure plan area has a potential to develop approximately 2270 residential lots and will require an estimated total load of 11.5MVA based upon a load allowance of 4.7kVA/lot and 1MVa for the primary schools and an interim Type 90 pump station.

The Western Power network capacity mapping tool (NCMP), at the time of producing this report provides the following forecasted remaining capacity:

- Forecasted remaining capacity of 20MVA to 25MVA – Years 2014
- Forecasted remaining capacity of 15MVA to 20MVA – Years 2015 to 2020
- Forecasted remaining capacity of 10MVA to 15MVA – Years 2021 to 2024
- Forecasted remaining capacity of 5MVA to 10MVA – Years 2025 to 2029
- Forecasted remaining capacity of less than 5MVA – Years 2030 onwards

The Western Power NCMT does not indicate the need for a new feeder, but this can only be determined at detail design stage

There is currently some spare capacity on the Byford feeder but the actual spare capacity is variable as other developments n the area consume capacity and confirmation from Wester Power will be required at the time of subdivision. This capacity is available on a first-come first-served basis.

Western Power has plans to construct a major Zone Substation along Gossage Road in Oldbury in 2025 to provide additional network capacity.

A standard subdivision condition will most likely stipulate that the existing HV (22kV and less) and LV aerials adjacent to the subdivision are to be undergrounded and any existing consumers affected must have their consumer mains reconnected to the underground network.

8.3 Development Infrastructure

Western Power will require that this development is serviced by underground phase power.

It is anticipated that at a minimum of thirteen switchgear and twenty five transformers are needed to service the proposed development in its entirety, however this is dependent on the staged layout and loading required. This will be determined during detail design stage.

Low voltage (LV) feeders will extend from each transformer feeding the pillar units servicing each new lot. The provision of LV and HV interconnection to the adjoining development areas will also have to be catered for.

It should be noted that Western Power may require for the power to be connected to the existing underground network to the eastern side of Kiernan Street which will require railway crossings.

8.4 Funding

The extension of any HV infrastructure to the Site will require developer contributions as the initial stages of the project will most likely not meet the economic test of the Western Power HV Pool.

Developers may be entitled to a capital contribution from Western Power if capacity provided in the main extension is in excess of that required for the specific project.

Project feasibility studies should be conducted by Western Power to determine optimum infrastructure requirements on a project by project basis and any developer contributions that may be required.

9 GAS

There is an existing ATCO Gas (formally WA Gas Networks) 150mm dia high pressure gas main running along Soldiers Road from Byford. This pressure main turns westbound along Bishop Road where it terminates prior to Taylor Road.

ATCO has advised that a connection can be made to this high pressure main and that the network has capacity to supply gas to the residential lots.

Provision of natural gas to the Site will require the construction of headworks high pressure gas main and will be designed by ATCO Gas.

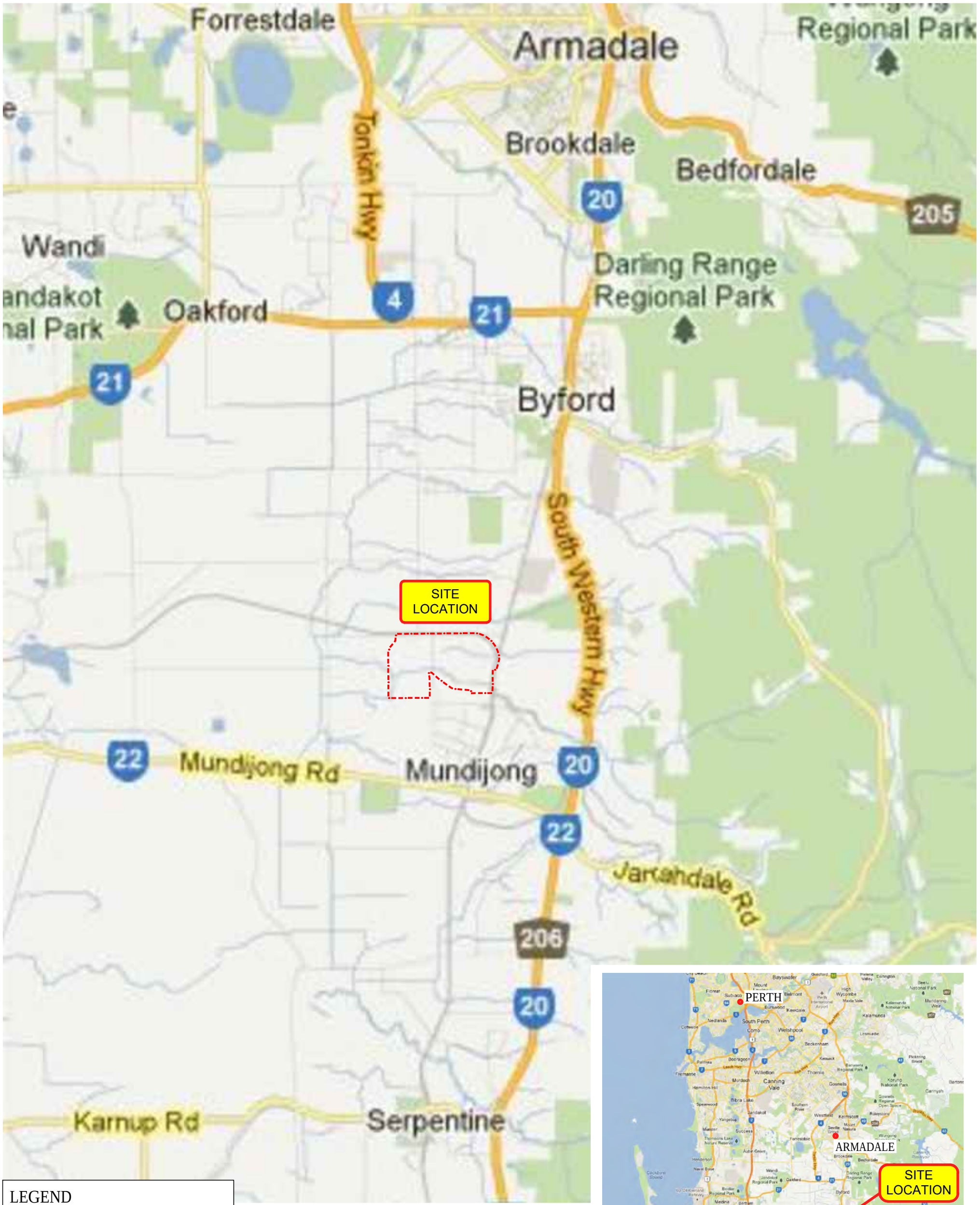
The location of the existing ATCO Gas main can be seen in Figure 7.1.

