DEVELOPMENT PLAN REPORT

Lot 504 Nickol, Karratha
(Former Tambrey Primary School Site)

Part 1 – Statutory Provisions

Prepared by:

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Report No: 3789
Version/Date: Rev 7 May 2012

Prepared for:

ABN DEVELOPMENTS

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Osborne Park WA

Document Status

Version	*Purpose of Document*	*Orig*	*Review*	*Review Date*	*Format Review*	*RPS Release Approval*	*Issue Date*
Draft A	*Internal Review*	*TK*	*FV*	*06.09.11*	*07.09.11*		
Draft B	*For Client Review*	*TK*	*FV*	*09.09.11*	*09.09.11*	*Filipe Vieira*	*09.09.11*
Rev 0	*Final Draft for Issue*	*TK*	*FV*	*21.09.11*	*22.09.11*	*Filipe Vieira*	*22.09.11*
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Rev 3	*Final Report for Council Meeting*	*TK*	*FV*	*01.12.11*	*02.12.11*	*Filipe Vieira*	*02.12.11*
Rev 4	*Modifications to Built Form provisions*	*FV*	*FV*	*03.02.12*	*03.02.12*	*Filipe Vieira*	*03.02.12*
Rev 5	*Final Draft for Council endorsement*	*FV*	*FV*	*29.02.12*	*29.02.12*	*Filipe Vieira*	*29.02.12*
Rev 6	*Final for Council adoption*	*FV*	*FV*	*27.03.12*	*27.03.12*	*Filipe Vieira*	*27.03.12*
Rev 7	*Final for WAPC endorsement*	*TK*	*TV*	*14.05.12*	*14.05.12*	*Tom Kestel*	*14.05.12*

Disclaimer

TABLE OF AMENDMENTS – DEVELOPMENT PLAN FOR LOT 504 NICKOL (KARRATHA)

Amendment No.	*Description of Amendment*	*Endorsed by Council*	*Endorsed by WAPC*

CERTIFICATION OF DEVELOPMENT PLAN

IT IS HEREBY CERTIFIED THAT THE DEVELOPMENT PLAN FOR LOT 504 NICKOL (KARRATHA) WAS ADOPTED BY RESOLUTION OF THE WESTERN AUSTRALIAN PLANNING COMMISSION ON

3 May 2012

Being an officer of the Commission duly

Authorised by the Commission pursuant to

Section 16 of the Planning and Development Act 2005

AND BY

RESOLUTION OF THE COUNCIL OF THE SHIRE OF ROEBOURNE ON

AND THE SEAL OF THE MUNICIPALITY WAS PURSUANT TO THE COUNCIL'S RESOLUTION HEREUNTO AFFIXED IN THE PRESENCE OF:

PRESIDENT, SHIRE OF ROEBOURNE

CHIEF EXECUTIVE OFFICER, SHIRE OF ROEBOURNE

SHIRE OF ROEBOURNE COMMON SEAL

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1.0 DEVELOPMENT PLAN AREA

1.1 The Development Plan area relates to Lot 504, Nickol (Karratha) as identified on the Development Plan Map (Ref: 3789-5-005).

2.0 DEVELOPMENT PLAN CONTENT

2.1 The Development Plan comprises the following sections:

- Part One – Statutory Section
- Part Two – Explanatory Information
- Appendices – Technical Reports

2.2 Part One includes only the provisions and requirements that need statutory effect including the Development Plan Map.

2.3 Part Two of the Development Plan provides justification and clarity on the provisions contained in Part One, and is to be used as a reference to guide interpretation and implementation of Part One.

3.0 INTERPRETATIONS

3.1 The terms used in the Development Plan have the respective meaning given to them in the Shire of Roebourne Town Planning Scheme No. 8.

4.0 OPERATION DATE

4.1 The Development Plan will become operative following the endorsement of the Plan by the Shire of Roebourne and adoption of the Plan by the Western Australian Planning Commission pursuant to Clause 7.2 of Town Planning Scheme No. 8. The operative date of the Plan is the later of the endorsement or adoption as identified on the Certification page.

5.0 RELATIONSHIP TO THE SCHEME

5.1 The provisions of this Development Plan are made pursuant to Clause 5.2, Clause 6.4, Clause 7.2 and Appendices 7 and 8 of the Shire of Roebourne Town Planning Scheme No. 8. The Development Plan is a Policy Statement and forms part of the Shire of Roebourne Land Use Planning Policy Manual.

5.2 The Shire of Roebourne Town Planning Scheme No. 8 provides that land use, development and subdivision of land within the Development Plan area shall be generally be in accordance with the Development Plan subject to compliance with the provisions of the Scheme.

5.3 Land uses permitted within the Development Plan area shall be in accordance with the Shire of Roebourne Town Planning Scheme No. 8 "Residential Zone".

6.0 PUBLIC OPEN SPACE PROVISION

6.1 The Development Plan does not contemplate the provision of any land for the purposes of Public Open Space (POS) on the basis that the subject site is situated immediately adjacent to existing POS (to the east) and Tambrey Oval (to the north-east).

6.2 It is intended that the POS contribution be provided through a cash-in-lieu arrangement.

7.0 RESIDENTIAL DENSITY

7.1 The residential areas of the Development Plan are coded R20 and R30, as illustrated on the Development Plan.

7.2 Part Two of the Development Plan provides justification for the location and distribution of residential densities within the Development Plan area.

8.0 SUBDIVISION AND DEVELOPMENT REQUIREMENTS

8.1 Subdivision is to be in accordance with the applicable density code indicated on the Development Plan Map and the minimum lot sizes listed under Table 1 of State Planning Policy 3.1 Residential Design Codes.

9.0 BUILT FORM PROVISIONS

9.1 The Built Form provisions provided for in Section 9.2 below form part of and are to be read in conjunction with the Development Plan Map.

9.2 Except as otherwise determined by the Council, development is to be in accordance with the following:

a) Raised Floor Levels

- Where a concrete slab is provided it shall not be raised in a manner which requires stairs from the laneway or crossovers.

b) Outdoor Living Areas

Each dwelling shall be provided with an Outdoor Living Area at the front of the home - with a minimum of half of the Outdoor Living Area being suitably covered - consistent with the Performance Criteria of the Residential Design Codes. The minimum prescribed dimensions of the Outdoor Living Areas shall be as follows:

A. Cottage Lots

Minimum Depth - 3.5m

Minimum Width – 4.0m

In the case of the Cottage Lot identified in Appendix 8 - Outdoor Living Areas - the Minimum Depth of the Outdoor Living Area shall be 2.8m

B. Traditional Lots

Minimum Depth – 3.5m

Minimum Width – 6.0m

In the case of the Traditional Lots identified in Appendix 8 - Outdoor Living Areas - the Minimum Width of the Outdoor Living Area shall be 4.0m

c) Eaves

- Eaves shall have a minimum depth of 800mm where glazing is provided.

- Glazing on the east and west sides of a dwelling shall be kept to a minimum and be small in format.

d) Colours and Materials

- Colours and materials are to be predominantly light in tone and reflect the harsh sunlight.

- Tones shall be reflective of the natural landscape and local vernacular of Karratha.

e) Elevation Treatments

- No two adjoining building shall have the same front elevation or colour scheme.

f) Boat Parking

- Boat parking for lots serviced by a rear lane must be located off the rear lane.
- Boat parking will not be permitted in car parking bays located on streets.
- Boat parking for lots not serviced by a rear lane must be located behind the front building line of the dwelling.

g) Access

- All buildings shall be accessed without the use of stairs either by the laneway for cottage lots or via the driveway for traditional lots.

h) Fencing

- Fencing to all streets, including the adjoining POS, shall be a maximum height of 1800mm and visually permeable above 1200mm

i) Setbacks to Laneways

- a 1.1m setback shall be provided to allow for bins and to facilitate larger vehicle turning circles.

10.0 VARIATIONS TO THE RESIDENTIAL DESIGN CODES

10.1 The Development Plan provides for the following variations to the Residential Design Codes:

- A reduction in the front setback for all R20 lots from 6m to 3m (with no average setback);
- A reduction in the front setback for all R30 lots from 4m to 2.5m (with no average setback) and;
- Permanent roof cover is permitted over 100% of outdoor living areas for all lots.

10.2 Part Two of the Development Plan provides justification for the abovementioned variations to the Residential Design Codes.

11.0 OPERATION AND IMPLEMENTATION

11.1 Prior to any subdivision or development being supported, the Shire will, as a minimum, require the following reports to be completed (refer Table A below).

Table A – Reports and Plans

Documentation	Approval Stage	Approving Authority
Urban Water Management Plan	Prior to clearance of development and/or subdivision conditions	Shire of Roebourne & Department of Water
Landscaping Plan	Prior to clearance of development and/or subdivision conditions.	Shire of Roebourne

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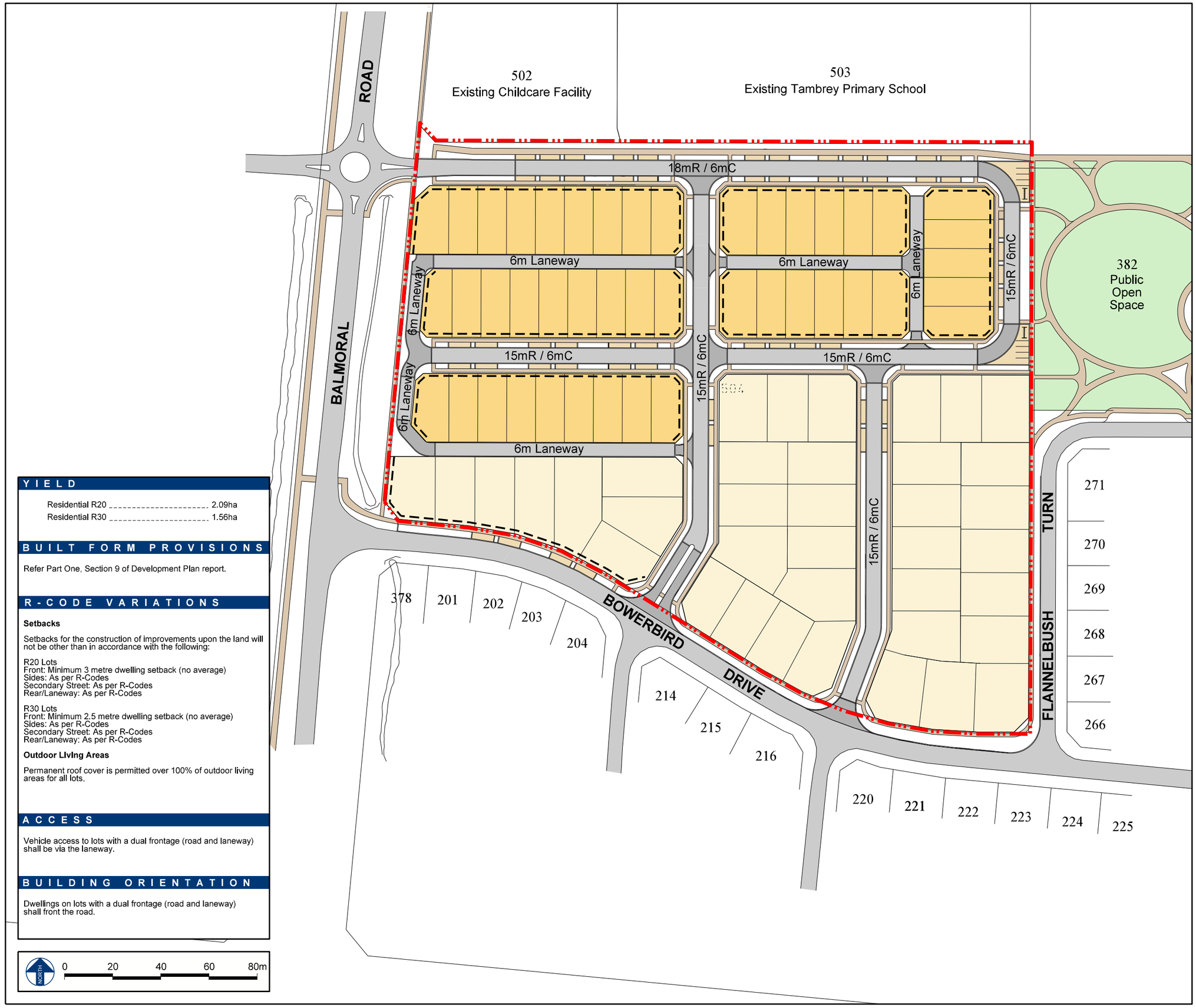
DEVELOPMENT PLAN

Lot 504 NICKOL (KARRATHA)

DEVELOPMENT PLAN

Lot 504 Nickol, TAMBREY



LEGEND

- Development Plan Boundary
- No Vehicle Access
- Residential R20
- Residential R30
- Pedestrian Footpath
- Visitor Car Bays

YIELD

Residential R20 ..... 2.09ha
Residential R30 ..... 1.56ha

BUILT FORM PROVISIONS

Refer Part One, Section 9 of Development Plan report.

R-CODE VARIATIONS

Setbacks

Setbacks for the construction of improvements upon the land will not be other than in accordance with the following:

R20 Lots
Front: Minimum 3 metre dwelling setback (no average)
Sides: As per R-Codes
Secondary Street: As per R-Codes
Rear/Laneway: As per R-Codes

R30 Lots
Front: Minimum 2.5 metre dwelling setback (no average)
Sides: As per R-Codes
Secondary Street: As per R-Codes
Rear/Laneway: As per R-Codes

Outdoor Living Areas

Permanent roof cover is permitted over 100% of outdoor living areas for all lots.

ACCESS

Vehicle access to lots with a dual frontage (road and laneway) shall be via the laneway.

BUILDING ORIENTATION

Dwellings on lots with a dual frontage (road and laneway) shall front the road.

NORTH 0 20 40 60 80m

ABN Developments : CLIENT
1:1,500@A3 : SCALE
16 May 2012 : DATE
3789-5-005a.dgn : PLAN No
a : REVISION
N.T. : PLANNER
L.W. : DRAWN
- : CHECKED

Base data supplied by Whelans and Simon Youngleson Architects.
Accuracy +/- 4m. Projection KAR94.

Areas and dimensions shown are subject to final survey calculations.
All carriageways are shown for illustrative purposes only and are subject to detailed engineering design.

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DEVELOPMENT PLAN REPORT

Lot 504 Nickol, Karratha
(Former Tambrey Primary School Site)

Part 2 – Explanatory Report

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Report No: 3789
Version/Date: Rev 6, May 2012

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FIGURE 15: Section through Entry Boulevard

FIGURE 16: Section through Street adjacent to POS

FIGURE 17: Section through Street adjacent to Primary School Site

FIGURE 18: Street with Cottage Lots opposite Traditional Lots

FIGURE 19: Laneway Entry

FIGURE 20: Typical Laneway Section

APPENDICES

APPENDIX 1: Preliminary Site Investigation (GHD)

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APPENDIX 3: Concept Masterplan

APPENDIX 4: Transport Assessment Report (ARUP)

APPENDIX 5: Local Water Management Strategy (Emerge)

APPENDIX 6: Engineering Services Report (Wood & Grieve Engineers)

APPENDIX 7: Geotechnical Report (Douglas Partners)

APPENDIX 8: Outdoor Living Areas

1.0 PLANNING BACKGROUND

1.1 Introduction and Purpose

This Development Plan report has been prepared on behalf of ABN Developments for Lot 504 Nickol (the subject site).

In October 2010, LandCorp sought Expressions of Interest (EOI) from selected builders to enter into a Structured Sale Agreement for a land and built form development arrangement for approximately 5.3ha south of the Tambrey Primary School. The land was identified as being surplus to Department of Education requirements.

ABN's proposal was accepted by LandCorp and in 2011 ABN and LandCorp entered into a conditional Contract of Sale for the site.

ABN's vision for the site is to deliver a high quality residential estate that is in keeping with the surrounding area, while trying to provide a diverse and quality built form outcome with enhanced streetscapes. ABN will utilise its manufactured housing division, TR Homes, to facilitate the quick delivery of a quality housing outcome for the site.

The proposed Development Plan has been designed to incorporate environmentally sensitive design initiatives around a highly connected road network, and provides low and medium density housing options which contribute to the required supply of housing in Karratha.

The preparation of the Development Plan has been supported by a number of technical and design investigations, including input from the following disciplines:

- **Emerge** – Landscaping and Local Water Management Strategy
- **GHD** – Environmental Investigations
- **Wood and Grieve** – Civil Infrastructure
- **ARUP** - Traffic and Transportation
- **Simon Youngleson Architects and Urban Design** – Architecture and Urban Design
- **Whelans** – Surveying
- **Douglas Partners** – Geotechnical Investigations

The Development Plan has been prepared in accordance with the design requirements established by Liveable Neighbourhoods and responds to the core elements of the Karratha Vernacular Design Principles.

1.2 Land Description

1.2.1 Location

The subject site is located at the corner of Balmoral Road and Bowerbird Drive within the suburb of Nickol, approximately 5.5 kilometres to the west of the Karratha town centre (refer **Figure 1**).

1.2.2 Area and Land Use

Lot 504 has a total land area of 5.3066 hectares. The subject site is vacant and has no structures or infrastructure (refer **Figure 2** and **Figure 3**).

1.2.3 Legal Description and Ownership

The subject site is formally described as Lot 504 on Certificate of Crown Land Title Volume LR3160, Folio 298 on Deposited Plan 68025.

The subject site is currently Unallocated Crown Land (UCL) and vested with the State of Western Australia.

1.3 Planning Framework

1.3.1 Zoning and Reservations

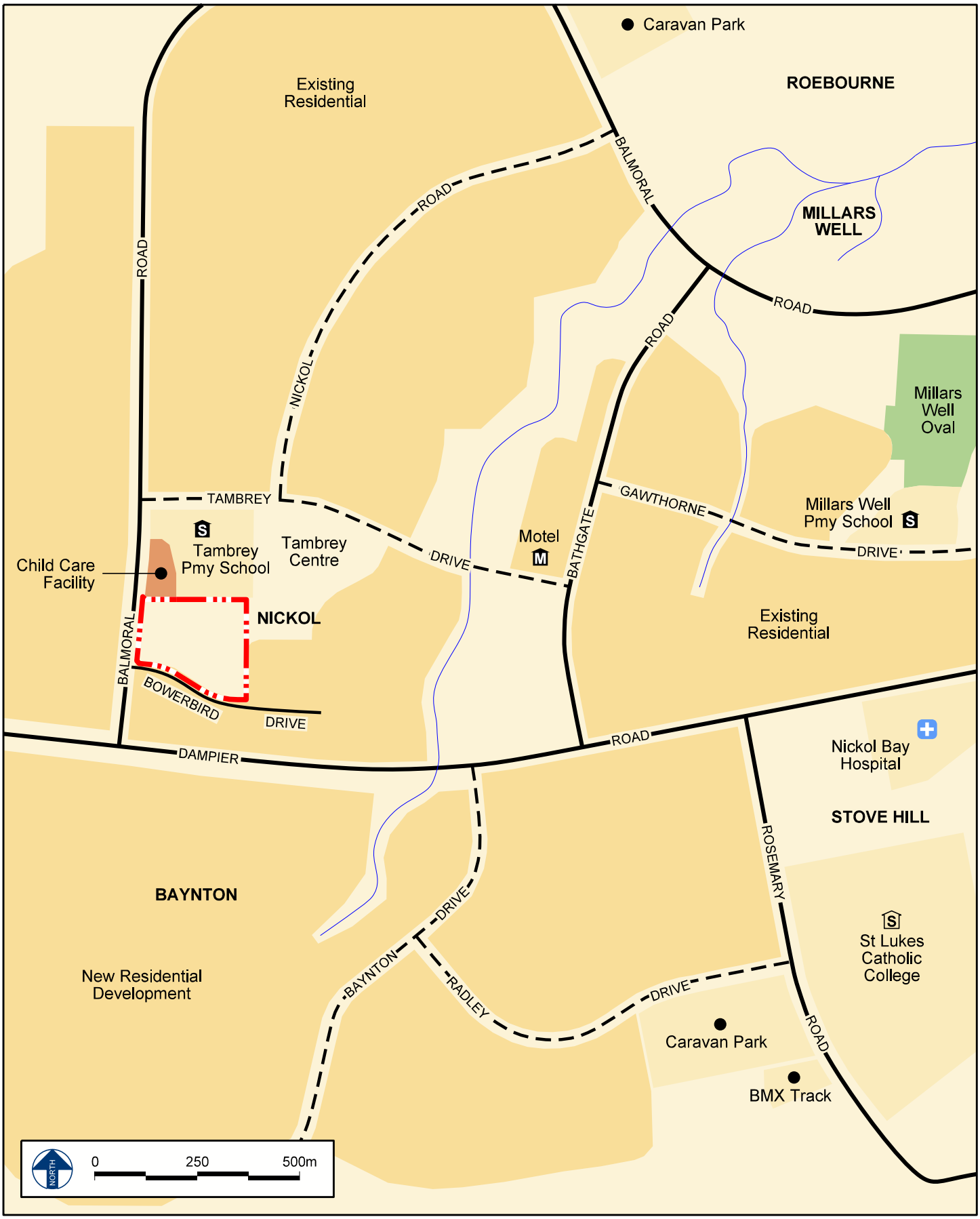
The subject site was recently rezoned to "Urban Development" under the Council of Roebourne Town Planning Scheme No. 8 (TPS 8) - refer Section 1.3.3 below for further details.

1.3.2 Strategic Planning Framework (Regional)

Karratha City of the North Plan

The Karratha City of the North Plan (KCNP), adopted by the Council of Roebourne on 18 May 2010, comprises a series of strategic documents including the Karratha City Growth Plan, the Karratha City Centre Master Plan and the Implementation Blueprint. Together, these documents identify a range of spatial and non-spatial requirements to guide the future growth of Karratha to a regional city of up to 50,000 residents.

The KCNP provides the basis for guiding decision makers in assessing rezoning, subdivision and development applications, as well as the provision of infrastructure and community facilities over time.



Site Boundary

LOCATION PLAN

Property Description
Lot 504 Nickol,
TAMBREY

Base data supplied by Landgate.
Accuracy +/- 4m. Projection MGA Zone 50.
Areas and dimensions shown are subject to final survey calculations.
All carriageways are shown for illustrative purposes only and are subject to detailed engineering design.

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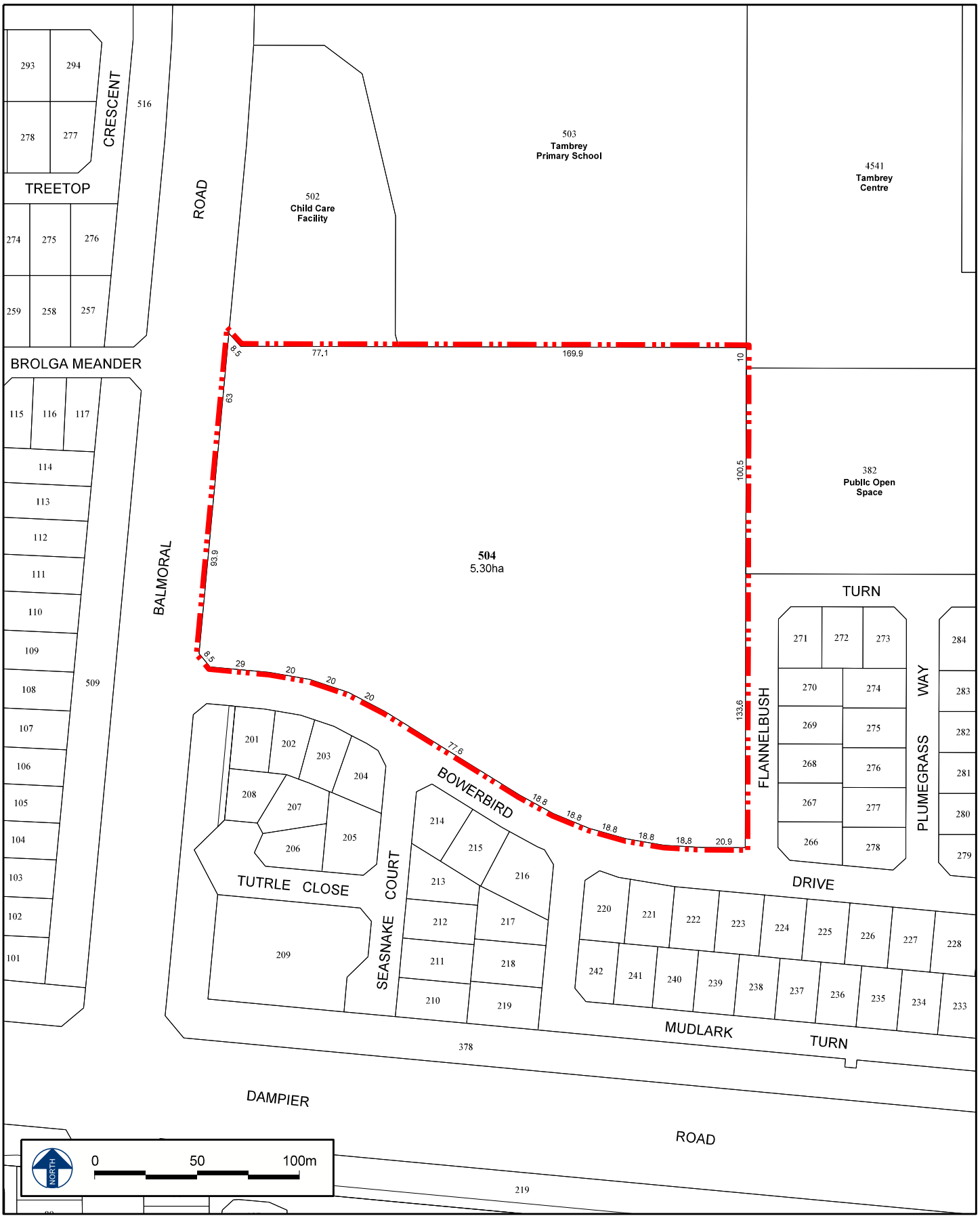
FIGURE 1



Site Boundary

SITE PLAN

Property Description

Lot 504 Nickol, TAMBREY

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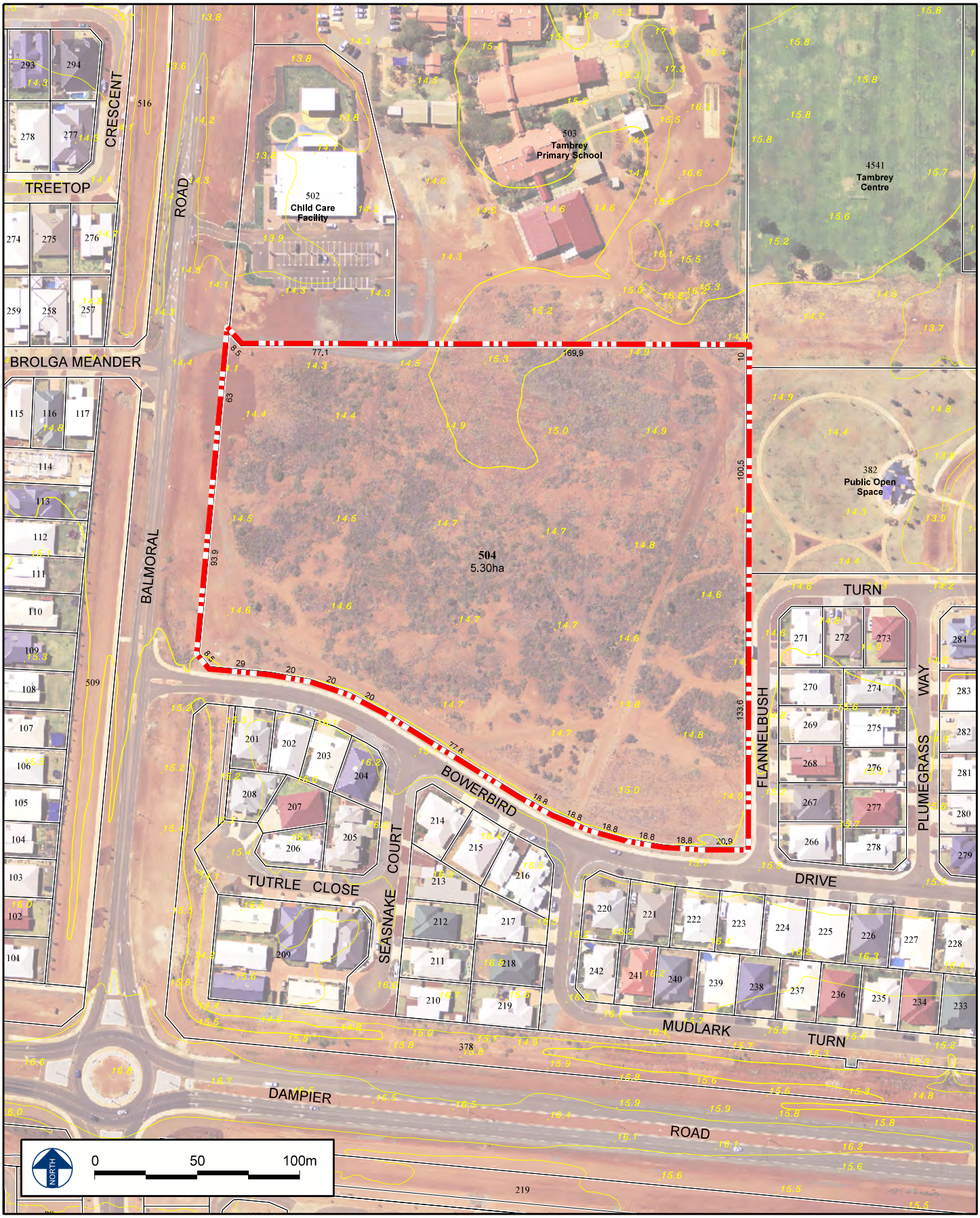
FIGURE 2



Site Boundary

AERIAL PLAN

Property Description

Lot 504 Nickol, TAMBREY

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3789-5-003.dgn	PLAN No
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FIGURE 3

Karratha City Growth Plan

The Karratha City Growth Plan (CGP) is a city-wide strategy to guide the future development of Karratha into a city of 50,000 residents. Specifically the CGP will guide the future spatial and non-spatial development requirements for the growth of Karratha, identifying the need for land supply, housing diversity, open spaces, commercial nodes, entertainment and retail areas, as well as the provision of community and servicing infrastructure.

The CGP identifies Karratha as a series of neighbourhood precincts. Each precinct is described in terms of its desired urban character, land use and urban structure as well as identifying key assumptions and planning considerations requiring further resolution.

Under the CGP, the subject site is situated within the 'Nickol/Baynton' precinct which is identified as an 'Enhanced Existing Residential' area with the 'Potential for Increased Density' (refer **Figure 4**).

The general design and intent of the Precinct is for the development of a site responsive, walkable and connected residential neighbourhood that provides good pedestrian and vehicular connectivity within, to and from existing residential areas.

Generally the Karratha CGP envisages residential development to provide a range of densities to encourage housing diversity, including densities of R40 with some areas of R60 around centres of activity.

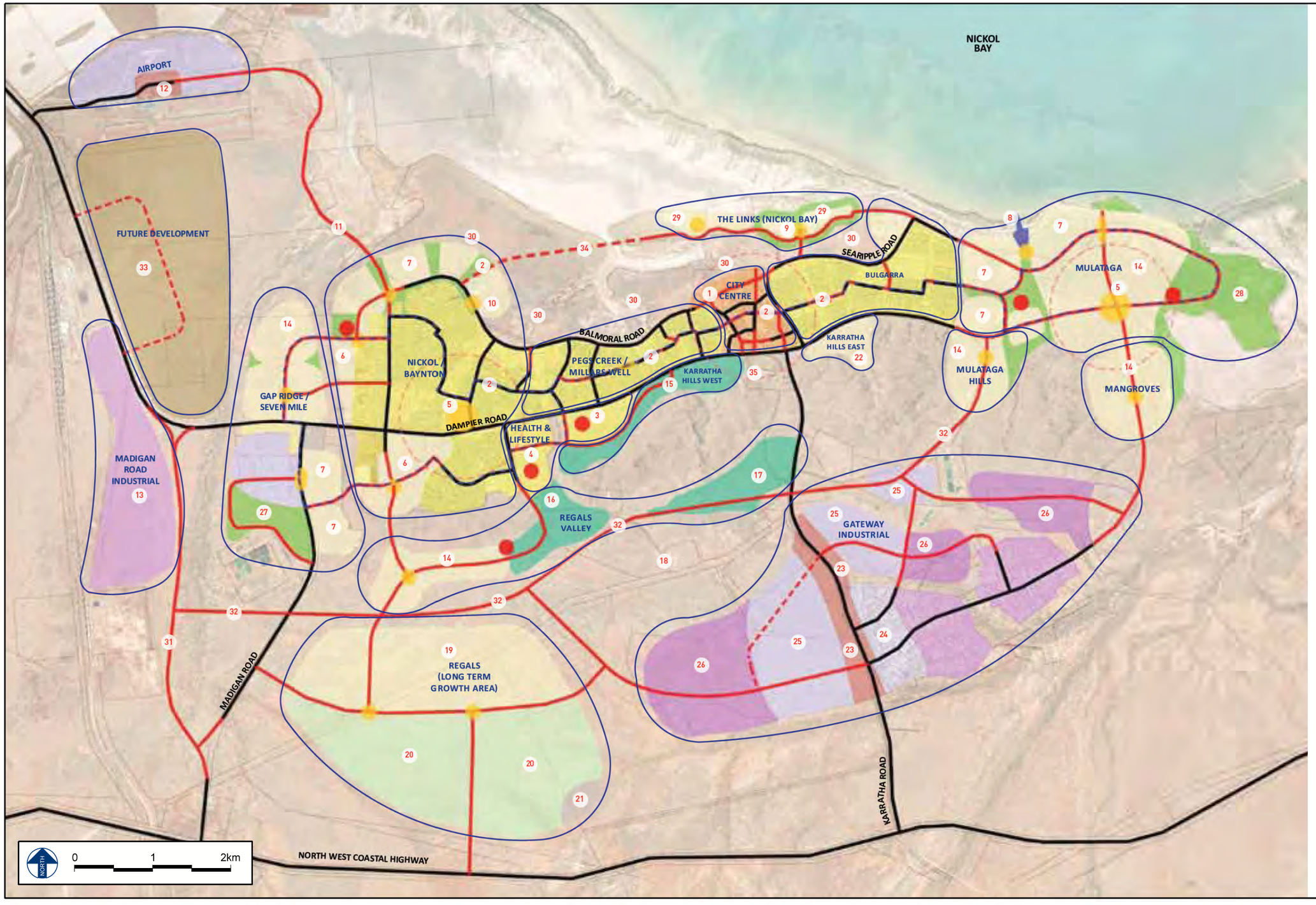
The proposed Development Plan responds strongly to the objectives of the City Growth Plan, making efficient use of available land, and providing a highly walkable, pedestrian friendly design which offers a range of housing densities to facilitate a range of dwelling types.

Karratha Area Development Strategy

The Karratha Area Development Strategy provided the strategic direction for the development of Karratha and planning at the local level for a period of 12 years, however the document has now been superseded by the KCNP.

Karratha Regional HotSpots Land Supply Update

The Karratha Regional HotSpots Land Supply Update, updated recently by the WAPC in December 2010, provides an overview of land supply within Karratha based on the status of major projects and current and anticipated lot creation activity. The latest update reflects the Karratha City Growth Plan which is proposed to be reflected in the Scheme via Amendment 21 (refer Section 1.3.3).



1. Town Centre revitalised and expanded with new links to include link from Balmoral Road to Searipple Road.
2. Existing communities linked with bus and cycle route. Traffic calming to limit traffic volumes and speed.
3. Leisure and Learning Centre to consolidate and integrate major new facilities.
4. Health and wellbeing centre campus.
5. New local retail and commercial centres to service daily needs and eastern and western neighbourhoods.
6. Expansion of existing neighbourhoods.
7. Proposed neighbourhoods to address immediate population demands.
8. Waterfront development with potential for swimming lagoon focus.
9. New country club and international hotel.
10. Expanded caravan park and resort.
11. New link to airport and Karratha gateway feature and developments.
12. Airport hotels and commercial with surrounding logistic services area.
13. New heavy industrial area (in progress).
14. City growth neighbourhoods.
15. Hillside research and development facility, apartments and villa development integrated into landscape.
16. Education related playfields, health and education, staff accommodation, retirement development and short stay accommodation compatible with power station.
17. Tourism uses, adventure tour buses and short stay accommodation compatible with power station.
18. Power station.
19. Long term future residential neighbourhoods.
20. Rural living lots.
21. Potential cemetery use.
22. Hillside apartments and villa development integrated into landscape.
23. Urbanised industrial area lining gateway boulevard.
24. Industrial area converted to light industrial with workers camps and short stay accommodation.
25. Future light industrial area.
26. Future heavy industrial area.
27. New playfield potentially using water treated waste.
28. Future playfield area with potential for second public golf course and mangrove estuary enhancement.
29. Elevated course estate with reconfigured international quality golf course.
30. Ecological and landscape enhancement zone as foreground to view of Nickol Bay and Bumps.
31. Western bypass road.
32. New south of Karratha Hills bypass.
33. Land for future non urban city uses.
34. Possible northern bypass link and causeway. Possible inclusion of a lock to create link.
35. Nickol Bay lookout and cultural centre incorporating water tanks and indigenous heritage trails.

KARRATHA CITY GROWTH PLAN

Shire of Roebourne

Image supplied by Shire of Roebourne.
Accuracy +/- 4m. Projection MGA Zone 50.

Areas and dimensions shown are subject to final survey calculations.
All carriageways are shown for illustrative purposes only and are subject to detailed engineering design.

LEGEND

LEGEND

- City Centre
- Enhanced Existing Residential (Potential for increased density).
- New Residential Neighbourhoods
- New District Open Space
- Institutional
- Industry
- Light Industry/Administration/Accommodation
- Logistics / Short Stay Accommodation with Airport
- Rural (future urban growth beyond 50,000.
- New Important Connection
- Activity Centre
- High School
- Bus Route
- Future Investigation Area

ABN Developments : CLIENT
1:50,000@A3 : SCALE
9 September 2011 : DATE
3789-5-006.dgn : PLAN No
- : REVISION
T.K. : PLANNER
R.F. : DRAWN
- : CHECKED

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FIGURE 4

The subject site is identified on Map 6 of the Hotspots document as Area KA35. The document identifies the subject land as surplus to the requirements of the Department of Education and subject to the adoption and formal gazettal of Scheme Amendment No. 11 and No. 21.

This document is relevant to the future planning of the site, as it guides infrastructure agencies in the planning of future servicing requirements.

Karratha 2020

The Karratha 2020 Vision and Community Plan (2009), prepared by the Council of Roebourne in partnership with the State Government and industry, assesses Karratha's infrastructure and service needs in response to anticipated future population growth.

The key themes highlighted in the document include the need to provide affordable, non-mining related housing to address the escalating costs of housing as well as the need to provide a diverse range of housing types, including housing for seniors, which appeal to a greater variety of family types and increase the Council's liveability.

The proposed Development Plan meets the objectives of Karratha 2020 by providing for a range of non-mining related housing types in a walkable, pedestrian friendly and community focused development.

1.3.3 Statutory Planning Framework

Shire of Roebourne Town Planning Scheme No. 8

The Council of Roebourne Town Planning Scheme No. 8 (TPS 8) was gazetted on 22 August 2000 and provides the statutory basis for the planning of all land within the Council of Roebourne.

With regard to the development of land within the "Urban Development" zone of the Scheme, Clause 6.4.1 of TPS 8 states:

> *"Before considering any proposal for subdivision or development of land within the Urban Development Zone, the Council may prepare or require the preparation of a Development Plan for the entire development area or any part or parts as is considered appropriate by Council."*

TPS 8 outlines the following matters that are required to be addressed by a Development Plan:

"All development plans shall address the following matters:

(i) Landform, topography, landscape, vegetation and soils of the area;
(ii) Location, existing roads, land uses and surrounding land uses and features;
(iii) Legal considerations, ownership, title description, area and encumbrances;

(iv) Existing and proposed services and infrastructure including reticulated or other portable water supply, sewerage, energy, communications, drainage and catchment considerations;

(v) Existing places and features of Aboriginal and non-Aboriginal heritage and/or cultural significance, including natural landscapes, flora and fauna in addition to built structures and other modified environments;

(vi) Road layouts and traffic assessments, communal and incidental parking areas, pedestrian/cycle network/underpasses, including impacts on the surrounding movement network;

(vii) Public open space and recreation provision, environmental protection areas, and relationships to natural features;

(viii) Assessments of the impact of the proposal on the natural environment, including management of potential effluent, emissions and other forms of pollution;

(ix) Comprehensive drainage systems for stormwater runoff and natural drainage lines;

(x) Indicate the design of the proposal including lot layout, major buildings, roads and landscaping proposals;

(xi) The demand for the development in relation to the overall market for similar developments;

(xii) The method of carrying out the development including the projected times of completion of each stage;

(xiii) Provide provisions, as may be considered appropriate by Council, for inclusion in the Policy Manual; and

(xiv) Other information as may be required by Council.

Development plans in specific zones should also address the following matters:

Urban Development Zone

(i) Location and density of housing areas, including lot and dwelling yield, population outcomes, net residential density and detailed subdivision standards relating to solar access, efficient use of water resources, design features and density rationale; and

(ii) Indicate demand for commercial and community facilities, including schools, generated by the proposal and implications for the provision of these within the development area or elsewhere."

Clause 3.2.3 of the Scheme states that development may only be permitted within the "Urban Development" zone where:

> *"(a) A Development Plan has been adopted for the subject land and the development is in accordance with the plan; or*
>
> *(b) Council has resolved that a Development Plan is not required."*

Scheme Amendment No. 11

Amendment No. 11 to TPS No. 8 rezoned the subject site from "Public Purpose – Education" to "Urban Development". The Amendment was gazetted in May 2011.

Scheme Amendment No. 18

While the initial intent of Amendment No. 18 was to address the Karratha Town Centre, remove the R40 density cap and create a City Centre, the Council resolved to undertake an 'Omnibus Amendment' which, in addition to creating a City Centre zone for Karratha and inserting numerous provisions into the Scheme, contained provisions in relation to the preparation, adoption and operation of Development Plans.

Scheme Amendment No 18 was gazetted in March 2011.

Proposed Amendment No. 21

Pursuant to Amendment No. 21, the subject site is to be designated Development Area (DA) number 'DA 31' where the Special Conditions are proposed to be:

- An approved Development Plan together with all approved amendments shall apply to the land in order to guide subdivision and development;
- To provide for residential development; and
- Land uses classified on the Development Plan apply in accordance with clause 7.2.11.4.

Amendment 21 is yet to be gazetted, however, the proposed Development Plan meets the intent of the stated objectives for DA 31.

1.3.4 Planning Policies

Liveable Neighbourhoods

Liveable Neighbourhoods is an adopted policy intended to guide the subdivision and development of land in Western Australia. The key principles of this policy include:

- Providing a variety of lots sizes and housing types to cater for the diverse housing needs of the community at a density that can ultimately support the provision of local services;
- To ensure cost-effective and resource efficient development to promote affordable housing; and
- To maximise land efficiency.

The proposed Development Plan not only acknowledges the objectives of Liveable Neighbourhoods in providing a greater diversity in housing types, but meets the important objective of maximising land efficiency by rationalising development in an established and well serviced residential area. The proposed development will also allow for the development of housing options that will directly target ongoing affordability constraints and housing demand in Karratha.

2.0 SITE CONDITIONS AND ENVIRONMENT

2.1 Environmental Assets and Constraints

GHD undertook a Preliminary Site Investigation (PSI) of the subject site to ascertain the environmental and social particulars of the site (refer **Appendix 1**). A summary of the findings of the investigation is provided below.

2.1.1 Contaminated Sites

The PSI indicates there are no known risks of Acid Sulfate Soils occurring within three metres of the natural surface on site.

A search of the DEC Contaminated Sites Database reveals that the Development Plan area and surrounding land have not been identified as contaminated sites.

2.1.2 Flora and Fauna

The site is well vegetated with grasses and small shrubs, including some areas of dense shrubs and small trees. There are no known Declared Rare and Priority Flora or Threatened Fauna on the site.

2.2 Landform and Soils

The PSI indicates that the subject site is relatively flat with an elevation between 14.6m and 15.2m AHD, and falls gradually from the north-east down to the south and north-west.

Soils within the subject site are categorised as "Clay Soils", with proximity to deep sandy and sandy earth soils.

2.3 Ground Water and Surface Water

The PSI has concluded that no detailed information is available on the depth of groundwater at the subject site. However, based on information provided in the Department of Water (DoW) bore search, it is likely to be at depths greater than 4m below Ground Level (bGL).

There are no potentially sensitive environmental receptors in the form of surface water, wetlands or watercourses on or in close proximity to the subject site.

2.4 Heritage and Cultural Significance

A search of the Australian Government Heritage Database has not uncovered any areas of Aboriginal or European heritage significance on the subject site.

A search of the Western Australian Heritage database identified the Tambrey Centre, located on Lot 4227, as a building of heritage significance. The Tambrey Centre is located approximately 200m to the north east of the subject site and therefore will not adversely impact on the future development of the land.

2.5 Climate

Karratha is located within a hot, semi-arid climatic zone. Summers (October to April) are extremely hot with an average maximum temperature of 36.1°C. Winters average a minimum temperature of 13.6°C.