10 COMMUNICATIONS

It is envisaged that Site would fall under the ambit of the National Broadband Network (NBN) which requires developers to install an approved pipe and pit system as part of the development.

Network infrastructure will be installed subsequently by NBN appointed contractors at no cost to the developers.

APPENDIX A - PRELIMINARY INFRASTRUCTURE SERVICES LAYOUTS



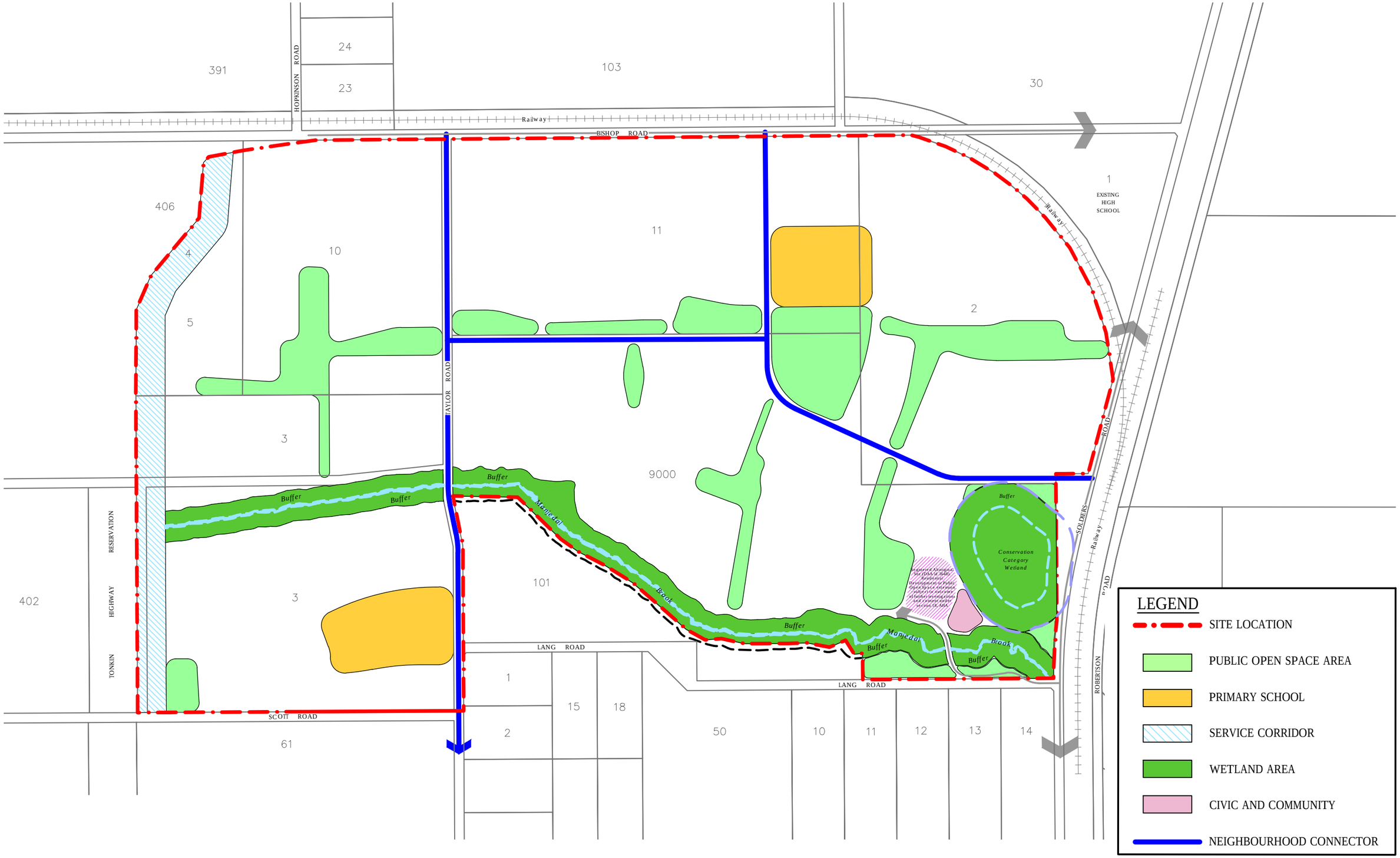
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PEET LIMITED
MUNDIJONG NORTH
INFRASTRUTURE PLAN

SITE LOCALITY PLAN

Job Number	2680-23
Revision	B
Date	NOV 2014

FIGURE 1.1



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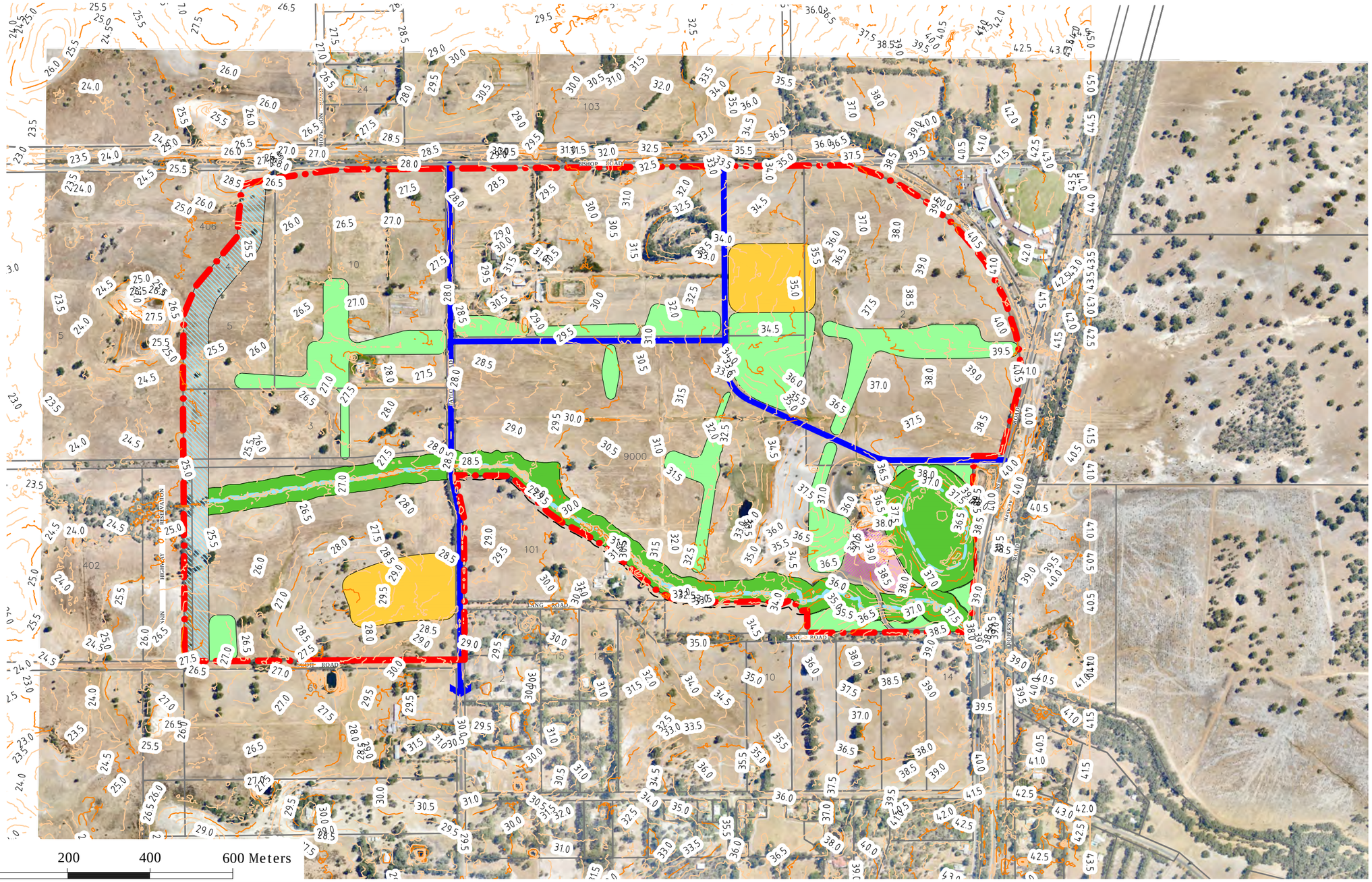
PEET LIMITED
MUNDIJONG NORTH
INFRASTRUCTURE PLAN

LOCAL STRUCTURE PLAN LAYOUT

Job Number	2680-23
Revision	D
Date	JAN 2016

FIGURE 1.2

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SCALE 1 : 10000

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PEET LIMITED
MUNDIJONG NORTH
INFRASTRUTURE PLAN

TOPOLOGY AND AERIAL PHOTOGRAPH

Job Number	2680-23
Revision	D
Date	JAN 2016

FIGURE 1.3

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PROPOSED INTERIM PRESSURE MAIN TO EXISTING BYFORD PUMP STATION PS086-02

PROPOSED FUTURE DUAL Ï600 PRESSURE MAIN

HOPKINSON ROAD

BETT ROAD

FREIGHT RAILWAY LINE

BISHOP ROAD

BISHOP ROAD

FREIGHT RAILWAY LINE

SOLDIERS ROAD

ROBERTSON ROAD

TAYLOR ROAD

FREIGHT RAILWAY LINE

Ï225

Ï225

Ï225

Ï300

Ï225

Ï150

Ï450

Ï375

LEIPOLD ROAD

MANJEDAL BROOK

MANJEDAL BROOK

LANG ROAD

LANG ROAD

SCOTT ROAD

SCOTT ROAD

TAYLOR ROAD

PATERSON STREET

MANJEL

Ï225

KEIRNAN STREET

Ï1200

Ï600

Ï600

Ï150

PROPOSED FUTURE PUMP STATION BYFORD MAIN FUTURE T1000 (T500/T350)