2.6 Context Analysis

2.6.1 Historical Context

Prior to being developed as a Primary School in October 1989, the subject site had been set aside by the Department of Education (DoE) as a future District High School. However, a subsequent educational needs assessment in the Karratha area revealed that a District High School would not be required, and that a Primary School would be sufficient to meet the educational needs of the local population.

The Tambrey Primary School was subsequently only developed on a portion of the subject land.

In 2007, the DoE resolved that the existing Karratha Primary School would be re-built on its existing site and new facilities would be constructed for students in Years 11 and 12 on the Pilbara TAFE (Karratha Campus) site.

At the same time, the DoE resolved that funding for an upgraded Karratha Primary School and additional facilities at Pilbara TAFE should come from the excision and disposal of the vacant portion of the Tambrey Primary School site, the subject of this Development Plan.

The DoE has resolved to support the proposed Development Plan on the basis that the use of the subject site for future residential development will not adversely impact upon provision of education in the area i.e. the Department has confirmed that the remaining portion of the Tambrey Primary School site will adequately meet the educational needs of the Tambrey area and any future expansion of the Tambrey Primary School (refer **Appendix 2**).

2.6.2 Surrounding Land Use and Development Pattern

The local area surrounding the subject site has generally been developed for single residential purposes at R20 – R30 densities. Grouped dwelling lots at a density of R25/30 have been created in the area on the western side of Balmoral Road. Reserve 48995, immediately to the east of the subject site, is a children's playground surrounded by a significant grassed area. Located north-east of the subject site is the Tambrey Oval and the Tambrey Tavern and Function Centre (refer **Figure 5**).

The Karratha City Growth Plan identifies a new local retail and commercial centre located at the intersection of Bathgate Road and Dampier Road, approximately 800m from the subject site (refer **Figure 4**). LandCorp, as the developer of the retail and commercial centre, has advised that detailed planning for development of this centre has not yet commenced. However, it is reasonable to assume that the centre will be of sufficient size and diversity to provide the necessary services to meet the needs of surrounding residents, including those within the Tambrey development.

2.6.3 Karratha Housing Market

Karratha is currently experiencing a critical shortage of accommodation for both long-term residents and short-term fly-in / fly-out workers which is recognised as one of the biggest constraints affecting the growth of the Council into a city.

The quarterly Housing and Land Snapshot report prepared by the Pilbara Development Commission (PDC) in June 2011 outlines the average advertised price of the residential properties for sale in Karratha based on the number of bedrooms, over the previous three quarters.

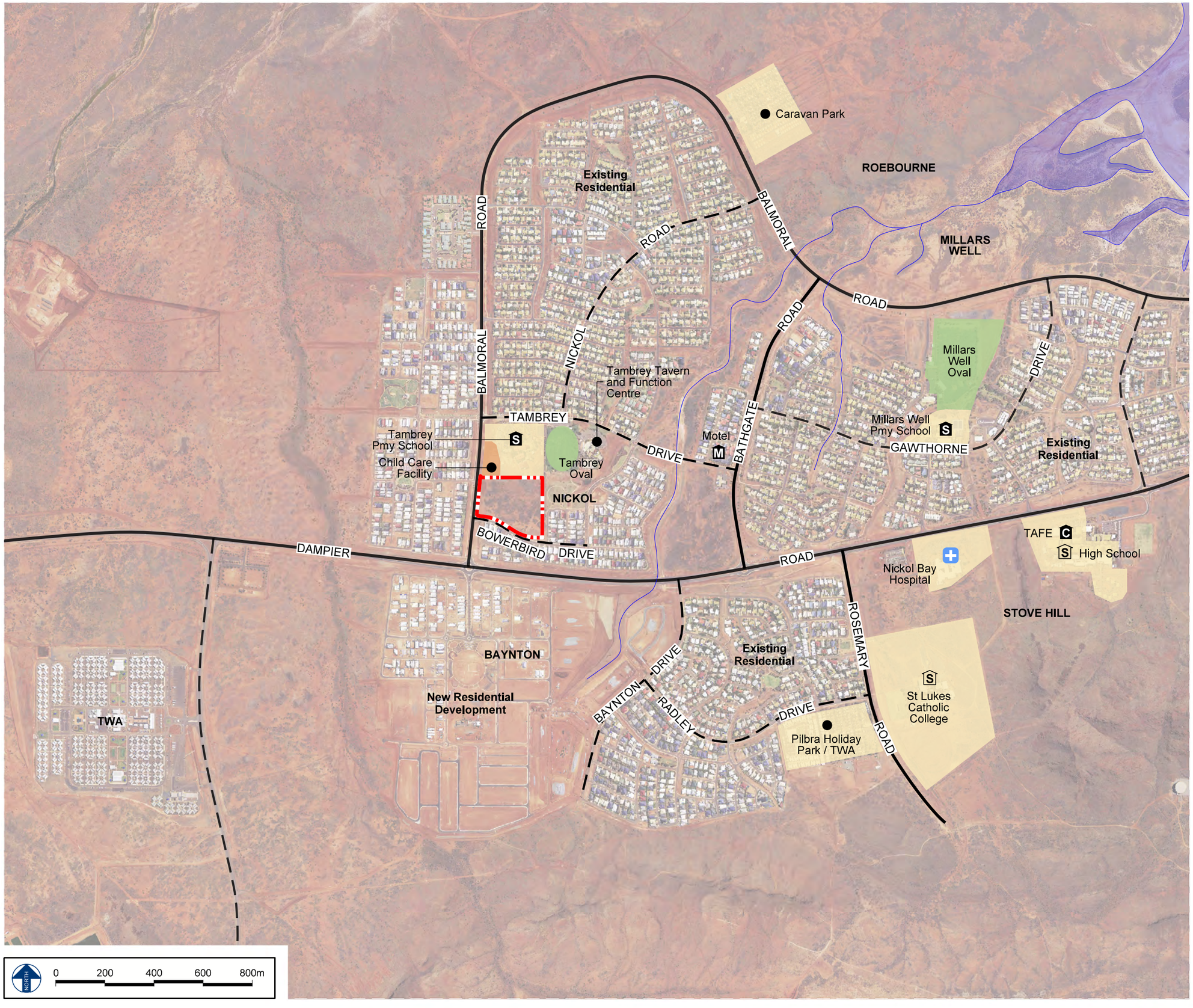
Table 1: Karratha Housing Market

Karratha	Quarter	Number	Min $	Max $	Avg $
One Bedroom	Dec-10	5	$ 275,000	$ 530,000	$ 446,800
	Mar-11	5	$ 265,000	$ 600,000	$ 431,800
	Jun-11	2	$ 490,000	$ 525,000	$ 507,500
Two Bedroom	Dec-10	4	$ 507,000	$ 739,000	$ 578,750
	Mar-11	14	$ 507,000	$ 850,000	$ 620,786
	Jun-11	14	$ 459,000	$ 710,000	$ 599,000
Three Bedroom	Dec-10	99	$ 535,000	$ 1,125,000	$ 767,009
	Mar-11	116	$ 485,000	$ 1,150,000	$ 760,780
	Jun-11	102	$ 580,000	$ 1,150,000	$ 757,920
Four Bedroom & above	Dec-10	78	$ 749,000	$ 1,420,000	$ 1,023,156
	Mar-11	95	$ 650,000	$ 1,395,000	$ 1,002,989
	Jun-11	87	$ 650,000	$ 1,700,000	$ 1,029,744
Total	**Dec-10**	**186**	$ 275,000	$ 1,420,000	**$ 861,769**
	Mar-11	**230**	$ 265,000	$ 1,395,000	**$ 845,150**
	Jun-11	**205**	$ 459,000	$ 1,700,000	**$ 859,983**

The proposed Development Plan will facilitate development of critical additional housing stock, which in turn will assist in relieving the severe shortage currently being experienced throughout the Council and broader Pilbara region.

LOCAL CONTEXT PLAN

Lot 504 Nickol,
TAMBREY



LEGEND

Site Boundary

FIGURE 5

ABN Developments	CLIENT
1:15,000@A3	SCALE
7 September 2011	DATE
3789-5-004.dgn	PLAN No
-	REVISION
T.K.	PLANNER
R.F.	DRAWN
N.T.	CHECKED

Base data supplied by Landgate.
Aerial Photography dated 2010.
Accuracy +/- 4m. Projection MGA Zone 50.

Areas and dimensions shown are subject to final survey calculations.
All carriageways are shown for illustrative purposes only and are subject to detailed engineering design.

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3.0 PROPOSED DEVELOPMENT PLAN

3.1 Design Intent and Philosophy

Simon Youngleson Architects and Urban Designers (SYAUD) have prepared a concept Masterplan to support the Development Plan (refer **Appendix 3**).

The concept Masterplan is consistent with the design intent and philosophy of the site, which is to provide for the creation of a village, with a vibrant sense of place, purpose, community and integrity where residents have an opportunity to be part of a successful, integrated and supportive community in Karratha.

The Masterplan (and associated Development Plan) is underpinned by the following Urban Design principles:

- Increased passive surveillance of the school site and POS through the provision of a greater number of lots with direct frontage to these areas;
- Improved level of pedestrian safety with the absence of crossovers on the street fronting the school site;
- The provision of a variety of lot sizes and product choices to ensure purchasers have a range of options for cottage and traditional lots in a range of different price points;
- Improved pedestrian movement with enhanced connectivity through streets to the school site and eastern POS;
- The creation of internal focal points and vistas through to the open space that will be treated with landscaping features to break up the mass of the project;
- The creation of a permeable road network that also provides a more appropriate overland flow path for stormwater drainage;
- Lot frontages on traditional lots which will facilitate the construction of homes more in keeping with the lifestyle needs of Karratha's residents, including accommodating off street boat parking;
- The provision of wider lots in areas fronting existing properties that will facilitate the construction of homes with comparable elevations which mirror the existing streetscape;
- The creation of laneways with clear sightlines and no 'dead' corners;
- The creation of a pedestrian friendly environment through the reduced dominance of the automobile and a greater provision of rear-loaded cottage lots;
- Increased community interaction and surveillance of the street encouraged through the provision of large front Outdoor Living Areas (verandahs) to both cottages and traditional homes;
- All homes to address the street through defined entries and front living spaces;

- Embed the development with an identity unique to Karratha through a colour and materials palette reflective of the surrounding built and natural environment;
- Address parking shortages and create activity in the street through the provision of on-street parallel parking bays;
- The use of appropriate permeable fencing will provide a clear definition between the public and private domain and create aesthetically pleasing streetscapes;
- The provision of street trees to both sides of the street to provide, shade, scale and beauty to the streetscape; and
- Minimised front setbacks will ensure homes address the street, community interaction is promoted, and a more intimate scale to the streetscape is achieved.

Figure 6: Design Features

3.2 Karratha Vernacular

In addition to the design intent and philosophy outlined in Section 3.1 above, the Development Plan responds to key elements of the Karratha Vernacular Design Principles (2011), namely:

Residential Streetscapes

The Development Plan has considered the provision of boat parking, which will be through the provision of laneways (in order to remove boats from the streetscape entirely) as well as front verge parking for the

traditional lots. Street trees and ground cover planting will be provided on all streets being accessed by a Cottage lot, providing a pedestrian friendly environment.

The Development Plan proposes avenues of trees on all streets. It also considers the front verandah as an important element of the delivery of the built form and an important element of the vernacular style. The Development Plan also details the delivery of permeable fencing on residential properties providing an interactive streetscape.

Landscaping

The approach to landscaping for the proposed development will respond to the *Karratha Vernacular Design Guidelines* in a number of ways.

Where possible, vehicle access to lots has been located at the rear of properties (via laneways) to reduce the dominance of vehicles within the streetscape. Low, semi permeable fencing will be used at the front of lots to increase passive surveillance and encourage neighbourhood interaction. All fencing will be cyclone rated.

Where practical, local materials will be used and the colour palette of materials/finishes selected shall reflect the natural environment of Karratha.

Low maintenance, predominantly native plant species will be used which are better adapted to the local conditions. Local plant species will also enhance the sense of place. Only hardy exotic species shall be used where appropriate. Street trees will be mainly native species and assist in providing shade, improving the aesthetics of the streetscape and in creating microclimates.

Trees within the proposed lots will be selected to provide a canopy for shade whilst not becoming too large for the residential scale.

Vegetation will be used around the perimeter of housing to filter the breeze path and aid in cooling. In addition, climbers will add further shading to the houses and alfresco areas.

Xeriscaping principles will be adopted including suitable plant selection (as mentioned above), stone mulch to aid in retention of moisture in the soil and limited use of lawn areas. Irrigation will be subsurface and directed to individual plants to minimise water wastage, with the aim of gradually reducing the amount of irrigation over time as plants become established.

Location of Breezeways

Due to the compact size of the proposed dwellings a breezeway throughout the extent of the homes will not be possible. Nevertheless, as a preferred alternative to breezeways, a large covered outdoor room will

be provided for each dwelling, accessed from the main living areas designed with multiple openings to promote cross ventilation.

Moreover, the planning of the dwellings has been designed around separating the building into zones to ensure that bedroom wings are well sealed to allow for efficient mechanical cooling of these spaces where it is required.

Outdoor Living Areas

Large Outdoor Living Areas will be provided for all dwellings in the form of deep elevated, covered, front verandahs, with an additional covered alfresco area in one of the cottage products and all the traditional products. Section 9.0 in Part 1 – Statutory Provisions - of the Development Plan report prescribes, among other matters, minimum dimensions for the Outdoor Living Areas. In addition, **Appendix 8** highlights those lots where minor variations to the prescribed dimensions are required as a result of physical lot constraints.

The Outdoor Living Areas are consistent with the Performance Criteria of the Residential Design Codes in that they are all capable of use in conjunction with a habitable room of the dwelling and take best advantage of the lot orientation for solar gain.

The location of the covered Outdoor Living Areas adjacent to the main living spaces at the front of the dwellings will be ideal for the barbecue and nocturnal lifestyle of Karratha's residents, and will facilitate community interaction and surveillance of the street.

In addition to being roofed and having permeable balustrading, the Outdoor Living Areas have been designed to be fitted with vertical canvas blinds to provide additional shade, privacy and comfort for residents and to enable flexibility in how the outdoor rooms are utilised. The use of blinds on the Outdoor Living Areas will also aid in creating an interesting and varying streetscape.

Eaves (Shade)

This design principle is a key element of the design response for the housing through the use of large shaded verandahs or "outdoor rooms" on all dwellings.

Maximum transportable dimensions restrict the size of eaves. However, a minimum 800mm sized eave will be provided where there is glazing.

The deep covered front verandahs and rear alfresco areas provide a large amount of shade and enable all major openings accessed from the adjacent living areas to be located under constant shade.

Glazing on the east and west facades will be kept to a minimum and be small in format, located under the eaves or fitted with additional shading attachments such as awnings or external window boxes.

Colours and Materials

The delivery of the homes at Tambrey will be exclusively constructed in lightweight construction as a result of being modular homes.

Using imagery from site visits to Karratha, and with the aid of a specialist colour consultant, a unique colour palette has been produced that consists of tones that reflect and complement the natural landscape and local vernacular buildings of Karratha.

The colours in the Tambrey palette are predominantly light in tone to reflect the harsh sunlight and when applied across the development will tie in to create a common architectural language and coherency across the built form.

The intended colour scheme for housing in Tambrey is for the bases of the buildings and streetscape, such as retaining walls and decking, to consist of rich, earthy tones to reference the surrounding ground plane, and for the houses and attachments to be lighter in tone with a textural quality to reflect the cooler pastel tones of the unique Karratha vegetation.

Boat Parking

The demand for boat bays has been carefully considered and incorporated into the designs of the dwellings without detracting from the intended urban design outcomes.

Each traditional dwelling type makes provision for a boat bay located at the side of the house in addition to a double carport. A number of the cottage products also cater for two (2) covered car bays and a boat bay accessed off the rear laneway.

In addition, a large amount of on-street parking has been provided within the Development Plan to accommodate visitors.

Access

All dwellings will be easily accessed without the use of stairs either by the laneway for the cottage lots or via the driveway for the traditional lots.

Fencing to Streets and POS

Fencing to all streets, including those lots adjacent to the POS, will be a maximum height of 1800mm and visually permeable above 1200mm. For the lots adjacent to the existing POS, a small amount of retaining

will be required, including a low permeable fence fixed above to facilitate community interaction, enable surveillance of the street and to allow breezes through. The provision of this type of front and side fencing will also create a distinction between the public and private domain.

Setbacks to Laneways

The laneway design consists of a 6m carriageway with a 1.1m setback to allow for bins and to facilitate larger vehicle turning circles.

Designated areas for planting have been incorporated into the laneway design, to soften the laneway. A narrower entry 'throat' to laneways has also been designed to differentiate the laneway from the main access roads.

3.3 Built Form

ABN intends to utilise its manufactured housing division, TR Homes, to facilitate a quick delivery of a range of Traditional (R20) and Cottage (R30) modular housing products across the site, designed specifically on the unique local environment and lifestyle.

Some conceptual/indicative examples of the housing products are illustrated below:

Traditional Modular Housing Products

Figure 7: Front Elevation TO1 – Type A

Figure 8: Front Elevation TO2 – Type A

Figure 9: Front Elevation TO3 – Type A

Cottage Modular Housing Products

Figure 10: Front Elevation CO1 – Type A

Figure 11: Front Elevation CO2 – Type A

Figure 12: Front Elevation Co3 – Type A

Indicative Design Outcomes

Figure 13: Transect Elevation (Cottage Dwellings)

Figure 14: Transect Elevation (Traditional Dwellings)

3.3.1 Integration with Surrounding Development

Surrounding development consists of the Primary School site to the north and north-east, existing POS to the east, and residential development adjacent to Balmoral Road, Bowerbird Drive and Flannel Bush Turn.

The proposed development has been designed to appropriately address the POS and Primary School site with all R30 lots orientated toward the adjacent sites providing passive surveillance and enhancing the amenity, safety and security of the area. The provision of on-street parking also encourages the active use of the adjacent sites for recreational purposes.

The Development Plan has been prepared having regard to the adjacent Child Care Centre and likely future expansion of the Tambrey Primary School. This notwithstanding, the Department of Education has advised that planning for the expansion of the Primary School has not yet commenced.

The Development Plan provides parallel car parking embayments, a shared-use path and wider road reserves to accommodate potential increases in vehicular and pedestrian traffic during peak periods of demand. The verge adjacent to the Child Care Centre also provides adequate space to facilitate the construction of a new crossover at some point in the future (it is acknowledged that the current location of the cross-over to the child care centre off Balmoral Road is less than ideal).

3.4 Residential

3.4.1 R-Code Variations

In order to achieve the 'vision' for the site and address the Urban Design principles identified, the proposed Development Plan will require the Council's support to a number of variations to the R-Codes notably in relation to front setbacks and outdoor living areas.

With respect to the proposed Development Plan, the provisions of Clause 6.2.1 (A1.1) and Table 1 of the R-Codes prescribe the following minimum primary street setback requirements:

- R20 zoned land: 6 metres; and
- R30 zoned land: 4 metres.

Furthermore, Clause 6.4.2 (A2) of the R-Codes states the following:

> *"outdoor living area[s] [are] to be provided [with] at least two-thirds of the required area without permanent roof cover".*

Specifically, the Council is requested to support variations to the abovementioned R-Code requirements as follows:

i. A reduction in the front setback for all R20 lots to 3m (with no average setback);

ii. A reduction in the front setback for all R30 lots to 2.5m (with no average setback) and;

iii. Permanent roof cover over 100% of outdoor living areas for all lots.

Reducing the minimum front setback requirements for all lots within the Development Plan will facilitate more effective use of private open space on the lots and will place greater emphasis on the dwelling's articulation toward the primary street, thereby increasing community interaction and surveillance of the street.

Given the design of the cottage style modular housing product, and the extreme climatic conditions experienced in Karratha, it is considered appropriate to provide 100% roof cover for the R30 outdoor living areas. This will not only mitigate the harsh climatic conditions but will also encourage the outdoor areas to be used on a more frequent basis resulting in greater interaction with neighbours and the street.

A variation to the R-Code requirements for outdoor living areas is not required for the R20 lots as these are of sufficient size to satisfy the requirements of Clause 6.4.2 (A2) above (while at the same time providing sufficient permanently covered outdoor areas for protection from the weather and promoting interaction with the street).

3.4.2 Density and Diversity

The Development Plan incorporates a mix of low and medium density housing generally of densities R20 and R30 and provides for the creation of thirty-eight (38) R20 lots and forty-four (44) R30 lots. While the total yield is marginally less than the number of lots that could be achieved - based on the strict interpretation of the minimum average lot size requirements of the R-Codes - it is important to note that the development has been holistically planned to achieve the highest possible urban design outcomes, and that the lots have been designed around the dwellings, rather than the other way around, where lot yields are maximised at the expense of good design.

The Residential R20 sites occupy the southern portion of the Development Plan. These R20 sites are provided with direct street access and will be developed to provide the 'Traditional' modular housing product. The Residential R30 sites generally occupy the northern portion of the Development Plan area and are provided with rear laneway access. The R30 sites will be developed to provide the 'Cottage' style modular housing product.

The proposed densities will facilitate the provision of a built form development that represents the unique lifestyle and climatic conditions which characterise Karratha while helping to relieve the severe housing demand currently being experienced throughout the town and broader region.

The site is located within 100m of the Tambrey Primary School and a large area of POS increasing the walkable catchment and further supporting the proposed densities.

3.4.3 Lot Type and Shape

The proposed Development Plan has been specifically designed to provide lot sizes which are capable of accommodating the 'Traditional' and 'Cottage' modular housing product developed by TR Homes.

The R30 lots are largely characterised by narrower lot widths of 13m with rear laneway access. The R20 lots generally have widths of between 16.5m to 17.5m.

Laneways have been used to reduce the dominance of carports and vehicles and to achieve a positive urban design outcome by promoting walkability, and designing houses to address the street with large elevated front Outdoor Living Areas (verandahs) and facilitate passive surveillance.

The reliance on vehicular travel and the high number of vehicles per household has been acknowledged and addressed through an efficient laneway design that enables the majority of cottage homes to have two covered car bays and one boat bay.

The laneway product has been designed to be narrow and compact at only 120sqm to ensure the availability of affordable housing product in the development. Having regard to the design principles associated with the cottage and traditional lot product, and the resulting passive surveillance opportunities that these dwellings will provide, the addition of a second storey to accommodate studio apartments is considered unnecessary.

Critically, the provision of studio apartments would significantly raise the cost of the houses, which in turn would need to be reflected in higher prices for prospective purchasers.

3.4.4 Lot Orientation

The majority of the cottage (R30) lots are oriented north-south to ensure that living areas and the large Outdoor Living Areas (verandahs) addressing the street are north facing to capture the prevailing north-westerly breezes and cooling north-easterly breezes. This orientation also enables residents to effectively control the amount of daylight entering the dwellings on the northern façade, and enables all major openings to be located in shade under the roof of the front Outdoor Living Area.

In addition to the front Outdoor Living Areas the cottage lots, have a large covered rear alfresco and living area with a northern aspect for lots that have a southern frontage.

This layout and integral design feature of the Outdoor Living Areas that encourage community interaction and surveillance ensures that the dwellings effectively address the street, and will enable a good urban design outcome to be achieved. In the Development Plan, dwellings will appropriately address the main entry road adjacent to the Primary School and existing Bowerbird Drive, mirroring the lot layout of the neighbouring developments along this route.

All traditional lots have a large covered front Outdoor Living Areas and covered rear alfresco of comparable size to allow flexibility in the plans through the arrangement of secondary living spaces and extra bedrooms to facilitate multiple living arrangements, and to ensure all living spaces and outdoor rooms have a northern aspect.

It should be noted that as a result of the location of the main drainage route parallel to Balmoral Road, a number of roads and laneways are aligned east-west to cater for overland drainage in accordance with the civil engineering requirements.

3.4.5 Climatic Responsiveness

The proposed Development Plan has been designed to respond to the unique microclimate that characterises Karratha through the implementation of passive solar design and natural cross ventilation.

The design of the cottage modular dwellings are narrow to promote cross ventilation, with minimal side setbacks between buildings to increase shade on the eastern and western facades. As previously highlighted, glazing on the eastern and western facades will be kept to a minimum and be small in format, located under the eaves or fitted with additional shading attachments such as awnings or external window boxes.

The use of microclimate landscaping will also be applied close to the houses to further provide shade for the buildings and a comfortable environment.

3.5 Movement Network

Located in an existing urban environment, the Development Plan integrates with the existing street network. The street network proposed by the Development Plan is a modified connected grid pattern and includes the following characteristics:

- A North-south road alignment allowing cooling breezes to flow between dwellings;
- Provision of dedicated on-street parking;
- No vehicular access to Flannel Bush Turn on the site eastern boundary to reduce through traffic movement and increase safety for pedestrians; and
- Three (3) external access points to the development being one (1) onto Balmoral Road and two (2) on Bowerbird Drive providing a high level of accessibility.

The primary point of access into the proposed development will be via the road at the northern end of the Development Plan adjacent to the proposed Balmoral/Brolga Meander roundabout. Notwithstanding the primacy of this entry point the Development Plan provides a further access focal point at the southern end of the main north-south road link. The creation of a short boulevard at this location is intended to provide an attractive alternative way into and out of the proposed development.

A detailed Transport Assessment Report (TAR) was prepared by ARUP (refer **Appendix 4**) which assesses the impacts of the proposed development on the adjacent road network. ARUP's investigations can be summarised as follows.

3.5.1 Surrounding Road Network

The TAR established that the intersections considered to be significantly affected by the proposed development are the intersection of Balmoral Road and Bowerbird Drive and, the intersection of Balmoral Road and Brolga Meander. The TAR concluded both intersections are expected to operate well within capacity during peak hour in 2013 when the residential development is finished, assuming the Balmoral Road and Brolga Meander intersection is converted to a four-way roundabout with direct access to the development.

It should be noted that the TAR has considered operating conditions in the ultimate design year. The analysis took into account baseline traffic growth at a rate of 5% *per annum* (agreed with Council) plus full development traffic (using conservative estimates). The analysis of the roundabout shows that it is highly likely to operate effectively in the ultimate design year with significant residual capacity.

3.5.2 Local Streets

The internal road network includes predominantly 15m road reserves with a 6.0m carriageway. An 18m road reserve has been provided adjacent to the Primary School site to the north consistent with 'Liveable

Neighbourhoods' principles of design. The wider road reserve adjacent to the school site allows for the provision of a 2.5m shared use path on one side of the road.

On-street parking provision is anticipated for all streets with bays at 2.5 metres in width interspersed with landscaping nibs. Given the close proximity to the Primary School, the overall design intent is to reduce the visual width of the trafficable reserve to support low traffic speeds and create a highly pedestrian friendly environment.

A number of indicative cross sections for the streets within the proposed development have been prepared, examples of which are illustrated below:

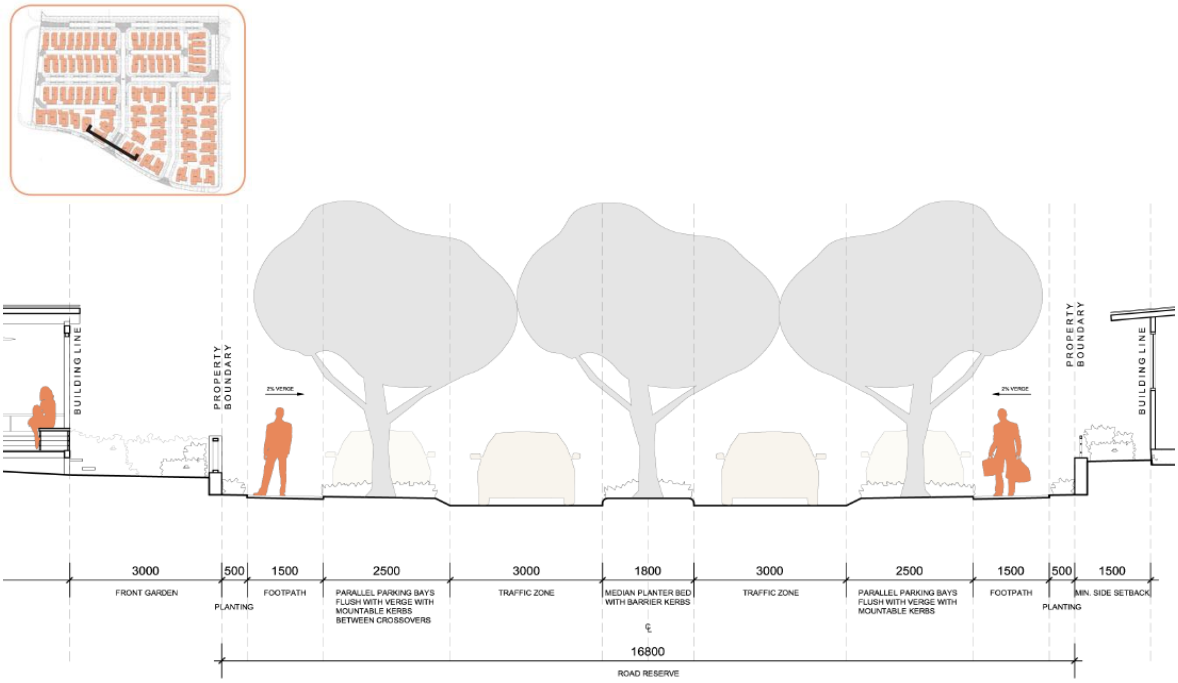

Figure 15: Section through Entry Boulevard

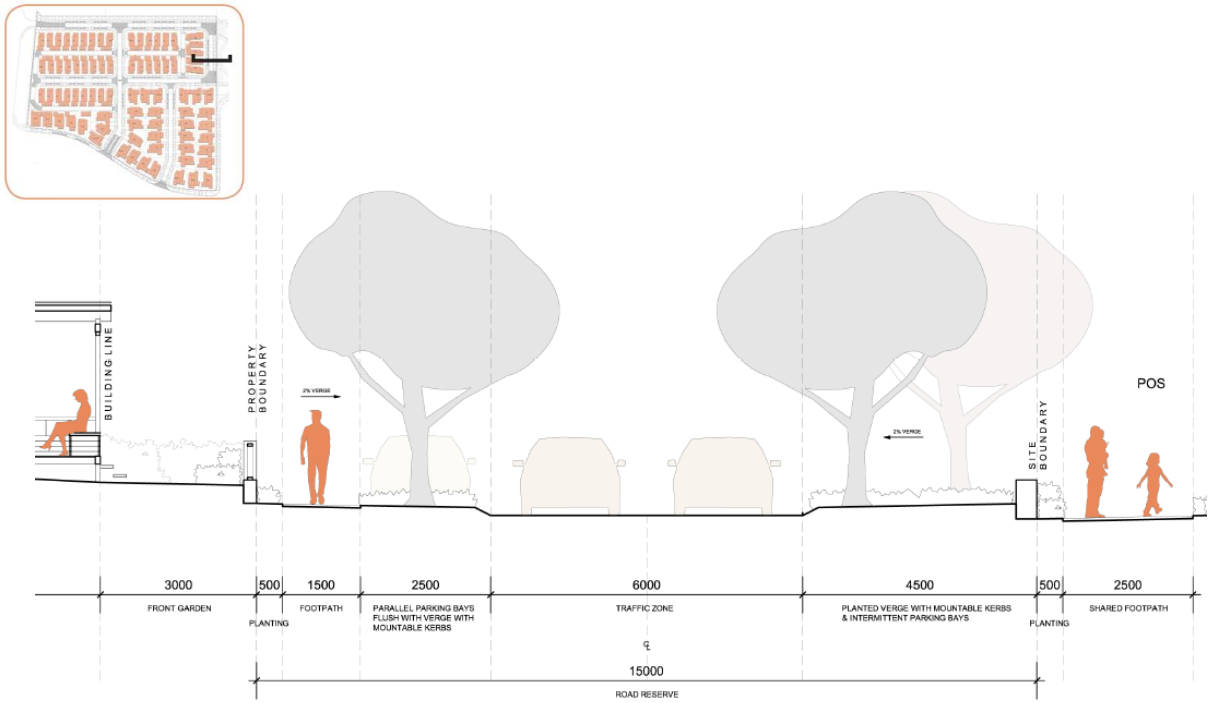

Figure 16: Section through Street adjacent to POS

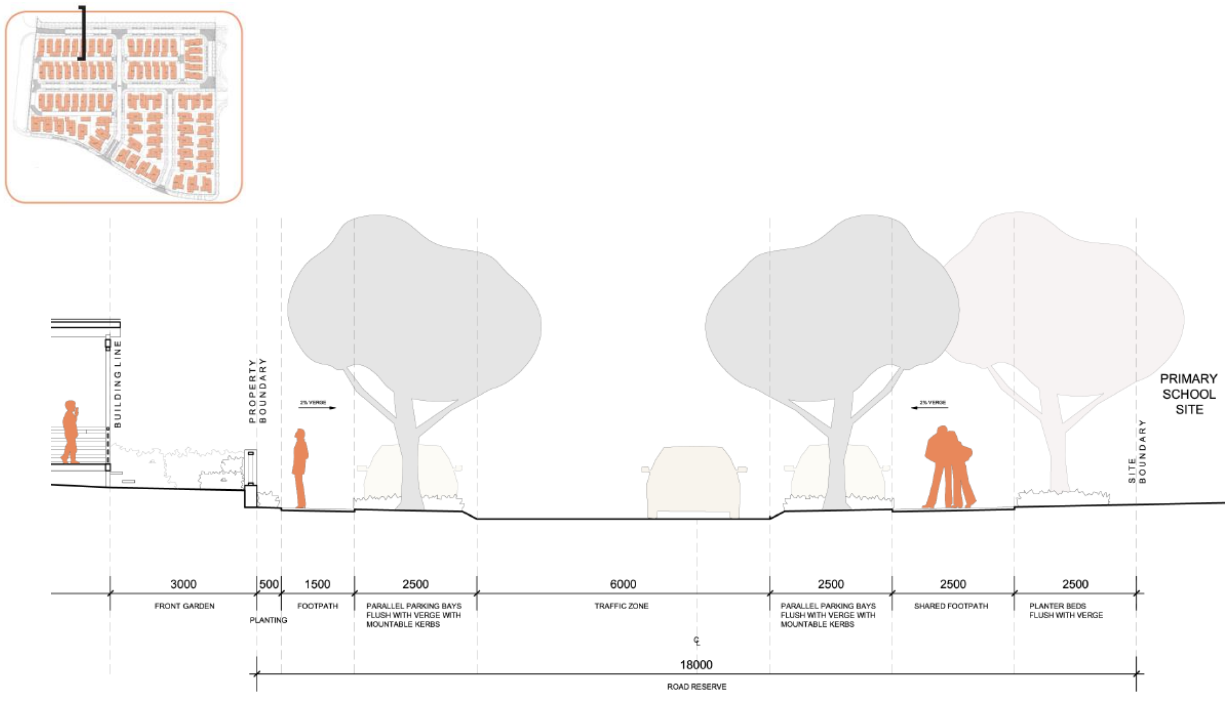

Figure 17: Section through Street adjacent to Primary School Site

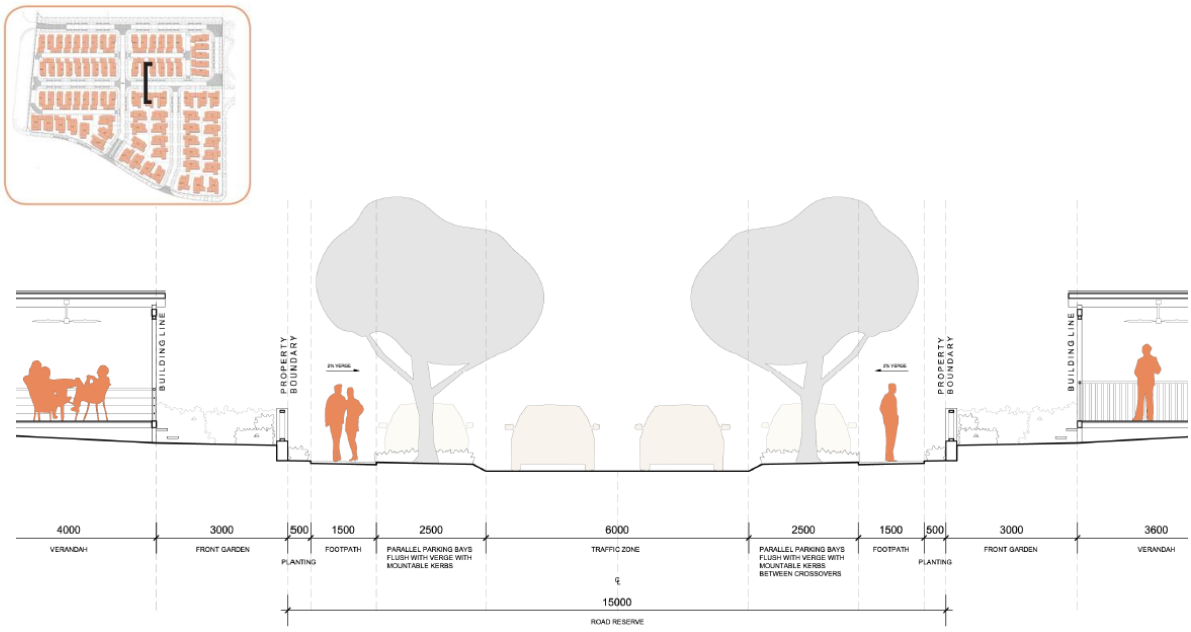

Figure 18: Street with Cottage Lots opposite Traditional Lots

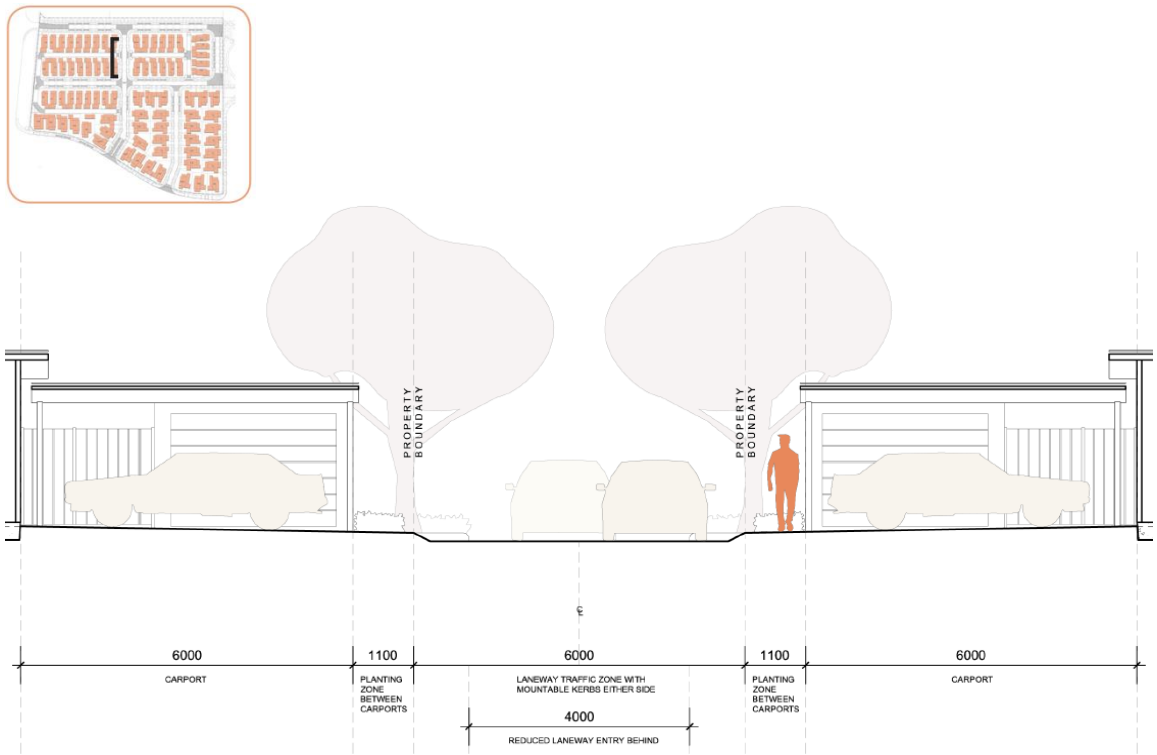

Figure 19: Laneway Entry

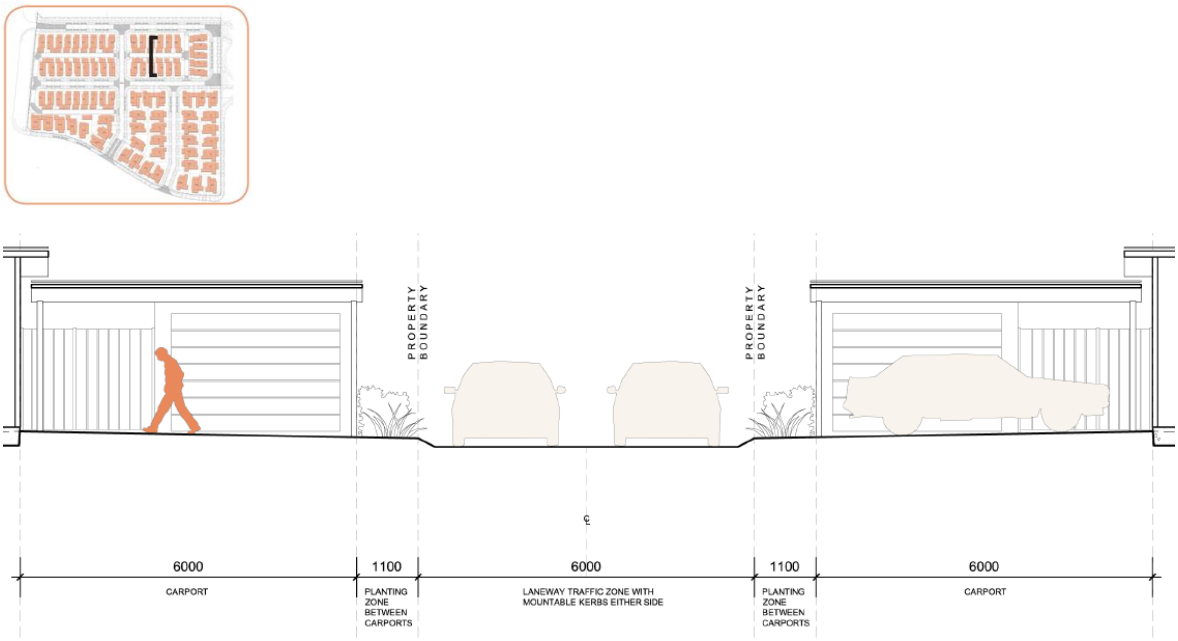

Figure 20: Typical Laneway Section

3.5.3 Laneways

The proposed laneways have been designed to a width of 6m which is sufficient given the narrower 'throat' intended to restrict access to one way at a time. While Liveable Neighbourhoods suggests a 5.5m carriageway for access ways, the Council of Roebourne's technical services personnel advised that a 6m carriageway for laneways is preferred given the prevalence of larger vehicles in Karratha. The 6m width of the laneways will also effectively help reduce traffic speeds and increase the safety for crossing pedestrians and on-street cyclists.

3.5.4 Intersection Spacing

All intersections are spaced so as to comply with the requirements of the Liveable Neighbourhoods. Accordingly, the Development Plan will result in a safe environment for pedestrians, cyclists and motorists.

3.5.5 Traffic Speed

The local streets proposed by the Development Plan are designed to produce the target vehicle speeds as prescribed by Liveable Neighbourhoods. The proposed local streets are short in length and do not create opportunities for speeding.

3.5.6 Public Transport

Currently, there is little public transport provided in the Karratha region, with a single bus route currently operating twice a day on Tuesdays, Saturdays and Sundays between Dampier and Port Sampson. A bus stop associated with this route is situated at Tambrey Oval approximately 400 metres north of the development site.

A new bus route may be considered as part of the development of Karratha consistent with the vision articulated in the Karratha City of the North Plan. This route is only at the concept planning stage and is unlikely to be in operation in the short-medium term. Public transport is therefore unlikely to affect the mode split of residents in the proposed development for the foreseeable future.

3.5.7 Pedestrian Circulation and Amenity

The proposed walking and cycling network within the development has been developed to provide for the convenient and safe movement of pedestrians and cyclists through and external to the site, notwithstanding limitations to surrounding infrastructure. It is expected that residents of the development will utilise the walking and cycling network for recreational purposes, as well as for access to the nearby Tambrey Primary School and proposed child care centre in the future.

The provision of an east-west shared path aligned along the northern boundary of the site should, in the future facilitate an external connection northwards to the Tambrey route shown in the Council Bike Plan.

The following principles will be implemented as part of the proposed development to contribute to the amenity of the streetscape and to facilitate safe movement of pedestrians and cyclists north to the Tambrey Primary School, as well as through to the existing path network external to the subject site:

- Footpaths on both sides of internal streets;
- Footpaths with a minimum width of 1.5m;
- A 2.5m shared use path adjacent to POS and the Primary School site which connects to the existing path network on Bowerbird Drive, Flannelbush Turn and the western side of Balmoral Road;
- The provision of street trees adjacent to footpaths at a distance of 10m to 12m providing ample shade for pedestrians on both sides of the street; and
- The design of the modular homes for the traditional and cottage lots provide front Outdoor Living Areas and living spaces that protrude into the front setback area to encourage street surveillance, pedestrian activity and community interaction.

3.5.8 Streetscape

The proposed street network has been designed to convey to users its primary function and unique character, and identify and encourage appropriate driver behaviour. Development will be subject to specific design provisions which have been established by the Built Form Vision document developed by SYAUD.