PROPOSED FUTURE PRESSURE MAIN TO EAST ROCKINGHAM WWTP

200 100 0 200 400 600 Meters

SCALE 1 : 10000

LEGEND

- DEVELOPMENT AREA BOUNDARY
- PROPOSED GRAVITY MAIN (WCP)
- PROPOSED PRESSURE MAIN (WCP)
- PROPOSED GRAVITY MAIN
- PROPOSED INTERIM PRESSURE MAIN

1. CONSTRUCT NEW INTERIM TYPE 90 PUMP STATION.
2. CONSTRUCT NEW INTERIM PRESSURE MAIN TO EXISTING BYFORD PUMP STATION.
3. CONSTRUCT INTERNAL SEWER RETICULATION.
4. POTENTIAL ALTERATION TO WATER CORPORATION PLANNING (SUBJECT TO WATER CORPORATION ACCEPTANCE).

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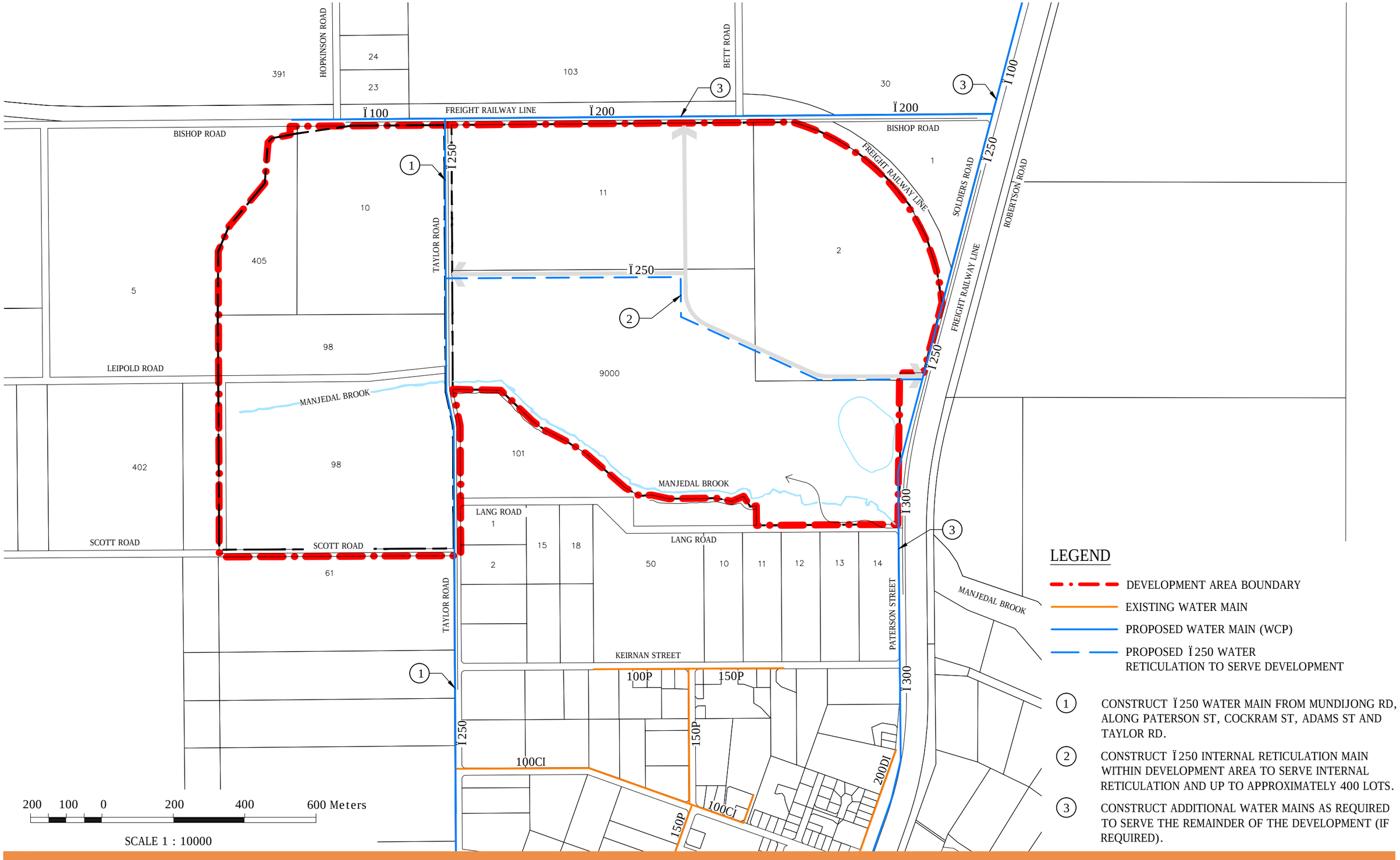
PEET LIMITED
MUNDIJONG NORTH
INFRASTRUCTURE PLAN

EXISTING AND PROPOSED SEWER INFRASTRUCTURE

Job Number	2680-23
Revision	C
Date	JAN 2016

FIGURE 3.1

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LEGEND

- DEVELOPMENT AREA BOUNDARY
- EXISTING WATER MAIN
- PROPOSED WATER MAIN (WCP)
- PROPOSED Ï250 WATER RETICULATION TO SERVE DEVELOPMENT

1. CONSTRUCT Ï250 WATER MAIN FROM MUNDIJONG RD, ALONG PATERSON ST, COCKRAM ST, ADAMS ST AND TAYLOR RD.
2. CONSTRUCT Ï250 INTERNAL RETICULATION MAIN WITHIN DEVELOPMENT AREA TO SERVE INTERNAL RETICULATION AND UP TO APPROXIMATELY 400 LOTS.
3. CONSTRUCT ADDITIONAL WATER MAINS AS REQUIRED TO SERVE THE REMAINDER OF THE DEVELOPMENT (IF REQUIRED).

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C

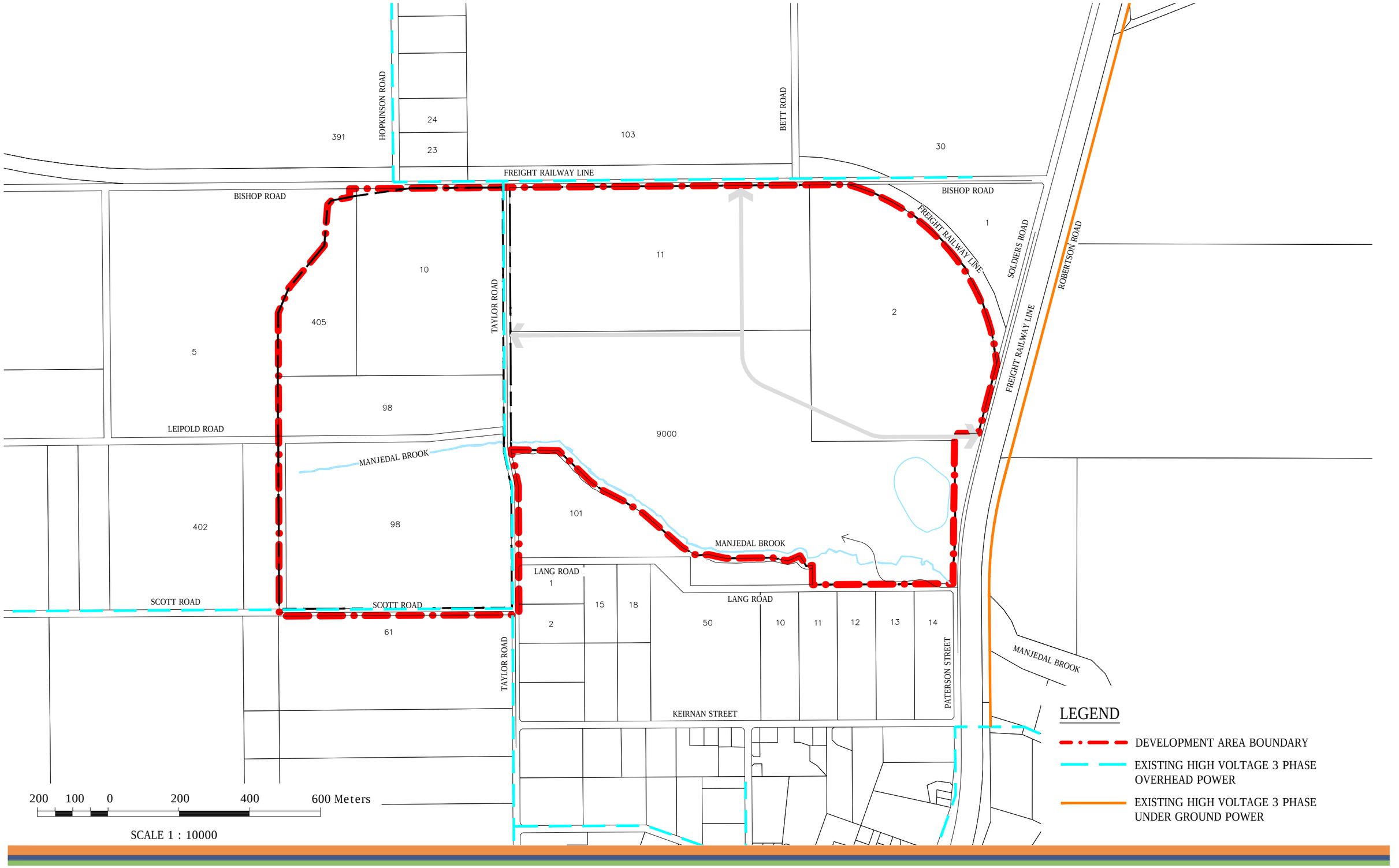
PEET LIMITED
MUNDIJONG NORTH
INFRASTRUCTURE PLAN

EXISTING AND PROPOSED WATER INFRASTRUCTURE

Job Number	2680-23
Revision	C
Date	JAN 2016

FIGURE 4.1

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PEET LIMITED
MUNDIJONG NORTH
INFRASTRUCTURE PLAN

EXISTING POWER INFRASTRUCTURE

Job Number	2680-23
Revision	C
Date	JAN 2016

FIGURE 6.1

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PEET LIMITED
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INFRASTRUCTURE PLAN

EXISTING GAS INFRASTRUCTURE

Job Number	2680-23
Revision	C
Date	JAN 2016

FIGURE 7.1

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TABEC
Civil Engineering Consultants

Peet Mundijong Syndicate Limited
Level 7, 200 St Georges Terrace
Perth WA 6000

19 April 2023
2405-REP-001

Attention: Mr Jordan Pyne

Dear Jordan,

RE: LOT 2, 10, 11, 98 405 & 9000 TAYLOR ROAD, MUNDIJONG
INFRASTRUCTURE SERVICING REPORT ADDENDA

The following addenda has been prepared by TABEC Pty Ltd for the proposed Peet Mundijong Syndicate development (the Site) to supplement the Mundijong Precinct G1 Infrastructure Servicing Report dated February 2015. The Infrastructure Servicing Report was prepared as an appendix to the Local Structure Plan encompassing the site, within the broader Mundijong District Structure Plan (DSP) Area. The Mundijong Precinct G1 Infrastructure Servicing Report discusses the civil engineering aspects which inform and support the delivery of the development plan and the impact of the proposed development on the civil engineering servicing capability and requirements within the LSP area.