3.6 Public Open Space (POS)

The WAPC's Policy No. DC 2.3 'Public Open Space in Residential Areas' requires that for residential subdivision, 10% of the gross subdivisible area shall be given up free of cost by the subdivider for POS purposes. The aim of the policy is to ensure that the provision of POS allows for a reasonable distribution of land for active and passive recreation.

However, WAPC Planning Bulletin No. 21 'Cash-in-Lieu of Public Open Space' provides for the following:

"In some circumstances the provision of an area of land for public open space is not practical and it may be more appropriate for cash-in-lieu of public open space to be given for the following reasons:

- *in small subdivisions, the provision of public open space may result in a small unusable area of land being set aside;*
- *there may be sufficient public open space already available in the locality;*
- *public open space may have been provided in earlier subdivisions; or*
- *open space is planned in another location by way of a town planning scheme or local structure plan."*

The principles of Planning Bulletin No. 21 are consistent with 'Liveable Neighbourhoods'.

The proposed development is situated in an area which contains adequate amounts of POS. In this regard, the site is located immediately adjacent to an existing area of POS (1.6ha) and the Tambrey Oval (to the north-east), which provides a further 2ha (approx.) of open space (refer **Figure 5**).

Accordingly, a cash payment in lieu of the 10% POS is considered appropriate in this instance, with the amount to be determined by the Council in accordance with prevailing market conditions.

3.7 Urban Water Management

Emerge Associates have prepared a Local Water Management Strategy (LWMS) to support the Development Plan, consistent with the requirements established by the WAPC's Better Urban Water Management policy (refer **Appendix 5).**

The LWMS establishes a Total Water Cycle Management approach to water management at the site, and has been developed based on detailed site-specific investigations, industry best-practice and relevant state and Council of Roebourne policies relating to water management. The overall objective for the LWMS is to mimic the hydrological regime that currently exists prior to urban development of the site. Underpinning this is the requirement to protect life, property and the environment from intense rainfall events.

The water management approach associated with the Development Plan includes:

- Surface runoff should be conveyed by surface drainage within road reserves, not piped drainage;
- On-site detention should only be considered if absolutely necessary to slow down peak flows;
- There will be no onsite retention;
- There are no requirements to address water quality, or to treat runoff prior to leaving site;
- Culverts will be required to convey flows at road crossings;
- Finished floor levels should be driven by separation requirements from 100 year flood levels, and from established tidal inundation levels;
- Drainage design elements must comply with the Council of Roebourne drainage standards; and
- Water should be conserved wherever possible, and the State Water Strategy consumption target of 40kL/person/year has been adopted.

The LWMS was prepared with the intention of not only demonstrating that the Development Plan is spatially able to accommodate the water management approaches proposed, it also guides the future detailed designs for the site by providing clear, auditable criteria that will ensure that overall objectives are met.

The criteria established for the LWMS includes:

Water Conservation Criteria:

- WC 1 Ensure the efficient use of all water resources; and
- WC 2 Consumption target for scheme water of 40 kL/person/year.

Surface Water Criteria:

- SW1 Post-development critical 5 year and 100 year ARI peak flows will be generally consistent with pre-development peak flows;
- SW2 Conveyance of the 5 year ARI event will be achieved by open swales within road reserves;
- SW3 Conveyance of events up to the 100 year ARI to be achieved in a combination of the open drainage channel and road pavement;
- SW4 Maximum flow velocity for surface runoff conveyance is 2m/s;

- SW5 Finished floor levels of lots must have a 300 mm clearance from the 100 year ARI event flows being conveyed within road pavement;
- SW6 Finished floor levels of lots must have a 500 mm clearance above the 100 year ARI flood level within major drainage channels;
- SW7 The finished floor levels must have a minimum of 500 mm clearance from the tidal influence level of 7.6m AHD;
- SW8 Culverts are to be used for road crossings, and these should be greater than 450 mm in diameter; and
- SW9 Reduce nutrient loads by applying appropriate non-structural measures.

As a part of the LWMS investigation process Emerge Associates determined the pre-development catchments to establish which direction of surface water will flow. This included referencing the design contours within the drain adjacent to Dampier Drive. The design contours from this drain indicate that upstream runoff flows from a localised high point within the drain. This high point (15.5mAHD) is adjacent to the end of Seasnake Court. From this point the flows within the drain are west towards Balmoral Road and then north along Balmoral Road. Analysis of contours further downstream (i.e. north) along Balmoral confirm that the next downstream culvert under Tambrey Drive is of lower elevation (12.38m AHD) than Bowerbird drive (14.28 mAHD). Consequently, discharging runoff from the Tambrey site in a southerly direction would not be possible.

The approach taken for earthworks is to minimise the modification to the landscape and thereby reduce the amount of fill to be brought onto the site. The earthworks plan introduces a uniform grade across the site towards Balmoral Road, resulting in the minor portion of the eastern end of the site being drained to the west.

This approach is further justified by analysis of the land area available adjacent to Balmoral Drive and the capacity of culverts downstream at Tambrey Drive, which indicates that both the road reserve and the culverts have sufficient capacity to adequately convey runoff from the site.

The 'baseline' criteria that the Council stated needed to be met – that pre-development flows should not be exceeded – can be achieved within the Balmoral Rd reserve.

The LWMS has been endorsed by the Department of Water.

3.8 Infrastructure Coordination, Servicing and Staging

Wood & Grieve Engineers were commissioned by ABN to undertake a servicing investigation to establish the availability of services for the development of the subject land (refer **Appendix 6**).

A summary of the key findings of the investigation are provided below.

3.8.1 Earthworks and Retaining Walls

The investigation undertaken by Wood and Grieve Engineers established the need to import fill with minor on-site cut to fill to create flat lots that provide adequate clearance to the proposed lot levels and overland stormwater flood routing. WGE's Concept Earthworks Plan demonstrates the proposed finished surface levels.

Investigations revealed that the site will achieve a site classification of M-D (moderately [M] reactive clay or silts with deep seated [D] movement) which is typical of most developments in the Karratha Area.

The construction of sewer mains deeper than the underlying natural bedrock layer may require rock breaking.

No retaining walls are proposed for this development.

On-site test pitting undertaken by Douglas Partners discovered Gilgai (highly reactive clay) soils in the north western and south eastern corners of the site. Proof rolling during construction will confirm any further deposits exist across the site, or between testpits. Gilgai soils may be excavated and treated onsite, or more likely removed from site.

Douglas Partners Geotechnical Investigation provides further technical background on subsurface conditions (refer **Appendix 7**).

3.8.2 Stormwater Drainage

The drainage system proposed for this site is typical of that found in Karratha, consisting of overland flow paths discharging into open channel drains.

This development will be split into two drainage sub-catchments in general accord with the pre-development grade of the site. Two drainage discharge locations have been determined to efficiently and effectively convey overland flows to Balmoral Road.

3.8.3 Water Reticulation

A Media Statement released by the Government on 9 September 2011 announced Rio Tinto's agreement to surrender its priority entitlement to the Millsteam water supply system for use by towns in the Pilbara. In light of this recent initiative, the proposed development should be able to have access to a potable water supply in the near future.

3.8.4 Sewer Reticulation

The Water Corporation are unable to confirm whether the existing sewerage system has adequate capacity to service the proposed development until the provision of a potable water service is determined.

Upon securing an appropriate water source, the majority of the proposed development can be serviced via existing Water Corporation infrastructure which surrounds the development being two sewer connections within Balmoral Road. A number of lots will also be serviced from infrastructure within Flannelbush Turn.

No off-site sewer extensions will be required.

3.8.5 Roadworks and Footpaths

Road pavement design and construction will be in accordance with the City of Roebourne's minimum design standards and recommendations made by Douglas Partner's Geotechnical Investigation. All roadways would be designed to accommodate the 100yr stormwater design flow, including the laneways.

Brickpaved intersection thresholds and parallel car parking embayment's have been proposed adjacent cottage lots and appropriate locations throughout the development.

Two trafficable links to Bowerbird Drive are proposed as well as new roundabout to access the development from Balmoral Road, at the existing intersection of Brolga Meander.

A 2.5m wide dual use path is proposed along the northern boundary of the development to cater for the influence of the neighbouring school site and cycling links through the adjacent POS. Concrete footpaths are proposed on both sides of all proposed access roads.

3.8.6 Power

Supply of underground power and street lighting to the site will come from connection to existing infrastructure surrounding the site. Timing of access will be subject to the implementation of the Karratha 22kV power upgrade as part of the Pilbara Underground Power Project. These works have commenced and it is anticipated that the upgraded system will be available at the time of construction.

Details relating to on street lighting and lighting to shared paths and adjoining public areas will be provided at the detailed design stage.

3.8.7 Telstra

On the basis of the new Government initiative under the National Broadband Network (NBN), all telecommunications infrastructure is capable of being provided to the development site by NBN Co subject to a formal application being made and an agreement being negotiated with the Developer.

3.9 Implementation and Staging

A subdivision application has been lodged with the Department of Planning. The application has been referred to stakeholders for comment with a determination by the WA Planning Commission pending the Council's endorsement of the Development Plan.

4.0 CONCLUSION

The proposed Development Plan, prepared on behalf of ABN Developments, illustrates the preferred development option for Lot 504 Nickol.

The Development Plan will facilitate development of critical housing stock that will assist in meeting a demand for housing in this region.

The Development Plan has been based on a number of best-practice design principles, including climatic responsiveness, legibility, walkability, diversity and connectivity and is supported by a concept Masterplan and Built Form Vision. Development will also integrate with the existing urban structure and land use.

The Development Plan has been prepared in accordance with the design requirements established by Liveable Neighbourhoods and responds to the core elements and design principles outlined in the Karratha Vernacular.

Having regard to the matters raised in this report, the Council's endorsement of the Development Plan is respectfully requested at the earliest opportunity.

RPS

APPENDIX I

Preliminary Site Investigation (GHD)

CLIENTS | PEOPLE | PERFORMANCE

Chenin Grove Pty Ltd

Report for Lot 504 Balmoral Road

Preliminary Site Investigation

September 2011

INFRASTRUCTURE | MINING & INDUSTRY | DEFENCE | PROPERTY & BUILDINGS | ENVIRONMENT

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Executive Summary

Background

Chenin Grove Pty Ltd (Chenin Grove) commissioned GHD Pty Ltd (GHD) to undertake a Preliminary Site Investigation (PSI) of the Karratha Tambrey School Surplus Site ('the Site'). The Site location is shown in Figure 1, and site layout is shown in Figure 2.

GHD understands that Chenin Grove is preparing a Development Plan Report to support a planning application to subdivide Lot 504 at the corner of Balmoral Road and Bowerbird Road.

Chenin Grove Pty Ltd have commissioned GHD to provide environmental input into the Development Plan Report.

The scope of work included:

- Review the proposed development and identify environmental inputs to the Development Plan Report;
- Seek approval from LandCorp and arrange, via report reassignment, for the proponent to be able to rely upon existing information;
- Undertake site inspection to confirm current site condition and applicability of previous report;
- Review and update the existing land contamination report to reflect any new information and support the development;
- Provide a brief letter report to address potential land contamination aspects of the Development Plan Report.

A review of historical Certificates of Title and historical aerial photographs for the Site provide historical information back to the 1950s. The Site history was determined using this information in concert with information provided by the City of Roebourne Environmental Officer, and a Dangerous Goods search under the *Freedom of Information Act (1992)*.

Conclusions

Based on the investigations completed, the following conclusions are made:

- A review of Certificates of Title and aerial photographs between 1957 and 2008 did not identify any land uses or activities that could potentially be sources of contamination on the Site.
- Zoning and surrounding land uses indicate that areas adjacent to the site are zoned, or are currently in use as residential or urban development areas. This is predominately found in the form of housing, roads, schools and parks.
- A review of topography and geology of the Site indicated elevations between 14.6 and 15.2 mAHD, with clayey sand/sandy clay soils overlaid by red-brown silty sand.

- No detailed information is available on the depth of groundwater at the site. However, based on information provided in the DoW bore search, it is likely to be at depths greater than 4 mbgl.
- The closest surface water body is located approximately 5km to the north-east of the site, being the Indian Ocean. No other potentially sensitive environmental receptors were identified within close proximity to the Site.
- No RAMSAR internationally significant wetlands or Public Drinking Water Source Areas are found within the vicinity of the Site.
- A preliminary Acid Sulfate Soil (ASS) desktop assessment indicated the Site to have no known risk of ASS within 3m of the natural surface.
- A Department of Mines and Petroleum (DMP) Dangerous Goods Licence Freedom of Information (FOI) search found no information or documentation containing information relating to potentially hazardous materials that have been licensed for use or storage at the Site.
- A search of the DEC Contaminated Sites Register indicated that the Site and surrounds have not been reported as known contaminated sites at the time of the search.
- No Aboriginal or European heritage sites were identified within the site boundary.
- No Declared Rare and Priority Flora and Fauna or Threatened Ecological Communities in the Karratha Township area.
- Discussions with the Shire of Roebourne indicated there have been no environmental incidents on the Site.
- The Site walkover did not identify any areas of potential contamination, or any obvious signs of contamination. Observations made during the site visit were consistent with that identified in relevant desktop studies.

Based on the information presented in this report, the following recommendations are made for the Site:

- The minor quantities of waste onsite should be removed and disposed to landfill.
- The desktop study and site inspection did not identify any potentially contaminating activities or sources of contamination at the Site that would impact human health and ecological receptors.
- Based on the findings of the PSI it is considered that at the time of the investigation there are no restrictions to development of the Site as proposed by Chenin Grove resulting from contamination of soil or groundwater from previous activities on the site.

1. Introduction

In 2010, LandCorp commissioned GHD to undertake a Preliminary Site Investigation (PSI) of the Tambrey School Surplus Site ('the Site'). The Site is located on the corner of Balmoral Road and Bowerbird Drive in Nickol, Karratha and was then legally identified as Lot 4225 on Deposited Plan DP212628. At the time LandCorp were investigating the opportunity to acquire the southern portion of Lot 4225 on DP 216828 to facilitate development, which was then subject to Crown Subdivision being undertaken by the Department of Education to create three separate properties. The Preliminary Site Investigation (PSI) for LandCorp was completed in July 2010.

In 2011, GHD were commissioned to review the previous work and to provide an updated PSI to Chenin Grove Pty Ltd (Chenin Grove).

Chenin Grove intend to develop the site, known as Lot 504 on Deposited Plan 68025. The Site location is shown in Figure 1 and Site layout is shown in Figure 2.

GHD understands that Chenin Grove propose to subdivide and redevelop the Site for residential purposes. In order to satisfy with development approval requirements Chenin Grove wish to identify potentially contaminating activities or sources of contamination that may have occurred on the Site which may pose constraints on the Site's suitability for residential development.

This PSI has been prepared using the findings of the previous report that was prepared for LandCorp with reference to the Department of Environment and Conservation (DEC) Contaminated Sites Management Series Guidelines. An additional site inspection was undertaken by GHD to identify changes to the previous findings.

1.1 Objectives

The objective of the PSI is to identify potential risks to human health and the environment as a result of former and/or current land uses in relation to contamination of soil and/or groundwater through a desktop review and site inspection.

1.2 Previous Reports

This PSI has been prepared using the findings of the previous report that was prepared for LandCorp in 2010.

No previous reports were identified for the Site.

1.3 Community Consultation

GHD understands that appropriate community consultation will be undertaken Chenin Grove and the Shire of Roebourne as part of the normal statutory process for development of the land. GHD was not commissioned to undertake any community consultation works and has therefore not undertaken or reported on any community consultation as part of the scope of works for the PSI.

2. Scope of Works

The scope of work completed by GHD is described in the following sub-sections.

2.1 Desktop Study

A review of available information was undertaken during preparation of the LandCorp PSI in 2010 to provide evidence of potential past or present contamination issues at the Site. The desktop study included the following:

- A search of current and historical Certificates of Title to determine past owners of the Site and the likely associated site uses and a review of these against the DEC *Potentially Contaminating Activities, Industries and Landuses Guideline* (Department of Environment, 2005);
- A review of historical aerial photographs of the Site at approximately 10 yearly intervals to assist in establishing the patterns of site development over time;
- A review of the local topography and surface waters to identify potential contaminant receptors, should the Site be found to be a source of contamination;
- A review of regional geology and hydrogeology, to assist in determining the likely soil type and groundwater regime at the Site, including a review of Department of Water bore search to ascertain local hydrogeological conditions and the use of groundwater within a 5 km radius of the Site;
- A review of surrounding land uses to assess potentially sensitive environmental and human health receptors to any possible contamination and to assess surrounding land uses that have the potential to affect the Site;
- A Department of Mines and Petroleum Dangerous Goods Licence Freedom of Information (FOI) search to ascertain whether underground storage tanks (USTs) are present at the property;
- An Acid Sulphate Soils (ASS) desktop review to assess the potential for ASS to be present beneath the Site and the potential effects on redevelopment;
- A Declared Rare and Priority Flora and Fauna and Threatened Ecological Communities search;
- A search of the DEC *Contaminated Sites Register* to ascertain whether the Site or surrounding properties have been registered as potentially contaminated sites; and
- Contacting local planning authorities to ascertain whether any past or present land use activities are likely to have potentially contaminated the Site.

2.2 Site Visits

An initial site visit was undertaken by a GHD Engineer on the 7th May 2010 to confirm the findings of the desktop review and identify any potential sources of contamination that were not identified as part of the desktop review. During the site inspection, an assessment of site conditions and neighbouring land uses was also undertaken to

identify any potentially contaminated land uses adjacent to the Site and locate the nearest anthropogenic and environmental receptors.

A subsequent site inspection was undertaken by a GHD Engineer on 19th August 2011 to identify any changes to site conditions and any additional sources of contamination that were not identified during the previous investigation.

No soil or groundwater sampling was undertaken as part of this or the previous PSI.

Photographs were taken during both Site visits and are discussed in Section 6 of this report.

2.3 Conceptual Site Model

A Conceptual Site Model (CSM) illustrates any potential sources of contamination, primary and secondary release mechanisms and pathways to environmental and human health receptors. After consideration of potential sources of contamination and potentially sensitive environmental and human health receptors, a CSM was deemed unnecessary for this investigation as no potential sources of contamination were identified.

The CSM is discussed further in Section 7 of this report.

2.4 Reporting

This Stage 1 PSI report has been prepared with reference to DEC guidelines. The report presents information obtained through the desktop study, summarises the findings of the Site visit and identifies any areas that require further investigation or remediation under current Western Australian legislation.

Where other parties have supplied information or data, the data is included and used in the form provided by other parties. The responsibility for the accuracy of such data remains with the issuing authority, not with GHD. Attention is drawn to Section 10, which outlines the limitations of this report.

3. Site Identification

3.1 Legal Identification

The legal description of the current Lot where the Site is located is reported in Table 1 below.

Table 1 Lot Details

Lot	Street Address	Description	Certificate of Title (Volume - Folio)
504	Cnr Balmorall Rd and Bowerbird Dr, Nickol, Karratha	Lot 504 on Deposited Plan 68025	LR3160 - 298

Copies of Certificates of Title and DEC Site Summary Form are presented in Appendix A.

3.2 Site Description

The Site is located approximately 4 km east of Karratha town centre, situated in the Pilbara region of Western Australia. The Site area is approximately 5.3 ha and is trapezoidal in shape. The Site can be accessed from Balmoral Road and Bowerbird Drive.

The inspections of the site undertaken on 7th May 2010 and 19th August 2011, indicated that the Site was relatively flat and well vegetated with grasses (Spinifex) and small shrubs, with some areas of dense shrubs and small tress. There is no infrastructure on the Site and the Site is not fenced. There is also no formalised stormwater drainage on the Site and it is anticipated that surface water will infiltrate on site and sheet flow off the Site during high rainfall periods. The nearest open drain is on the eastern side of Balmoral Road which drains via a culvert under Bowerbird Road and may be receiving flow from the western portion of the Site, more distant parts of the site seemingly drain through localised ponding and evaporation and infiltration.

3.3 Zoning

The Shire of Roebourne Town Planning Scheme (TPS) No. 8 indicates that the Site is currently zoned for *Urban Development*. The areas north of the site (Tambrey School) are zoned for *Public Purposes, Education*, and the areas to the east, south and west are zoned for *Urban Development*.

Prior to rezoning in 2010, the site was zoned *Public Purposes, Education* as part of the Tambrey School Site. Historic zoning for the Site could not be obtained as no records were held by the Shire of Roebourne. Zoning information of Town Planning Scheme No. 8 is provided in Appendix B.

3.4 Surrounding Land Use

The surrounding land uses are shown in Figure 2 and are summarised below.

North: The Site is bound to the north by Tambrey Primary School, with residential properties of Nickol further north. The Indian Ocean is located approximately 5km to the north-east of the site.

South: The Site is bound to the south by Bowerbird Drive, with residential properties immediately south of Bowerbird Drive. Karratha-Dampier Road is situated approximately 400m south of the site, which fronts the newer urban suburb of Baynton.

East: The Site is bound to the east by new urban development residential properties of Nickol and a recreation park is located to the north east of the site.

West: The Site is bound to the west by residential properties of Nickol. Balmoral Road abuts the western boundary of the site, with residential properties further west of this. Open stormwater drains are located along Balmoral Road adjacent to the Site.

3.5 Climate

The area has an arid-tropical climate, with hot and humid summers from October to April and moderate winters from May to September. The nearest meteorological monitoring station is Karratha Airport which is approximately 7 km to the north-west. The recorded climate data from this source is summarised in Table 2.

Table 2 Climate information from Karratha Airport Weather Station

Station	Mean Annual Minimum Temperature Range	Mean Annual Maximum Temperature Range	Mean Annual Rainfall	Mean Annual Rain Days ≥ 1mm
Karratha Airport	13.6˚C (July) and 26.8˚C (January)	26.8˚C (July) and 36.1˚C (January, March)	277.8 mm	36

(Source: Bureau of Meteorology Climatic Averages of Australian Sites, 2010)

3.6 Topography

Based on a site survey plan provided by LandCorp in 2010, the site is relatively flat and is located at an elevation between 14.6 to 15.2 mAHD (Landgate, 2010). The highest point is in the north east corner, with a very gradual grade down towards the south and north-west.

3.7 Geology

According to a map search using Shared Land Information Platform (SLIP) soil at the site is categorises as *Clay soils*, with proximity to *deep sandy and sandy earth soils* (Natural Resource Management, 2010).

Nickol Bay-Legendre geological map identifies the geology of the Site to be underlain by red-brown silty sand, overlain by clayey sand/sandy clay (Department of Mines, 1978).

Further, stratigraphy from two bores located within a 5 km radius derived from a Department of Water (DoW) WIN search identified similar characteristics (Appendix C).

This soil type is consistent with the surface observations made during the site visits.

3.8 Hydrogeology

3.8.1 Groundwater

The site is located in the Port Hedland Coast drainage Basin (DoW, 2010).

Regional groundwater resources in the Pilbara originate directly from infiltration by rainfall and surface water flows, most easily located and accessed in close proximity to surface-water drainage lines (DoW, 2008a). Yields of groundwater bores differ year to year as a direct result with groundwater salinity generally increasing away from rivers and towards the coast (DoW, 2008b; DoW, 2008a).

Fractured and weathered rock aquifers (local aquifers) are predominant in proximity to the Site where water is stored in cracks and voids in the rocks and therefore tends to be localised (DoW, 2008b). This localisation results in a drop in groundwater during events of no rainfall, resulting in highly variable water availability (DoW, 2008b).

No detailed information is available on the depth of groundwater at the site. However, based on information provided in the DoW bore search, it is likely to be at depths greater than 4m below Ground Level (bGL).

3.8.2 DoW WIN Bore Search

The results from a Department of Water (DoW) bore database search undertaken in 2010 indicated that 16 registered bores are located within a 5 km radius of the Site (Appendix C).

Of the 16 registered bores none are found within Site boundaries, and the majority of registered bores are not operating or inactive. Two active bores (WIN Site IDs: 20050734 and 20050733) are located within 2.5 km of the site to the north-east and to the west respectively.

Available quality data was limited for these bores and is summarised in Table 4. These bores were sampled in 1971, at which time the static water level was recorded 5.030 and 3.960 mbGL. Total Dissolved Solids (in-situ) within bore 20050734 was 2670 mg/L, and 288mg/L within bore 20050733.

It is pertinent to note that unregistered bores may exist within and around the Site which could potentially be used for domestic consumption.

Table 4 DoW Bore details relating to the Hydrogeology of the Locality

WIN Site ID (Estimated Establishment Date)	Sampling Date	Static Water Level (meters below Ground Level) (mbGL)	Total Dissolved Solids (TDS) (In-situ) (mg/L)
20050734 (Unknown)	15/06/1971	5.030	2670
20050733 (Unknown)	15/06/1971	3.960	288

3.9 Hydrology

3.9.1 Surface Water

Based on the relatively flat topography at the Site and clayey soils, it is anticipated that surface water is likely to sheet flow off the site and infiltrate during high rainfall periods. No formalised stormwater drainage was identified at the Site.

Review of hydrology maps and the Site visit indicate that there are no wetlands or watercourses located at the Site. The Indian Ocean is located approximately 5 km to the north-west of the Site and no RAMSAR registered internationally significant wetlands within 10 km of the Site (Department of the Environment, Water, Heritage and the Arts, 2010). The nearest open stormwater drain is located on the western Side of Balmoral Road adjacent to the Site.

3.9.2 Drinking Water

A search of the Department of Water (DoW) Geographic Data Atlas indicates that the study area is not in, or within close proximity to any Gazetted Public Drinking Water Source Area (PDWSA) (Department of Water, 2010). The nearest PDWSA's are approximately 40 km to the south-east and 37 km to the east of the Site.

Karratha drinking water is supplied by the West Pilbara water supply scheme, whereby water is sourced from a combination of Harding dam and the Millstream Bore field (DoW, 2008b).

3.10 Preliminary Acid Sulfate Soil Assessment

A desktop assessment of the Site completed in May 2010 on the WA Atlas (Landgate, 2010) was referred to for risk mapping of Acid Sulfate Soils (ASS) at the Site. The mapping indicated there is no known risk of Acid Sulfate soils occurring within three meters of the natural surface on Site.

Further risk mapping was completed via the Australian Soil Resource Information System (ASRIS), which indicated the Site was situated in an area of *extremely low probability of occurring* ASS (CSIRO, 2006).

The elevation of the Site and underlying geology and hydrogeology, also indicate there is a low potential for acid generation in the top three meters as a result of onsite disturbances (DEC, 2009).

Given the desktop assessment, relevant geological information and depth to groundwater in nearby areas, GHD considers the Site to have a low potential for ASS within three meters of the natural soil surface.

3.11 DEC Contaminated Sites Database

The DEC *Contaminated Sites Database* presents information on known or suspected contaminated sites that have been classified by the DEC within the following categories:

- Contaminated - remediation required;
- Contaminated - restricted use; or
- Remediated for restricted use.

The DEC *Contaminated Sites Database* does not provide details of sites that are listed as 'Possibly contaminated – investigation required'.

A search of the DEC *Contaminated Sites Database* shows that the Site and surrounds have not been reported as known contaminated sites at the time of the search (06 May 2010).

A Basic Summary of Records Request for Lot 422 on DP216828 reported that DEC records indicate that as of 06/05/2010 the Site has not been reported to the DEC as a known or suspected contaminated site.

Results from the *Contaminated Sites Database* search are presented in Appendix D.

3.12 Flora and Fauna

A review of the Department of Agriculture and Food SLIP database (accessed November 2009) did not identify any Declared Rare and Priority Flora or Threatened Fauna in the Karratha Township area.

Flora and Fauna Search results are included in Appendix E.

3.13 Aboriginal and European Heritage

A search of the Australian Government Australian Heritage Database did not identify any areas of European heritage significance on the site or surrounding area. A search of the Western Australian Heritage database identified the Tambrey Centre, located on Lot 4227 DP216828 as a building of heritage significance. The Tambrey Centre is located approximately 200m to the north east of the Site and is not anticipated to impact on the site development.

A search of the Western Australian Government Aboriginal Heritage Inquiry System (undertaken in 2010) identified two areas of significance that are located outside the Site boundary to the south. They included:

- Lck/16 - Grinding Set, Mythological, Grinding patches / Grooves; and
- Baynton West Scatter 2 Artefacts / Scatter.

No aboriginal or European heritage sites were identified within the Site boundary.

Aboriginal and European Heritage Search Results are included in Appendix F.

3.14 Shire of Roebourne

The Shire of Roebourne was contacted in 2010 in regards to any available development or environmental information that they held on record for the Site. The Manager of Environmental Health for the Shire of Roebourne, Craig Watts, was unable to provide any documentation relating to the Site. Further, Mr Watts had said there has been no development or land use on the Site historically, nor any activities that may be sources for potential contamination.

3.15 Sensitive Receptors

Based on a review of surrounding land uses and activities at the Site, the potential sensitive environmental and anthropogenic receptors that may be affected by any potential soil or groundwater contamination at the Site include the following:

- groundwater beneath the Site;
- users of potential registered and unregistered groundwater bores within the area;
- visitors to the Site: the Site is open to public access;
- construction workers during Site development;
- future onsite residents; and
- adjacent offsite residents.

4. Data Quality Objectives

The Data Quality Objectives (DQOs) for the investigation are based on guidance presented in AS 4482.1 - 2005 and as further described in *Guidance on Systematic Planning Using the Data Quality Objective Process (EPA QA/G-4)* (US EPA, 2000). DQOs establish the framework for contamination investigations as a seven stepped process that develops from defining the problem at a site to optimising the design for the investigation. The seven steps are outlined below:

- Step 1: State the Problem
- Step 2: Identify the Principal Study Question
- Step 3: Inputs to the Decision
- Step 4: Boundaries of the Study
- Step 5: Decision Rules
- Step 6: Tolerable Limits on Decision Errors
- Step 7: Optimisation of the Data Collection Process

At this stage of the PSI, GHD has developed the DQOs to Steps 1 and 2; to "State the Problem" and "Identify the Principal Study Question". It is not considered appropriate at this stage of the PSI to complete the DQOs to Step 7 as these will be developed in the Sampling and Analysis Plan, should future intrusive soil and groundwater investigations be undertaken.

4.1 Step 1: State the Problem

"The proponent of the development needs to consider if contamination present on the Site that poses an unacceptable risk to human health or the environment that restricts development of the Site for residential development purposes."

4.1.1 Identify Members of the Planning Team

Table 5 Investigation Team Main Parties

Role	Company	Responsibility
Client	Chenin Grove Pty Ltd	Land owners and financial decision makers.
Regulator	Department of Environment and Conservation	Review and endorsement of all reports.
Consultant	GHD	Prepare PSI.

4.1.2 Develop the Conceptual Site Model

Details regarding the Conceptual Site Model are provided in Section 7 of this report.

4.1.3 Define the Exposure Scenarios

Details of exposure scenarios are provided in the Conceptual Site Model in Section 7 of this report.

4.1.4 Specify Available Resources and Constraints

Resources

GHD to provide and/or contract the necessary resources and suppliers for the work as specified in a financial proposal for the investigation of the Site, which was approved by LandCorp prior to commencing investigations onsite.

Constraints

Budget and time constraints are not considered to be an issue.

4.2 Step 2: Identify the Decision

4.2.1 Identify the Principal Study Question

Is there evidence of contamination present on the Site that poses an unacceptable risk to human health or the environment that restricts development of the Site for residential development purposes?

4.2.2 Identify Alternative Actions that Could Result from Resolving the Principal Study Question

Should contamination identified as present on the Site not pose an unacceptable risk to human health or the environment that restricts development of the Site for residential development purposes no further action will be required.

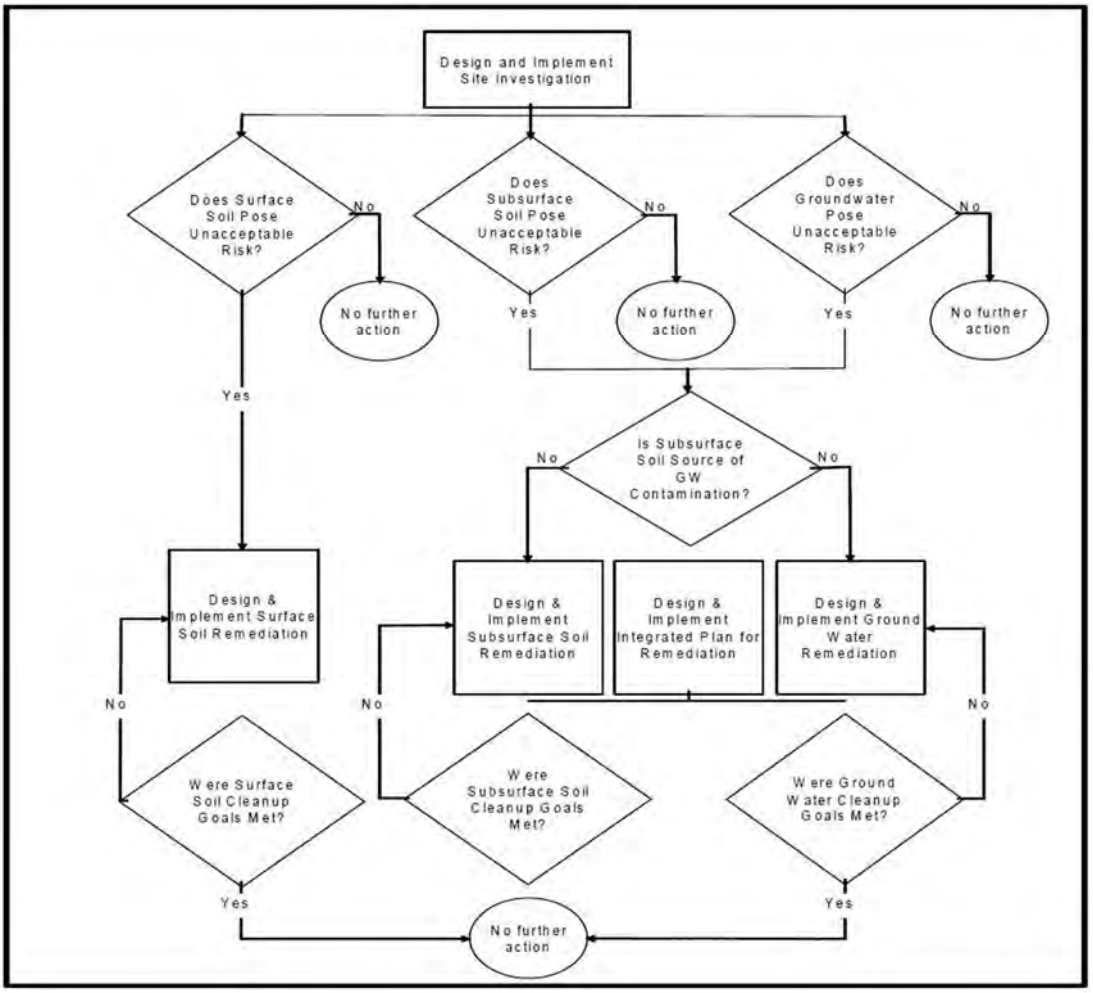
Should contamination identified as present on the Site pose an unacceptable risk to human health or the environment that restricts development of the Site for residential development the following actions may be undertaken:

- Undertake a quantitative Environment and/or Health Risk Assessment to assess the risks to the occupiers of the Site;
- Remove impacted soils from the Site and validate to DEC guidelines or treat soil *in-situ*; and
- Restrict, treat or monitor impacted groundwater as required.

4.2.3 Combine the Principal Study Question and Alternative Actions into a Decision Statement

Determine whether contamination identified as present on the Site poses an unacceptable risk to human health or the environment that restricts development of the Site for residential development purposes, and requires necessary remediation and management of contaminated soil and/or groundwater to allow development of the Site for residential development purposes, and prevents contamination impacting identified receptors.

4.2.4 Organise Multiple Decisions



(Reference: US EPA, 2000)

5. Site History

5.1 Aerial Photographs

Aerial photographs of the Site were sourced in order to ascertain the development history and land use practices that may have led to any contamination at the Site. Aerial photography from 1957, 1964, 1975, 1987, 1992 and 2008 were sourced and reviewed. Summaries of observations are provided below and aerial photographs are provided in Appendix G.

5.1.1 06 September 1957

Within the aerial photograph, the town of Karratha is not yet established, and the site and its surrounds are native Pilbara scrub. There appears to be limited to no disturbance within the area with rivers and ridges visible through the future town site and surrounding residential areas.

5.1.2 09 September 1964

The site is unchanged since the 1957 aerial photograph.

5.1.3 05 August 1975

The site is predominately unchanged since the 1964 aerial photograph. To the south of the site, the construction of Karratha-Dampier Road is underway. Some dirt tracks can be seen within the vicinity of the site though no significant development or clearing has occurred.

The Karratha town centre can be seen to the east with the beginnings of town expansion in the direction of the site signified by road development and some clearing. Aside from the construction of Karratha-Dampier Road the surrounding areas to the site are unchanged.

5.1.4 04 September 1987

The Site is now bound to the north by residential development of Nickol and the clearing and construction of Tambrey Drive. Extension of Balmoral Road has occurred to the west and further west remains mostly undisturbed though some dirt tracks are visible. No development of residential areas has occurred to the east of the site though some clearing appears to have occurred to the north-east. The areas to the south also remain undeveloped.

The site itself remains undeveloped, and maintains visual consistency with native vegetation and soils of previous aerial photography.

5.1.5 06 September 1992

The Site and surrounding areas remain relatively unchanged compared to the 1987 photographs except for the development and construction of Tambrey Primary School directly north of the Site. There also appears to be higher density residential development to the north within Nickol due to increased housing construction in the area. Karratha-Dampier Road to the South appears to have been upgraded or sealed along with the Balmoral Road which binds the site to the east.

Further construction to the north-east has also occurred, while areas to the south and west remain unchanged along with the Site itself.

5.1.6 07 November 2008

The Site has remained relatively unchanged, though disturbance from vehicles and some clearing to the boundaries appears to have occurred. Continued residential development has occurred in Nickol to the north and the east. Parkland to the north-east has been established along with Tambrey Primary to the north.

Directly south has seen the construction of Bowerbird Drive along with further development of Karratha-Dampier Road, between which residential properties now stand. West of the Site has been cleared and residential development has commenced on the cleared lots. Roads surrounding the site have all been sealed and a round-about has been constructed on the corner of Balmoral Road and Tambrey Drive, and also on the corner of Balmoral Road and Karratha-Dampier Road.

5.2 Certificates of Title

GHD have reviewed Certificate of Title deeds supplied by Landgate that document changes in land ownership. The current title was created during the recent subdivision of the land which was previously a reserve for the Tambrey School Site. Therefore there are two registered titles which describe the history of ownership. Details of the current and historic titles are summarised in Table 6 below and supplied in Appendix A.

Table 6 Summary of Lot Ownership

Lot Number	Volume – Folio	Date	Registered Proprietors
4225	LR3141 – 559	unknown	Reserve under management order- Minister of Education
504	LR3160 – 298	unknown	Unallocated crown land – State of Western Australia.

5.3 Dangerous Goods

A request was lodged with the Department of Mines and Petroleum (DMP) under the *Freedom of Information Act* (1992) to undertake a search of the Dangerous Goods Licence Register to determine whether any potentially hazardous materials have been licensed for use or storage at the Site.

The search failed to produce any documentation containing information relating to the Site. However, it should be noted that although no documentation could be located by DMP there is still potential for current and historic storage of dangerous goods at the Site. Documentation provided by DMP is provided in Appendix H.

5.4 Summary of Site History

The review of the aerial photographs indicates that the Site has always been characterised by bushland and there is no evidence of any buildings or other activities being undertaken on the Site. The Certificate of Titles search supports this, with the Site classified as Unallocated Crown Land, with no listed site occupier or site use. The dangerous goods search did not identify the storage of any dangerous goods at the Site. The Site history does not indicate any potential sources of contaminating activities having occurred at the Site.

6. Site Inspections

The first site inspection was undertaken by a GHD Engineer on the 7th May 2010 to inform the PSI prepared for LandCorp. A subsequent site inspection was undertaken by a GHD Engineer on 19th August 2011. Photographs taken during the visit are presented in Appendix I

The Site was dry at the time of both site inspections. The Site was observed to be relatively flat and well vegetated with grasses, (Spinifex), and small shrubs covering most of the site with some areas of dense shrubs and small trees.

There is limited ground disturbance at the Site with the exception of some cleared areas that have been used for vehicle access to the Site and evidence of ground disturbances which appears to be associated with geotechnical testing (performed in May 2011) undertaken to inform development plans.

Topsoil stockpiles that were observed on the western boundary of the Site (adjacent to Balmoral Road) during the inspection in 2010 appeared to be derived from the construction at Tambrey Primary School. At that time, the construction area was fenced, and there did not appear to be any adverse effects from the construction on the proposed site. The stockpiles were not observed during the subsequent site inspection in 2011, suggesting that they have been removed.

Dumping of steel mesh and waste concrete has occurred adjacent to Bowerbird Drive as well as dumping of lawn clippings near the eastern boundary of the Site. Some general littering was also observed adjacent to access tracks within the site boundaries. The litter included plastic and paper and no potential sources of contamination were identified within the litter.

A surface inspection suggests the soils are clayey sands. The nearest open drain is on the western side of Balmoral Road with the rest of the Site seemingly draining through infiltration.

No evidence of staining or odours of other indicators of potential contamination were identified during the site visit.

7. Preliminary Conceptual Site Model

A Conceptual Site Model is based on information available to date presented in this report that identifies potential primary sources of contamination, pathways and receptors.

After consideration of the land use history of the Site in order to identify existing or past practices that have the potential to cause contamination of soil and/or groundwater, it is concluded there are no potential sources for contamination that pose an unacceptable risk to human health or the environment. Therefore there is no restriction to development of the Site for residential purposes, as per Step 1 of the Data Quality Objectives in Section 4 of this report.

As a result, there is no need for a Preliminary Conceptual Site Model to outline potential contaminants of concern, pathways or receptors related to the Site.

8. Conclusions

Based on the investigations completed, the following conclusions are made:

- A review of the Certificates of Title indicates Lot 504, on deposited plan 68025, is currently under the status of: 'Unallocated Crown Land', for the Primary Interest Holder: 'State of Western Australia'.
- A review of aerial photographs between 1957 and 2008 indicate the Site has not been subject to any development. There has been significant construction of residential areas surrounding the Site, including a sealed road. Construction of Tambrey Primary school has also occurred to the North. Most of this development occurred between 1987 and 1992, with higher density residential areas and roundabouts seen in the 2008 aerial photograph. The locality of Nickol grew progressively in 1992, and complete construction of roads that perimeter the site, and construction of residential areas to the south were most prominent in the 2008 photograph. No significant land uses or activities were identified that could potentially be sources of contamination on the Site.
- Zoning and surrounding land uses indicate that the site and areas adjacent to the site are zoned, or are currently in use as residential or urban development areas. This is reflected in the presence of existing housing, roads, schools and parks adjacent to the site.
- A review of topography and geology of the Site indicated elevations between 14.6 and 15.2 mAHD, with clayey sand/sandy clay soils overlaid by red-brown silty sand.
- Groundwater in the area is characterised by localised aquifers of fractured and weathered rock where rainfall infiltration commands variable water availability. The groundwater water supply for the Karratha area lies 100km to the south of the Site in the form of Harding Dam and the Millstream Bore field.
- A DoW bore databases search identified 16 bores within a 5km radius of the Site for which there was limited available data. Two bores located within 2.5 km of the Site indicated Static groundwater levels were between 4m and 5 meters below ground level (mbGL).
- No detailed information is available on the depth of groundwater at the site. However, based on information provided in the DoW bore search, it is likely to be at depths greater than 4 mbGL.
- No potentially sensitive environmental receptors in the form of surface water, wetlands or watercourses are found on or in close proximity to the Site. The Indian Ocean is situated approximately 5 km to the north-west. Desktop studies also indicate there is no RAMSAR registered internationally significant wetlands or Public Drinking water Source Areas within the vicinity of the site. Surface water is likely to sheet flow off the site and infiltrate during high rainfall events.

- A preliminary Acid Sulfate Soils (ASS) desktop assessment indicated the Site to have no known risk within 3 m of the natural soil surface of ASS. GHD conclude that the site has a *low potential* for ASS within 3m of the natural soil surface.
- A Department of Mines and Petroleum (DMP) Dangerous Goods Licence Freedom of Information (FOI) search found no information or documentation containing information relating to potentially hazardous materials that have been licensed for use or storage the site.
- A search for the DEC Contaminated Sites Register indicated that the Site and surrounds have not been reported as known contaminated sites at the time of the search.
- No Aboriginal or European heritage sites were identified within the Site boundary.
- No Declared Rare and Priority Flora and Fauna or Threatened Ecological Communities in the Karratha Township area.
- Discussions with the Shire or Roebourne indicated there have been no environmental incidents on the Site.
- The Site walkovers did not identify any areas of contamination that would restrict or affect development of the Site. Minor quantities of steel mesh, waste concrete and litter are present onsite. Observations made during the site visit were consistent with that identified in relevant desktop studies.
- GHD has not conducted soil or groundwater investigations of the Site and consequently cannot confirm the status of these strata's.

9. Recommendations

Based on the information presented in this report, the following recommendations are made for the entire Site:

- The minor quantities of waste onsite should be removed and disposed to landfill.
- The desktop study and site inspection did not identify any potentially contaminating activities or sources of contamination at the Site that would impact human health and ecological receptors.
- Based on the findings of the PSI it is considered that at the time of the investigation there are no evidence of contamination of soil or groundwater from previous activities on the site that should restrict the development of the Site for residential uses.