TABEC have sought updated preliminary servicing advice from Water Corporation and Western Power in response to the Department of Planning, Lands and Heritage (DPLH) request for incorporation of current Water Corporation and Western Power servicing strategies and requirements.

Current wastewater and water scheme planning information has been received from the Water Corporation although updated planning information from Western Power is yet to be received.

SITE SUMMARY AND LAND USE PLANNING

The 199-hectare Site is located approximately 38km southeast of the Perth CBD and 2km north of the Mundijong Town Centre within the Shire of Serpentine Jarrahdale.

The Shire of Serpentine Jarrahdale formalised a revised Mundijong/Whitby District Structure Plan (DSP) in July 2021 which supersedes the 2010 Mundijong Whitby DSP. The site is zoned Urban and within Local Structure Plan Area G (Mundijong North) of the Mundijong DSP area, as indicated in the following Figure 1.

The Site is bound by Soldiers Road and the Perth–Bunbury Railway line to the east, the future Tonkin Highway extension to the west, Manjedal Brook and Scott Road to the south and Bishop Road to the north. The Structure Plan covering the northern portion of Area G, produced by Talyor Burrell Barnett (TBB), has been amended in response to Schedule of Modifications provided by DPLH and is presented in Figure 2.

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Figure 1 - Mundijong Local Structure Plan Areas (Figure 2 extracted from Mundijong DSP, Hames Sharley, July 2021)



Figure 2 – Structure Plan as per Appendix A to "Taylor Road, Mundijong Local Structure Plan" (April 2023)

WASTEWATER

The Site is within the Water Corporation license area and covered by the Byford Sewer District conceptual wastewater planning. Water Corporation have provided updated scheme planning as per the following Figure 3, which remains largely unchanged from previous advice presented in the Infrastructure Servicing Report.

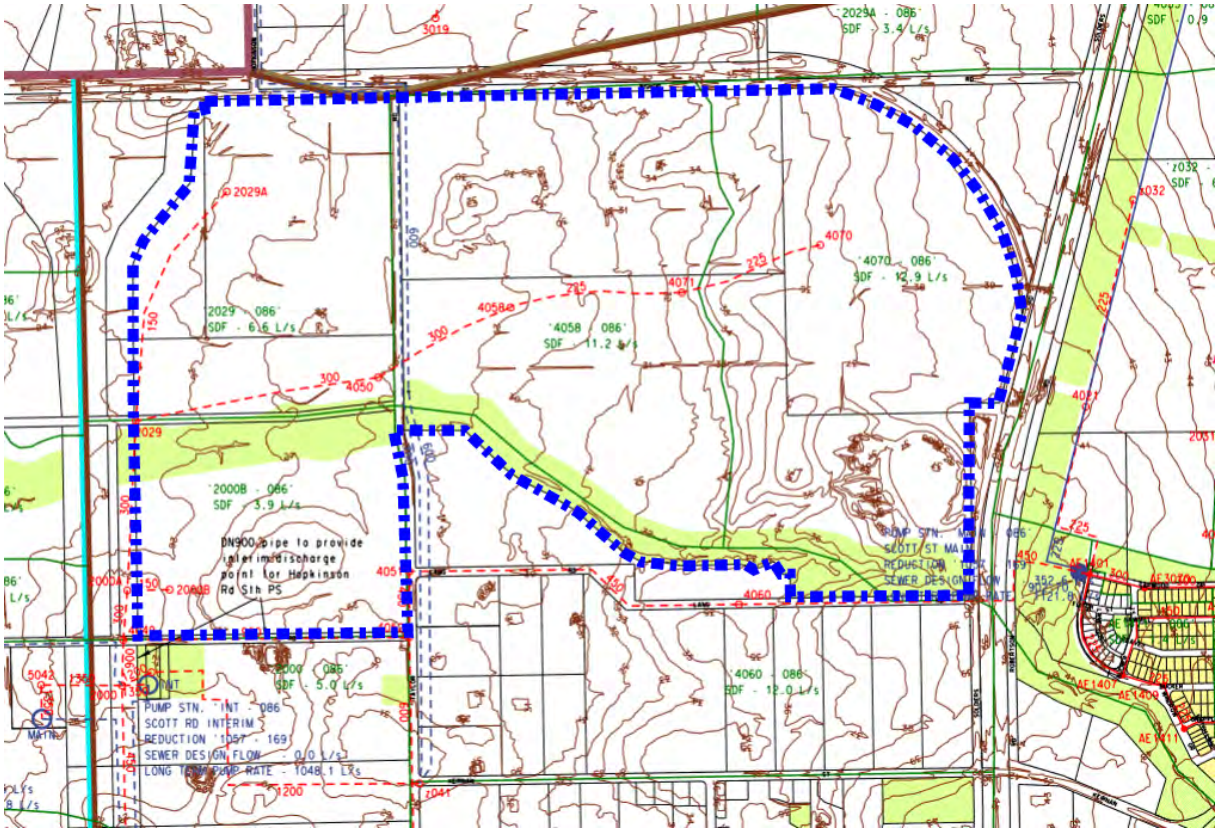


Figure 3 - Water Corporation Wastewater Planning (March 2023)