10. Limitations of Report

This Preliminary Site Investigation Report ("Report"):

1. has been prepared by GHD Pty Ltd ("GHD") for Chenin Grove Pty Ltd (Chenin Grove);
2. may only be used and relied on by Chenin Grove;
3. must not be copied to, used by, or relied on by any person other than Chenin Grove without the prior written consent of GHD;
4. may only be used for the purpose of considering the potential for contamination of the site at the date of this report (and must not be used for any other purpose).

GHD and its servants, employees and officers otherwise expressly disclaim responsibility to any person other than Chenin Grove arising from or in connection with this Report.

To the maximum extent permitted by law, all implied warranties and conditions in relation to the services provided by GHD and the Report are excluded unless they are expressly stated to apply in this Report.

This report has been prepared by GHD for Chenin Grove. No warranties, expressed or implied, are offered to any third party and no liability will be accepted for the use of this report by any third party.

The services undertaken by GHD in connection with preparing this Report:

- were limited to those specifically detailed in section 2 of this Report;
- did not include consultation with community members regarding the site or testing of soils or groundwater for potential contamination.

This report presents the results of Preliminary Site Investigation prepared for the purpose of this commission. The data and advice provided herein relate only to the project and structures described herein at the time of visual inspection and must be reviewed by a competent Engineer/Scientist before being used for any other purpose. GHD accepts no responsibility for other use of the data.

The work conducted by GHD under this commission has been to the standard that would normally be expected of professional environmental consulting firm practising in this field in the State of Western Australia. However, although strenuous effort has been made to assess contamination issues required by this brief we cannot guarantee that other issues outside of the scope of work undertaken by GHD do not remain.

Where information or data has been supplied by other parties, the data is included and used in the form provided by the parties. The responsibility for the accuracy of such data remains with the issuing authority, not with GHD.

An understanding of the site conditions depends on the integration of many pieces of information, some regional, some site specific, and some experienced based. Hence, this report should not be altered, amended or abbreviated, issued in part or issued incomplete in any way without prior checking and approval by GHD. GHD accepts no responsibility for any circumstances that arise from the issue of this report that has been modified other than by GHD.

Subject to the paragraphs in this section of the Report, the opinions, conclusions and any recommendations in this Report are based on conditions encountered and information reviewed at the time of preparation and may be relied on until 31 December 2011, after which time, GHD expressly disclaims responsibility for any error in, or omission from, this Report arising from or in connection with those opinions, conclusions and any recommendations.

The limitations of this report should be read in conjunction with the entire report.

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Water and Rivers commission 1999, *Millstream Water Reserve Water Source Protection Plan: West Pilbara Water Supply Scheme*, water and rivers commission, water resource protection series No WRP 32.

Western Australian Planning Commission. (2009). *Planning Bulletin Number 64/2009 Acid Sulfate Soils.* January 2009.

Figures

Figure 1: Site Location

Figure 2: Site Layout

LEGEND

Site boundary

1:500,000 (at A4)

0 2.5 5 10 15 20

Kilometers

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 50

N

GHD CLIENTS | PEOPLE | PERFORMANCE

Chenin Grove Pty Ltd
Lot 504 Balmoral Road

Job Number	61-27368
Revision	A
Date	01 Sep 2011

Site Location

Figure 1

G:\61\27368\GIS\Maps\MXD\61_27368_KarrathaPSI_G001.mxd

239 Adelaide Terrace Perth WA 6004 Australia T 61 8 6222 8222 F 61 8 6222 8555 E permail@ghd.com.au W www.ghd.com.au

Data source: GHD : Site boundary - 20100602; Landgate (SLIP) : Traveller Atlas - 2004. Created by: Nik Fadhil

Legend

Site boundary

Cadastre

1:3,000 (at A4)

0 0.015 0.03 0.06 0.09 0.12

Kilometers

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 50

N

GHD CLIENTS PEOPLE PERFORMANCE

Chenin Grove Pty. Ltd.
Lot 504 Balmoral Road

Job Number 61-27368
Revision A
Date 01 Sep 2011

Site Layout Map

Figure 2

G:\61\27368\GIS\Maps\MXD\61_27368_KarrathaPSI_G002.mxd

239 Adelaide Terrace Perth WA 6004 Australia T 61 8 6222 8222 F 61 8 6222 8555 E permail@ghd.com.au W www.ghd.com.au

Data source: GHD : Site boundary - 20100602; Landgate (SLIP) : Karratha Townsite Mosaic - 082008, Cadastre (LGATE-002) - 20100602, Roads (LGATE-012) - 20100602. Created by: Nik Fadhi,

Appendix A

Site Summary Form and Certificates of Title

Department of Environment and Conservation

Site Summary Form – Contaminated Site Assessment

For completion by the person(s) submitting a report(s) to be assessed by the Department of Environment and Conservation (DEC) as per the information requirements of the DEC *Reporting on Site Assessments (2001)* guideline. Completing this form enables DEC to maintain accurate records for the site.

Please note: A completed site summary form must accompany each report submitted to DEC for assessment. Each box must be filled out appropriately. Please do not write "refer to report" in any section. Copies of all relevant/current Certificates of Title must accompany this form.

Site location details:

Site name (e.g. where site may be known by a common/ business name): Tambrey surplus school site

Lot no.: 504 | House no.: | Street: Cnr Balmorall Rd and Bowerbird Drive

Suburb: Nickol, Karratha | State: WA | Postcode: 6714

Crown Reserve (if applicable):

Certificate(s) of Title (or equivalent): Volume/Folio: LR3160-298

Where the subject site comprises of multiple certificates of title, please list all certificates:.....

Where substances have migrated beyond the cadastral boundaries of the subject site, please provide the addresses, relevant Certificates of Title documentation and owners details for all offsite properties impacted (includes soil and/or groundwater), as an attachment to this form.

Is a hard copy of Certificate of Title and associated sketch for all listed sites attached? (Y/N): Y

WAPC reference no. (where applicable): NA

Current Owner/Occupier details:

Site owner (Name and address): Unallocated Crown Land – State of Western Australia

Site owner company ACN/ABN:

Site occupier (name and address): Site is not occupied

Site occupier company ACN/ABN:

Site status (at time of reporting):

Proposed land use (e.g. high density residential/child care facility): Residential

Identified substances and relevant media (e.g. benzene in soil and groundwater, xylene in soil only): NA

Asbestos (Y/N)	N	Health Risk Assessment (Y/N)	N	Community health concerns identified (Y/N)	N	Radiological issues (Y/N)	N
Air quality issues (Y/N)	N	Past/present landfill (Y/N)	N	Potential human exposure to identified substances > DEC's Health Investigation Levels or equivalent (Y/N)	N	Other human health issues (Y/N)	N

Specify other health issues.....

Where 'yes' is recorded for at least one of the above categories, please submit two copies of the report(s) (relevant documentation) to DEC for referral to the Department of Health (or Radiological Council, in the case of radiological issues)

Are site activities licensed under the *Environmental Protection Act 1986?* (Y/N)	NA
Where laboratory analysis has been undertaken, is the laboratory NATA accredited for all analytes and analytical methodologies used? (Y/N) (If not, why not?)	NA

Community Consultation: (as per the DEC's *Community Consultation (December 2006)* guideline)

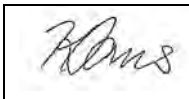
Community consultation program commenced/proposed (Y/N)	Not required at this stage of the development.
Are consultation program details (e.g. community consultation plan) provided in attached report (Y/N)	N

History of Investigation:

Have previous site investigations been undertaken? (Y/N - if yes, please provide details below)	Y
Report title, date and author:	Tambrey Surplus School Site Preliminary Site Investigation, July 2010, GHD Pty Ltd for LandCorp

Declaration:

The information contained in this site summary form is a true representation of the information contained in the attached report(s)/document(s).

Full name (print)	Kelly Norris		
Position held	Senior Environmental Engineer		
Signature		Date	05/09/2011

Please ensure that a hardcopy of the current Certificate(s) of Title and associated sketch accompanies the site summary form. DEC cannot proceed with the assessment of the report if this information is not provided.

DEC Registrar Only

Registrar name:		Signature:			
CoT verified (Y/N)		Owner details verified (Y/N)		Complete form (Y/N)	
Awaiting Classification (Y/N)					
Awaiting Re-Classification (Y/N)					
Incomplete Form (Y/N)					
LWQB Assessment Officer:					
Comments/Actions:					
Date of data entry:					

REGISTER NUMBER	
504/DP68025	
DUPLICATE EDITION	DATE DUPLICATE ISSUED
N/A	**N/A**

WESTERN AUSTRALIA

VOLUME **LR3160** FOLIO **298**

RECORD OF CERTIFICATE OF CROWN LAND TITLE

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

NO DUPLICATE CREATED

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

REGISTRAR OF TITLES

LAND DESCRIPTION:

LOT 504 ON DEPOSITED PLAN 68025

STATUS ORDER AND PRIMARY INTEREST HOLDER:
(FIRST SCHEDULE)

STATUS ORDER/INTEREST: UNALLOCATED CROWN LAND

PRIMARY INTEREST HOLDER: STATE OF WESTERN AUSTRALIA

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

Warning: A current search of the sketch of the land should be obtained where detail of position, dimensions or area of the lot is required. Lot as described in the land description may be a lot or location.

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

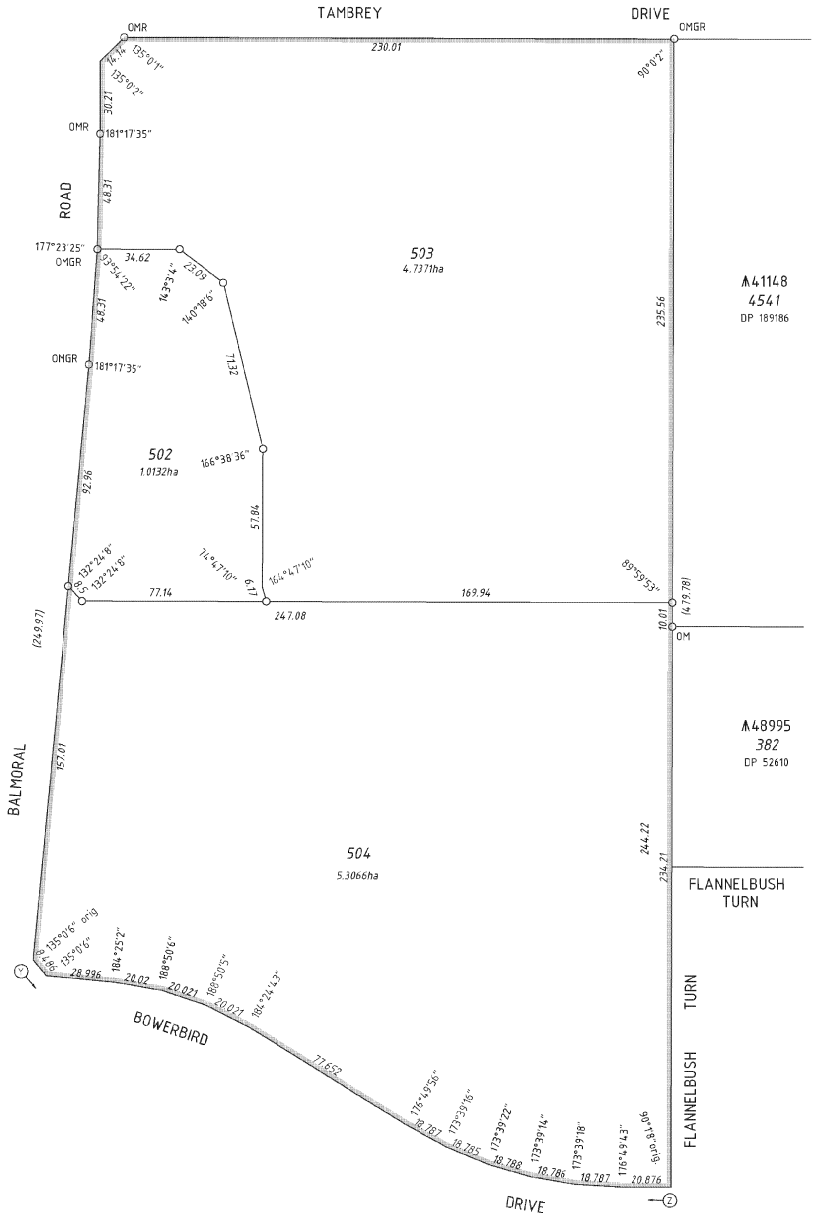
STATEMENTS:

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

SKETCH OF LAND:	DP68025 [SHEET 1].
PREVIOUS TITLE:	LR3141-559.
PROPERTY STREET ADDRESS:	NO STREET ADDRESS INFORMATION AVAILABLE.
LOCAL GOVERNMENT AREA:	SHIRE OF ROEBOURNE.
RESPONSIBLE AGENCY:	DEPARTMENT OF REGIONAL DEVELOPMENT AND LANDS (SLSD).

NOTE 1: L496083 CORRESPONDENCE FILE 03081-1987-02RO.

VER	AMENDMENT	AUTHORISED BY	DATE



I . . . BRIAN F.C. HILL . . . being eligible, in accordance with the Land Surveyors' Licensing Board's requirements, to verify survey documents, have checked this plan (and its digital record) by . . . NEIL WILLIAM FARNSWORTH (Licensed Surveyor) and I verify that the plan is error free and consistent with the field record and digital record and complies with the Landgate Survey and Plan Practice Manual, except where good reason has been shown to the contrary, and with all regulations applicable to it.

Signed . . . Brian Francis Cyprian Hill 2010.09.03 02:32:08 Z
Approved Examiner

ALL DIMENSION BETWEEN (Y) TO (Z) IN AN ANTI-CLOCKWISE DIRECTION ARE ORIGINAL

HELD BY LANDGATE IN DIGITAL FORM ONLY.

TYPE . . . CROWN

PURPOSE . . . SUBDIVISION

PLAN OF

LOTS 502 - 504

DISTRICT . . . DE WITT
TOWNSITE . . . KARRATHA
DPI FILE . . . 03081-'987 v2
LOCAL AUTHORITY . . . SHIRE OF ROEBOURNE
LOCALITY . . . NICKOL

SSA ~~YES~~/NO

FORMER TENURE
LOT 4225
DP 216828
LR 3141/559

ON
INDEX . . . BH65 (2) 27.26, 27.27, 28.26, 28.27

FIELD BOOK
114890
(SAM 4567)

20 0 20 40 60 80 100
SCALE: 1:1500 AT A2 SIZE ALL DISTANCES ARE IN METRES

SURVEYOR'S CERTIFICATE - Reg 54
I, NEIL WILLIAM FARNSWORTH
hereby certify that this is accurate and is a correct representation of the
(a) +survey and /or
(b) +calculations from measurements
(+delete if inapplicable)
undertaken for the purposes of this plan and that it complies with the relevant written law(s) in force
2010.09.03 02:30:54 Z
Licensed Surveyor . . . Date

SURVEYOR'S CERTIFICATE - Compiled
I, . . .
hereby certify that this compiled plan
(a) is a correct and accurate representation of the survey(s) of subject land ; and
(b) is in accordance with the relevant law in relation to which it is lodged.
Licensed Surveyor . . . Date

SURVEYING & DRAFTING BY
WHELANS (WA) PTY LTD
(08) 9443 1511 www.whelans.com.au

LODGED	TYPE OF VALIDATION	APPROVED BY
DATE 20-Sep-10	FULL AUDIT	WESTERN AUSTRALIAN PLANNING COMMISSION
FEE PAID N/A	LEGAL COMPONENT B. Francs	FILE EXEMPT FROM WAPC APPROVAL
ASSESS No. N/A	DOCKET PLAN/DIAG 4892-2010/5	
	CERTIFIED CORRECT 24-9-2010	Delegated Under S16 P & D ACT 2005
	L.S.C.	DATE
	F.S.C.	

IN ORDER FOR DEALINGS

SUBJECT TO

- Reserve Action

24-9-2010
FOR INSPECTOR OF PLANS & SURVEYS / AUTHORIZED LAND OFFICER DATE

APPROVED
2/12/10
INSPECTOR OF PLANS & SURVEYS / AUTHORIZED LAND OFFICER DATE

Landgate
Western Australian Land Information Authority

DEPOSITED PLAN

68025

SHEET 1 OF 1
VERSION 1

whelans
s:/projects/13/13544/carto/13544dp1.dgn
0919-card layout.dwg FP 13544-001 VER 1.0

WESTERN AUSTRALIA

REGISTER NUMBER	
4225/DP216828	
DUPLICATE EDITION	DATE DUPLICATE ISSUED
N/A	N/A

VOLUME LR3141 FOLIO 559

RECORD OF QUALIFIED CERTIFICATE OF CROWN LAND TITLE

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

NO DUPLICATE CREATED

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

REGISTRAR OF TITLES

LAND DESCRIPTION:

LOT 4225 ON DEPOSITED PLAN 216828

STATUS ORDER AND PRIMARY INTEREST HOLDER:
(FIRST SCHEDULE)

STATUS ORDER/INTEREST: RESERVE UNDER MANAGEMENT ORDER

PRIMARY INTEREST HOLDER: MINISTER FOR EDUCATION

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

1. RESERVE 40378 FOR THE PURPOSE OF SCHOOL SITE MANAGEMENT ORDER. CONTAINS CONDITIONS TO BE OBSERVED.

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

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

STATEMENTS:

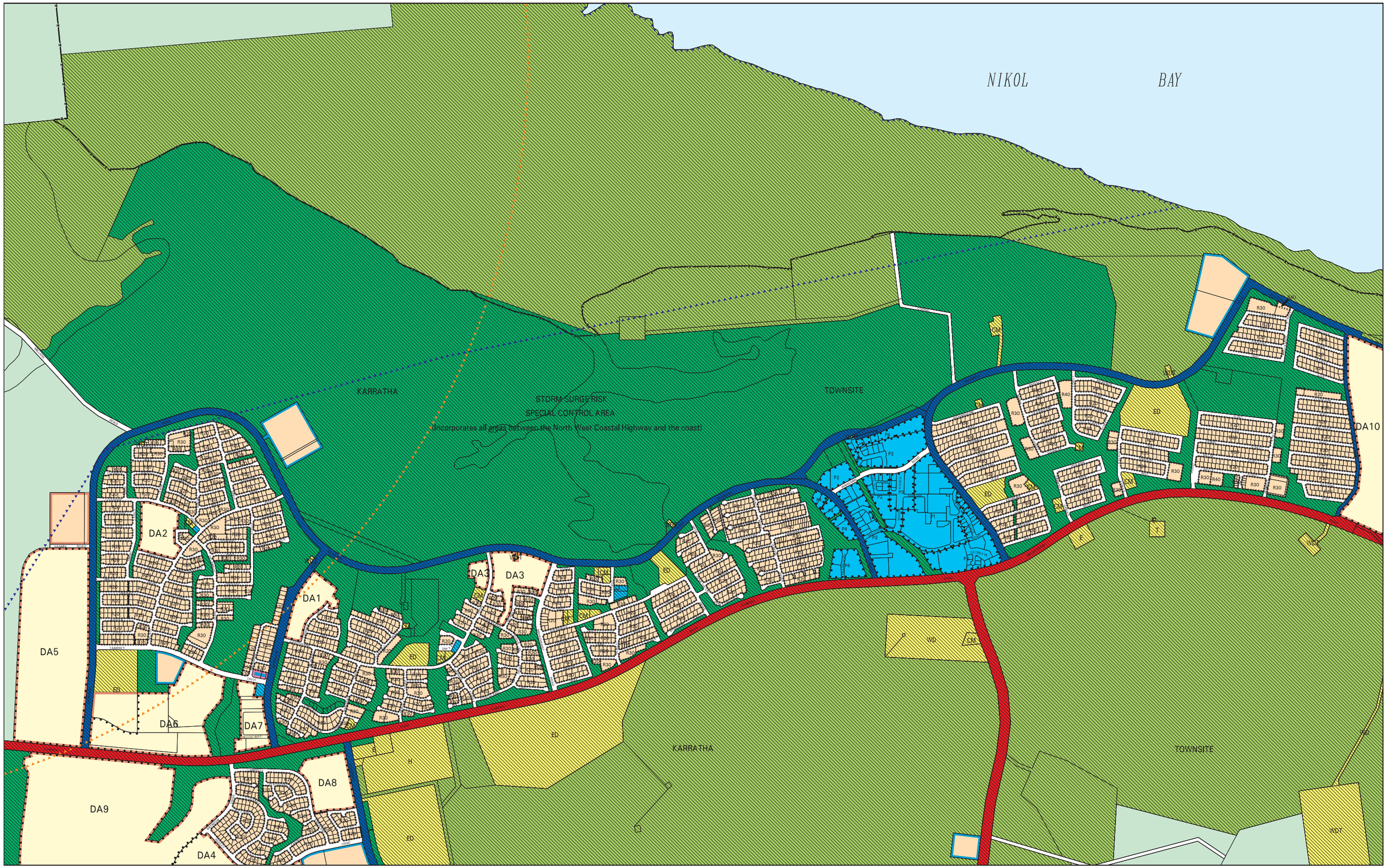
The statements set out below are not intended to be nor should they be relied on as substitutes for inspection of the land and the relevant documents or for local government, legal, surveying or other professional advice.

SKETCH OF LAND:	DP216828 [SHEET 1].
PREVIOUS TITLE:	THIS TITLE.
PROPERTY STREET ADDRESS:	LOT 4225 TAMBREY DR, NICKOL.
LOCAL GOVERNMENT AREA:	SHIRE OF ROEBOURNE.
RESPONSIBLE AGENCY:	DEPARTMENT OF EDUCATION.

NOTE 1: K072987 CORRESPONDENCE FILE 03081-1987-01RO
NOTE 2: K962889 DEPOSITED PLAN 64463 LODGED.

Appendix B

Town Planning Scheme



Produced by Mapping and GeoSpatial Data Branch, Department of Planning.

Whilst all care has been taken to accurately portray the current Scheme provisions, no responsibility shall be taken for any omissions or errors in this documentation.

Consultation with the respective Local Government should be made to view a legal version of the Scheme. Please advise the Department of Planning of any omissions or errors in the document.

Base Information Supplied by the Western Australian Land Information Authority, GL248-2007-2

SHIRE OF ROEBOURNE

TOWN PLANNING SCHEME NO 8

(DISTRICT SCHEME)

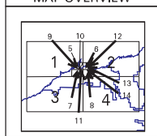
N

GDA

SCALE 1:20000

0 500 m

MAP OVERVIEW



Authorised: Victor Chew
Plot date: 31 May 2011
G.Gazette: 22-August-2000

TOWN PLANNING SCHEME MAP No. 10 of 14

LEGEND

LOCAL SCHEME RESERVES

- CONSERVATION RECREATION AND NATURAL LANDSCAPES
- DISTRICT ROADS
- INFRASTRUCTURE
- LOCAL ROADS
- PARKS, RECREATION AND DRAINAGE
- PUBLIC PURPOSES
- PUBLIC PURPOSES
  DENOTED AS FOLLOWS:

A	AIRPORT
C	CEMETERY
CM	COMMUNITY
E	ENERGY
ED	EDUCATION

- PUBLIC PURPOSES
  DENOTED AS FOLLOWS:

H	HEALTH
T	TELECOMMUNICATIONS
WD	WATER AND DRAINAGE
WDT	WASTE DISPOSAL AND TREATMENT

- STATE AND REGIONAL ROADS

ZONES

- RESIDENTIAL
- TRANSIENT WORKFORCE ACCOMMODATION
- URBAN DEVELOPMENT
- CITY CENTRE
- COMMERCIAL
- MIXED BUSINESS
- TOURISM
- TOWN CENTRE
- INDUSTRIAL DEVELOPMENT
- INDUSTRY
- STRATEGIC INDUSTRY
- RURAL
- RURAL RESIDENTIAL

OTHER

- R20 — R CODES
- A1 — ADDITIONAL USES
- SCHEME BOUNDARY
- LOCAL GOVERNMENT BOUNDARY
- TOWNSITE – LAND ACT
- WITHNELL BAY SCA
- INDUSTRY BUFFER SCA
- COSSACK HISTORIC TOWN SCA
- AIRPORT NOISE RESTRICTION SCA
- AIRPORT OBSTACLE HEIGHT LIMITATION AREA SCA
- DAMPIER SALT SCA
- ROEBOURNE FLOOD MANAGEMENT SCA
- DA18 — SCA DEVELOPMENT AREAS (SEE SCHEME TEXT)
- P1 — CITY CENTRE PRECINCT - RETAIL (SEE SCHEME TEXT)
- P2 — CITY CENTRE PRECINCT - COMMERCIAL (SEE SCHEME TEXT)
- P3 — CITY CENTRE PRECINCT - ENTERTAINMENT (SEE SCHEME TEXT)
- P4 — CITY CENTRE PRECINCT - ACCOMODATION (SEE SCHEME TEXT)

VERSION No 1

SHIRE OF ROEBOURNE

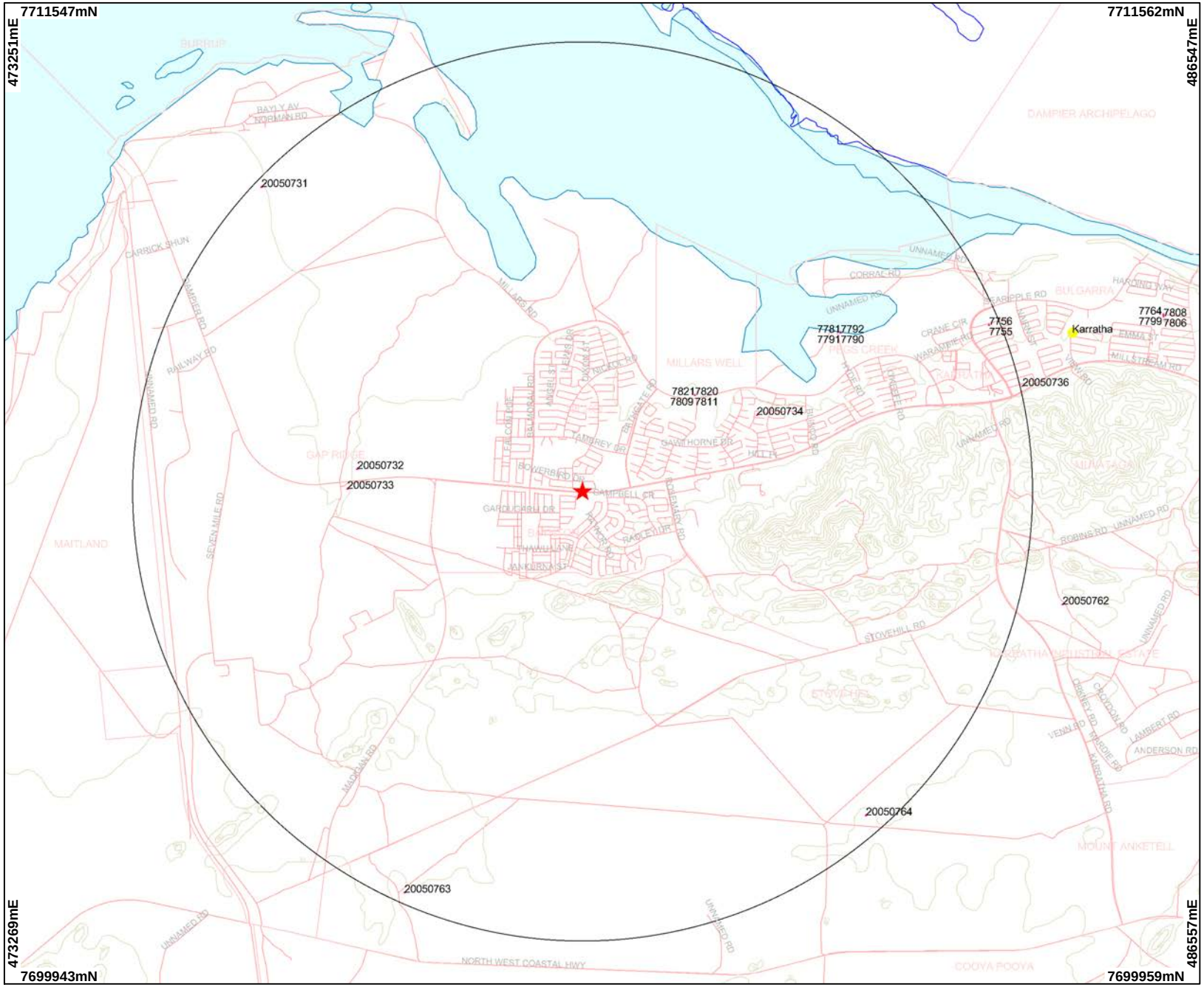
TOWN PLANNING SCHEME NO. 8

(DISTRICT SCHEME)

Appendix C

Department of Water Search Results

Bores Within a 5km Radius of Requested Co-ordinate on Dampier Rd, Karratha



LEGEND

- Road Centrelines - Landgate
- Towns - DLI 8/04
- Hydrography, linear (hierarchy) - DOW
  - Coastal Waterline
  - Estuarine
  - Infrastructure
  - Insignificant Trib
  - Inundation Area
  - Mainstream
  - Major River
  - Major Trib
  - Minor River
  - Minor Trib
  - Paleo-Drainage Line
  - Significant Stream
- Hydrography, Lakes (medium scale, 250k GA)
- Hydrography, Lakes (coarse scale, 1M GA)
- Topographic Contours, Metropolitan Area - DLI
- Topographic Contours, Statewide - Landgate
- WA Coastline - DoE
- Localities - DLI
- WIN Groundwater Sites, Water Corporation
- WIN Groundwater Sites, Other - non DoW
- WIN Groundwater Sites, Monitoring - non DoW
- WIN Groundwater Sites, Other - DoW
- WIN Groundwater Sites, Monitoring - DoW

N

0 ~1.5 km

Scale 1:63771
(Approximate when reproduced at Letter)

Geocentric Datum Australia 1994

Note: the data in this map have not been projected. This may result in geometric distortion or measurement inaccuracies.

Prepared by: stevens
Prepared for: DR27657
Date: 20/04/2010 12:41:05 PM

Information derived from this map should be confirmed with the data custodian acknowleged by the agency acronym in the legend.

Government of Western Australia
Department of Water

Summary of Bore Details – 5 km Radius of Site

WIN Site ID	AWRC Reference	Easting	Northing	Commence	Cease	Asset Owner	River Basin	Borehole water supply (m3/day)	Static Water Level (mBGL)	TDSolids (in situ) (mg/L)	WIN Site Id	Date Established	Date Reliability
7755	70918301	484203	7707751	19/09/1974	07/05/1982	Department Of Agriculture	709 - Port Hedland Coast	-	-	-	7755	30/06/1974	Estimate
7756	70918302	484203	7707751	19/09/1974	04/08/1981	Department Of Agriculture	709 - Port Hedland Coast	-		-	7756	30/06/1974	Estimate
7781	70918327	482555	7707657	10/11/1975	11/11/1975	Department Of Agriculture	709 - Port Hedland Coast	-	-	-	7781	10/11/1975	Unknown
7790	70918336	482555	7707657	06/11/1975	07/11/1975	Department Of Agriculture	709 - Port Hedland Coast	-	-	-			
7791	70918337	482555	7707657	06/11/1975	07/11/1975	Department Of Agriculture	709 - Port Hedland Coast	-	-	-	7791	06/11/1975	Unknown
7792	70918338	482555	7707657	07/11/1975	08/11/1975	Department Of Agriculture	709 - Port Hedland Coast	-	-	-	7792	07/11/1975	Unknown
7809	70918355	480936	7706916	17/08/1977	02/10/1980	Department Of Agriculture	709 - Port Hedland Coast	-	-	-	7809	17/08/1977	Unknown
7811	70918357	480936	7706916	18/08/1977	19/08/1977	Department Of Agriculture	709 - Port Hedland Coast	-	-	-	7811	18/08/1977	Unknown
7820	70918366	480936	7706916	24/08/1977	25/08/1977	Department Of Agriculture	709 - Port Hedland Coast	-	-	-	7820	24/08/1977	Unknown
7821	70918367	480936	7706916	19/08/1977	13/01/1981	Department Of Agriculture	709 - Port Hedland Coast	-	-	-	7821	19/08/1977	Unknown
20050731	70910025	476119	7709372	30/06/1931	-		709 - Port Hedland Coast	-	-	-	20050731	30/06/1931	Estimate
20050732	70910026	477187	7706040	-	-	WA Government	709 - Port Hedland Coast	-	-	-	20050732	1000-01-01 00:00:00.000	Unknown
20050733	70910027	477079	7705805	-	-	Hamersley Iron	709 - Port Hedland Coast	-	3.96	288	20050733	1000-01-01 00:00:00.000	Unknown
20050734	70910028	481628	7706681	-	-	Hamersley Iron	709 - Port Hedland Coast	-	5.03	2670	20050734	1000-01-01 00:00:00.000	Unknown
20050763	70910038	477719	7701033	30/06/1933	-	Hamersley Iron	709 - Port Hedland Coast	-	-	-	20050763	30/06/1933	Estimate
20050764	70910039	482841	7701952	30/06/1929	-	Hamersley Iron	709 - Port Hedland Coast	-	-	2140	20050764	30/06/1929	Estimate

Bore Construction – Geological Details

WIN Site ID	Log Date	Depth From	Depth To	Stratigraphy
7755	30/06/1974	0.000	0.710	BLACK SILTY CLAY
7755	30/06/1974	0.710	1.520	BLACK SILTY AND ROCK
7755	30/06/1974	1.520	2.430	SILTY CLAY AND GRAVEL
7755	30/06/1974	2.430	3.350	HARD SILTY CLAY AND GRAVEL
7755	30/06/1974	3.350	3.480	VERY HARD SILTY CLAY
7755	30/06/1974	3.480	4.160	NOT LOGGED
7756	30/06/1974	0.000	0.610	POWDERY BLACK SILT AND CLAY
7756	30/06/1974	0.610	2.130	BROKEN LIMESTONE, SILTY CLAY
7756	30/06/1974	2.130	2.580	LIMESTONE
7756	30/06/1974	2.580	2.740	BASE ROCK
7756	30/06/1974	2.740	3.130	NOT LOGGED

Appendix D

DEC Search Results

Government of **Western Australia**
Department of **Environment and Conservation**

Your ref:
Our ref: DMO5553
Enquiries: Registrar
Phone: 1300 762982
Fax:
Email:

Imogen Bird
GHD Pty Ltd
GHD House
239 Adelaide Terrace
Perth WA 6000

Dear Sir/Madam

BASIC SUMMARY OF RECORDS REQUEST

Thank you for your Basic Summary of Records request for the site consisting of the following parcel(s) of land:

- LOT 4225 ON PLAN 216828 as shown on certificate of title LR3141/559 known as 4225 Tambrey Dr, Nickol WA 6714 ("the Site"),

which Department of Environment and Conservation ("DEC") received on 21/04/2010.

A search of DEC's records of known and suspected contaminated sites was undertaken however, our records indicate that as of 06/05/2010 this Site has not been reported to DEC as a known or suspected contaminated site either prior to or after the commencement of the *Contaminated Sites Act 2003*.

For general enquiries, please contact the Registrar on 1300 762982.

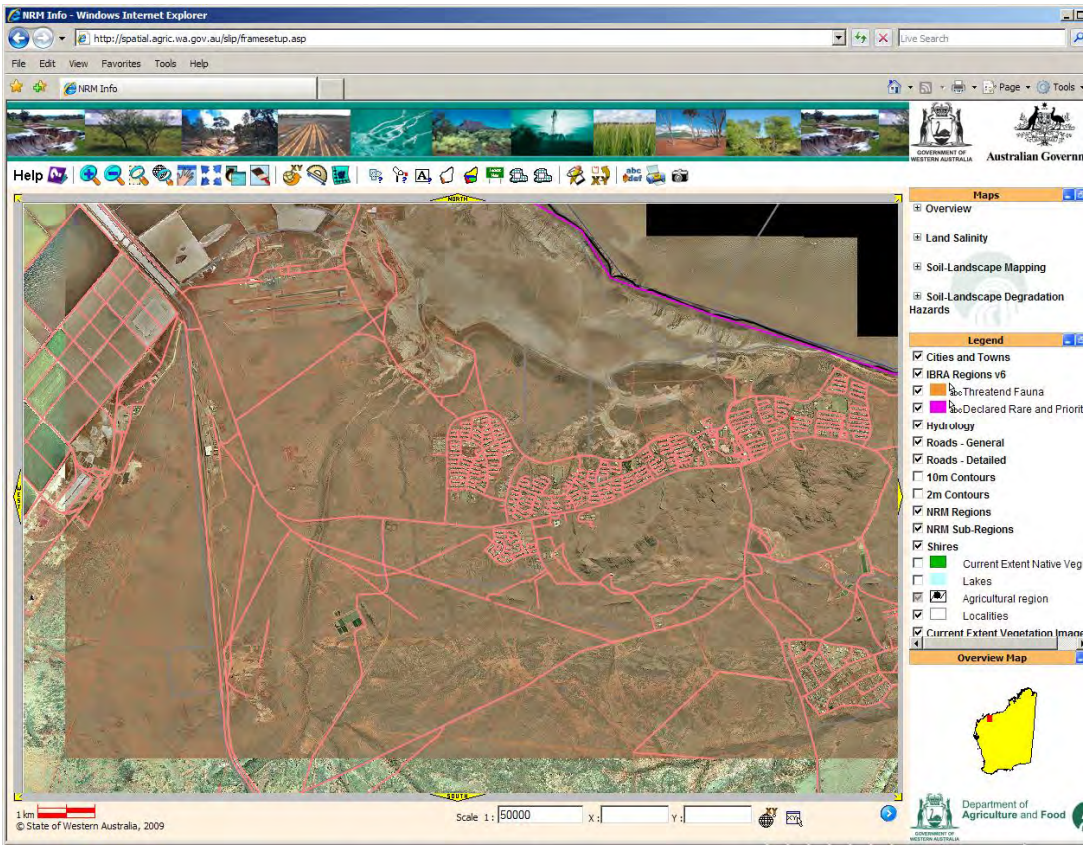
Yours sincerely

Andrew Miller
SECTION MANAGER
CONTAMINATED SITES BRANCH
Delegated Officer under section 91
of the *Contaminated Sites Act 2003*

06/05/2010
Enc. Receipt Number 142498

Appendix E

Flora and Fauna Search Results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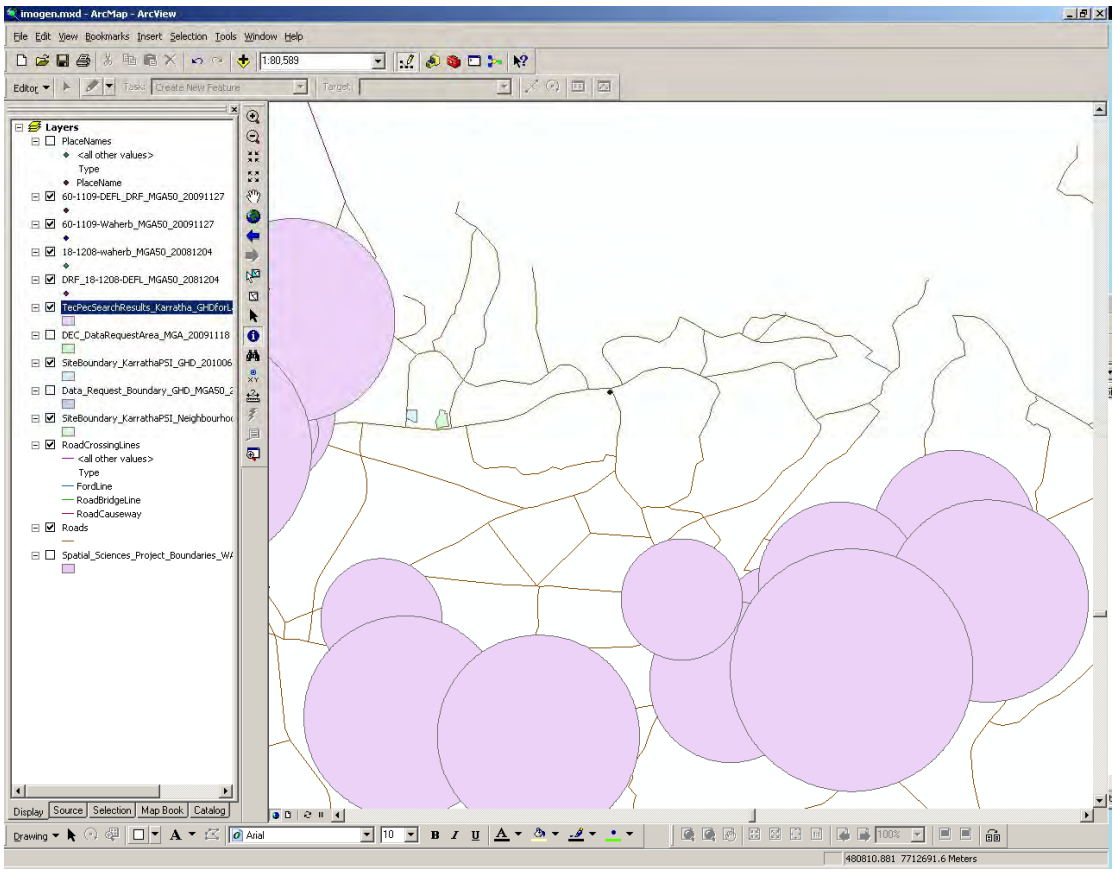
http://spatial.agric.wa.gov.au/slip/framesetup.asp
File Edit View Favorites Tools Help
Help
Maps
Overview
Land Salinity
Soil-Landscape Mapping
Soil-Landscape Degradation Hazards
Legend
Cities and Towns
IBRA Regions v6
Roads - General
Roads - Detailed
10m Contours
2m Contours
NRM Regions
NRM Sub-Regions
Shires
Lakes
Agricultural region
Localities
Overview Map
1 km
© State of Western Australia, 2009
Scale 1 : 50000
Department of Agriculture and Food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Layers
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RoadCrossingLines
FordLine
RoadBridgeLine
RoadCauseway
Roads
Display Source Selection Map Book Catalog
Drawing
Arial
480810.881 7712691.6 Meters

Appendix F

Aboriginal and Heritage Search Results

Search Criteria

Site 21287

Disclaimer

Aboriginal sites exist that are not recorded on the Register of Aboriginal Sites, and some registered sites may no longer exist. Consultation with Aboriginal communities is on-going to identify additional sites. The AHA protects all Aboriginal sites in Western Australia whether or not they are registered.

Copyright

Legend

Restriction

N	No restriction
M	Male access only
F	Female access

Access

C	Closed
O	Open
V	Vulnerable

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 reported.

Status

L	Lodged	IR	Insufficient Information (as assessed by Site Assessment Group)
I	Insufficient Information	PR	Permanent register (as assessed by Site Assessment Group)
P	Permanent register	SR	Stored data (as assessed by Site Assessment Group)
S	Stored data		

Site Assessment Group (SAG)

Sites lodged with the Department are assessed under the direction of the Registrar of Aboriginal Sites. These are not to be considered the final assessment.

Final assessment will be determined by the Aboriginal Cultural Material Committee (ACMC).

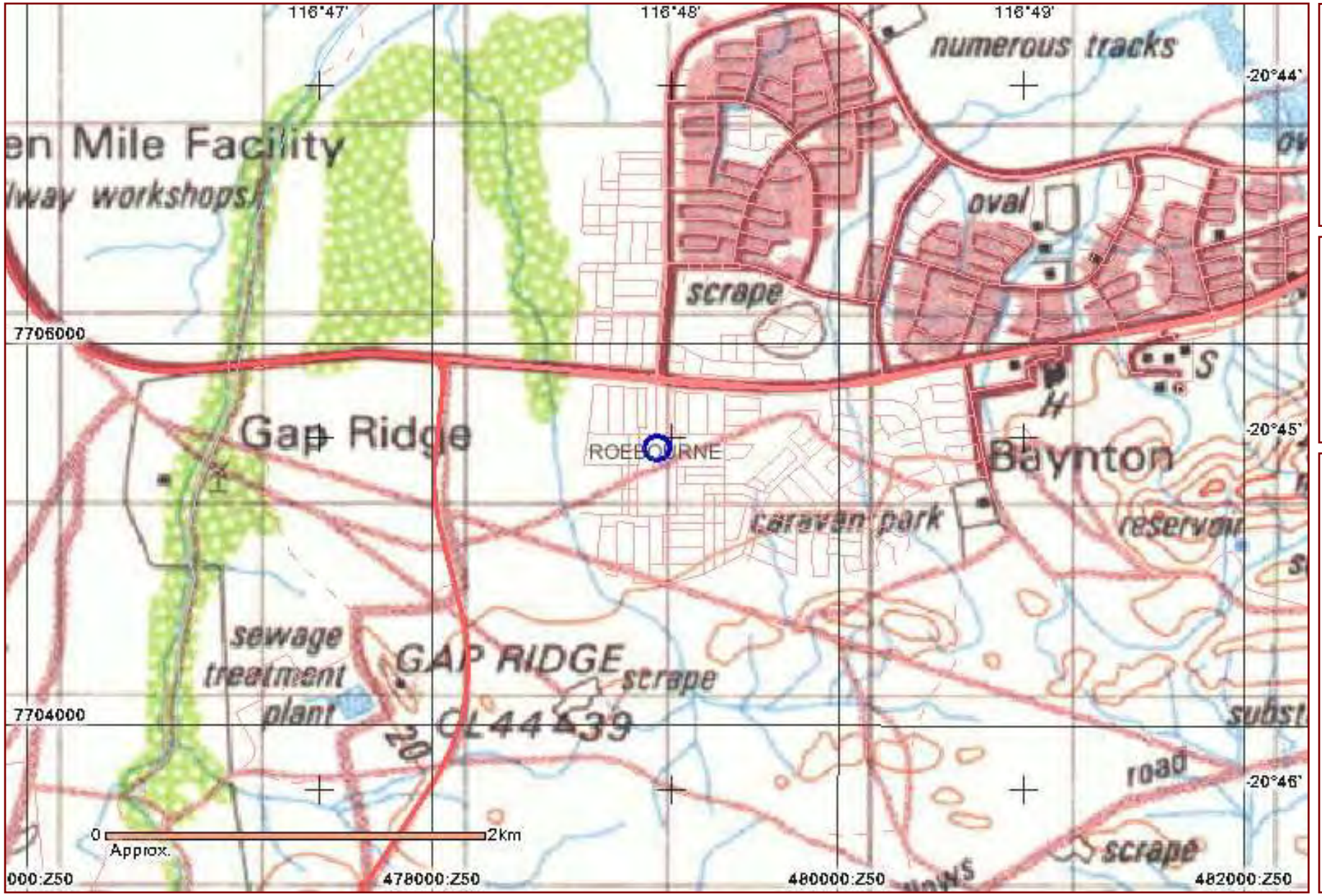
Spatial Accuracy

Index coordinates are indicative locations and may not necessarily represent the centre of 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.