Water Corporation planning has made allowance for sewer design flows adequate to cater for the proposed ~2,900 lots/dwellings and other land uses such as proposed school sites. As indicated in Figure 3, the Water Corporation scheme planning generally indicates a series of gravity sewers, grading from east to west and north to south connecting to an interim Type 90 Wastewater Pumping Station (WWPS) fronting Scott Road. The Water Corporation's planning currently shows sections of DN300 gravity sewer through the northern portion of the Site that serve the greater Mundijong catchment. DN300 gravity sewers constructed by Developers are to be refunded by the Water Corporation at a fixed rate. Standard Water Corporation wastewater headworks are applicable in this area.

The interim Scott Road WWPS will service the immediate Mundijong gravity sewer catchment, including development of the Site and pump approximately 8km northwards to an existing WWPS off Hopkinson Road in Byford.

Water Corporation have advised that sewer concept planning is in the process of being revised to incorporate proposed development outcomes for Lots 90 and 103 north of Bishop Road and the rail freight line. The catchment scoping plan for the interim Scott Road WWPS is presently being revised to include additional flows from Lots 90 and 103, which is likely to result in an increase in the size of the gravity collection main traversing through the western side of the Site.

Water Corporation has advised that development of the Site will need to connect to the interim Scott Road WWPS by a gravity sewer extension. Subdivision and development of the Site is therefore reliant on the prior construction and commissioning of the WWPS asset. Coordination with the adjacent development to the south may be required depending on the timing of the development and the delivery of the WWPS. However, as the WWPS site has already been acquired by the Water Corporation and is adjacent to Scott Road, access to the WWPS and associated wastewater infrastructure is not expected to be a constrained.

Water Corporation has allocated funding for the interim WWPS within the 5 Year Capital Investment Program. Further inquiries are to be made via the Water Corporation Headworks Delivery team at the appropriate time to provide more exact timeframes for the delivery of the interim WWPS asset.

Water Corporation long-term planning is to construct a permanent Type 1000 WWPS at the Scott Road sites to ultimately service the greater Mundijong/Byford/ Armadale area. The WWPS will be developed as multiple Type 350 and Type 500 units located on two separate sites, east and west of the future Tonkin Highway. The WWPS will be developed to the ultimate capacity over several decades as required.

WATER

Water Corporation have provided updated water servicing advice since the original preparation of the Infrastructure Servicing Report for the Site, which considers recently installed infrastructure in the area.

The Site is within the Water Corporation license area. Water Corporation has confirmed that their long-term Mundijong Gravity Scheme water planning has made allowance for the future development of the Site.

The main water supply to Mundijong is currently supplied off the Serpentine Trunk Main on Summerfield Road south of Mundijong Road. A DN600 water distribution main has recently been constructed along Paterson Road up to the intersection of Kiernan Street, connecting into trunk main assets south of Mundijong Road. The DN600 distribution main is indicated by the red line in Figure 4.

Based on the Water Corporation advice, the water supply for the Site can be achieved by staged construction of suitably sized water reticulation mains, nominally DN250 reticulation main, which is to connect into the DN600 water distribution main at the intersection of Kiernan Street and Paterson Street. Based on the Water Corporation advice, the water supply can be obtained from constructing a DN250 reticulation main from Kiernan Street northwards along Soldiers Road to the Site. Alternatively, DN250 water reticulation main could be constructed via Paterson Street, Cockram Street, Adams Street and Taylor Road as per Figure 4.1 of the Infrastructure Servicing Report.

The Water Corporation has suggested that developers and other landholdings to the west of Taylor Road/Adams Street will need to coordinate and fund the cost of water reticulation mains extensions, from the end of the existing DN600 distribution main.

An internal water reticulation network for the Site is to be constructed to service proposed lots in accordance with the Water Corporation requirements. No planning is currently available from the Water Corporation in regard to the internal reticulation network.

Standard Water Corporation water headworks are applicable in this area.

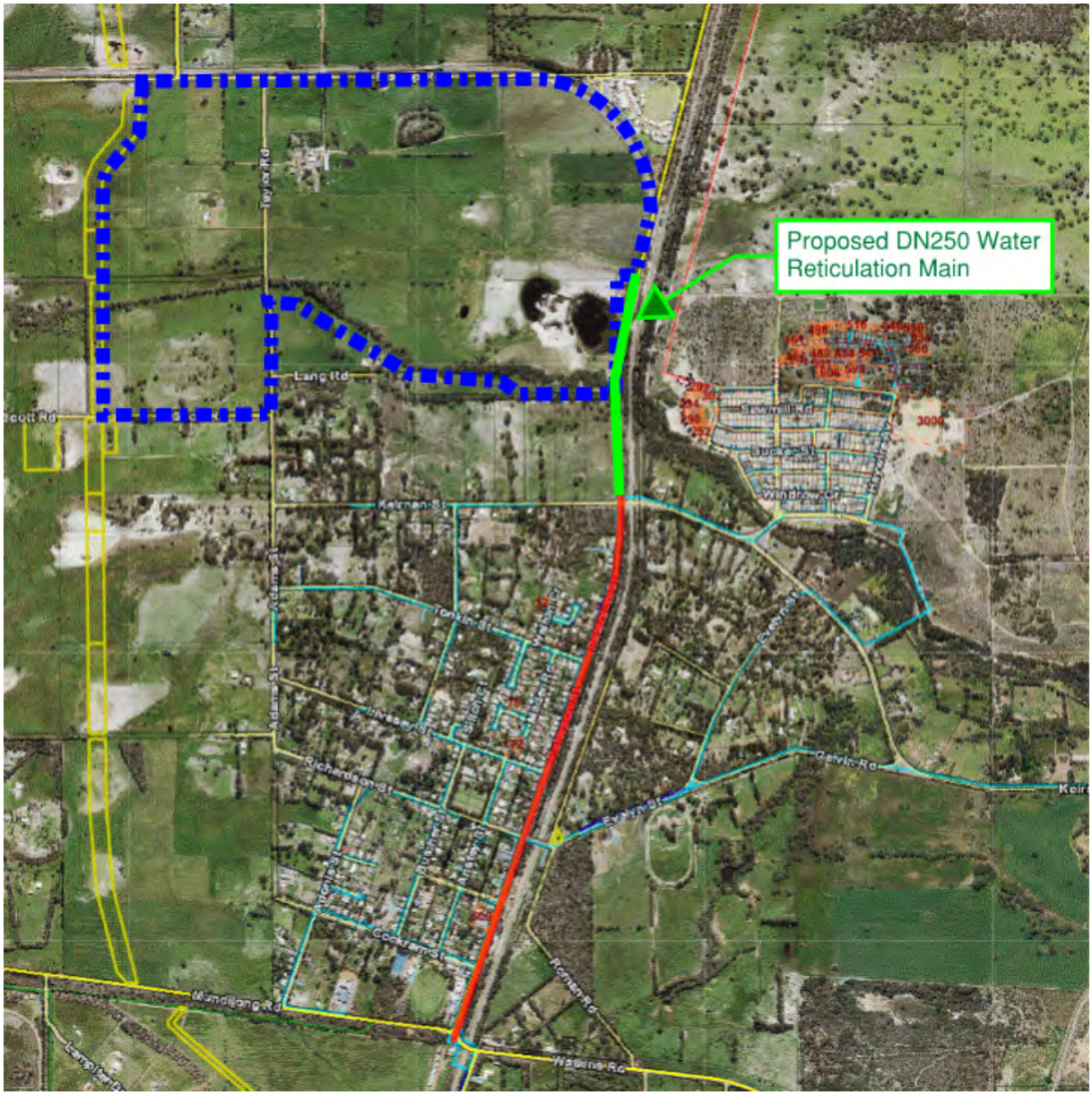


Figure 4 - Existing DN600 Water Distribution Main and Potential DN250 Connection (Water Corporation, March 2023)

UNDERGROUND POWER

Section 8.1 of the Infrastructure Servicing Report outlines existing Western Power high voltage (HV) overhead power infrastructure in proximity to the site, which generally remains current. The feeder line running on Taylor Road which continues south on Adams Street. This feeder within Taylor Road/ Adams Street is fed from the Byford zone substation and is likely to be utilised for the provision of services to developments to the south of the Site. Consistent with the Infrastructure Servicing Report, there is the potential for conflict with the competing power needs of the developments from the same feeder.

The Site is located towards the end of the 22kV feeder network, hence the capability of the overhead network cables to deliver the power requirements to the proposed development will need to be assessed by Western Power. It is understood that Western Power has already carried out some

network reinforcement on the overhead network in the vicinity of the feeder that the proposed development will likely connect to. It is anticipated that the initial stage of development is likely to require an assessment of the feeder capacity by Western Power. Western Power network capacity is available on a first-come first-served basis.

The feeder may need to be extended as a HV ring to the proposed development areas. To the east of the Site at the intersection of Paterson Street and Keirnan Street there is another existing HV overhead power line which could be a potential source of connection and extended as part of the HV ring to serve the development.

During November 2018, Western Power confirmed that there are some constraints in the Byford Zone Substation, but the constraints are manageable over time. If the development occurs over a reasonable timeframe in line with normal development timeframes, Western Power will have time to complete the necessary network upgrades as the normal natural load growth on the Network. Western Power were unclear on the timing for a new major zone substation to allow part of the Byford zone substation load to be offloaded to a new zone substation.

The likely power infrastructure network internal to the Site is expected to remain consistent with Section 8.3 of the Infrastructure Servicing Report. Generally, transformer and switchgear infrastructure would be located in public open space (POS) and green areas throughout the development, with a transformer and switchgear likely to be located on the proposed school site. The ultimate location of switchgear and transformers assets will be dependent on the staged layout for the development and will ultimately be determined during detail design.

As per Section 8.4 of the Infrastructure Servicing Report, the extension of any HV infrastructure to the Site will need to be informed by Western Power feasibility studies to determine the infrastructure requirements and any developer contributions required.

Western Power standard system charges and HV pool credits would be applicable to the proposed development.

SUMMARY

Based on the current preliminary scheme planning provided by service authorities, there would appear to be no engineering or servicing constraints to the development of the Site.

Should you wish to discuss any aspect of the above, please do not hesitate to contact the undersigned.

Yours sincerely
TABEC Pty Ltd



MICHAEL ARENA


Shaping places
that are truly
exceptional