Aboriginal Heritage Inquiry System

Register of Aboriginal Sites

Site ID	Status	Access	Restriction	Site Name	Site Type	Additional Info	Informants	Coordinates	Site No.
21287	S	O	N	Lck/16 - Grinding Set	Mythological, Grinding patches / grooves		*Registered Informant names available from DIA.	479105mE 7705454mN Zone 50 [Reliable]	



Legend

- Highlighted Area
- Town
- Map Area
- Search Area

Search Criteria

Site 24885

Disclaimer

Aboriginal sites exist that are not recorded on the Register of Aboriginal Sites, and some registered sites may no longer exist. Consultation with Aboriginal communities is on-going to identify additional sites. The AHA protects all Aboriginal sites in Western Australia whether or not they are registered.

Copyright

Legend

Restriction

N	No restriction
M	Male access only
F	Female access

Access

C	Closed
O	Open
V	Vulnerable

Coordinate Accuracy

Accuracy is shown as a code in brackets following the site coordinates.

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[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 reported.

Status

L	Lodged	IR	Insufficient Information (as assessed by Site Assessment Group)
I	Insufficient Information	PR	Permanent register (as assessed by Site Assessment Group)
P	Permanent register	SR	Stored data (as assessed by Site Assessment Group)
S	Stored data		

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Final assessment will be determined by the Aboriginal Cultural Material Committee (ACMC).

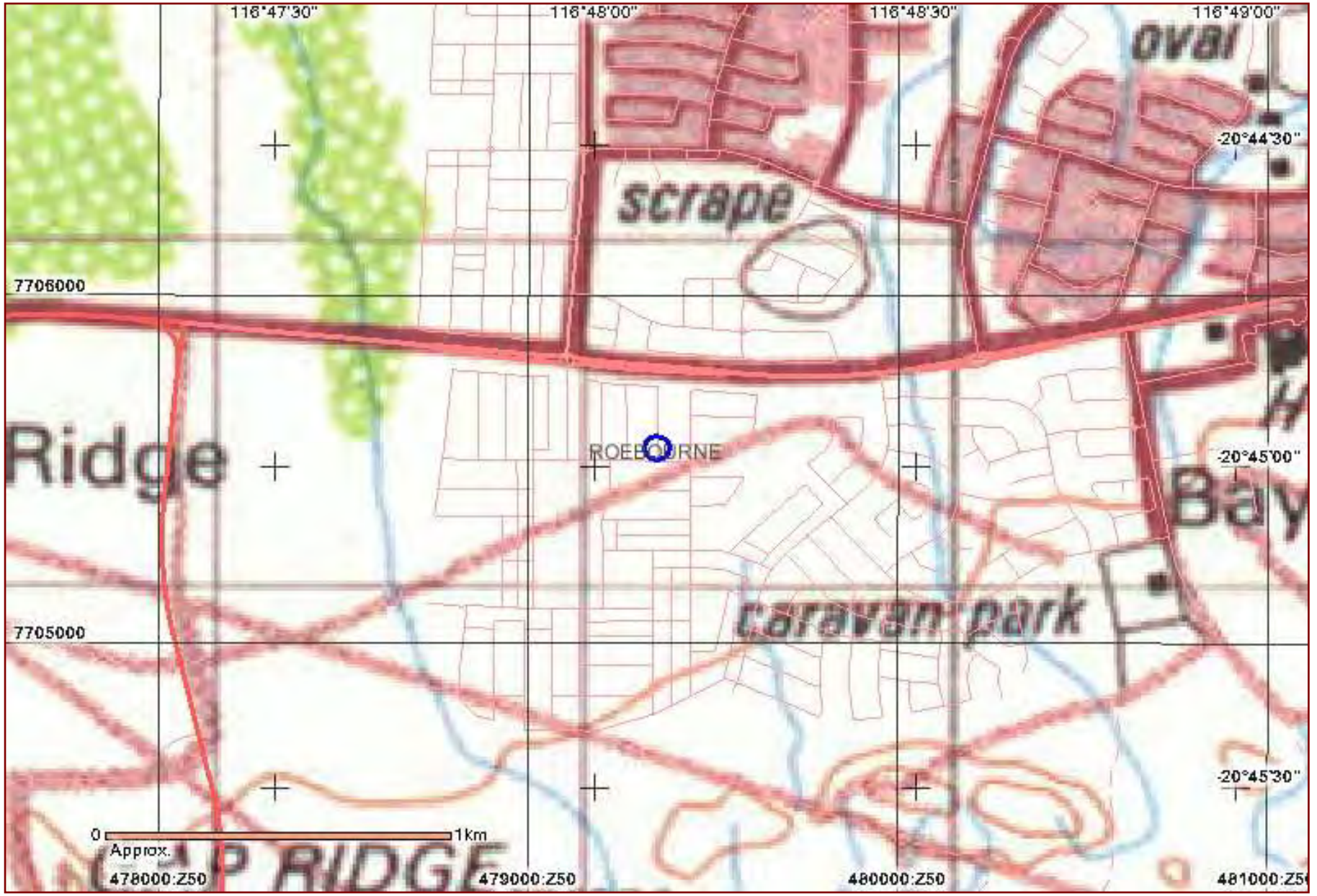
Spatial Accuracy

Index coordinates are indicative locations and may not necessarily represent the centre of 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.

Aboriginal Heritage Inquiry System

Register of Aboriginal Sites

Site ID	Status	Access	Restriction	Site Name	Site Type	Additional Info	Informants	Coordinates	Site No.
24885	S	O	N	Baynton West Scatter 2	Artefacts / Scatter		*Registered Informant names available from DIA.	479347mE 7705561mN Zone 50 [Reliable]	



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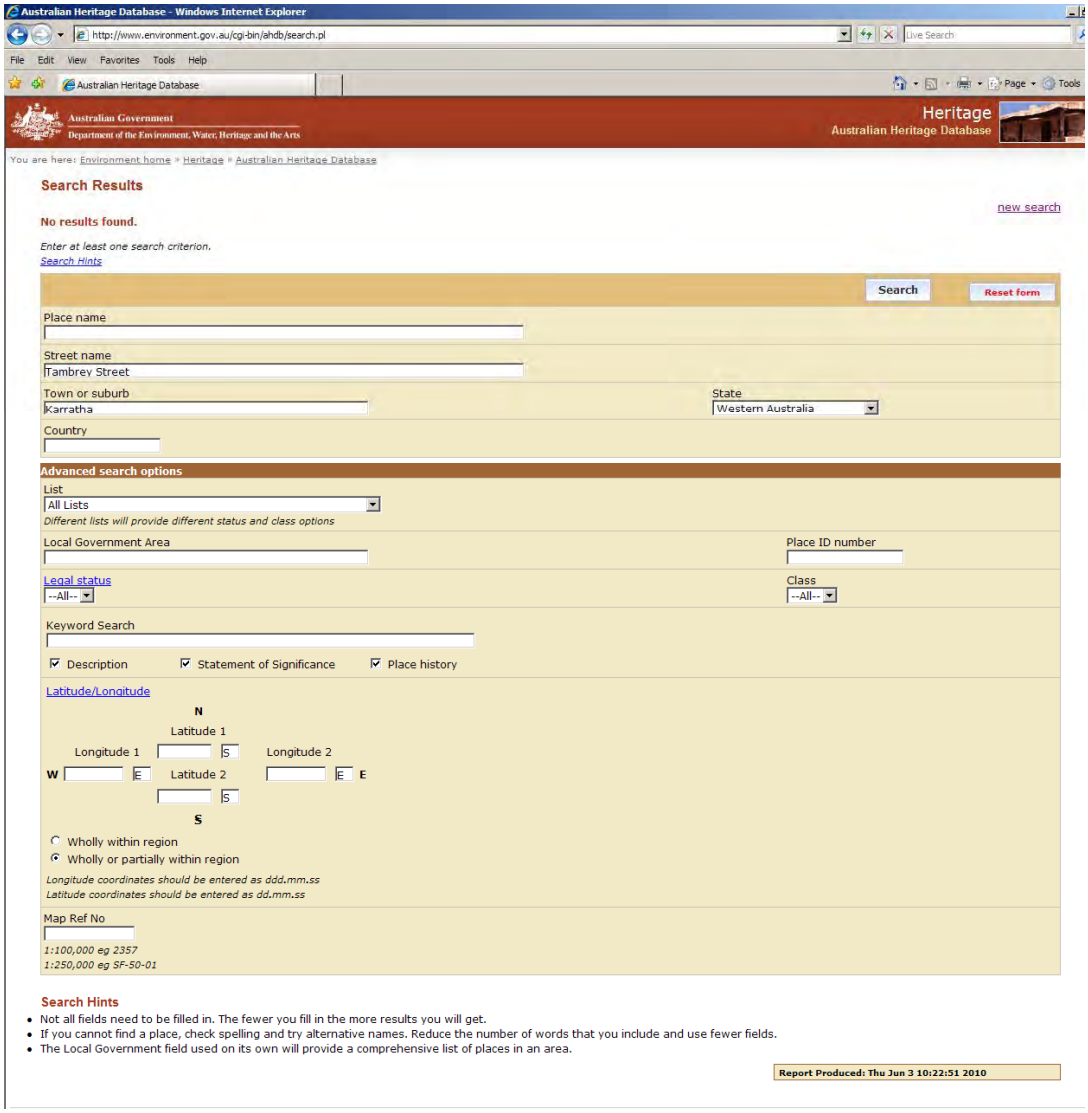
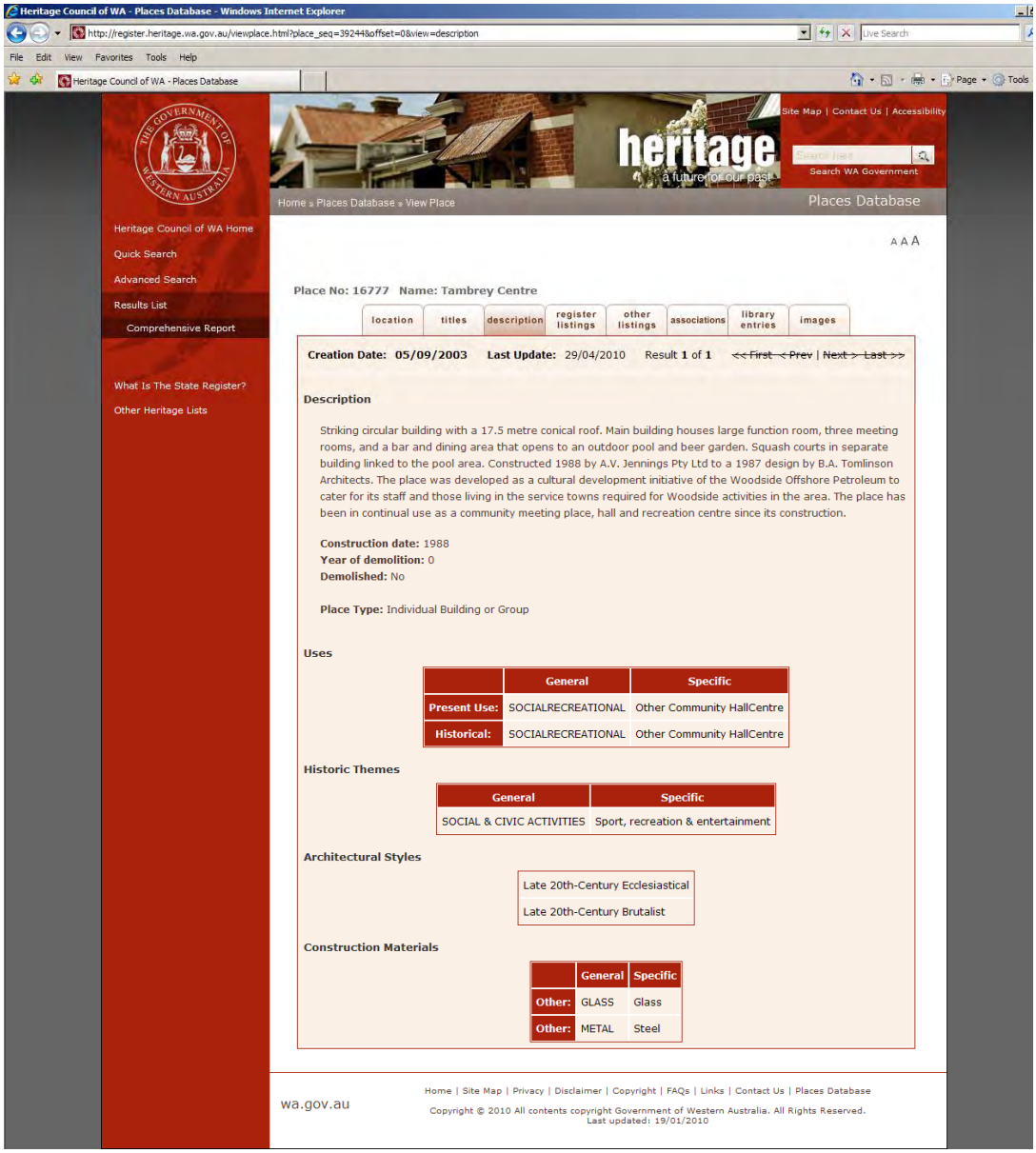
- Town
- Map Area
- Search Area


Australian Heritage Database - Windows Internet Explorer
http://www.environment.gov.au/cgi-bin/ahdb/search.pl
File Edit View Favorites Tools Help
Australian Heritage Database
Australian Government
Department of the Environment, Water, Heritage and the Arts
Heritage
Australian Heritage Database
You are here: Environment home » Heritage » Australian Heritage Database
Search Results
new search
No results found.
Enter at least one search criterion.
Search Hints
Search
Reset form
Place name
Street name
Tambrey Street
Town or suburb
Karratha
State
Western Australia
Country
Advanced search options
List
All Lists
Different lists will provide different status and class options
Local Government Area
Place ID number
Legal status
--All--
Class
--All--
Keyword Search
Description
Statement of Significance
Place history
Latitude/Longitude
N
Latitude 1
Longitude 1
S
Longitude 2
W
E
Latitude 2
E
E
S
Wholly within region
Wholly or partially within region
Longitude coordinates should be entered as ddd.mm.ss
Latitude coordinates should be entered as dd.mm.ss
Map Ref No
1:100,000 eg 2357
1:250,000 eg SF-50-01
Search Hints
Not all fields need to be filled in. The fewer you fill in the more results you will get.
If you cannot find a place, check spelling and try alternative names. Reduce the number of words that you include and use fewer fields.
The Local Government field used on its own will provide a comprehensive list of places in an area.
Report Produced: Thu Jun 3 10:22:51 2010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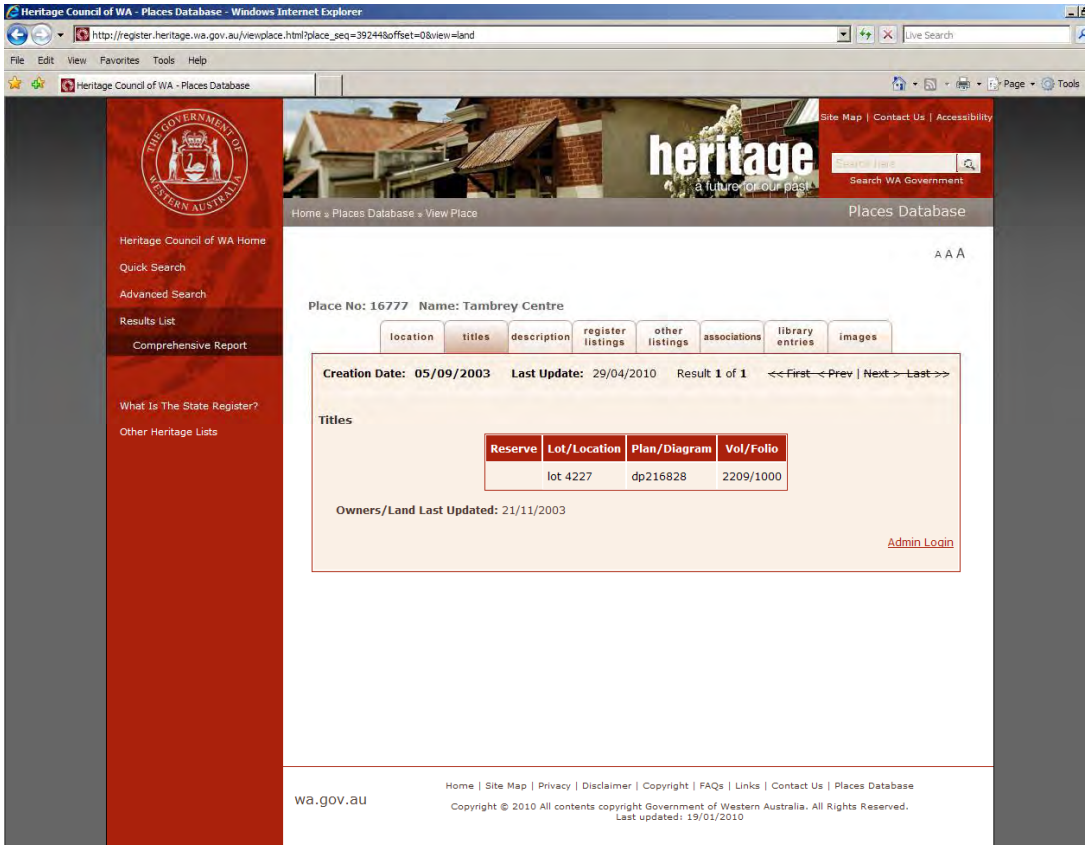
http://register.heritage.wa.gov.au/viewplace.html?place_seq=39244&offset=0&view=description
File Edit View Favorites Tools Help
Heritage Council of WA - Places Database
Site Map | Contact Us | Accessibility
heritage
a future for our past
Search WA Government
Home » Places Database » View Place
Places Database
Heritage Council of WA Home
Quick Search
Advanced Search
Results List
Comprehensive Report
What Is The State Register?
Other Heritage Lists
Place No: 16777 Name: Tambrey Centre
location titles description register listings other listings associations library entries images
Creation Date: 05/09/2003 Last Update: 29/04/2010 Result 1 of 1 << First < Prev | Next > Last >>
Description
Striking circular building with a 17.5 metre conical roof. Main building houses large function room, three meeting rooms, and a bar and dining area that opens to an outdoor pool and beer garden. Squash courts in separate building linked to the pool area. Constructed 1988 by A.V. Jennings Pty Ltd to a 1987 design by B.A. Tomlinson Architects. The place was developed as a cultural development initiative of the Woodside Offshore Petroleum to cater for its staff and those living in the service towns required for Woodside activities in the area. The place has been in continual use as a community meeting place, hall and recreation centre since its construction.
Construction date: 1988
Year of demolition: 0
Demolished: No
Place Type: Individual Building or Group
Uses
General Specific
Present Use: SOCIALRECREATIONAL Other Community HallCentre
Historical: SOCIALRECREATIONAL Other Community HallCentre
Historic Themes
General Specific
SOCIAL & CIVIC ACTIVITIES Sport, recreation & entertainment
Architectural Styles
Late 20th-Century Ecclesiastical
Late 20th-Century Brutalist
Construction Materials
General Specific
Other: GLASS Glass
Other: METAL Steel
wa.gov.au
Home | Site Map | Privacy | Disclaimer | Copyright | FAQs | Links | Contact Us | Places Database
Copyright © 2010 All contents copyright Government of Western Australia. All Rights Reserved.
Last updated: 19/01/2010


Heritage Council of WA - Places Database - Windows Internet Explorer
http://register.heritage.wa.gov.au/viewplace.html?place_seq=39244&offset=0&view=land
File Edit View Favorites Tools Help
Heritage Council of WA - Places Database
Site Map | Contact Us | Accessibility
heritage
a future for our past
Search WA Government
Home » Places Database » View Place
Places Database
Heritage Council of WA Home
Quick Search
Advanced Search
Results List
Comprehensive Report
What Is The State Register?
Other Heritage Lists
Place No: 16777 Name: Tambrey Centre
location
titles
description
register listings
other listings
associations
library entries
images
Creation Date: 05/09/2003 Last Update: 29/04/2010 Result 1 of 1 << First < Prev | Next > Last >>
Titles
Reserve
Lot/Location
Plan/Diagram
Vol/Folio
lot 4227
dp216828
2209/1000
Owners/Land Last Updated: 21/11/2003
Admin Login
wa.gov.au
Home | Site Map | Privacy | Disclaimer | Copyright | FAQs | Links | Contact Us | Places Database
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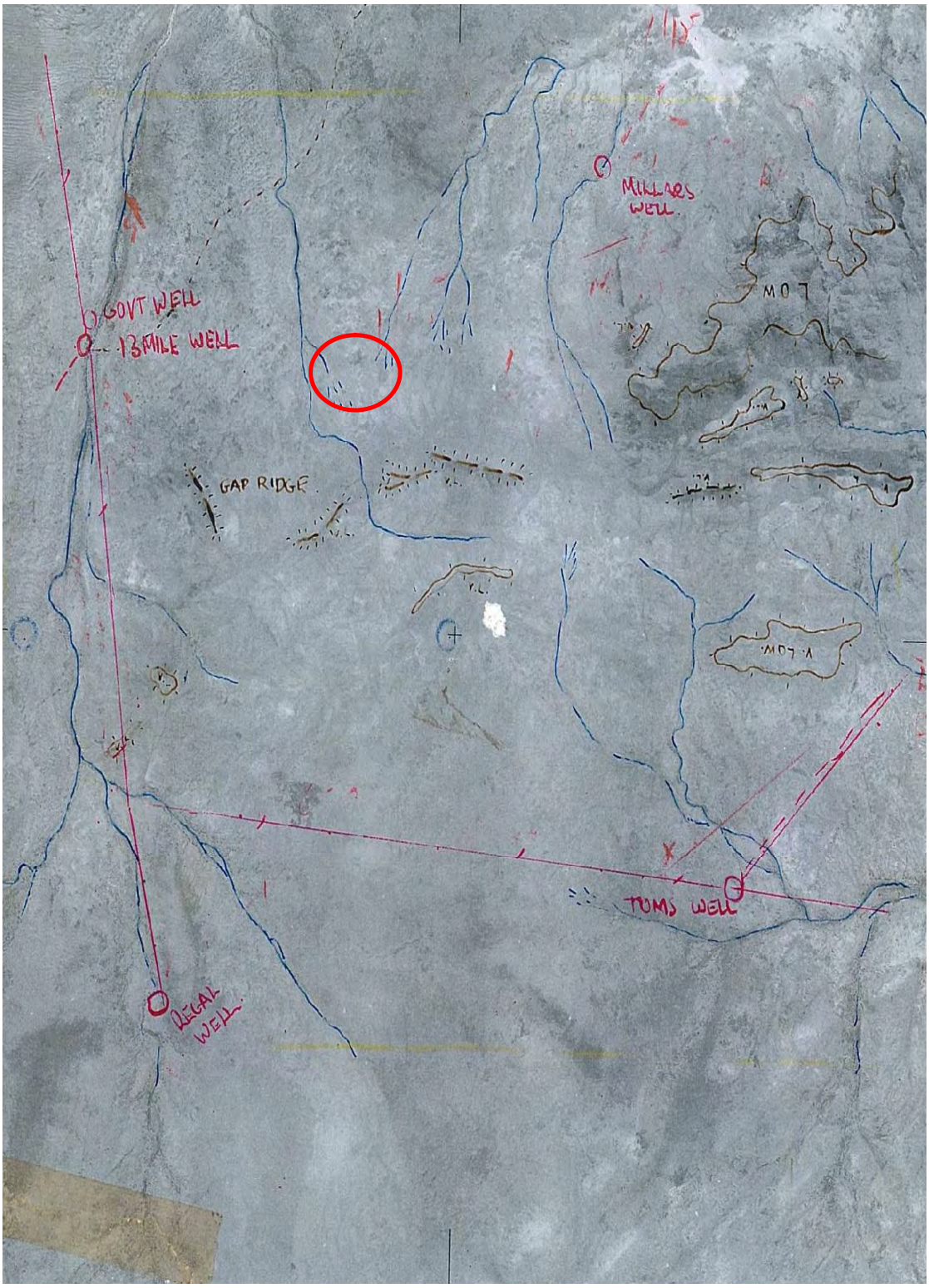
Last updated: 19/01/2010

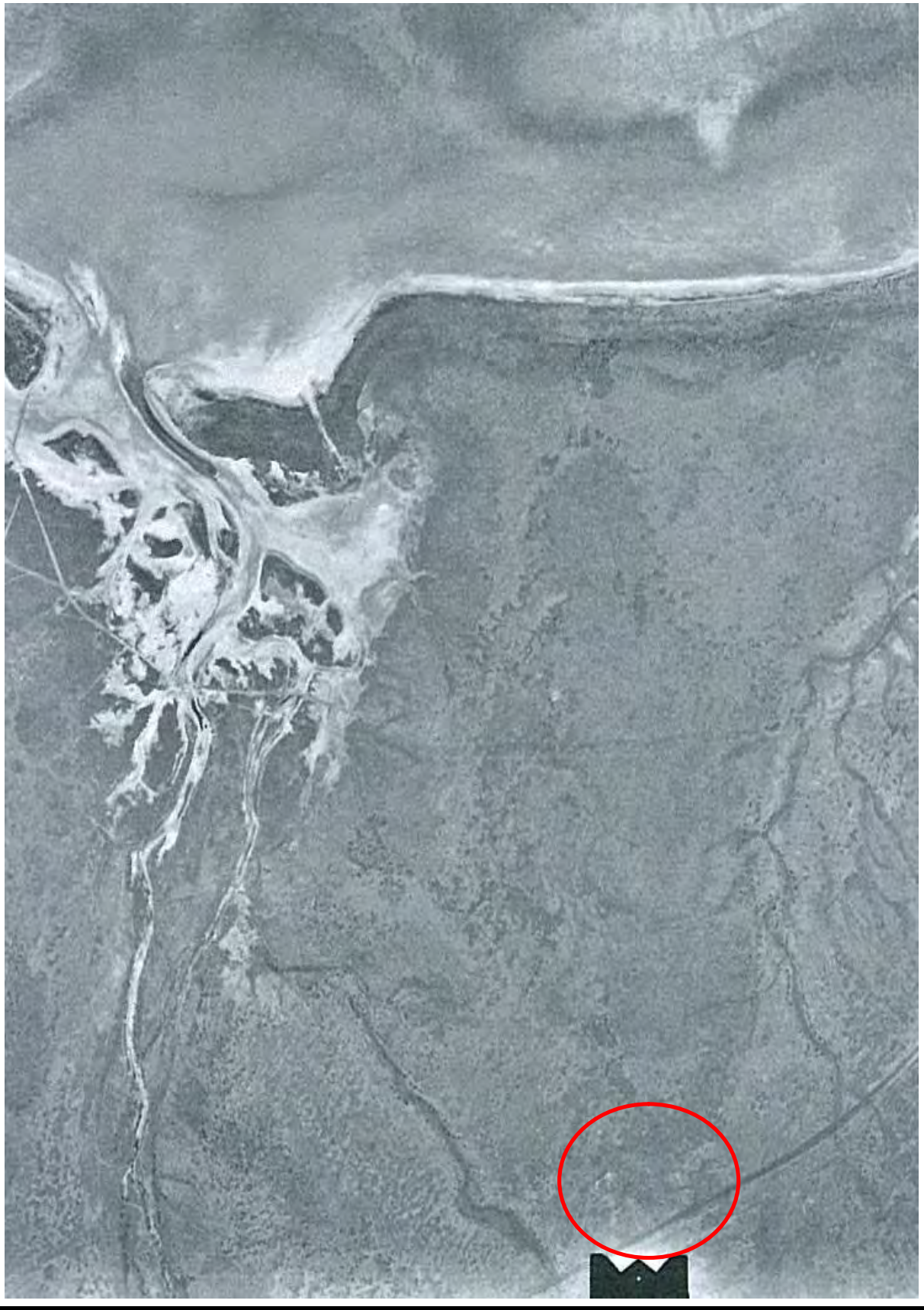
Appendix G

Historical Aerial Photographs



GHD	N	Created By: SM	Date: 30/05/2010	**Lot 4225 Cnr Balmoral Rd and Bowerbird Dr**
		Checked:	Source: Landgate	Preliminary Site Investigation
		Approved:	Revision: 0	**1957 Aerial Photograph**

GHD N	Created By: SM	Date: 30/05/2010	**Lot 4225 Cnr Balmoral Rd and Bowerbird Dr**
	Checked:	Source: Landgate	Preliminary Site Investigation
	Approved:	Revision: 0	**1964 Aerial Photograph**



GHD N	Created By: SM Checked: Approved:	Date: 30/05/2010 Source: Landgate Revision: 0	**Lot 4225 Cnr Balmoral Rd and Bowerbird Dr** Preliminary Site Investigation **1975 Aerial Photograph**

GHD N	Created By: SM Checked: Approved:	Date: 30/05/2010 Source: Landgate Revision: 0	**Lot 4225 Cnr Balmoral Rd and Bowerbird Dr** Preliminary Site Investigation **1987 Aerial Photograph**

GHD N	Created By: SM Checked: Approved:	Date: 30/05/2010 Source: Landgate Revision: 0	**Lot 4225 Cnr Balmoral Rd and Bowerbird Dr** Preliminary Site Investigation **1992 Aerial Photograph**

GHD N	Created By: SM Checked: Approved:	Date: 30/05/2010 Source: Landgate Revision: 0	**Lot 4225 Cnr Balmoral Rd and Bowerbird Dr** Preliminary Site Investigation **2008 Aerial Photograph**

Appendix H

Department of Mines and Petroleum Search Results

Government of **Western Australia**
Department of **Mines and Petroleum**
Resources Safety

Your Ref: 61/25426-A
Our Ref: 09/10-223: A0661/201001
Enquiries: Ruth Pawsono
Email: ruth.pawson@dmp.wa.gov.au
Facsimile: 9358 8000

Mrs Imogen Bird
Senior Environmental Engineer
GHD Pty Ltd
239 Adelaide Terrace
PERTH WA 6004

Dear Mrs Bird

NOTICE OF DECISION: s30 FREEDOM OF INFORMATION ACT 1992 (the Act)

Your application requested access to dangerous goods storage (DGS) licence documents for **Lot 4225 Tambrey Drive, Nickol, Karratha WA 6714.**

1. On the information you provided, a search of our records has failed to locate any documentation containing the information you seek. Under s26 of the Act, the failure of the Department to locate any documents after a diligent search is deemed as a refusal to grant access.

2. Consequently, it was decided on 29 April 2010 by Ann Revell FOI Co-ordinator Resources Safety (delegated decision maker under s100(1)(b) of the Act), that you may not have access to documents as the Department has no record of any such documentation.

3. Location descriptors provided by applicants may not always match site location details in our database and we ask if possible applicants provide the DGS Licence number of the site of interest to them. We recognise this is not always possible and do all we reasonably can to search for the site from the information provided.

4. The lack of information held by the Department in relation to this property does not necessarily mean the property is not or has ever been a dangerous goods storage site. Accordingly, if you have any reason to suspect the property is or may have been the subject of a DGS licence or dangerous goods may have been stored there, you may need to consider carrying out additional site inspection investigations.

5. If you wish to contest the decision to refuse access, you have a right to have the decision reviewed. Details of the review process are set out in the attached notes.

Yours sincerely

Ann Revell
FOI CO-ORDINATOR
29 April 2010

Appendix I

Site Inspection Photographs

Plate 1: View north from Bowerbird Drive (2010).

Plate 2: View south of Bowerbird Drive (2010).

Plate 3: View north adjacent to topsoil (2010).

Plate 4: View north to school development (2010).

Plate 5: View south with typical vegetation on-site (2010).

Plate 6: View north (2010).

Plate 7: East Boundary looking north (2011).

Plate 8: East Boundary looking south (2011).

Plate 9: Ground disturbance, assumed geo-technical testing site (2011).

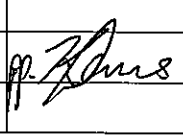
Plate 10: Construction waste (2011).

Plate 11: Construction waste (2011).

GHD

GHD House, 239 Adelaide Tce. Perth, WA 6004
P.O. Box 3106, Perth WA 6832
T: 61 8 6222 8222 F: 61 8 6222 8555 E: permail@ghd.com.au

Document Status

Rev No.	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
DRAFT	K NORRIS	N DAWE		N DAWE		25-08-11
0	K NORRIS	N DAWE		N DAWE		05-09-11

RPS

APPENDIX 2

Department of Education Correspondence

Government of **Western Australia**
Department of **Education and Training**

Your ref
Our ref
Enquiries

Ms Collene Longmore
Chief Executive Officer
Shire of Roebourne
Welcome Road
KARRATHA WA 6714

Dear Ms Longmore

TAMBREY PRIMARY SCHOOL – SURPLUS LAND

I refer to the proposed scheme amendment request to the Shire of Roebourne to rezone the surplus land at the Tambrey Primary School site so that it may be zoned for residential development.

Prior to the establishment of the Tambrey Primary School site, being Reserve 40378, in February 1988, the Department of Education considered that a future district high school catering for students in Kindergarten to Year 10 may be required in this part of Karratha. On this basis, a school site of 11.06 hectares was established.

Subsequently, Tambrey Primary School was constructed and opened for the first time in October 1989.

However, further assessments of the need for educational facilities in Karratha over the ensuing years revealed that a district high school would not be required. ie only a primary school would be required in the Tambrey area.

Following a Local Area Education Planning process involving significant community consultation in 2006 and 2007, it was decided to rebuild a new Karratha Primary School on its existing site and to construct new facilities for students in Years 11 and 12 on the Pilbara TAFE (Karratha Campus) site.

The appropriation of funding ($26 million) to rebuild Karratha Primary School was part of a decision taken by the Government's Expenditure Review Committee at its meeting on 23 May 2007 to fund a $97.5 million package of work to construct six new replacement schools and to upgrade three schools. The funding plan for this package of work included the proceeds from the excision and disposal of portion of the Tambrey Primary School site.

The use of this surplus land for residential development or other non-education purposes will not adversely affect the on-going provision of early childhood and primary education in the area. Moreover, the remaining 5.7 hectare primary school site will adequately meet the educational needs of the Tambrey suburb.

Accordingly, the Department of Education fully supports the proposed scheme amendment.

Yours sincerely

M. Parr

MAL PARR
DIRECTOR
STRATEGIC ASSET PLANNING

8 February 2010

151 Royal Street, East Perth Western Australia 6004

RPS

APPENDIX 3

Concept Masterplan

TAMBREY PRIMARY SCHOOL SURPLUS SITE | CONCEPTUAL SUBDIVISION DESIGN

Plan- 1:500@ A1 | June 2011

SIMON YOUNGLESON
ARCHITECTS AND URBAN DESIGNERS

RPS

APPENDIX 4

Traffic & Transport Assessment Report (ARUP)

Chenin Grove Pty Ltd

Tambrey Primary School Surplus Site, Lot 504, Karratha

Transport Assessment

Final | August 2011

Arup
Arup Pty Ltd ABN 18 000 966 165

Arup
11 Harvest Terrace
West Perth
WA 6005
Australia
arup.com.au

Job number 221741-00

ARUP

Document Verification

ARUP

Job title		Tambrey Primary School Surplus Site, Lot 504, Karratha			**Job number** 221741-00
Document title		Transport Assessment			**File reference**
Document ref		221741-00			
Revision	**Date**	**Filename**	Draft1.docx		
Draft 1	12/05/11	**Description**	First draft		
			Prepared by	Checked by	Approved by
		Name	Christie McKinnon	Ryan Falconer	Danya Alexander
		Signature			
Draft 2	07/06/11	**Filename**	Draft20110607.docx		
		Description			
			Prepared by	Checked by	Approved by
		Name	Christie McKinnon	Ryan Falconer	Danya Alexander
		Signature			
Final	31/08/11	**Filename**	0004Transport Assessment_Karratha Tambrey_FINAL		
		Description			
			Prepared by	Checked by	Approved by
		Name	Ryan Falconer	Danya Alexander	Danya Alexander
		Signature			
		Filename			
		Description			
			Prepared by	Checked by	Approved by
		Name			
		Signature			
				Issue Document Verification with Document	✓

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Executive Summary

This Transport Assessment has been prepared to assess the traffic and transport implications arising from the forecast development of the Tambrey Primary School Surplus Site (Lot 504) 82 lot residential development in Karratha, Western Australia. The site is bounded by Balmoral Road to the west, Bowerbird Drive to the south, Flannelbush Turn to the east, and the proposed Tambrey Primary School extension to the north. The development is proposed to be completed by the fourth quarter of 2013.

Two intersections were considered to warrant analysis given the traffic generation as a result of the development:

- Balmoral Road and Brolga Meander (proposed roundabout control); and
- Balmoral Road and Bowerbird Drive (proposed priority control).

Both intersections were analysed using industry standard software SIDRA. Baseline traffic volumes were calculated based on spot counts conducted at the aforementioned locations. A growth factor of 5% per annum, discussed and agreed with the Shire of Roebourne, was applied to extrapolate to 2013 figures.

Traffic generated as a result of the development was calculated based on first principles, with a trip generation rate of 8.4 trips per unit per day adopted. This rate was validated through a comparison with existing residential traffic count data for Karratha. By applying the rate, approximately 690 daily vehicle trips may be anticipated with about 70 vehicle trips occurring in the PM peak hour.

SIDRA analysis revealed that both intersections are forecast to operate well within capacity, and the introduction of additional traffic on the network as a result of the development should be acceptable from a network operations perspective.

Provisions for walking and cycling in and around the development should promote these modes of transport. The following recommendations apply:

- Provision of shade to improve the walking and cycling environment;
- Footpaths on both sides of internal streets;
- Minimum footpath widths of 1.5m; and
- Provision of a shared path along the northernmost east-west internal access street linking from Balmoral Road to the existing public open space.

1 Introduction and Background

1.1 Purpose of this report

This Transport Assessment has been prepared by Arup for Chenin Grove Pty Ltd, and Alcock Brown-Neaves (ABN) Group (project managers for Chenin Grove) to report on the traffic and transport implications of the proposed 82 lot residential development on lot 504 in Karratha.

The forecast vehicle trip generation associated with the new development exceeds 10 but is less than 100 in the PM peak hour. The Western Australian Planning Commission's draft *Transport Assessment Guidelines for Developments* require the preparation of a Transport Assessment to support a structure plan, which has objectives to:

- *Assess the proposed internal transport networks with respect to accessibility, circulation and safety for all modes, ie. vehicle, public transport, pedestrian and cyclist;*
- *Assess the level of transport integration between the structure plan area and the surrounding land uses;*
- *Determine the impacts of the traffic generated by the structure plan area on the surrounding land uses; and*
- *Determine the impacts of the traffic generated by the structure plan area on the surrounding transport networks.*

However, the transport assessment report has been developed to a level of detail suitable for the scale of the development and its likely level of impact on the transport network.

1.2 Previous and relevant reports

Previous and relevant reports and plans include:

- Shire of Roebourne (2010) *City Centre Master Plan: Karratha City of the North, Vol 3* (this makes broader references to the Karratha Townsite)
- Transcore (2010) *Karratha Revitalisation Project: Transport Context*.
- Shire of Roebourne (2011) *Shire of Roebourne Bike Plan*.
- Shire of Roebourne (2008) *Town Planning Scheme No. 8.*
- Western Australian Planning Commission (2004) *Liveable Neighbourhoods Design Code 3rd Ed.*
- Institute of Public Works Engineering Australia (2009) *Local Government Guidelines for Subdivisional Development 2nd Ed.*

1.3 Summary of consultation

This report has been prepared in consultation with the Shire of Roebourne. A meeting was held with the Shire of Roebourne on 19 May 2011 to discuss their views on traffic management and trip generation associated with the development and agree on basic transport inputs and intersections to be analysed. On 19th August, Arup held a follow up conversation with the Shire's technical services officers regarding road reserve requirements for local access streets.

Main Roads Western Australia (MRWA) was not consulted in the preparation of this study as impacts of development traffic on Dampier Road, a MRWA controlled road, are considered to be low.

2 Existing Context

An 82 lot residential development (R30) is proposed to be constructed at the Tambrey Primary School Surplus Site, Lot 504. It is anticipated that the development will be completed by quarter four 2013.

The site is located approximately 4.5 kilometres to the west of the Karratha town centre and is bounded by Balmoral Road to the west, Bowerbird Drive to the south, Flannelbush Turn to the east and Tambrey Primary School to the north. The location and extents of the site can be seen in **Figure 1**.

The north of the site is to integrate with the proposed extension of Tambrey Primary School (lot 503), and a proposed child care facility (lot 502). In 2010, the Tambrey Primary School reported 499 enrolments on the *My Schools* website, with this number expected to increase following completion of the expansion works. No information is available relating to the proposed childcare centre; however, it is assumed that access to this site will be via a new road connecting to the Tambrey residential development. In the future, it is reasonable to assume that some traffic associated with these land uses – particularly school set down and pick up – would utilise a future street internal to the Tambrey residential development connecting with Balmoral Road at Brolga Meander. Currently, lot 504 is greenfield land.

Figure 1 Site Location

3 Existing External Network

3.1 Road network

As the area is currently greenfield, there are no existing formalised roads within the site. Balmoral Road to the west is a key integrator arterial route between Dampier Road (roundabout control) and the Karratha town centre to the east. MRWA is currently undertaking the duplication of Dampier Road; the section of Dampier Road between Balmoral Road east (adjacent to the town centre) and Balmoral Road west has already been constructed to this standard.

Balmoral Road consists of a single paved lane in each direction with a posted speed limit adjacent to the site of 60 km/ hr (see **Figure 2**). The speed limit on Balmoral Road changes to 70km/ hr north of the intersection of Balmoral Road and Tambrey Drive (roundabout control). Prior to construction of the roundabout, the speed limit was 70 km/ hr for the entire length of Balmoral Road. The Shire of Roebourne has identified speeding as an issue along Balmoral Road, which is likely related to its exurban, open character and lack of speed mitigation.

Bowerbird Drive connects to Balmoral Road at the south-west corner of the site at a T-intersection. Currently there is no provision for turning lanes or channelisation on Balmoral Road on the southern approach to the intersection with Bowerbird Drive although a short section of median has been constructed by the Shire to direct turning traffic into the appropriate lanes. Some localised widening and new seal has also been established but it is not sufficient for a vehicle to queue while performing a right hand turn without obstructing through traffic heading north.

Figure 2 Balmoral Road to the west of the site

Both Bowerbird Drive and Flannelbush Turn are Neighbourhood Connectors with an approximate width of six metres and a speed limit of 50km/ hr. Both are paved with no line marking and have a footpath on one side. Bowerbird Drive is shown in **Figure 3** and Flannelbush Turn in **Figure 4**. To the north of Flannelbush Turn there is a park that also abuts to the site (see Figure 1).

Figure 3 Bowerbird Drive to the south of the site

Figure 4 Flannelbush Turn to the east of the site

3.2 Recent traffic volumes

Available traffic volumes for the road network surrounding the site are summarised in **Table 1**. The drop in volume from 2008 to 2009 is believed to be as a result of the duplication of Dampier Road east of Balmoral Road, which makes this route more attractive for district east-west trips.

Table 1 Existing Traffic Volumes

Location	Traffic Volume (Vehicles per Day)	Year of Count
Balmoral Road West – North of Dampier Highway	5,394	2008
Balmoral Road West – North of Dampier Highway	4,150	2009

(Source: MRWA)

On 19 May 2011, PM peak hour spot counts were conducted at the intersection of Balmoral Road and Brolga Meander, and Balmoral Road and Bowerbird Drive. These counts were conducted for 15 minute periods and then extrapolated to generate an estimate of peak hour volumes. A summary of the peak hour count data has been provided in **Figure 5** and **Figure 6**.

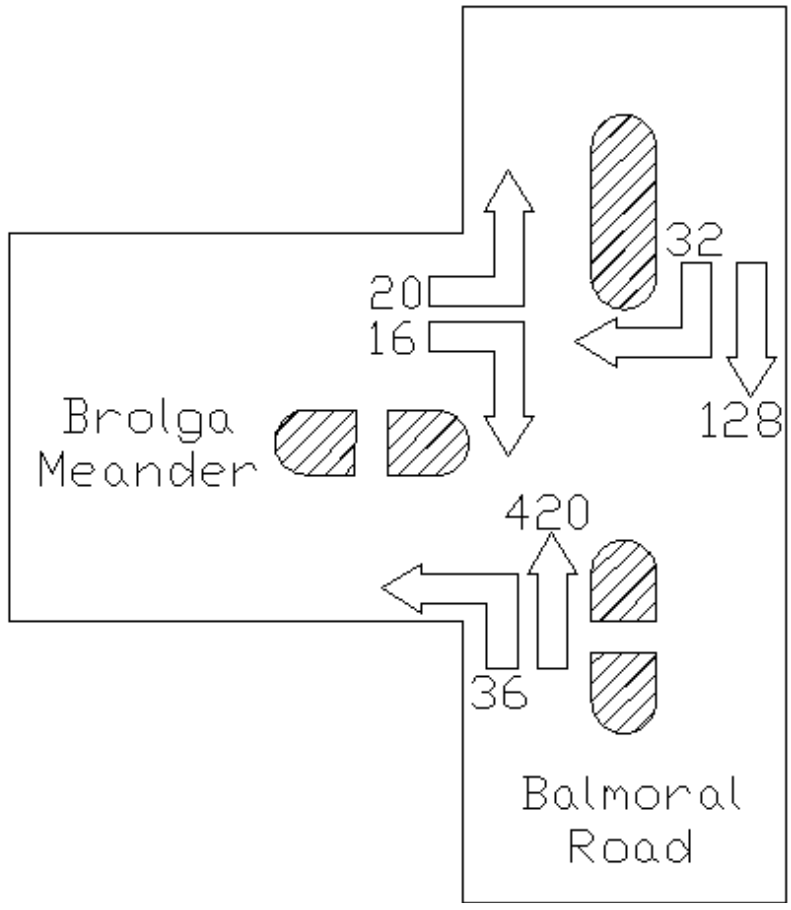

Figure 5 Spot counts: Intersection of Balmoral Road and Brolga Meander

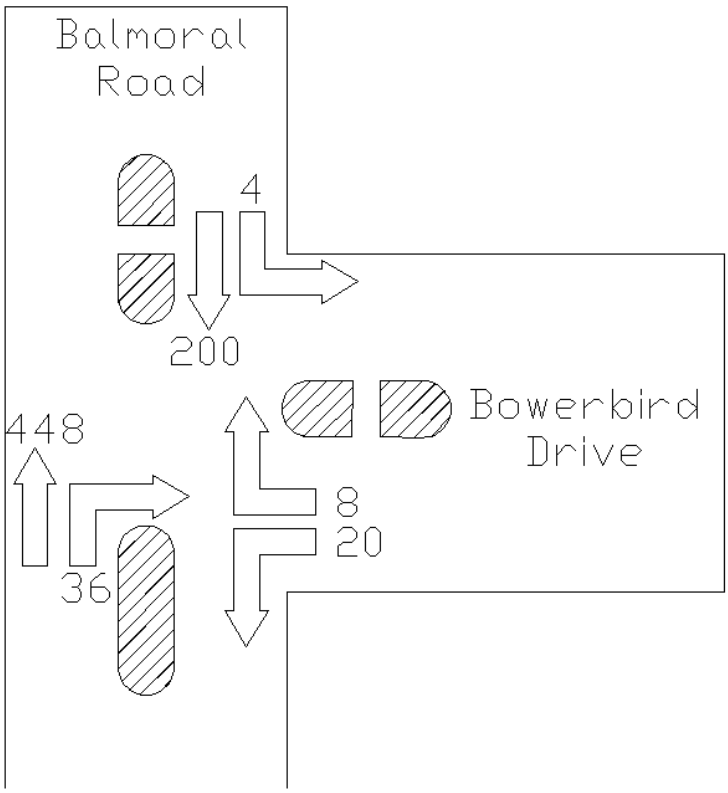

Figure 6 Spot counts: Intersection of Balmoral Road and Bowerbird Drive

3.3 Public transport network

Currently there is little public transport provided in the Karratha region for community use. There is a bus that operates twice a day on Tuesdays, Saturdays and Sundays between Dampier and Port Sampson. A bus stop associated with this route is situated at Tambrey Oval approximately 400 metres north of the development site. The lack of bus services in Karratha contributes to a high degree of car dependence for utilitarian transport.

3.4 Walking and cycling network

Due to the arid temperatures and limited shade in Karratha, walking and cycling are relatively uncomfortable. Moreover, the relatively low densities in Karratha, agglomeration of industry/ jobs outside of the townsite in industrial estates and at minesites, and historical Radburn-style layout of residential cells discourages utilitarian active transport.

The Shire of Roebourne's current and proposed bicycle network for Karratha can be seen in **Figure 7**. This plan is intended to increase the attractiveness of cycling by providing safer, more direct routes between residential cells and typical destinations, and providing more opportunities for leisure cycling when weather conditions are favourable.

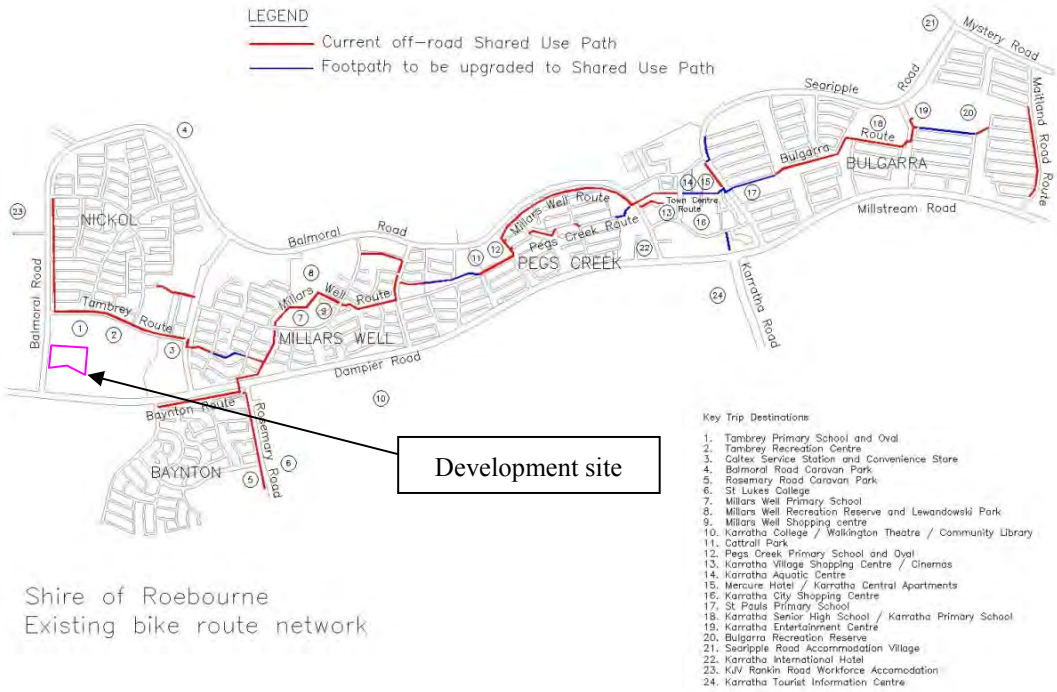

Figure 7 Karratha bicycle network
(Source: Shire of Roebourne)

A footpath is provided on the west side of Balmoral Road. It is approximately 1.8m wide and generally well maintained with crossing points provided at intersections (e.g. ramped kerb and median breaks). However, there is little shade provided to promote a pleasant walking environment. Drainage infrastructure on the east side of Balmoral Road inhibits provision of a footpath on this side.

At discussed in Section 3.1, approximately 1.8 metre wide footpaths are provided on the north side of Bowerbird Drive and east side of Flannelbush Turn. In some locations, these paths are beginning to degrade with cracks becoming evident (see **Figure 8**) and are becoming overgrown with vegetation (principally a maintenance issue).

Figure 8 Examples of footpath deterioration adjacent to the site

4 Internal Road Network

4.1 Overview

The proposed internal street network is shown on the precal plan included as **Figure 9**. The western north-south laneway will need to be divided from Balmoral Road by verge with a width agreed with the Shire of Roebourne.

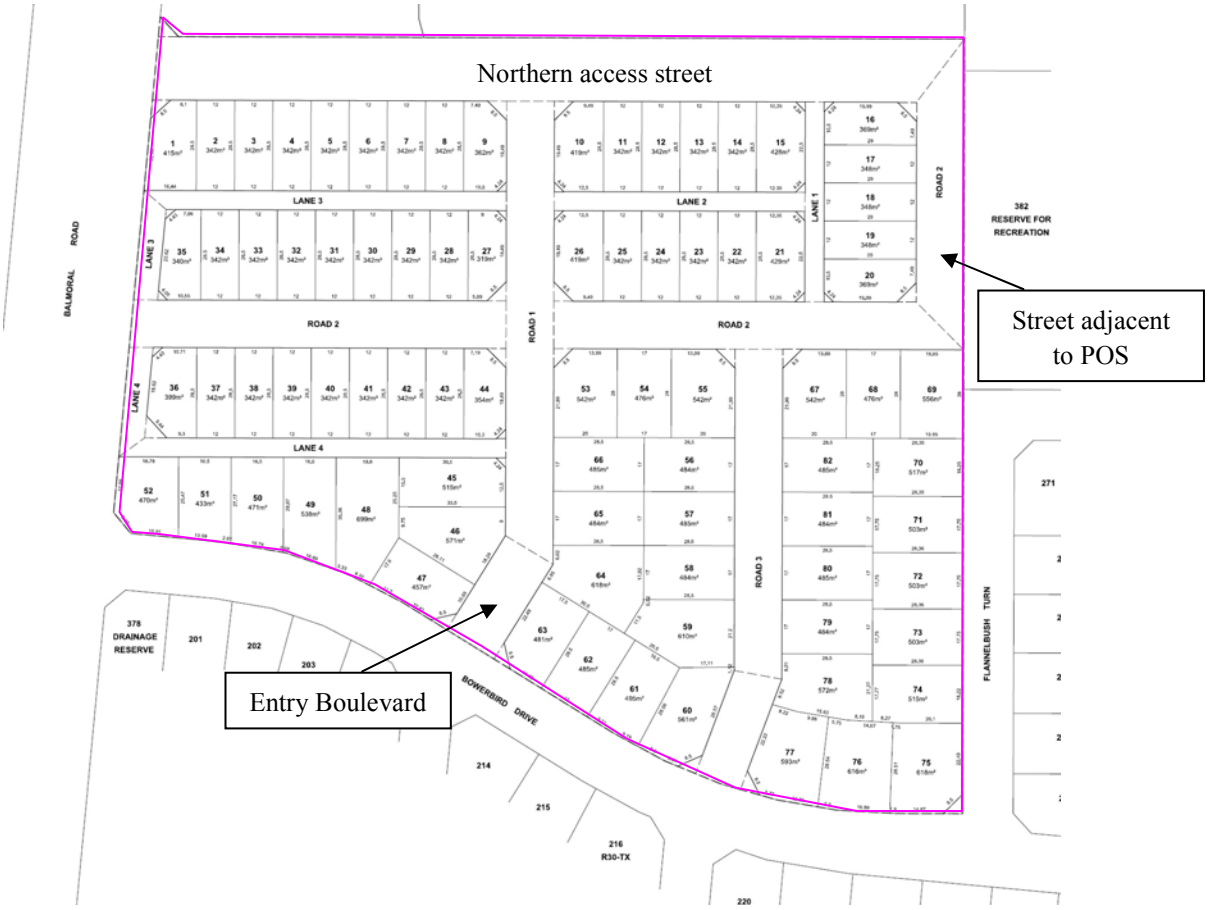

Figure 9 Internal street network

4.2 Street typologies

All streets within the network excepting laneways will be designed and function as access streets. The project team has developed indicative cross sections for the streets within the development, shown in Figure 11.

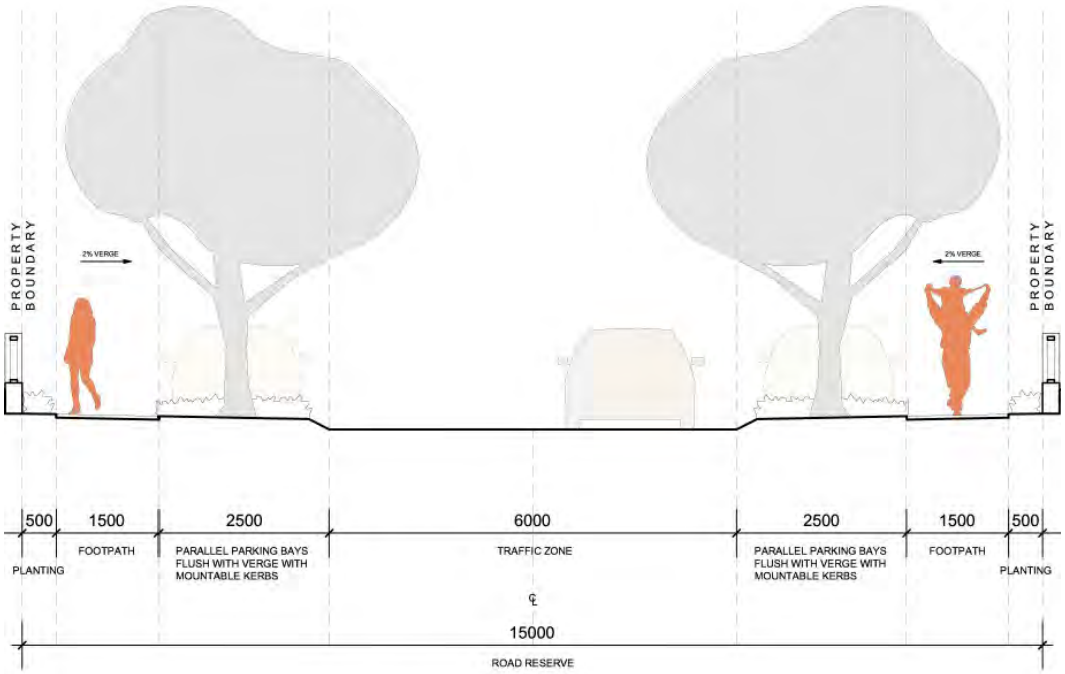

Figure 10 Typical internal street cross section (Roads 2 and 3)

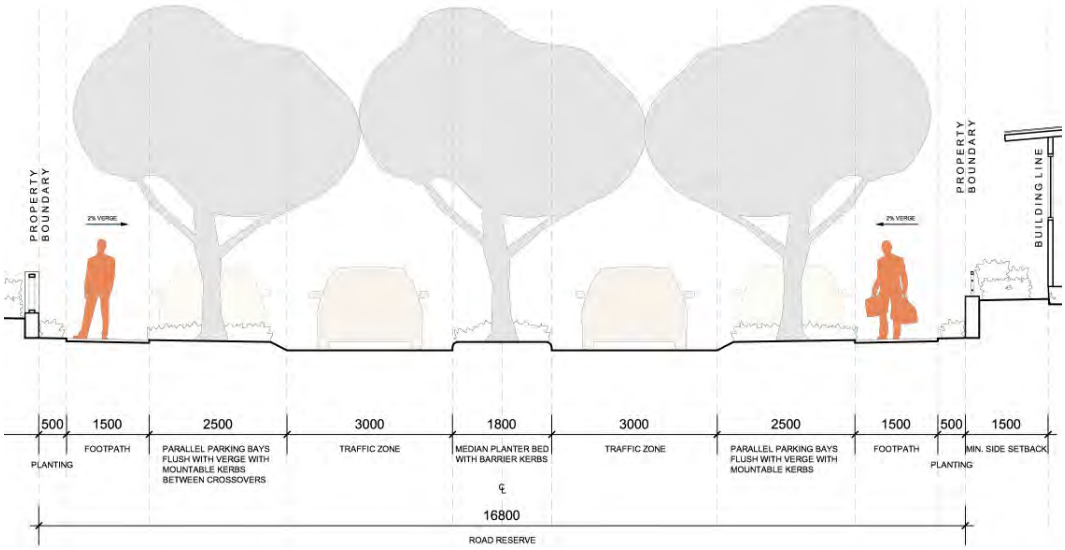

Figure 11 Entry boulevard cross section (southern entry to Road 1)

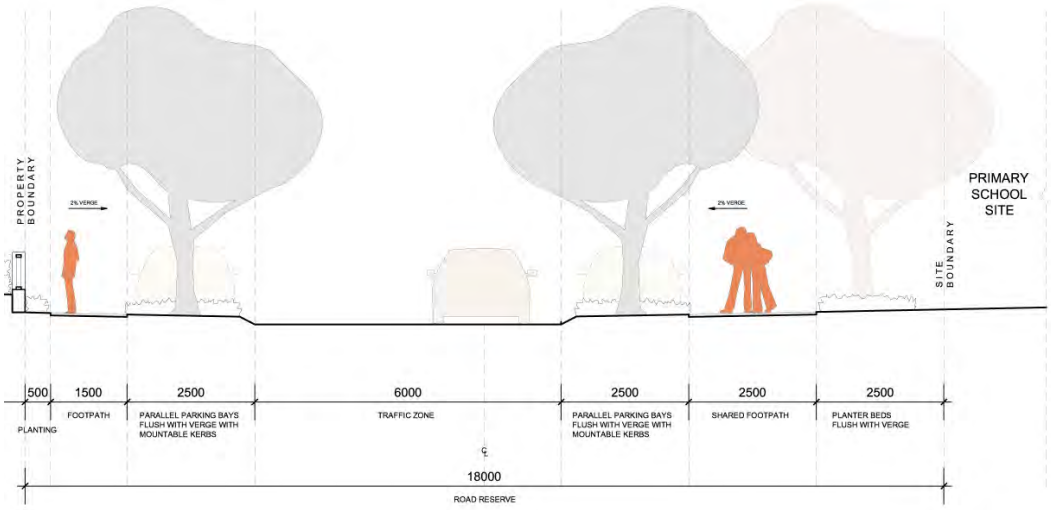

Figure 12 Northern access street cross section

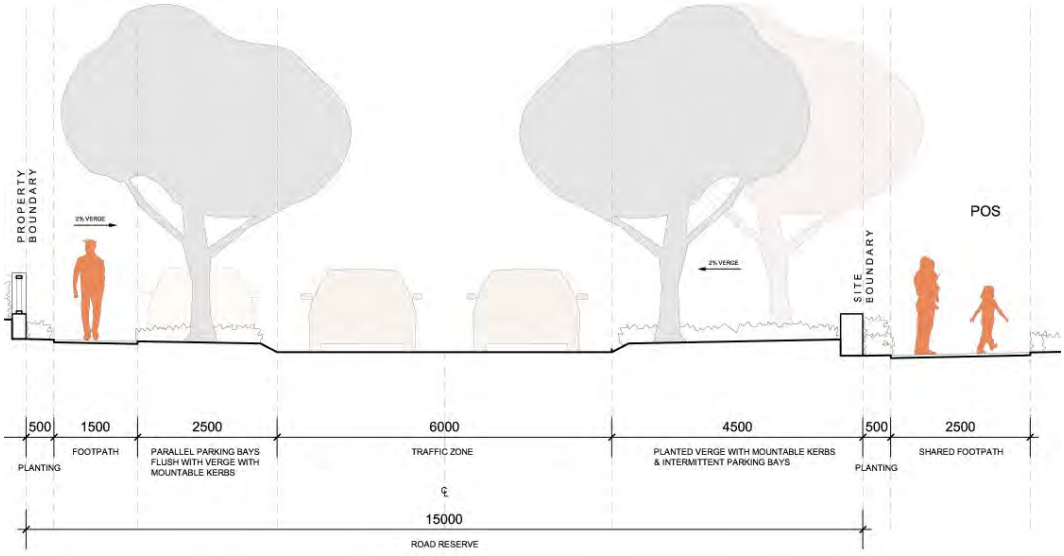

Figure 13 Street adjacent to POS cross section

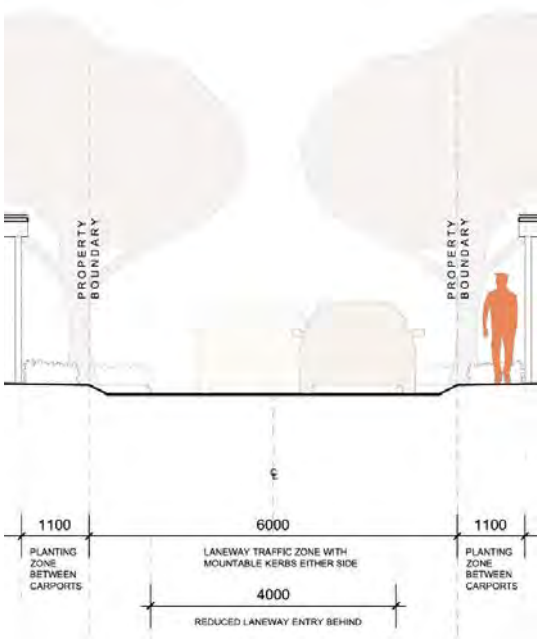

Figure 14 Typical laneway cross section

The access streets are estimated to attract traffic volumes of less than 1,000 vehicles per day. The typical street section (Figure 10) is anticipated to apply excepting adjacent to the Primary School site (i.e. along the northernmost east-west access street) POS, where provisions for a shared path are added. Additionally, an entry statement is proposed on Road 1 incorporating a short section of median and three metre traffic lanes (see Figure 11). In general, on-street parking provisions anticipated on all streets with bays at 2.5 metres in width interspersed with landscaping nibs. These provisions should be sufficient for visitors. The overall design intent is to reduce the visual width of the trafficable reserve to support low traffic speeds.

Six metres is anticipated to be sufficient for laneways with a narrower throat proposed to restrict access to one way at a time (subject to swept path analysis). The footpath is to be paved over the laneway access to demonstrate that pedestrians have the right of way over vehicles. Simon Youngleson Architects are preparing a concept plan that will show the laneway threshold treatment.

Liveable Neighbourhoods notes that 5.5m carriageway (excluding car parking) is sufficient to support the design intent for local access streets while still enabling two vehicles to pass each other. This is also articulated in IPWEA's guidelines for local government. Having consulted with the Shire of Roebourne's technical services personnel, it is noted that six metre carriageway is preferred given the preponderance of larger vehicles in Karratha. There is no case for widening the carriageway any further as there is no real benefit to wider roads in this local environment and it may have the unintended consequence of encouraging higher speeds and therefore reduced safety for crossing pedestrians and on-street cyclists.

Local access streets should have reduced speed limits of 30 or 40 km/hr, subject to approval by MRWA. Reduced speed limits should be supported by minimisation of kerb radii and building truncations in general accordance with the Liveable Neighbourhoods Design Code.

4.3 External connections

Key proposed connections between the development and the external network are illustrated in Figure 9. There are three external connection points proposed for the development:

- Four-way intersection at Balmoral Road/ Brolga Meander/ Northern Access Road;
- Four-way intersection at Bowerbird Drive/ Snakeskin Court/ Road 1; and
- Four-way intersection at Bowerbird Drive/ Mudlark Turn/ Road 3.

Access at the northwest corner of the site is proposed to be via a new access road connecting to Balmoral Road and Brolga Meander. This intersection is proposed to be roundabout controlled. Based on discussions with the Shire of Roebourne it is their preference that a roundabout be installed at this location rather than it operating under priority control.

Two four-way priority controlled intersections are to be introduced along Bowerbird Drive; at Snakeskin Court and Mudlark Turn. As the traffic volumes at these intersections are expected to be low they are anticipated to function well within capacity although threshold treatments on the minor approach are recommended (e.g. paving treatments as per the Liveable Neighbourhoods Design Code).

4.4 Intersection controls

Proposed intersection control treatments are summarised in **Figure 15**. Intersection threshold treatments and low platforms/ differential paving/ differential colouring are recommended at internal intersections and on minor approaches to external intersections to provide drivers with added cues. Three by three metre truncations would generally be supported as articulated in Liveable Neighbourhoods.

Three-way intersections are proposed to operate as standard T-intersections with give way control on the minor approach. Four-way intersections are proposed to give priority to the major approaches.

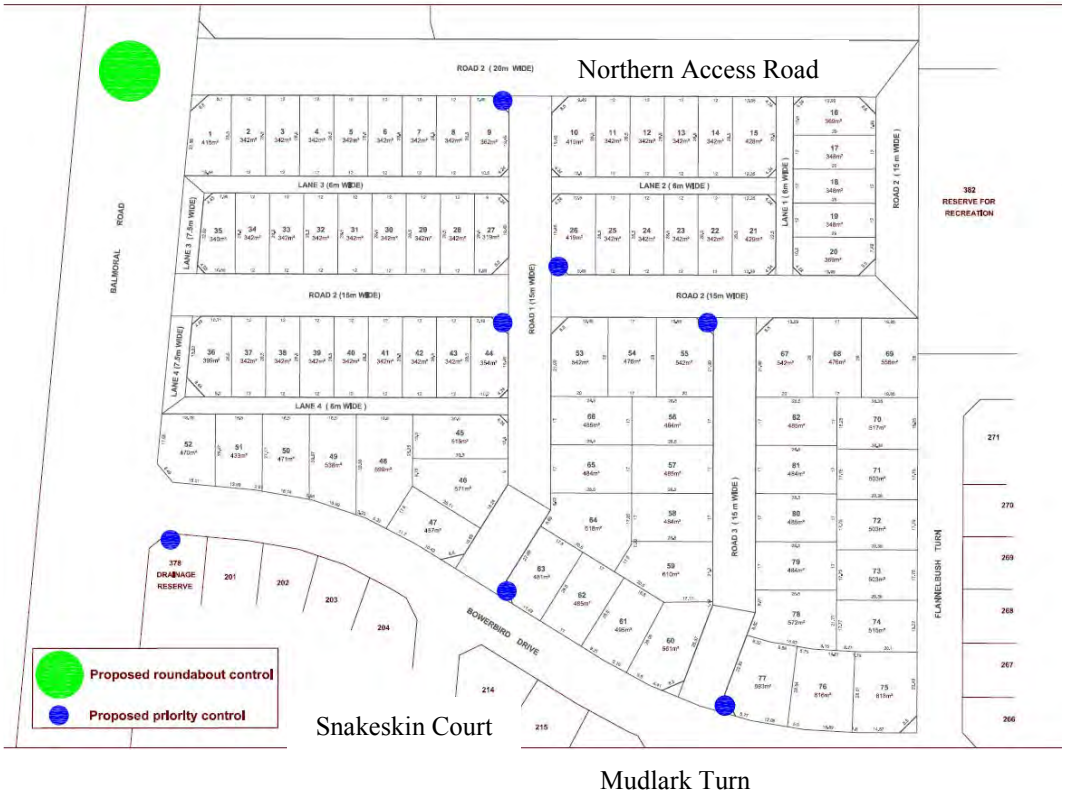

Figure 15 Intersection controls

5 Traffic Generation, Distribution and Impacts

5.1 Subdivision generated traffic

Trip generation rates for the subdivision have been calculated based on first principles and engineering judgement. The basic assumptions were also discussed and agreed with the Shire of Roebourne. Factors used in calculating the trip generation rate are as follows:

- Dwelling yield: 82
- Occupancy: 2.7 residents per unit (based on demographic references in the Karratha City of the North Plan and validated with the project planners, RPS)
- Total trips per person (all modes): 3.5 trips per day
- Visitor trips (e.g. people visiting residential premises in the development): 15% additional trips
- Driver mode split: 77%

Given limited opportunities to walk, cycle or use public transport, Karratha has a high vehicle mode split. Census data from the Australian Bureau of Statistics (2006) for commuter trips in Karratha reports a car driver mode split of approximately 77 percent. Tube counter data collected in mid 2011 for another existing residential cell in Karratha found similarly.

In Karratha there is a high portion of resource workers transported to mine sites via mini-bus. Increases in mining activity since 2006 may have increased the overall mode share of car passengers (and in turn decreased car-driver mode split). In addition, some non-work trips may be expected to be via non-car modes (e.g. walking and cycling), for example for education and leisure purposes. Very few commute trips may be anticipated to be by walking and cycling. A conservative driver mode split of 77 percent has been adopted for this study, which reflects the data available.

Based on the aforementioned factors, the trip generation rate applied to the development is 2.7 x 3.5 x 1.15 x 0.77 = 8.4 trips per unit per day. For an 82 lot development, this trip generation rate equates to 689 forecast vehicle trips per day and 69 vehicles in the peak hour (assuming the peak hour to be 10% of the daily total).

5.2 Traffic assignment and distribution

The following trip distributions have been assumed based on lot layout and the provision of three external access points:

- 50% via Balmoral Road/ Brolga Meander access
- 35% via Bowerbird Drive/ Snakeskin Court access
- 15% via Bowerbird Drive/ Mudlark Turn access

The following trip distribution has been assumed for trips with external origins or destinations. The proposed trip distribution is based on professional judgment as well as an understanding of trip attractors in the surrounding areas.

- North (via Balmoral Road) 30%
- South (via Balmoral Road) 60%
- East (via Bowerbird Drive) 10%

The most significant trip generators in Karratha are expected to be located in and around the city centre, as well as industrial and mine sites along Dampier Road (west). The majority of workers will travel south along Balmoral in order to access Dampier Road and consequently work sites. During peak periods it is expected that some trips into town may be made by travelling north on Balmoral Road in order to avoid congestion on Dampier Road. It is anticipated that little traffic from the development will travel east along Bowerbird Drive as there are very few trip attractors in the direction, as well as poor connectivity of streets.

The directional distribution of residential traffic in the PM peak hour is assumed to be:

- 80% inbound traffic
- 20% outbound traffic

5.3 Analysis of key intersections

Traffic volumes inputted into SIDRA were calculated based on 5 percent per annum baseline traffic growth, as well as the aforementioned distributions for residential generated traffic. Figures for traffic leaving the development are low due to the assumed 20% split for outbound traffic during this time (see Figure 16 and Figure 17). East-west movements at the intersection of Brolga Meander/ Balmoral Road/ Northern Access Road were assumed to be 10 in each direction to control for a low volume of traffic being attracted to perform this movement in the future.

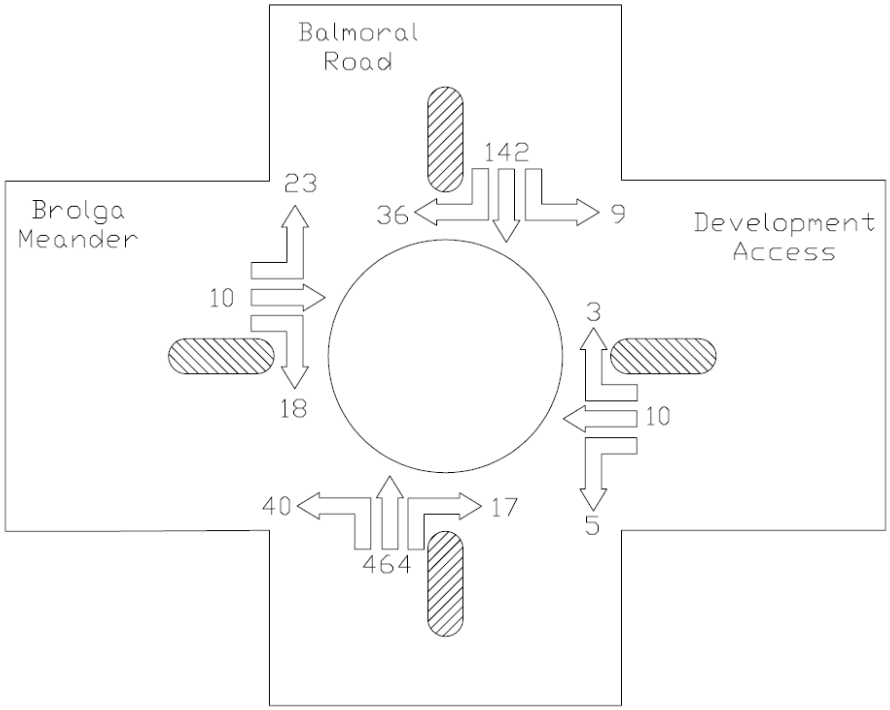

Figure 16 Forecast traffic volumes: intersection of Balmoral Road and Brolga Meander (PM peak hour)

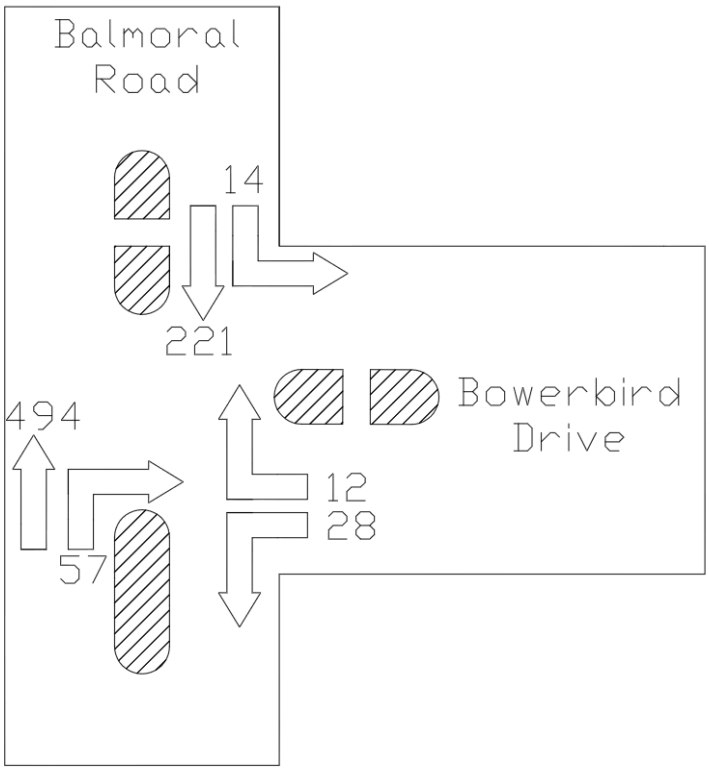

Figure 17 Forecast traffic volumes: intersection of Balmoral Road and Bowerbird Drive (PM peak hour)

To assess the impact of the generated traffic from the residential development on the existing road network, analysis was undertaken using industry standard computer modelling software (SIDRA). Intersections that were considered to be significantly impacted by the development (as per discussions with the Shire of Roebourne) include:

- Intersection of Balmoral Road and Bowerbird Drive; and
- Intersection of Balmoral Road and Brolga Meander (assuming conversion to four-way roundabout with direct access to the development).

To assist with the interpretation of the SIDRA output, the Degree of Saturation (DoS) is defined as the ratio of demand flow to intersection capacity. A DoS of 0.85 for a particular turning movement is generally understood to represent practical capacity having been reached.

The Level of Service (LoS) is a less continuous measure than DoS that describes the quality of traffic service. LoS is defined from A-F with LoS A representing the best operating condition – with conditions at or close to free flow – while LoS F represents the worst, most congested, conditions.

Both intersections have been tested assuming conservative traffic conditions: i.e. peak hour 2013 when the residential development is completed. Peak hour was determined to be between 5 and 6pm on Balmoral Road based on existing traffic count statistics. The intersection layouts tested in SIDRA are shown in Figure 18 and Figure 19, with the results of the analysis in Table 2. The intersection of Balmoral Road and Brolga Meander has been modelled as a single lane roundabout, and the intersection of Balmoral Road and Bowerbird Drive assuming no turning lane/ pocket for vehicles accessing Bowerbird Drive from the south.

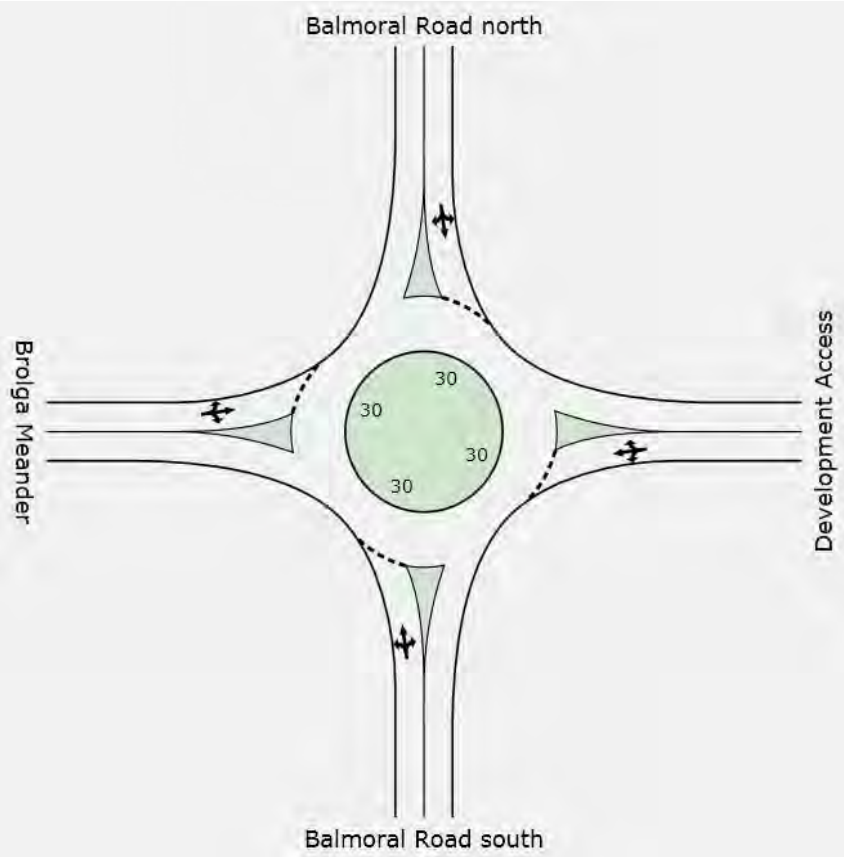

Figure 18 SIDRA intersection layout

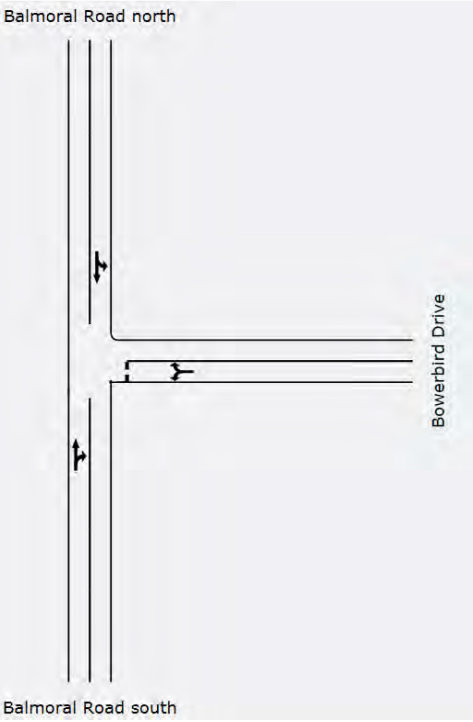

Figure 19 SIDRA intersection layout

Table 2 Intersection assessment

Approach	Degree of Saturation	Level of Service	95th Percentile Queue Length (m)
Intersection of Balmoral Road and Brolga Meander			
Balmoral Road south	0.34	LoS B	16
Development Access	0.01	LoS B	1
Balmoral Road north	0.13	LoS B	5
Brolga Meander	0.05	LoS B	2
Intersection of Balmoral Road and Bowerbird Drive			
Balmoral Road south	0.32	LoS A	19
Bowerbird Drive	0.09	LoS B	2
Balmoral Road north	0.13	LoS A	0

Both intersections analysed are expected to operate well within capacity with all approaches performing at LoS B or better. The DoS is satisfactory for all approaches, with the worst case in both instances, being for traffic travelling north on Balmoral Road. The queue lengths for all approaches are highly unlikely to cause any disruption of nearby intersections.

5.4 Impact on the internal street network

The estimated traffic volume within the development as a result of residential traffic is expected to be about 690 vehicles per day. In addition, it is expected that a proportion of external traffic will utilise the network primarily to access the school and child care centre. Even before there is an extension to the primary school, some traffic may be attracted to the new east-west street aligned with Brolga Meander, as it will offer a relatively safe opportunity for pick up and set down. Less than 1,000 vehicles per day are likely to use this northernmost access street even when development occurs to the north as it is not a through route. Other internal streets are likely to carry traffic volumes that are significantly less than this.

The carrying capacity of an access street as defined in Liveable Neighbourhoods is 3,000 vehicles per day assuming single traffic lanes in both directions and preferably, traffic speeds less than 50 kph. The forecast traffic volumes are therefore well within the capacity of an internal street network planned for local access with single carriageway not exceeding six metres in width.

6 Walking and Cycling

6.1 Proposed internal network and external connections

When integrated with compatible land uses, a high-quality walking and cycling network can:

- Reduce car dependency for residents;
- Reduce adverse environmental impacts of transport; and
- Facilitate improved personal health and fitness.

The proposed walking and cycling network within the development has been developed to provide for the convenient and safe movement of pedestrians and cyclists through and external to the site, notwithstanding limitations to surrounding infrastructure. It is expected that residents of the development will utilise the walking and cycling network for recreational purposes, as well as for gaining access to the nearby Tambrey Primary School, and proposed child care centre in the future. The provision of an east-west shared path aligned along the northern boundary of the site should, in future, facilitate an external connection northwards to the Tambrey route shown in the Shire Bike Plan (see Figure 7).

The following principles are recommended as part of network planning:

- Footpaths on both sides of internal streets;
- Footpaths with a minimum width of 1.5m; and
- Ample provision of shade to improve walking and cycling environment.

Possible features that could be included to improve pedestrian and cyclist comfort include:

- Regularly spaced, well-designed street crossing points;
- Ample shade to reduce the effects of Karratha's harsh climate;
- Ramped kerbs at crossing points for wheelchairs and prams; and
- Appropriate street lighting.

6.2 Safe routes to school

Tambrey Primary School is located to the north of the site. In 2010, the school was reported on the My Schools website to have 499 enrolments. It is proposed that the school be extended to the south to abut to the northern perimeter of the development site. However, this is not part of the current development plan. There will be pedestrian access to the school site from the residential development and a shared path is therefore recommended on the north side of the Northern Access Road connecting Balmoral Road with the POS to the east.

The planned roundabout at the intersection of the northern access street, Balmoral Road and Brolga Meander should be designed with median refuges, hand rails and

ramped kerbs at crossing points to support school access from the west and pedestrian movement more generally.

7 Public Transport

Currently, there is little public transport provided in the Karratha region, with a single bus route currently operating as described in Section 3.3. A new bus route may be considered as part of the development of Karratha as per the vision articulated in the Karratha City of the North Plan. Such a route is only at the concept planning stage and is unlikely to be in operation in the short-medium term. Thus, it is unlikely to affect the mode split of residents in the proposed development for the foreseeable future.

8 Car Parking

Residents parking should be provided on site as per the stipulations of the Residential Design Codes. On-street visitor car parking is considered the most efficient and appropriate method for provision of visitor car parking for residential access streets and the concept plan currently provides for this on most streets. On-street car parking can serve the additional role of reducing traffic speeds through reducing the visual width of the road reserve and provides a buffer between pedestrians and traffic. The Shire of Roebourne supports on-street parking and an example of on-street parking in the nearby Baynton West development can be seen in Figure 20.

Figure 20 Example of on-street parking provisions

9 Conclusions

Arup has undertaken a transport assessment, which has assessed the distribution and impacts of traffic generated by forecast development on the Tambrey Primary School Surplus Site, Lot 504, Karratha. Provisions for walking, cycling, public transport and car parking have also been considered. The following can be concluded from this assessment:

- Traffic generation for the site has been determined using first principles and engineering judgement and validated through a comparison with recent residential traffic count data.
- The forecast traffic generation from the 82 lot development is expected to be approximately 690 vpd.
- Background traffic volumes provided by MRWA showed approximately 5,050 vpd travelling along Balmoral Road west in the vicinity of the site in 2013 (based on a 5% annual growth rate).
- Peak hour spot counts were conducted at key intersections surrounding the site for the purpose of determining baseline counts for analysis. These counts were verified against MRWA counts.
- SIDRA analysis for two key intersections surrounding the site showed that both intersections are expected to operate well within capacity.
- A new roundabout is proposed to be created to connect the site with Balmoral Road and Brolga Meander. Four way intersections will also provide access to the site at the intersection of Bowerbird Drive/Snakeskin Court, and Bowerbird Drive/Mudlark Turn.
- To improve the walking and cycling environment for the development it is proposed that footpaths be provided on all internal streets and ample shade be provided. A shared path is recommended along the northernmost east-west internal access street linking from Balmoral Road to the existing public open space.

It can be concluded that the expected traffic generation from the residential development is well within the capacity of the surrounding road network, assuming the provision of external links and intersection treatments as recommended.

RPS

APPENDIX 5

Local Water Management Strategy (Emerge)

emerge ASSOCIATES
Integrated Science & Design

TAMBREY SCHOOL SURPLUS SITE

LOCAL WATER MANAGEMENT STRATEGY

Project Number EP11-020

Prepared for ABN Group
February 2012

Document Control

DOC NAME	TAMBREY SCHOOL SURPLUS SITE LWMS				
DOC NO.	EP11-020—003				
REVISION	DATE	AUTHOR		REVIEWER	
1	October 2011	Rachel Evans	RLE	Jason Hick	JDH
	Draft version for team comments				
A	October 2011	Rachel Evans	RLE	Dave Coremans	DPC
	Final report for issue to DoW and Shire of Roebourne				
B	February 2012	Rachel Evans	RLE	Dave Coremans	DPC
	Final Report				

Executive Summary

Emerge Associates have been engaged by ABN Group to prepare a Local Water Management Strategy to support the development plan for Lot 504 Balmoral Road. The study area is located to the north of the Karratha hills, approximately 6 km west of Karratha city centre within the locality of Nickol.

This Local Water Management Strategy (LWMS) is intended to satisfy the requirements of *Better Urban Water Management* (WAPC 2008) to prepare a Local Water Management Strategy (LWMS) to support the Development Plan.

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

- The study area receives 289 mm of average annual rainfall with the majority of rainfall received between January and June.
- The study area is generally flat, ranging between 14.3 m AHD and 15.0 m AHD in elevation.
- The upstream catchment is bounded by a drainage channel along Dampier Road, with a local high point part way along.
- The soil types underlying the study area consist of shallow clayey gravel over impermeable rock.
- ASS risk mapping indicate that there is a 'moderate to low' risk of encountering ASS at depths up to 3.0 m below natural surface.
- Surface water currently discharges from the study area at two locations; to the POS area to the east and the drainage channel along the western boundary.
- Modelling conducted using XPStorm indicates that the pre-development peak discharges from the study area to the drainage channel are 0.80 m^3/s and 0.67 m^3/s for the 100 year ARI event from two catchments. Discharge to the east of the study area reaches a peak of 0.50 m^3/s for the 100 year ARI event. Much of this flow within the study area would be widely dispersed across a broad front of overland flow.
- No surface water quality monitoring data is available for the study area as runoff is only experienced immediately after rainfall events.
- No groundwater quality or level data is available for the study area. Onsite observations suggest that there is no shallow aquifer. This has been confirmed by the Shire of Roebourne.
- There are no wetlands within the study area.
- The study area has no known historical landuses.

The primary objective for water management within the Tambrey Development plan area is to ensure that life and property is protected from major flooding events and high intensity runoff. This will be achieved by providing adequate conveyance of flow both upstream and within the study area via open drainage channels and within road pavement.

Given that there is no shallow aquifer, and on advice from the Shire of Roebourne, there are no criteria proposed for groundwater management within the Tambrey Development Plan area

Water conservation also requires active management, and the water conservation aims will be achieved by employing current best practice within dwellings.

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

Table E1 Water management criteria and compliance summary

Management Aspect	Criteria Number	Criteria Description	Manner in which compliance will be achieved	Responsibility for implementation	When Implemented
Water Conservation	WC 1	Efficient use of all water resources	Contemporary lot sizes	Developer	Structure planning
			Water efficient fittings	Developer	Building construction
			Water efficient appliances	Developer/Lot Owner	Point of sale and ongoing
			Water wise landscaping practices	Developer	Landscape implementation
	WC 2	Consumption target for scheme water of 40 kL/person/year	Contemporary lot sizes	Developer	Structure planning
			Water efficient fittings	Developer	Building construction
			Water efficient appliances	Developer/Lot Owner	Point of sale and ongoing
			Water wise landscaping practices	Developer	Landscape implementation
Surface Water	SW1	The post-development critical 5 year and 100 year ARI peak flows leaving the development will be generally consistent with pre-development peak flows.	Pre-development peak flows have been characterised, and surface runoff modelling demonstrates that the post-development peak flows are generally consistent with these.	Developer	Detailed civil design stage
	SW2	Conveyance of the 5 year ARI event will be achieved within the existing open drainage channel.	Surface runoff modelling has determined a channel with bottom width of 6 m and 1:6 side slopes will ensure that roads remain passable in a 5 year ARI event.	Developer	Detailed civil design stage
	SW3	Conveyance of events up to the 100 year ARI will be achieved in a combination of the open drainage channel and road pavements.	A concrete pipe network is not proposed. Surface runoff modelling confirms that adequate conveyance can be provided by the existing drainage channel and 6 m of road pavement. This will be confirmed at the UWMP and detailed design stage.	Developer	Detailed civil design stage
	SW4	Maximum flow velocity for surface runoff conveyance is 2m/s.	Surface runoff modelling of the proposed drainage channel and road pavement conveyance confirms that peak flow velocity will be 0.96 m/s, with 0.43 m/s within the drainage channel with use of a weir structure.	Developer	Detailed civil design stage

Management Aspect	Criteria Number	Criteria Description	Manner in which compliance will be achieved	Responsibility for implementation	When Implemented
	SW5	Finished floor levels of lots must have a 300 mm clearance from the 100 year ARI event flows being conveyed within road pavement	Earthworks confirm lot floor levels are 300 mm above maximum flood depths.	Developer	Detailed civil design stage
	SW6	Finished floor levels of lots must have a 500 mm clearance above the 100 year ARI flood level within major drainage channels.	Drainage channel invert level lowered to 13.7 mAHD maximum. Earthworks confirm lot floor levels are 500 mm above maximum flood depths.	Developer	Detailed civil design stage
	SW7	The finished floor levels must have a minimum of 500 mm clearance from the tidal influence level of 7.6 m AHD.	Earthworks confirm that floor levels are all greater than 500 mm clear of the tidal influence at 7.6 m AHD.	Developer	Detailed civil design stage
	SW8	Culverts are to be used for road crossings, and these should be greater than 450 mm in diameter.	The new culvert at road crossing to be designed as 2 x 1200 by 450 mm rectangular culverts. Upgrade existing culvert beneath access road to school to 2 x 1200 by 450 mm	Developer	Detailed civil design stage
	SW9	Reduce nutrient loads by applying appropriate non-structural measures.	Water wise landscaping practices	Developer	Landscape implementation
			Control of nutrient inputs	Maintenance contractor	Ongoing post-construction
			Maintenance of conveyance channels for accumulated sediments	Maintenance contractor	Ongoing post-construction

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Tambrey Development Plan

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1 Introduction

1.1 Background

Emerge Associates was engaged by ABN Group Pty Ltd to prepare a Local Water Management Strategy (LWMS) to support the development plan for Lot 504 Balmoral Road ("study area"). The study area is located to the north of the Karratha Hills, approximately 6 km west of the Karratha city centre within the locality of Nickol.

The study area covers an area of approximately 5.30 ha of remnant bushland. The location of the study area is shown in **Figure 1**. An aerial photograph illustrating the current condition and cadastral boundaries of the study area is provided in **Figure 2**.

It is important that the manner in which stormwater runoff from urban zoned areas is to be managed to avoid flooding and protect the environment are clearly documented early in the planning process. This approach provides the framework for actions and measures to achieve the desired outcomes at subdivision stage. This LWMS is intended to satisfy the requirements of *Better Urban Water Management* (WAPC 2008) to support the Tambrey Development Plan.

1.2 Town Planning Context

The study area is currently zoned as 'Urban Development' under the Shire of Roebourne (SoR) *Town Planning Scheme* (TPS) No. 8. Scheme amendment 18 was recently gazetted and changed the zoning of the land from 'Public Purposes: Education' to 'Urban Development' to enable the land to be used for residential development.

The 'Urban Development' zone will require a Development Plan (structure plan) to be prepared and approved prior to the land being developed or subdivided. The Tambrey Development Plan demonstrates how the study area can be developed and addresses matters such as land use, access, heritage issues, flora and fauna, drainage and environmental considerations. The Tambrey Development Plan requires advertising and comment of the servicing agencies before approval by the Shire of Roebourne and the Western Australian Planning Commission (WAPC).

1.3 Policy Framework

There are a number of State Government policies of relevance to the study area. These policies include:

- *State Water Strategy* (Government of WA 2003)
- *State Planning Policy 2.9 Water Resources* (Government of WA 2006)
- *Draft Guidance Statement No. 33: Environmental Guidance for Planning and Development (EPA 2005).*
- *Liveable Neighbourhoods Edition 4* (WAPC 2007b)
- *Planning Bulletin No. 64: Acid Sulfate Soils* (WAPC 2007d)
- *Pilbara Regional Water Plan* (DoW 2010).

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

- *Better Urban Water Management* (WAPC 2008)
- *Australian Runoff Quality* (Engineers Australia 2006)
- *Australian Rainfall and Runoff* (Engineers Australia 1987)
- *Decision Process for Stormwater Management in Western Australia* (DoW 2009)
- *Stormwater Management Manual for Western Australia* (DoW 2007)
- *National Water Quality Management Strategy* (ANZECC 2000)
- *Shire of Roebourne Stormwater Design Guidelines for Residential Developments* (Shire of Roebourne 2011).
- *Local Government Guidelines for Subdivisional Development Edition 2* (Shire of Roebourne 2009).

The document *Decision Process for Stormwater Management in WA* (DoW 2009) provides a decision framework for the planning and design of stormwater management systems. The document guides compliance with the objectives, principles and delivery approach outlined in the *Stormwater Management Manual for WA* (DoW 2007).

The Shire's recommended approach to managing stormwater is to ensure that runoff from intense rainfall events is adequately conveyed from the development area, and that adequate elevation from flood levels is provided. Conveyance of flows up to 100 year ARI event should be catered for by overland flow paths in roadside swales and road pavement.

1.4 Pilbara Regional Water Plan

The *Pilbara Regional Water Plan* (DoW 2010) focusses on water supply to the Pilbara region. This document provides the Department of Water (DoW) plan for the strategic management and development of the Pilbara regions water resources, and management priorities for DoW. It provides an assessment of water sources and demands for the Pilbara plan area, and proposes a five year action plan to be undertaken by the State Government and coordinated by DoW but does not establish specific per capita usage targets.

1.5 LWMS Objectives

This LWMS has been developed in consideration of the objectives and principles detailed in the guidance documents discussed in **Sections 1.3** and **1.4**. It is intended to support the Development Plan, and is further based on the following major objectives:

- Provide a broad level stormwater management framework to support future urban development.
- Incorporate appropriate best management practices (BMPs) into the drainage system that address the environmental and stormwater management issues identified.
- Minimise development construction costs, which will result in reduced land costs for future home owners.
- Minimise ongoing operation and maintenance costs for the land owners and the Shire of Roebourne.

- Gain support from the DoW and the Shire of Roebourne for the proposed method to manage stormwater within the study area and potential impacts on downstream areas.

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

2 Proposed Development

The development at the study area is proposed to provide medium density housing with 82 residential lots across 5.30 ha. No active public open space (POS) is to be included within the study area, however there is an existing POS area accessible to the east of the study area.

It is important to note that while the developer is proposing to subdivide the land, they will also be constructing the resident buildings on the lots they will create, therefore having direct control over the completed built form and landscaping across the development.

The water management approach described in **Sections 4** through **7** has been designed to accommodate the pre-development hydrology of the study area and nearby hydrological features.

This LWMS demonstrates and confirms that the study area can be readily serviced, with essential infrastructure already available in the region.

The Tambrey Development Plan is shown in **Appendix A.**

3 Pre-development Environment

3.1 Sources of Information

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

- *Regional 1:50 000 Geology Map Sheet* (Department of Mines 1979)
- *WA Atlas* (Landgate 2011)
- *Water Register* (DoW 2011)
- *Hydrogeological Atlas* (DoW 2011).

In addition to the above information, site-specific investigations have been conducted. These have aimed to provide more detail to the existing regional information. The study area-specific investigations for Tambrey Development Plan include '*Lot 504 corner Balmoral Road and Bowerbird Drive, Karratha Geotechnical Report'* (Douglas Partners 2011).

The above studies have been reviewed to determine any potential capacity limitations of local surface water flow paths (i.e. those within the Shire of Roebourne). This is important, as both can have implications for the stormwater management measures and the extent of earthworks that may be required to facilitate subdivision.

3.2 Climate

The study area experiences a dry climate with humid wet summers and warm, dry winters, with seasonal cyclones producing high intensity rainfall. Long term climatic averages indicate that the study area is located in an area of low rainfall, receiving 289 mm on average annually (BOM 2011) with the majority of rainfall received between January and June. On average, the region experiences rainfall for 20 days per annum.

3.3 Geotechnical Conditions

3.3.1 Topography

The study area is generally flat, with surface levels ranging from 14.3 m Australian Height Datum (AHD) to 15 m AHD.

The upstream catchment to the south of the study area is relatively small and flat and is bounded to the south by a drainage channel running parallel with Dampier Road. Design levels within this drainage channel indicate a local high point of 15.5 m along Dampier Road, approximately in-line with Seasnake Court (detailed in **Appendix B**).

Typical gilgai soil topography was seen in the south-eastern and north-western corners of the study area, featured by small hummocks and hollows with alternating patches of unvegetated and vegetated areas, consistent with highly reactive clayey materials (Douglas Partners 2011).

Topographic contours of the study area and upstream catchment are shown in **Figure 3** and historical design drawings are provided in **Appendix B**.

3.3.2 Soils and Geology

Regional geological mapping indicates that the shallow sub surface conditions beneath the study area comprise red-brown silty sand (Department of Mines 1979). The *Hydrogeological Atlas* (DoW 2011) indicates that the local area is underlain by granitoid rock with volcanic and sedimentary rocks within the greenstone belts to the south of the study area.

The geotechnical investigation undertaken for the study area (Douglas Partners 2011) indicated that the soils onsite generally consist of gravelly, sandy and clayey materials overlying weathered granitic bedrock.

An indicative soil profile is given below (Douglas Partners 2011):

- **Topsoil** – red-brown silty sand and silty clay topsoil to depths of between 0.05 m and 0.20 m.
- **Silty Sand/Clayey Silt** – generally medium dense/stiff to very stiff, red-brown silty sand with variable sand, silt and clay fractions to depths ranging from 0.15 m to 0.8 m.
- **Silty Clay/Sandy Clay/Clayey Sand** – stiff to hard, red-brown, clay and sandy clay from depths ranging between 0.1 m and 0.3 m, extending to depths of 1.6 m.
- **Sandy Gravel/Gravel/Clayey Gravel** – dense to very dense, red-brown and red-brown mottled off-white gravel with a variable clay and sand fraction from depths ranging between 0.1 m and 1.6 m, extending to depths of 3.3 m.
- **Weathered Granite** – extremely low strength, extremely weathered granite excavated as gravel and sand with variable content of silt and clay, to test pit determination depths between 1.9 m and 3.3 m.

Based on the regional mapped soil types, established infiltration rates of these soils and observations made onsite, the infiltration characteristics for the study area are assumed to be minimal. The soil types and vegetation types provide guidance to the infiltration assumptions used in the surface runoff model (further discussed in **Section 3.5)**.

3.3.3 Acid Sulfate Soils

The WA Atlas (DEC 2011) Acid Sulfate Soil (ASS) risk mapping classifies the majority of the study area as having a 'moderate to low risk of ASS within three metres of the natural surface'. The above assessment is consistent with observations made onsite, which indicate that the soil profile is largely hard impermeable soils that show no evidence of existing or historic shallow groundwater.

3.4 Wetlands

A site inspection and consideration of the known hydrological condition of the study area, including reported depth to groundwater as advised by the Sire of Roebourne (M Thorbjornsen [Shire of Roebourne] 2011, pers. comm., August) indicates that there are no wetlands located within the study area.

3.5 Hydrology

The study area is found within the Karratha Coast surface water allocation area and subarea. An existing surface water drainage channel runs along the western site boundary along Balmoral Road. This channel has culverts beneath road crossings; one twin 1200 x 450 mm culverts beneath the adjacent Bowerbird Drive at the south-western boundary of the study area, two 1200 x 450 mm

culverts beneath Tambrey Drive north of the study area and a single 600 x 300 mm culvert beneath a minor entry road to the school. The location of the existing drainage channel and the hydrological catchments is shown in **Figure 4**.

3.5.1 Surface Water Quantity

Surface water runoff has been estimated using data on topography, infiltration rates, vegetation and existing surface channels. This information was used in a hydraulic and hydrologic model to calculate discharges, volume of runoff and flow paths. A pre-development model (XPStorm) was created to provide a basis from which a comparison with the post-development peak discharges and volumes could be made.

3.5.1.1 Pre-development Sub-catchments

The whole catchment surrounding the study area was analysed to determine the contributing sub-catchments for the hydraulic and hydrologic model. One upstream catchment was identified adjacent to the study area, bounded by a drainage channel along Dampier Road. The existing drainage channel to the west of the study area contains 4 sub-catchments which flow consecutively northward along Balmoral Road. The study area contains three sub-catchments; the eastern sub-catchment discharges to the east while the remaining sub-catchments discharge into the western drainage channel. A further 3 sub-catchments are located downstream of the study area.

The pre-development catchments are shown in **Figure 4**, and their attributes are summarised below in **Table 1.**

Table 1 Pre-development sub-catchment characteristics

Sub-catchments	Sub-catchment areas (ha)	Slope
*DSCt1	1.308	0.004
*DSCt2	0.884	0.003
*DSCt3	0.335	0.003
Ct1	2.228	0.005
Ct2	0.918	0.005
Ct3	2.161	0.003
*SLCt1	0.096	0.002
*SLCt2	0.123	0.002
*SLCt3	0.151	0.003
*SLCt4	0.2	0.002
**USCt1	2.625	0.001

*Denotes catchment which is outside or partially outside the study area

** Denotes upstream catchment which is assumed to have full design flow for 1.2m x 0.45m existing culvert in 1 in 5 year critical duration event

3.5.1.2 *Pre-development Modelling Parameters*

An 'initial loss – 'continuous loss' infiltration model was adopted to generate stormwater runoff hydrographs in the hydraulic and hydrological model XPStorm. The infiltration rates for the different soil and land types are discussed in **Section 3.3** and detailed in **Appendix C**.

3.5.1.3 *Pre-development Modelling Results*

A multi-storm analysis was conducted to determine the critical duration storm event. This analysis indicated that the critical duration event is 1 hour for the 100 year ARI event. The pre-development peak discharges for the 100 year ARI event within each flow pathway and drainage channel as calculated in XPStorm are summarised in **Table 2**. Discharge locations are shown on **Figure 4**.

Table 2 Pre-development modelling results

Sub-catchment	100 yr 1 hr Peak flow (m^3/s)	Discharge Location	Flood Depth (m)
Ct1	0.8	Drainage Channel Section 2-2	N/A - Sheet flow
Ct2	0.449	Eastern Boundary of site to POS area	N/A - Sheet flow
Ct3	0.661	Drainage Channel Section 2-2	N/A - Sheet flow
USCt1	1.415	Existing Culvert 1	0.045 (max. culvert depth)
SLCt2	1.895	Drainage Channel Section 2-2	0.683
SLCt3	2.335	Drainage Channel Section 3-3	0.476
DSCt3	3.664	Existing Culvert 2	0.6 (max. culvert depth)

3.5.2 Surface Water Quality

There is no information regarding surface water quality within the ephemeral drainage channel. This channel is expected to contain flow only in direct response to rainfall events and water quality analysis has not been carried out.

3.5.3 Groundwater

The *Hydrogeological Atlas* (DoW 2011) indicates that the study area is underlain by low permeability rock, and that some localised aquifers may exist within fractures. The *Pilbara Regional Water Plan* also indicates this however it further indicates that these are highly variable and generally difficult to access (DoW 2010).

Site-specific monitoring of groundwater levels or quality has not been undertaken. The Shire of Roebourne has advised that interaction with groundwater is not of concern, and that the primary driver for subdivision design is surface runoff parameters (M Thorbjornsen [Shire of Roebourne] 2011, pers.

comm., August). This is supported by observations of the soil profile made onsite, which indicate that the lowest invert of the drainage channel does not intersect groundwater, and hence there is no significant shallow aquifer to be managed.

3.6 Current and Historical Land Uses

The study area is largely undisturbed by previous land uses. There has been no significant land clearing and no structures or earthworks have been undertaken. Residential development has occurred to the west, south and east of the study area including a turfed POS area to the east.

3.7 Summary of Existing Environment

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

- The study area receives 289 mm of average annual rainfall with the majority of rainfall received between January and June.
- The study area is generally flat, ranging between 14.3 m AHD and 15.0 m AHD in elevation.
- The upstream catchment is bounded by a drainage channel along Dampier Road, with a local high point part way along.
- The soil types underlying the study area consist of shallow clayey gravel over impermeable rock.
- ASS risk mapping indicate that there is a 'moderate to low' risk of encountering ASS at depths up to 3.0 m below natural surface.
- Surface water currently discharges from the study area at two locations; to the POS area to the east and the drainage channel along the western boundary.
- Modelling conducted using XPStorm indicates that the pre-development peak discharges from the study area to the drainage channel are 0.80 m^3/s and 0.67 m^3/s for the 100 year ARI event from two catchments. Discharge to the east of the study area reaches a peak of 0.50 m^3/s for the 100 year ARI event. Much of this flow within the study area would be widely dispersed across a broad front of overland flow.
- No surface water quality monitoring data is available for the study area as runoff is only experienced immediately after rainfall events.
- No groundwater quality or level data is available for the study area. Onsite observations suggest that there is no shallow aquifer. This has been confirmed by the Shire of Roebourne.
- There are no wetlands within the study area.
- The study area has no known historical landuse.

4 Design Criteria and Objectives

This section outlines the objectives and design criteria that this LWMS and future UWMPs will need to achieve. The overall water management strategy covers stormwater management, groundwater management and water consumption.

4.1 Total Water Cycle Management

The *State Water Strategy* (Government of WA, 2003) endorses the promotion of total water cycle management and the application of 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 total water cycle management include:

- Considering all water sources, including wastewater, stormwater and groundwater.
- Using all water sources sustainably.
- Allocating and using water equitably.
- Integrating water use with natural water processes, including maintaining environmental flows and water quality.

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

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

The first step in applying total water cycle management in urban catchments is to establish agreed environmental values for receiving waters and their ecosystems. The existing environmental context of the study area has been discussed in **Section 3** of this document. Guidance regarding environmental values and criteria is provided by a number of National and State policies and guidelines and site specific studies undertaken in and around the study area development. These were detailed in **Sections 1.3** and **3.1**.

The overall objective for preparing total water cycle management plans for proposed residential developments is to minimise pollution and maintain an appropriate water balance. This objective is central to the water management approach for the Tambrey Development Plan.

4.2 Water Conservation

Water conservation design criteria have been determined in line with the guidelines presented in *Better Urban Water Management*. The Tambrey Development Plan proposes the following water conservation criteria:

Criteria WC 1 Ensure the efficient use of all water resources in newly developing urban form and use scheme water efficiently wherever possible.

Criteria WC 2 Consumption target for scheme water of 40 kL/person/year.

The manner in which these objectives will be achieved is further detailed in **Section 5**.

4.3 Groundwater Management

Given that there is no shallow aquifer, and on advice from the Shire of Roebourne, there are no criteria proposed for groundwater management.

4.4 Surface Water Management

The overall guiding document for development of stormwater management strategies within urban areas is the *Stormwater Management Manual for Western Australia* (DoW 2007). Overlying this, the *Shire of Roebourne Stormwater Design Guidelines for Residential Developments* (Shire of Roebourne 2011) provides region-specific objectives that water management within the study area should achieve. Both of these references have been used to guide the adopted criteria.

The design criteria for surface water that are adopted for surface water management within the Tambrey Development Plan area are:

Criteria SW1 The post-development critical 5 year and 100 year ARI peak flows leaving the development shall be generally consistent with the pre-development environment.

Criteria SW2 Conveyance of the 5 year ARI event will be achieved by open swales.

Criteria SW3 Conveyance of events greater than the 5 year ARI and up to the 100 year ARI will be achieved by a combination of open swales and road pavement**.**

Criteria SW4 Maximum flow velocity for surface runoff conveyance is 2 m/s.

Criteria SW5 Finished floor levels of lots must have a 300 mm clearance from the 100 year ARI event flows being conveyed within swales and road pavement.

Criteria SW6 Finished floor levels of lots must have a 500 mm clearance above the 100 year ARI flood level within major drainage channels.

Criteria SW7 The finished floor levels must have a minimum of 500 mm clearance from the tidal influence level of 7.6 m AHD.

Criteria SW8 Culverts are to be used for road crossings, and these should be greater than 450 mm in diameter.

Criteria SW9 Nutrient loads should be managed by applying appropriate non-structural measures.

The manner in which these objectives will be achieved is further detailed in **Section 7**.

5 Water Source Allocation, Infrastructure and Fit-for-Purpose Water Use

5.1 Fit-for-Purpose water use

Conservation of water through fit-for-purpose use and Best Management Practices (BMPs) is encouraged so that scheme water is not wasted. Fit-for-purpose describes the use of water that is of a quality suitable for the required use of the water. Fit-for-purpose principles have been utilised in the water conservation strategy for the Tambrey Development Plan.

5.1.1 Scheme Water

Potable water supply for this area comes from the Harding Dam and Millstream borefield, located inland and east of the study area. This scheme is currently under extreme pressure however, a considerable amount of investment in source development and conveyance infrastructure is underway throughout Karratha (M Busher [DoW] 2011, pers. comm., 6 May).

It is proposed to access the Water Corporation's existing scheme water supply network to supply all potable and non-potable needs for the development.

5.2 Water Conservation Measures

The development proposes to utilise Contemporary Lot Sizes (CLS), scheme water for irrigation, WaterWise (Water Corporation 2003) principles for open space landscaping (WWL) and Water Efficient Fixtures and Appliances (WEFA) to ensure that the development minimises the use of water. Details of these measures are further discussed below.

5.2.1 Contemporary lot sizes

The Tambrey Development Plan incorporates a range of medium density housing with lot sizes ranging between 340 m^2 and 620 m^2. These contemporary lots reflect a trend towards smaller residential lots in new urban areas with reduced garden areas.

The lots proposed in the Tambrey Development Plan will have lot based landscaping installed by the developer to ensure a high degree of control over the design outcomes. By undertaking the design and installation of the exterior spaces, the outdoor areas are only anticipated to require approximately 35% of exterior space to be irrigated. The remaining areas will be a combination of hardscape for outdoor living, paving and alternative landscape treatments such as gravels.

5.2.2 Water efficient fixtures and appliances

Significant reduction in water uses within the house can be achieved with the use of WEFA. **Table 3** provides an example of the water uses of typical appliances versus water efficient appliances. These water use rates have been used in the water balance analysis.

Table 3 Water efficient fixtures and appliances (Australian Government 2009 & Melbourne Water 2008)

Appliance	Water use	
	Standard fittings and appliances	WEFA
Toilet	12 Litres/Flush	4 Litres/Flush
Washing Machine	130 Litres/Wash	40 Litres/Wash
Shower Head	15-25 Litres/Minute	6-7 Litres/Minute
Taps	15-18 Litres/Minute	5-6 Litres/Minute

The Tambrey Development Plan water conservation strategy proposes that all dwellings use water efficient fixtures. This will be implemented by the developer during the construction stage. Water efficient appliances will be promoted by the developer at point of sale.

5.2.3 Water Wise Landscaping

Reductions in water irrigation by employing water efficiency measures can significantly reduce total water usage. The water efficiency measures to be used on landscaped areas have been developed based on the Water Corporation WaterWise website (Water Corporation 2011) and include:

- Garden beds to be mulched to 75 mm with a product certified to *Australian Standard AS4454*.
- The irrigation system shall be designed and installed to be able to irrigate different zones with different irrigation rates. Emitters must disperse coarse droplets or be subterranean.
- Limiting the amount of turfed areas.
- Substituting turf with alternative finishes (e.g. crushed aggregate).
- Using turf species endorsed by the UWA Turf Industries Research Steering Committee (e.g. Couch grass – *Cynodon dactylon*).
- Planting local native plants to reduce water use and loss.
- Minimising water requirements for landscape maintenance within POS areas by implementing an appropriate management and maintenance program (to be further detailed in the UWMP).

5.3 Lot Water Balance

A water balance analysis has been undertaken to determine the effectiveness of the water conservation strategy proposed. The Tambrey Development Plan water balance analysis has been based on the rates and calculation methodology presented in the Water Corporation spreadsheet *AltWaterSupply_Water_Use_Model.xls*. This spreadsheet has been adapted to model the effects of using water efficient appliances and gardens.

The water balance analysis has assumed the following:

- Average of three residents per lot (household).
- WWL practices are used in all lots (50% of total garden area at 7500 kL/ha/year and 50% at 5000 kL/ha/year).
- 100% uptake of water efficient fittings.
- 35% uptake water efficient appliances.
- All estate irrigation assumed to be supplied by scheme water from lots.
- Total of 87 street trees across the estate (assumed 4m^2 / tree with irrigation rate of 7500 kL/ha/year).

- Each street tree includes an additional 4 m^2 of planting around base with native grass (irrigated at 7500 kL/ha/year).
- All additional road verge assumed to be gravel, aggregate or similar (and therefore it is not irrigated).
- Street trees and street irrigation is included with each lot scheme water use.

The total water consumption for the water conservation strategy proposed is presented in **Table 4.**

Table 4 Tambrey Development Plan lot water consumption

Water use	Per person (kL/year)	Per household (kL/yr)	Total water usage (ML)
In-house scheme water use	32.7	98.1	8.1
Ex-house scheme water use	16.3	48.9	4

The results of the water balance indicate that confirms that the water conservation approach proposed achieves the water consumption target of no more than 40 kL/year/person, and satisfies Criteria WC1 and WC2.

5.4 Estate Scale Water Use

As indicated in **Section 5.3**, the street trees immediately adjacent to lots will be irrigated using scheme water from the lot. In addition to the street trees adjacent to lots, there will be some minor landscaping along the northern boundary where the site interfaces with the school. The water balance analysis has been extended to include the irrigation requirements of these areas. The assumptions used for the estate water balance analysis include the following:

- 24 trees along POS and school interface (northern boundary) irrigated at same rate as street trees.
- 290 m^2 of planting along school interface (irrigated at 7500 kL/ha/year).

The results of the water balance showing estate irrigation requirements, and a total of all lot-scale and estate scale uses is shown in **Table 5**.

Table 5 Estate scale and total scheme water use

Water use	Per person (kL/year)	Per household (kL/yr)	Total water usage (ML)
Estate water use	6.5	19.5	1.6
All water uses combined	55.6	166.8	13.7

5.5 Wastewater Management

The wastewater generated from the Tambrey Development Plan area will be managed by connecting the development to the existing Water Corporation sewer system.

5.6 Water Conservation Criteria Compliance Summary

A summary of the proposed water conservation design criteria and how these are addressed within the Tambrey Development Plan is provided in **Table 6**.

Table 6 Water conservation criteria compliance

Criteria number	Criteria description	Manner in which compliance will be achieved
WC 1	Efficient use of all water resources	Use of contemporary lot sizes
		Use of water efficient fittings
		Promotion of water efficient appliances
		Use of water wise landscaping practices
WC 2	Consumption target for scheme water of 40 kL/person/year	Contemporary lot sizes
		Use of water efficient fittings
		Promotion of water efficient appliances
		Use of water wise landscaping practices

6 Groundwater Management Strategy

As detailed in **Section 3.5.3**, there is no shallow groundwater aquifer. On this basis, and on advice from the Shire of Roebourne, there are no groundwater management criteria proposed for the Tambrey Development Plan area.

7 Stormwater Management Strategy

The principle behind the stormwater management strategy for the Tambrey Development Plan aims to maintain the existing hydrology by continuing the existing surface flow regime through the study area. The drainage system has been designed to achieve the objectives and criteria stated in **Section 4.4**.

The primary objective for stormwater management onsite is to adequately convey runoff from all events up to the 100 year ARI event. Specifically, the objectives proposed in **Section 4.4** will be achieved by:

- Road pavement conveyance
- Use and adaptation of the existing drainage channel
- Providing adequate fill to provide sufficient separation from flood levels
- Providing protection against erosion.

7.1 Drainage Channel and Roadway Conveyance

The existing drainage channel that runs along the western boundary of the study area, parallel to Balmoral Road, will provide conveyance of stormwater offsite, consistent with the pre-development environment. This channel will convey runoff from upstream catchments and from within the study area. Stormwater runoff generated within the study area will be directed into the drainage channel via the road pavements and breaks in kerbing. The pre-development discharge to the east of the study area will also be re-routed to this drainage channel.

The Tambrey Development Plan includes a new road crossing, leading from the north-west of the study area to Balmoral Road. A culvert will be constructed beneath this new roadway to provide a continued path for flows within the drainage channel, as shown in **Figure 5**. The culvert has been designed as two rectangular 1200 x 450 mm culverts, in accordance with the Shire of Roebourne's stormwater drainage design criteria for culverts and consistent with the upstream infrastructure beneath Bowerbrid Drive.

The single 600 x 300 mm culvert beneath the minor entry road to the school is currently undersized and will require upgrading to allow large event flows to be adequately conveyed downstream. The upgraded culvert has been designed as two rectangular 1200 x 450 mm culverts.

The drainage channel invert level will require lowering to ensure that, during extreme flooding events, flood waters to not overtop the channel and flow into the study area. The drainage channel is currently modelled with an upstream invert level of 13.7 mAHD (section 2-2 on **Figure 5**) and 13.6 mAHD downstream invert level (section 3-3).

To enable the post-development peak flows leaving the study area to be consistent with the pre-development peak flows, the drainage channel will require a structure within the channel to slow flows down. This is currently modelled as a weir with a crest height of 400 mm above the drainage channel invert level at Section 2-2 of the drainage channel, as shown in **Figure 5.** The post-development hydraulic and hydrologic modelling assumptions are discussed below and detailed in **Appendix C**.

The channel and weir dimensions shown in **Figure 5** are nominal, and will need to be confirmed/revised following outcomes of the development of the detailed earthworks strategy and detailed civil designs. These structures will be provided in future UWMPs.

7.1.1 Post-development modelling

As described above, this LWMS proposes to utilise road pavement conveyance and the existing drainage channel to adequately convey peak runoff, and to ensure post-development peak discharges are comparable to the pre-development peak discharges.

The calculation of these discharges is best achieved via a computational model. The post-development modelling uses the same methodology and parameters as pre-development modelling (described in **Appendix C**). Post-development catchments are shown in **Figure 6**.

The post-development peak discharge from the entire Tambrey Development Plan area aims to be comparable to the pre-development peak discharge for rainfall events greater than the 5 year ARI up to the 100 year ARI. This is achieved by design of the discharge channel along the western boundary of the study area, as discussed above. The modelled drainage channel profile at two locations within the channel (consistent with the sections used in the pre-development model) and within two of the proposed roadways is provided within **Table 7**.

Table 7 Conveyance channel profiles and peak flow rates.

Conveyance Channel	5 year ARI event			100 year ARI event		
	Depth (m)	Pre-dev. peak flow rate (m^3/s)	Post –dev. peak flow rate (m^3/s)	Depth (m)	Pre-dev. peak flow rate (m^3/s)	Post-dev. peak flow rate (m^3/s
Drainage Channel (Section 2-2)	0.48	*0.74	0.72	0.86	*2.34	2.29
Drainage Channel (Section 3-3)	0.45	*1.07	1.04	0.73	*2.78	2.81
Road 1	0.01	N/A	1.50	0.03	N/A	0.96
Road 2	0.00	N/A	1.02	0.02	N/A	0.84

*Denotes combined flow from pre development catchments Ct1 and Ct2.

The discharge location of the existing drainage channel at the north-west corner of the study area (section 3-3 as shown in **Figure 5**) provides a suitable location to compare pre-development and post-development peak flows. Pre-development catchments Ct1 and Ct2 are combined as the pre-development discharge to the east is re-routed to the drainage channel in the post-development model.

The peak flow analysis provided in **Table 7** indicates that the pre-development 100 year ARI peak flow leaving the study area is 2.784 m^3/s while the post-development peak flow is 2.81 m^3/s. This comparison demonstrates that Criteria SW1, SW2 and SW3 can be achieved.

The peak velocity analysis provided in **Table 8** shows that the post-development maximum flow velocities are generally consistent with the pre-development velocities and within the 2 m/s maximum velocity requirement of the Shire of Roebourne. This comparison demonstrates that Criteria SW4 can be achieved.

Table 8 100 year ARI event peak flow velocities

Conveyance Channel	Pre-development peak flow velocity (m/s)	Post-development peak flow velocity (m/s)
Drainage Channel (Section 2-2)	0.20	0.23
Drainage Channel (Section 3-3)	0.59	0.43
Road 1	N/A	0.96
Road 2	N/A	0.84

7.2 Earthworks Strategy

The finished floor levels within the study area will need to achieve a 500 mm clearance from the tidal influence level of 7.6 m AHD, 500 mm clearance from flows within the drainage channel and 300 mm clearance from flows within road pavement. The earthworks plan indicates that a minimum floor level of 15.0 m AHD will be used across the study area. This provides a clear margin from the tidal influence level and demonstrates that Criteria SW7 can be achieved.

The flood depths within the two road sections have been calculated in XPStorm, and these are shown in **Table 9**.

Table 9 Flood depths within road pavement conveyance

Road Conveyance	1 in 5 year ARI event flood depth (m)	1 in 100 year ARI event flood depth (m)
Road 1	0.01	0.03
Road 2	0.00	0.02

The earthworks plan (provided in **Appendix D**) confirms that the lot floor levels will have a minimum 300 mm clearance from the 1 in 100 year ARI event flood level within road pavements demonstrating that Criteria SW5 can be achieved.

The drainage channel will be lowered between Bowerbird Drive and Road 1 to a maximum invert level of 13.7 mAHD. The maximum flood depth within the drainage channel of 0.86 m (detailed in **Table 7**) gives a 100 year ARI flood level of 14.56 mAHD within the drainage channel. The earthworks plan indicates that a minimum floor level of 15.0 m AHD will be used across the study area, demonstrating that SW6 can be achieved.

7.3 Erosion Protection

It is important that the conveyance structures are protected from erosion that may occur during extreme events. This can be achieved by a number of treatments that can be used within the drainage channel, such as rock spawls at key erosion areas and other armoured discharge areas/culverts. The design of the drainage channel will be detailed within the future UWMP and detailed civil designs. These designs will need to comply with the Shire of Roebourne stormwater drainage design criteria.

7.4 Surface water quality

Surface water nutrient loads within the study area will be reduced by use of non-structural measures including:

- Water wise landscaping practices
- Control of nutrient inputs
- Maintenance of conveyance channels for accumulated sediments.

These measures will help to achieve Criteria SW9.

7.5 Surface Water Criteria Compliance Summary

A summary of the adopted surface water design criteria and how these are addressed within the Tambrey Development Plan is provided in **Table 10**.

Table 10 Surface water management criteria compliance

Criteria number	Criteria description	Manner in which compliance will be achieved
SW1	The post-development critical 5 year and 100 year ARI peak flows leaving the development will be generally consistent with pre-development peak flows.	Pre-development peak flows have been characterised, and surface runoff modelling demonstrates that the post-development peak flows are generally consistent with these.
SW2	Conveyance of the 5 year ARI event will be achieved within the existing open drainage channel.	Surface runoff modelling has determined a channel with bottom width of 6 m and 1:6 side slopes will ensure that roads remain passable in a 5 year ARI event.
SW3	Conveyance of events up to the 100 year ARI will be achieved in a combination of the open drainage channel and road pavements.	A concrete pipe network is not proposed. Surface runoff modelling confirms that adequate conveyance can be provided by the existing drainage channel and 6m of road pavement. This will be confirmed at the UWMP and detailed design stage.
SW4	Maximum flow velocity for surface runoff conveyance is 2m/s.	Surface runoff modelling of the proposed drainage channel and road pavement conveyance confirms that peak flow velocity will be 0.96 m/s, with 0.43 m/s within the drainage channel with use of a weir structure.
SW5	Finished floor levels of lots must have a 300 mm clearance from the 100 year ARI event flows being conveyed within road pavement	Earthworks confirm lot floor levels are 300 mm above maximum flood depths.
SW6	Finished floor levels of lots must have a 500 mm clearance above the 100 year ARI flood level within major drainage channels.	Drainage channel invert level lowered to 13.7 mAHD maximum. Earthworks confirm lot floor levels are 500 mm above maximum flood depths.
SW7	The finished floor levels must have a minimum of 500 mm clearance from the tidal influence level of 7.6 m AHD.	Earthworks confirm that floor levels are all greater than 500 mm clear of the tidal influence at 7.6 m AHD.
SW8	Culverts are to be used for road crossings, and these should be greater than 450 mm in diameter.	The new culvert at road crossing to be designed as 2 x 1200 by 450 mm rectangular culverts. Existing culvert beneath access road to school to be upgraded to 2 x 1200 by 450 mm rectangular culverts.
SW9	Reduce nutrient loads by applying appropriate non-structural measures.	Waterwise landscaping practices.
		Controlling nutrient inputs.
		Maintenance of conveyance channels for accumulated sediments.

8 Subdivision and Urban Water Management Plans

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

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

- Modelling of local road drainage network
- Drainage channel configuration
- Implementation of water conservation strategies
- Management and maintenance requirements
- Construction period management strategy.

These are further detailed in the following sections.

8.1 Modelling of Local Road Drainage Network

It is acknowledged that the peak flows described in previous sections, and consequently the drainage strategies documented in this LWMS, are based upon broad-scale assumptions and regional data. These assumptions are considered adequate for assessment of the land area required, however confirmation of compliance with the criteria in this LWMS should be undertaken. Modelling will allow confirmation that the detailed civil designs are consistent with this LWMS. It is anticipated that this will occur during the detailed design process and detailed within future UWMPs.

The exception to the requirement to revise the surface runoff modelling is if the catchment details and drainage channel design are consistent with the assumptions made in this LWMS. If this were the case it would be acceptable to provide design calculations for the drainage channel to demonstrate compliance with the LWMS.

8.2 Drainage Channel Configuration and Conveyance Structures

The drainage channel configuration and road pavement conveyance estimates have been based on assumptions regarding post-development finished earthwork levels, the preliminary proposed structure plan and assumptions regarding soil infiltration characteristics. These should be revised once additional information is available clarifying these inputs. It is anticipated that this would be available at the detailed design stage, and detailed in future UWMPs.

8.3 Implementation of Water Conservation Strategies

A number of potential measures to conserve water have been presented within this LWMS. These water conservation strategies should be incorporated into the design and the ongoing maintenance of all landscaped areas. Landscape design measures that will be incorporated into the water conservation strategy should be further detailed within the future UWMP. The manner in which the

developer intends to promote water conservation measures discussed in this LWMS to future lot owners should also be discussed within the future UWMP.

8.4 Management and Maintenance Requirements

The management measures to be implemented will require ongoing maintenance. It is therefore expected that the future UWMP will provide detailed management and maintenance plans that will set out maintenance actions (e.g. gross pollutant removal), timing (e.g. how often it will occur), locations (e.g. exactly where it will occur) and responsibilities (e.g. who will be responsible for carrying out the actions). Given that approval from the Shire of Roebourne and DoW will be sought for the proposed measures, it is anticipated that consultation with these agencies will be undertaken and referral to guiding policies and documents will be made in the UWMP.

8.5 Construction Period Management Strategy

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

9 Implementation

This LWMS is a key supportive document for the Tambrey Development Plan. The development of this LWMS has been undertaken with the intention of providing a structure within which subsequent development can occur consistent with a total water cycle management approach. It is also intended to provide overall guidance to the general stormwater management principles for the study area and to guide the development of the future UWMP.

9.1 Roles and Responsibility

This LWMS provides a framework that the developer can utilise to assist in establishing stormwater management methods that have been based upon site-specific investigations, are consistent with relevant State policies and have been endorsed by the Shire of Roebourne. The responsibility for working within the framework established within the LWMS rests with the developer, although it is anticipated that the future UWMP will be developed in consultation with the Shire of Roebourne and DoW as these will be the ultimate approval agencies.

The Tambrey Development Plan area will be designed and constructed by the developer, and therefore it will be developed as a single stage. It will be the responsibility of the developer to prepare detailed designs and a supportive UWMP at the appropriate time. It is also the responsibility of the developer to demonstrate that the proposed detailed civil designs and the supportive UWMP complies with the objectives and management approaches provided in this LWMS.

9.2 Funding

As the study area constitutes a single landholding, the management strategies outlined in this LWMS will be borne solely by the developer.

9.3 Review

It is not anticipated that this LWMS will be reviewed, unless additional land parcels/lots are added to the Tambrey Development Plan area prior to detailed design or the Tambrey Development Plan undergoes significant change post-lodgement. If additional areas are required to be covered by the LWMS it is most likely that an addendum to cover these areas could be prepared. If the Tambrey Development Plan is substantially modified this LWMS will need to be reviewed and the criteria reviewed to ensure that all are still appropriate.

The next stages of water management are anticipated to be detailed design. Detailed civil designs should be supported by a UWMP. The UWMP is largely an extension of the LWMS, as it should provide detail to the designs proposed within this LWMS, and will demonstrate compliance with the Criteria proposed in **Section 4** (as discussed In **Section 8**).

The developer is intending to design and construct the entire development including the built form, and as such, the responsibility to implement the measures proposed in this LWMS rest solely with the developer. This does however provide a significant opportunity to ensure that the intentions of the LWMS and the future UWMP are followed through and implemented as intended.

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FIGURES

Figure 1: Locality diagram

Figure 2: Site boundary

Figure 3: Topographical contours

Figure 4: Pre-development hydrological features

Figure 5: Stormwater management features

Figure 6: Post-development catchments

Client:
ABN Group

Project:
Tambrey LWMS

Title:
Figure 1: Locality Diagram

Metres
0 12.5 25 50 75

Legend
Site boundary

07/10/11 :Date
1:3,000@A4 :Scale
EP11-020(01)--F01 :Plan Number
RLE :Checked
DPC :Approved

emerge ASSOCIATES
Integrated Science & Design

Client:
ABN Group

Project:
Tambrey LWMS

Title:
Figure 2: Site Boundary

Metres
0 10 20 40 60

Legend
Site boundary

07/10/11 :Date
1:2,000@A4 :Scale
EP11-020(01)--F02 :Plan Number
RLE :Checked
DPC :Approved

emerge ASSOCIATES
Integrated Science & Design

Client: ABN Group

Project: Tambrey LWMS

Title: Figure 3: Topographic Contours

Metres
0 12.5 25 50

Legend
- Site boundary
- Contours

Sources

The following datasets were used in the production of this map:

Contours - Whelans (2010)

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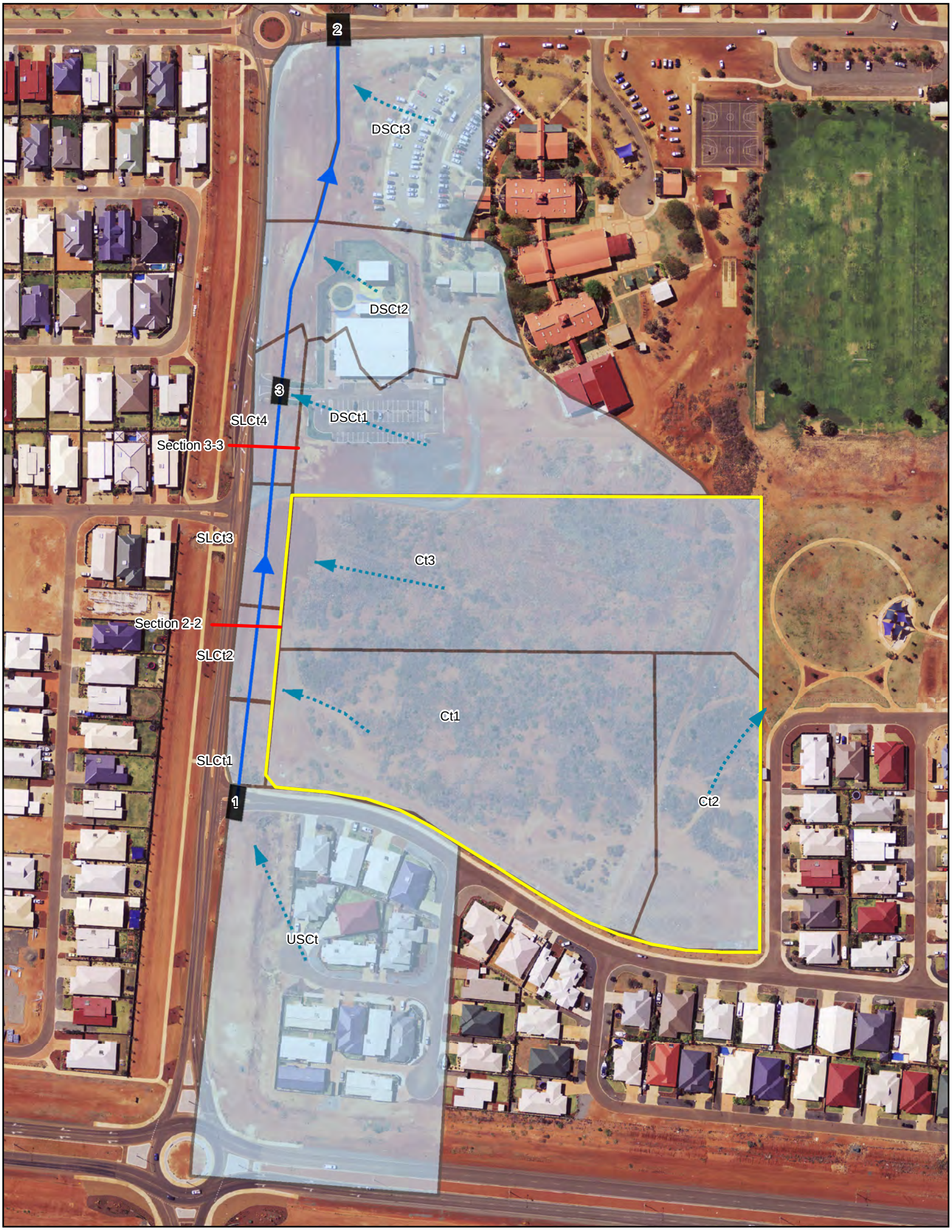
RLE :Checked
DPC :Approved

Notes: This drawing is the property of Emerge Associates and shall not be used without permission.



Client:
ABN Group

Project:
Tambrey LWMS

Title:
Figure 4: Pre-Development Hydrological Features

Metres
0 20 40 80

Legend
- Site boundary
- Culvert
- Pre-development catchments
- Existing drainage channel
- Flow path

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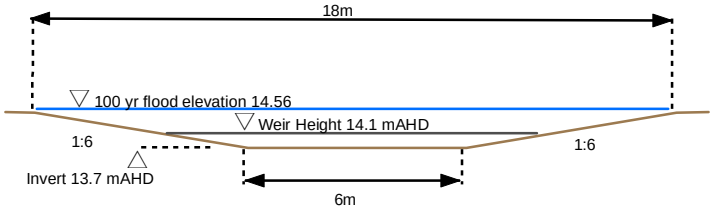
Section 2-2



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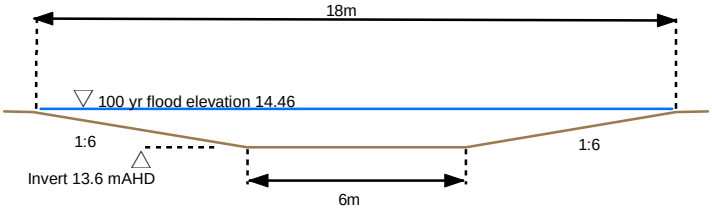
Section 3-3



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Client:
ABN Group

Project:
Tambrey LWMS

Title:
Figure 5: Stormwater Management Features

Metres
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Legend
Site boundary
Weir structure
Culvert
Catchment inflow
Drainage channel conveyance
Road pavement conveyance
Cadastre

07/10/11 :Date
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EP11-020(01)--F05 :Plan Number
RLE :Checked
DPC :Approved

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Client:
ABN Group

Project:
Tambrey LWMS

Title:
Figure 6: Post Development Catchments

Metres
0 20 40 80

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EP11-020(01)--F06 :Plan Number
RLE :Checked
DPC :Approved

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APPENDIX A

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TAMBREY DEVELOPMENT PLAN

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TAMBREY PRIMARY SCHOOL SURPLUS SITE | CONCEPTUAL SUBDIVISION DESIGN

Plan- 1:500@ A1 | June 2011

SIMON YOUNGLESON
ARCHITECTS AND URBAN DESIGNERS

APPENDIX B

HISTORICAL DESIGN DRAWINGS

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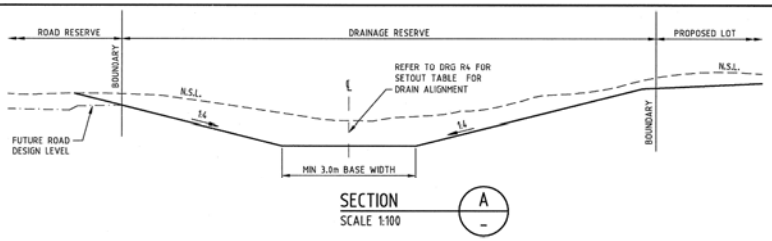
REV.	DESCRIPTION	DRN	VER'D	APPROVED
A	ORIGINAL ISSUE	-		
B	DRAIN ALIGNMENT & DESIGN AMENDED	PA	AHD	



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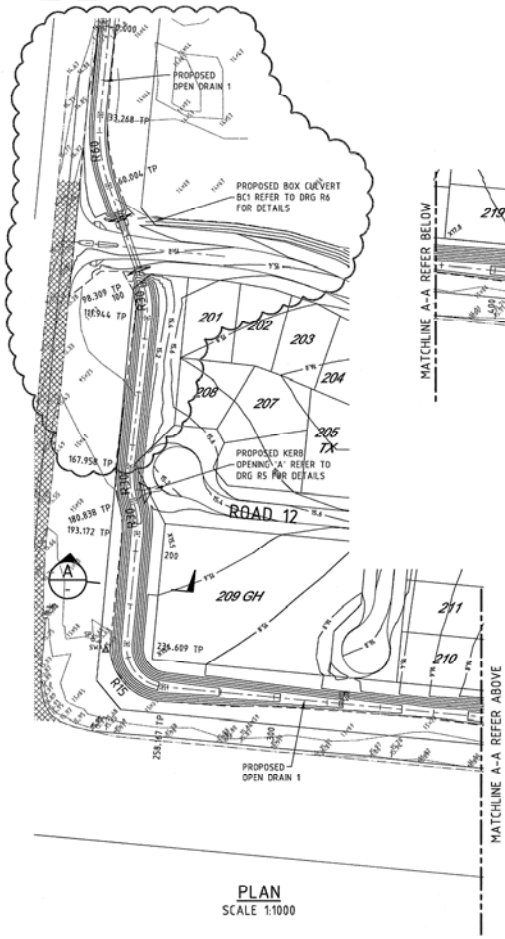
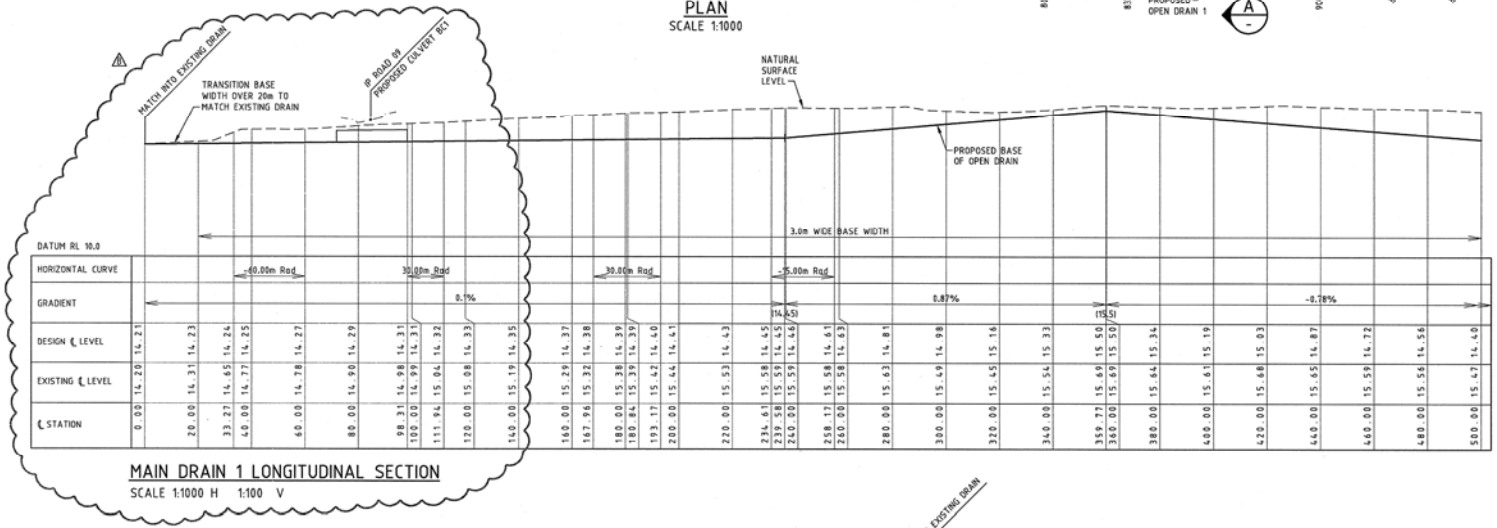


PLAN
SCALE 1:1000

PLAN
SCALE 1:1000



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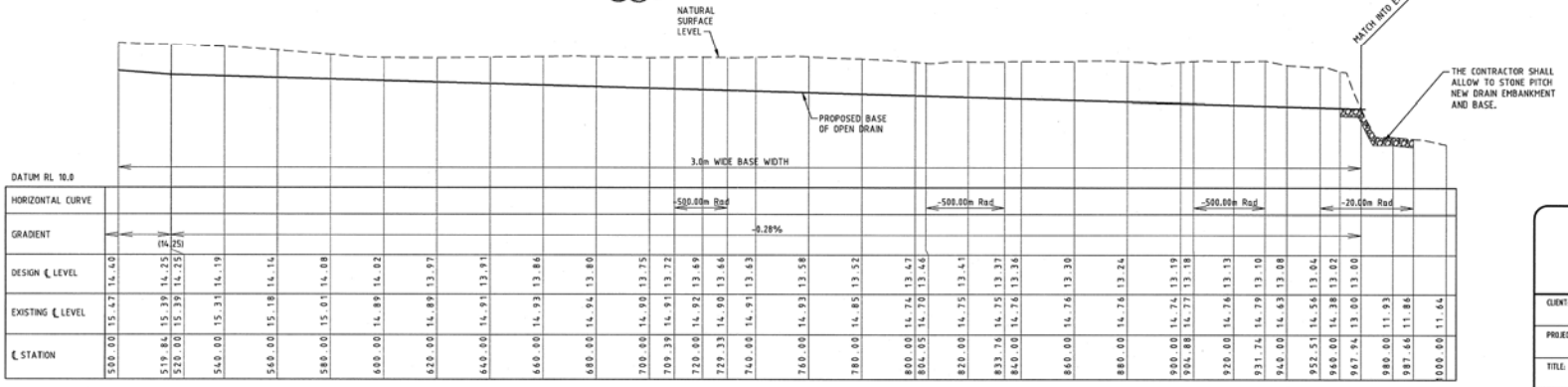

MAIN DRAIN 1 LONGITUDINAL SECTION
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NOTES

1. GENERAL
1.1. LEVELS ARE REDUCED FROM A.H.D.
1.2. THIS DRAWING SHALL BE READ IN CONJUNCTION WITH ALL 17183C-1 DRAWINGS AND THE SPECIFICATION.
1.3. THE CONTRACTOR SHALL LIMIT THE MOVEMENT OF EQUIPMENT & MANPOWER TO THE MINIMUM AREA NECESSARY AND PROTECT ALL VEGETATION ON SITE.

2. DRAINAGE
2.1. REFER TO INTERSECTION DETAILS FOR CULVERT SETOUT LOCATIONS

Wood & Grieve ENGINEERS
Wood & Grieve Pty Ltd
A.B.N. 75 988 985 652
Level 3, 3 Plain Street
East Perth W.A. 6004
Facsimile (08) 6222 2100
Telephone (08) 6222 2000
e-mail wge@wge.com.au

CLIENT:	LANDCORP				
PROJECT:	TAMBREY STAGE 1 & 2 - KARRATHA				
TITLE:	DRAINAGE PLAN - SHEET 1				
DESIGNED:	P.ALEBAKIS	VERIFIED: A.DETATA	01/12/05	WAPC No. 129292	DATUM: A.H.D.
DRAWN:	P.ALEBAKIS	APPROVED FOR TENDER: J.FABLING	01/12/05	DRAWING No.	REV.
APPROVED FOR CONSTRUCTION:			31/1/06	17183C-1/R3	B

REV.	DESCRIPTION	DRN	VER'D	APPROVED
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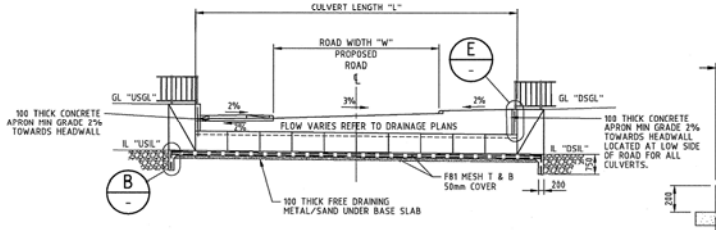

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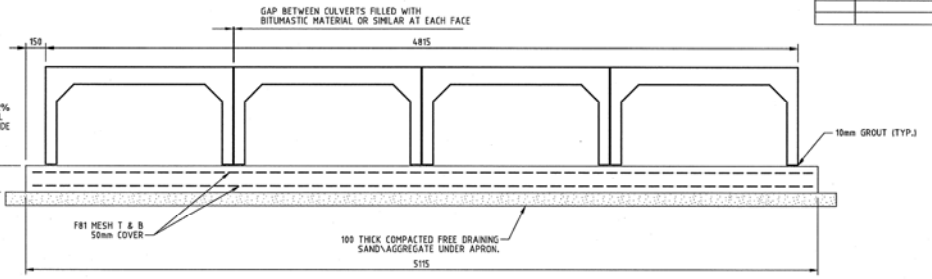

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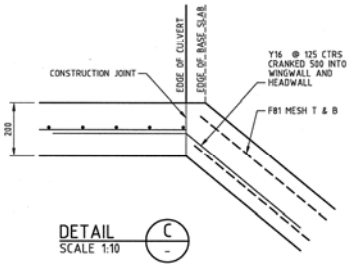

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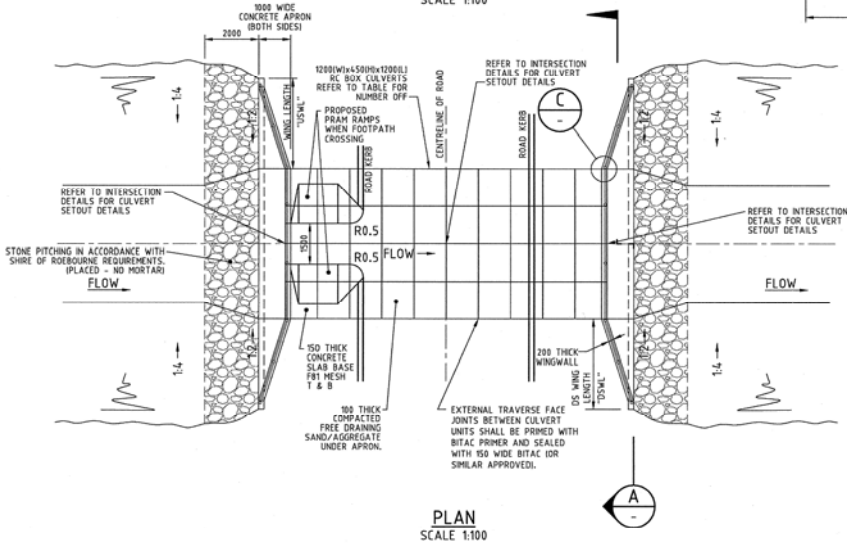

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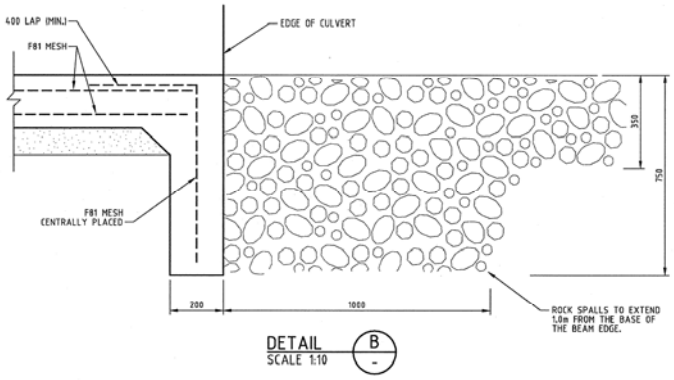

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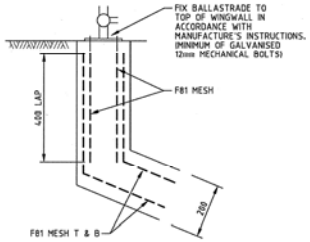

DETAIL D
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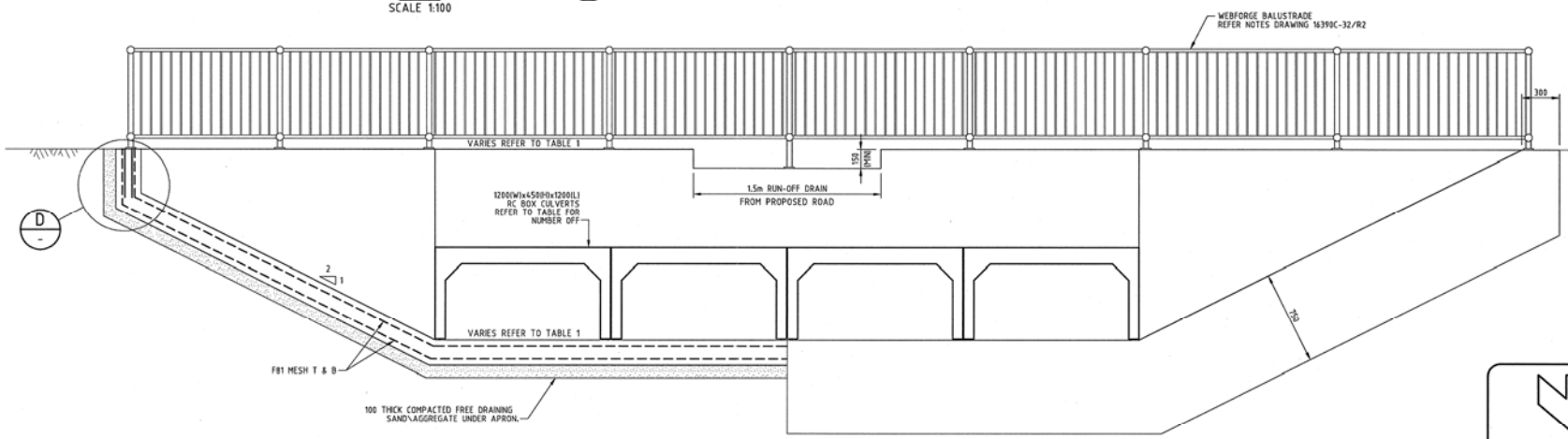
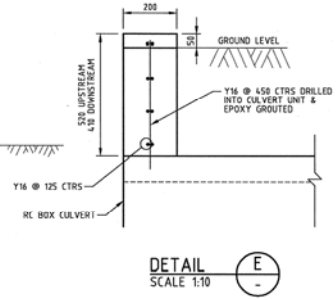


SECTION A
SCALE 1:20



DETAIL E
SCALE 1:10

TABLE 1 - CULVERT DETAILS

CULVERT REFERENCE	UPSTREAM I.L. "USIL"	UPSTREAM G.L. "USGL"	WING LENGTH U.S. "USWL"	DOWNSTREAM I.L. "DSIL"	DOWNSTREAM G.L. "DSGL"	WING LENGTH D.S. "DSWL"	CULVERT LENGTH "L"	ROAD WIDTH "W"	NUMBER OF BARRELS	NUMBER OF CULVERTS
BC1	14.32	15.32	2000	14.27	15.27	2000	19275	9794	2	32
BC2	11.20	12.20	2000	11.12	12.42	2600	22890	11300	3	57

A

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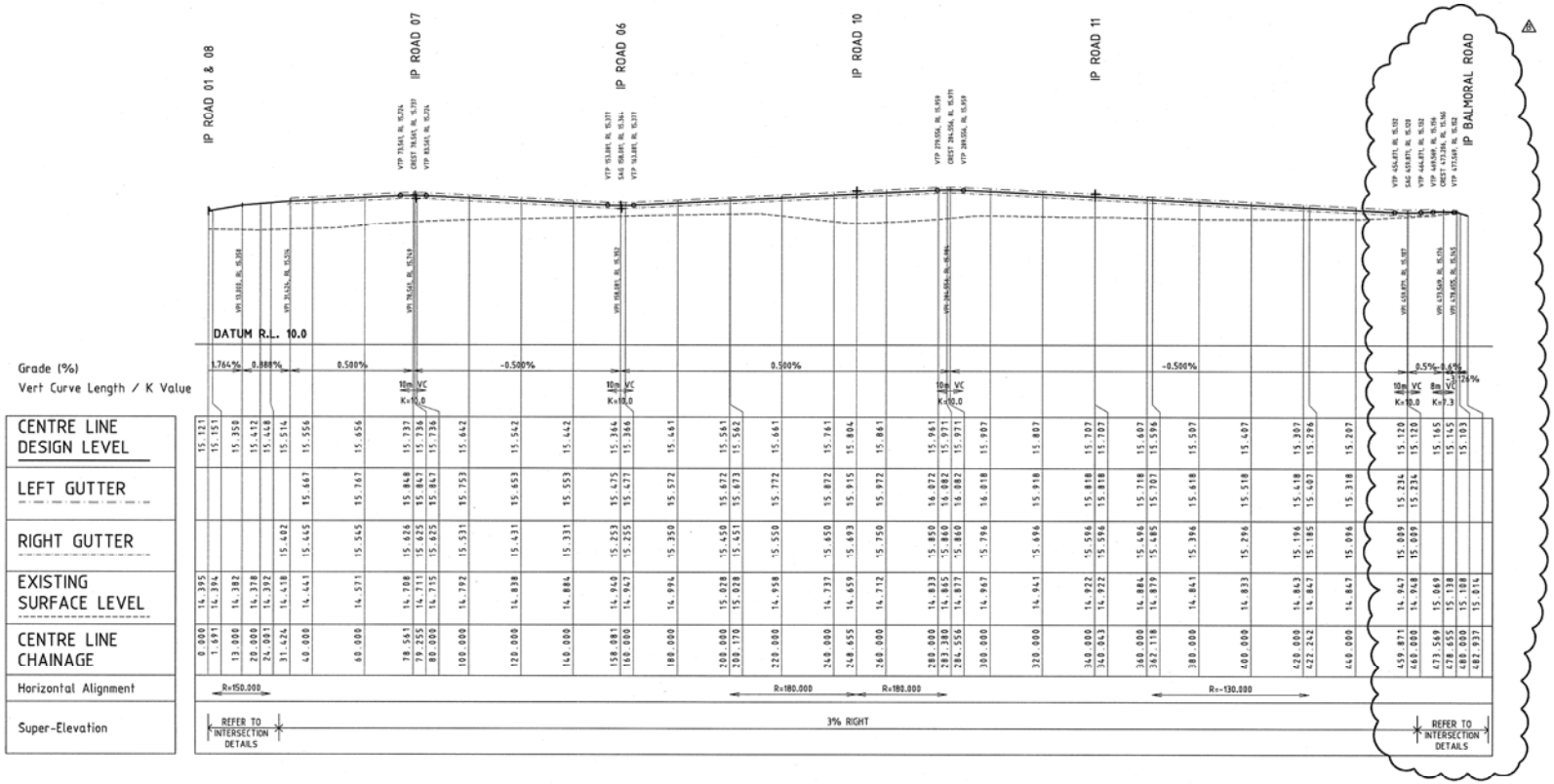
Quality Endorsed Company AS 9001

CLIENT:	LANDCORP				
PROJECT:	TAMBREY STAGE 1 & 2 - KARRATHA				
TITLE:	STORMWATER DRAINAGE BOX CULVERT DETAILS				
DESIGNED:	J.FABLING	VERIFIED: A.DETATA	01/12/05	WAPC No. 129292	DATUM: A.H.D.
DRAWN:	P.ALEBAKIS	APPROVED FOR TENDER: J.FABLING	01/12/05	DRAWING No. 17183C-1/ R6	REV. B
APPROVED FOR CONSTRUCTION:			31/1/06		

SCALE BAR 10mm @ ORIGINAL SHEET SIZE A1

REV.	DESCRIPTION	DRN	VER'D	APPROVED
A	ORIGINAL ISSUE	-	-	-
B	ROAD 09 DESIGN AMENDED	PA	AHD	31/1/06



LONGITUDINAL SECTION - ROAD 09

7.4m PAVEMENT

SCALE HORIZ 1:1000 metres

VERT 1:100 metres

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CLIENT:	LANDCORP				
PROJECT:	TAMBREY STAGE 1 & 2 - KARRATHA				
TITLE:	ROAD LONGITUDINAL SECTIONS - SHEET 7 OF 8				
DESIGNED:	P.ALEBAKIS	VERIFIED:	A.DETATA 01/12/05	WAPC No: 129292	DATUM: A.H.D.
DRAWN:	M.HARDMAN	APPROVED FOR TENDER:	J.FABLING 01/12/05	DRAWING No.	REV.
APPROVED FOR CONSTRUCTION:			31/1/06	17183C-1/ R13	B

APPENDIX C

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HYDRAULIC AND HYDROLOGIC MODELLING PARAMETERS

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EP11-020 Tambrey Modelling Assumptions

For the calculation of the surface water runoff at Tambrey School Surplus Site, XPStorm hydrologic and hydraulic modelling software was used. The hydrologic component of the software uses the Laurenson non-linear runoff-routing method to simulate runoff from design storm events. The Laurenson runoff-routing method assumes that runoff is proportional to slope, area, infiltration and percentage of imperviousness of a catchment. Sub-catchment areas and slopes are determined from surveyed topographical data and the project team. The infiltration rates and percentage imperviousness have been assumed based on experience with model preparation with similar soil conditions. The runoff from each sub-catchment is routed through the catchment using the hydraulic component of XPStorm.

An “initial loss - continuing loss” infiltration model was adopted for the pre-development, with loss values chosen based on regional soil types and field validation of these. The post-development model used "initial loss - continuing loss" infiltration parameters that were influenced by the existing loss rates used in the pre-development environment. The loss parameters for the pre and post-development models are shown in **Table 1.**

Table 1 Pre- and Post-development parameters

Land type	Initial Loss (mm)	Continuing Loss	Roughness
Pre-development			
Whole site	17.0	2.0	0.05
Post-development			
Roof and paved areas	3.0	0.1	0.02
Lot Garden	20.0	3.0	0.05
Road Surface	2.0	0.1	0.014
Road verges	17.0	2.0	0.05

Pre-development catchment areas were measured from surveyed topographical contours for the study area, and from publicly available contours for the upstream catchment (obtained from Landgate). The catchment areas and assumptions regarding them are shown in **Table 2**.

Table 2 Pre-development catchment areas

Sub-catchments	Total Area (sub-catchment) (ha)	Slope
DSCt1	1.3080	0.0040
DSCt2	0.8840	0.0030
DSCt3	0.3350	0.0030
Ct1	2.2280	0.0050
Ct2	0.9180	0.0050
Ct3	2.1610	0.0030
SLCt1	0.0960	0.0020
SLCt2	0.1230	0.0020
SLCt3	0.1510	0.0030
SLCt4	0.2000	0.0020
USCt1	2.6250	0.0010
Total	**11.0290**	

The post-development catchment areas were assumed to be consistent with the pre-development environment. Land types within the catchments were guided by the Tambrey Development Plan. The summary of post-development catchment information is shown in **Table 3**.

Table 3 Post Development Catchment Data

Post dev Catchment	Total Area (ha)	Lot paved (ha)	Lot Garden (ha)	Road Surface (ha	Road Verge (ha)	Slope
DSCt1	1.3080					0.0040
DSCt2	0.8840					0.0030
DSCt3	0.3350					0.0030
SLCt1	0.0960					0.0020
SLCt2	0.1230					0.0020
SLCt3	0.1510					0.0030
SLCt4	0.2000					0.0020
USCt1	2.6250					0.0010
CTL1	0.8492	0.6369	0.2123			0.0027
CTL2	0.7234	0.5426	0.1809			0.0029
CTL3	0.4187	0.3140	0.1047			0.0040
CTL4	0.3180	0.2385	0.0795			0.0033
CTL5	0.3085	0.2314	0.0771			0.0010
CTL6	0.3210	0.2408	0.0803			0.0010
CTL7	0.2245	0.1684	0.0561			0.0010
CTL8	0.2246	0.1685	0.0562			0.0010
CTL9	0.1827	0.1370	0.0457			0.0010
CTR1	0.2078			0.1559	0.0520	0.0027
CTR2	0.1566			0.1175	0.0392	0.0029
CTR3	0.0942			0.0707	0.0236	0.0060
CTR4	0.1766			0.1325	0.0442	0.0020
CTR5	0.0900			0.0675	0.0225	0.0010
CTR6	0.1170			0.0878	0.0293	0.0010
CTR7	0.0482			0.0362	0.0121	0.0010
CTR8	0.1820			0.1365	0.0455	0.0010
CTR9	0.0384			0.0288	0.0096	0.0010
CTER1	0.1208			0.0906	0.0302	0.0040
CTER2	0.4936			0.3702	0.1234	0.0016
Total	**11.0178**	**2.6780**	**0.8927**	**1.2939**	**0.4313**	

The infiltration rates used were predominantly based upon the following assumptions:

- There will be no infiltration on roads, pavements and driveways. There will however be some minor absorption storage loss.
- Landscaped areas will likely contain dense vegetation of turf over a sand base. This turfed area will become compacted over time and reduce initial infiltration rates. It is anticipated that the

initial loss and continuing loss will be generally consistent with the pre-development infiltration characteristics.

- Culverts have been modelled as 2no. 1200 x 450 mm box culverts at each location.

APPENDIX D

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EARTHWORKS PLAN

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NOTES

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1.4. EXISTING LEVELS & CONTOURS INDICATED ARE REFLECTIVE OF THE BULK EARTHWORKS DESIGN.

LEGEND

- 10.20 — EXISTING SPOT LEVELS
- 10.0 — EXISTING CONTOURS
- 15.4 — DESIGN PAD LEVEL
- (15.3) — PROPOSED ROAD DESIGN LEVEL
- EXTENT OF EARTHWORKS BOUNDARY

REV.	DESCRIPTION	DRAWN	VER	APPROVED
0	ORIGINAL ISSUE			

CELEBRATING 50 YEARS
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GOLD COAST
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SHENZHEN

CLIENT:
ABN GROUP

PROJECT:
TAMBREY SCHOOL SITE - KARRATHA

TITLE:
CONCEPT EARTHWORKS PLAN

PRELIMINARY

SECTION: CIVIL SERVICES	VERIFIED :	SCALE : A1 @ 1:1000
DESIGNED : MDI	APPROVED FOR TENDER:	DATUM : A.H.D.
DRAWN : TEG	APPROVED FOR CONSTRUCTION :	WAPC : -

PROJECT No.	DRAWING No.	REVISION
23054-PER-C	E1	0

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A1 @ 1:1000
A3 @ 1:2000

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RPS

APPENDIX 6

Engineering Services Report (Wood & Grieve Engineers)

CELEBRATING 50 YEARS
WOOD & GRIEVE ENGINEERS

ENQUIRIES: MICHAEL DEL BORRELLO
PROJECT NO: 23054-PER-C

29 August 2011

Chenin Grove Pty Ltd c/- ABN Group
3rd Floor Optima Building. 133 Hasler Road
OSBORNE PARK WA 6017

Attention: Mr Mitch Whalan

Dear Mitch

RE: TAMBREY, KARRATHA
ENGINEERING SERVICING REPORT

The following Engineering Servicing Report is a preliminary outline of Civil infrastructure required to service the development of 82 lots over the surplus school site (Lot 504), Tambrey. Refer Simon Youngleson's Conceptual Subdivisional Plan attached.

Earthworks & Retaining Walls

Importation of fill and minor onsite cut to fill will be required to create generally flat lots that provide adequate clearance to proposed lot levels and overland stormwater flood routing in accordance with Shire of Roebourne's requirements. The natural surface level of the site falls 1m from Bowerbird Drive to the northern boundary with the school site. WGE's Concept Earthworks Plan (attached) indicates proposed finished surface levels. No retaining walls are proposed for this development.

Douglas Partners have recently undertaken an investigation of subsurface conditions across the site. Onsite test pitting discovered Gilgai (highly reactive clay) soils in the north western and south eastern corners of the site. Proof rolling during construction will confirm any further deposits exist across the site, or between testpits. Gilgai soils may be excavated and treated onsite, or more likely removed from site.

The site will generally achieve a site classification of M-D. That being, moderately (M) reactive clay or silts with deep seated (D) movement, when experiencing varied moisture content. This classification is not unlike the geotechnical makeup to most developments in the Karratha area and is in accordance with AS2870-1996 Residential Slabs and Footings.

Excavation of shallow services included common trench services shall be undertaken by 30 tonne excavator. The construction of sewer mains deeper than the underlying natural bedrock layer may require rock breaking.

Douglas Partners Geotechnical Investigation provides further technical background on subsurface conditions.

Stormwater Drainage

The drainage system proposed for this site is typical of that found in Karratha, consisting of overland flow paths discharging into open channel drains.

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Wood & Grieve Engineers Limited ACN 008 808 786 trading as Wood & Grieve Engineers ABN 97 137 999 609
Perth Melbourne Sydney Brisbane Gold Coast Albany Busselton Shenzhen

No onsite stormwater attenuation is considered given the low infiltration rates of existing subsurface materials and the extreme rainfall intensities of the region. Conveyance of all stormwater up to the 1 in 100 year ARI event will be by overland flow within kerbed roads and laneways. Flows will discharge into the existing channel drain within Balmoral Road via kerb opening structures and appropriately sized culverts.

This development will be split into two drainage sub-catchments in general accord with the pre-development grade of the site. Two drainage discharge locations have been determined to efficiently and effectively convey overland flows to Balmoral Road.

Water Reticulation

The Water Corporation have advised that water supply to this development won't be available until the upgrade of the West Pilbara Water Supply Scheme is complete. The timing of this upgrade can not be confirmed at this time. We hope that as this development proceeds through to the construction stage, the new water supply scheme with be advanced enough to allow this development to draw potable water from the existing system.

Existing Water Corporation water infrastructure surrounds the proposed development. Water connections within Bowerbird Drive and Balmoral Road will be likely.

Our assumptions remain subject to formal review by the Water Corporation and timing of this project.

Sewer Reticulation

We envisage the existing sewerage system has adequate capacity to service the proposed development, however the Water Corporation are unable to confirm until the provision of a potable water service is determined.

Existing Water Corporation sewerage infrastructure surrounds the proposed development. The majority of the development will be serviced via two sewer connections within Balmoral Road. A hand full of lots will be serviced from infrastructure within Flannelbush Turn. No offsite sewer extensions will not be required.

Our assumptions remain subject to formal review by the Water Corporation and timing of this project.

Roadworks & Footpaths

Road pavement design and construction would be in accordance with the City of Roebourne's minimum design standards and recommendations made by Douglas Partner's Geotechnical Investigation. All roadways would be designed to accommodate the 100yr stormwater design flow, including the laneways.

Roadworks design would allow for kerbed red asphalt pavements for roads and laneways. Brickpaved intersection thresholds and parallel carparking embayments have been proposed adjacent cottage lots and appropriate locations throughout the development.

Two trafficable links to Bowerbird Drive have been proposed as well as new roundabout to access the development from Balmoral Road, at the existing intersection of Brolga Meander.

A 2.5m wide dual use path is proposed along the northern boundary of the development to cater for the influence of the neighbouring school site and cycling links through the adjacent POS. Concrete footpaths are proposed on both sides of all proposed access roads.

Road and footpath configuration and specification remains subject to detailed design and formal approval by the Shire of Roebourne.

Underground Power

Supply of underground power and streetlighting to the site will come from connection to existing infrastructure surrounding the site. Timing of access will be subject to the implementation of the Karratha 22kV power upgrade as part of the Pilbara Underground Power Project. These works have commenced and we envisage the upgraded system will be available at time of construction.

Telecommunications

The recently announced National Broadband Network (NBN) policy will likely be implemented on this development. However, confirmation can not be received until formal application is made and conditions of an agreement between NBN and the Developer are negotiated. Although the NBN policy framework has been released, many developments slightly below the 100 lot threshold may nonetheless be subjected to the requirements of NBN, on a case by case basis. At this time no clear answer could be sort from NBN.

Design and Approvals

These notional servicing concepts remain subject to local and other authority requirements and conditions, Client preference and detailed design.

General

This Engineering Servicing Report has been undertaken for the benefit of an associated Structure Plan Report. If this document is used for purposes other than this without our knowledge, we do not accept responsibility for any claims or actions which may arise as a result.

Please ensure this letter is always accompanied by the attached conceptual subdivision plan.

If you have any queries, please do not hesitate to contact the undersigned.

Yours faithfully

M. Del Borello

Michael Del Borrello (WGE)
for Wood & Grieve Engineers

Encl (Concept Subdivisional Plan, Concept Earthworks Plan)

DOCUMENT: M:\TECH\23000\54\C_TAMBREY SERVICING REPORT_001.DOCX (MJD)

NOTES

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LEGEND

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- EXISTING CONTOURS
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- EXTENT OF EARTHWORKS BOUNDARY

REV.	DESCRIPTION	DRAWN	VER.	APPROVED
0	ORIGINAL ISSUE			

CELEBRATING 50 YEARS

CLIENT: ABN GROUP

PROJECT: TAMBREY SCHOOL SITE - KARRATHA

TITLE: CONCEPT EARTHWORKS PLAN

PRELIMINARY

SECTION: CIVIL SERVICES	VERIFIED:	SCALE: A1 @ 1:500
DESIGNED: MDI	APPROVED FOR TENDER:	DATUM: A.H.D.
DRAWN: TE/S	APPROVED FOR CONSTRUCTION:	WAPC: -

PROJECT No.	DRAWING No.	REVISION
23054-PER-C	E1	0

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TAMBREY PRIMARY SCHOOL SURPLUS SITE | CONCEPTUAL SUBDIVISION DESIGN

Plan- 1:500@ A1 | June 2011

SIMON YOUNGLESON

RPS

APPENDIX 7

Geotechnical Report (Douglas Partners)

Douglas Partners
Geotechnics / Environment / Groundwater

Integrated Practical Solutions

Report on
Geotechnical Investigation

Proposed Residential Development
Lot 504 corner Balmoral Road and Bowerbird Drive
Karratha, WA

Prepared for
Chenin Grove Pty Ltd

Project 76195
July 2011

Douglas Partners
Geotechnics / Environment / Groundwater

Document History

Document details

Project No.	76195	Document No.	1
Document title	Report on Geotechnical Investigation Proposed Residential Development		
Site address	Lot 504 corner Balmoral Road and Bowerbird Drive, Karratha		
Report prepared for	Chenin Grove Pty Ltd		
File name	P:\76195 Lot 504 Balmoral St, Karratha\Docs\76195 Report on Geotechnical Investigation, Lot 504 cnr Balmoral Road and Bowerbird Drive, Karratha.doc		

Document status and review

Revision	Prepared by	Reviewed by	Date issued
0	D. Reaveley	T. Wiesner	7 July 2011

Distribution of copies

Revision	Electronic	Paper	Issued to
0	1	1	Haylee Shaw (ABN Group)

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

	Signature	Date
Author		8-7-2011
Reviewer		8 July 2011

NCS INTERNATIONAL CERTIFIED QUALITY MANAGEMENT SYSTEM

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   - 7.6 Pavement Design 8
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Appendix A:	About this Report
	Site Plan and Test Locations
	Results of Field Work
Appendix B	Geotechnical Laboratory Testing
Appendix C	CSIRO Notes on Foundation Maintenance and Footing Performance

Report on Geotechnical Investigation
Proposed Residential Development
Lot 504 corner Balmoral Road and Bowerbird Drive, Karratha

1. Introduction

This report presents the results of a geotechnical investigation undertaken for a proposed residential development located at Lot 504 corner Balmoral Road and Bowerbird Drive in Karratha, Western Australia. The work was commissioned in a service agreement dated 15 April 2010 by Mr Luke May of ABN Group on behalf of Chenin Grove Pty Ltd and was undertaken in accordance with Douglas Partners' proposal dated 13 April 2011.

The aim of the investigation was to assess the sub-surface soil and groundwater conditions across the site and thus:

- Determine the suitability of the site for the proposed development, including identifying the presence and extent of Gilgai soils, if encountered.
- Provide an appropriate site classification(s) in accordance with the requirements of AS 2870-2011.
- Provide recommendations on site preparation and compaction.
- Provide design parameters for earth retaining structures.
- Provide parameters for pavement design, including a suitable California bearing ratio (CBR) for likely subgrade materials.
- Provide a pavement design for the proposed roads within the development in accordance with the Shire of Roebourne requirements and comment on the requirements for subsoil drainage.
- Assess the groundwater levels and perched water table levels beneath the site at the time of the field work, if encountered.

The investigation included the excavation of fourteen test pits and laboratory testing of selected samples. The details of the field work are presented in this report, together with comments and recommendations on the issues listed above.

2. Site Description

The site is identified as Lot 504 corner Balmoral Road and Bowerbird in Karratha, WA and comprises an irregular shaped area of land covering approximately 5.30 ha. The site is bounded by Balmoral Road to the west, Bowerbird Drive to the south, Flannelbush Turn and a public open space to the east and Tambrey Primary School to the north (refer to Drawing 1, Appendix B).

At the time of the field work, the site was vacant and covered with high grass and some patches of thick bush. The ground, were exposed, consisted of red-brown gravelly silty clay.

Typical gilgai soil topography was observed in the south-eastern and north-western corners of the site, featured by small hummocks and hollows with alternating patches of unvegetated areas and vegetated areas. Gilgai soils are typically associated with highly reactive clayey materials. The shrinking and swelling of the highly reactive soil forms the hummocks and hollows. Large cracks and 'crab holes' can occur as a result of the ground movement. Cracks up to 70 mm in width were observed at this site, as shown in Figure 1 below. Areas where gilgai soils have been observed are shown on Drawing 1.

Figure 1: Cracks and 'crab holes' observed in the south-eastern part of the site

Survey data provided by ABN Group indicates that the site is generally flat with surface levels ranging from approximately RL 14.3 (relative to Australian Height Datum [m AHD]) to RL 15.2.

The 1:50 000 Nickol Bay Geological map indicates that the shallow sub surface conditions beneath the site are likely to comprise red-brown silty sand.

3. Field Work Methods

Field work was carried out on 5 and 6 May 2011 and comprised the excavation of fourteen test pits with a dynamic cone penetrometer (DCP) test adjacent to each test pit.

The test pits (TP1 to TP14) were excavated to a maximum depth of 3.3 m, using a backhoe equipped with a 600 mm wide bucket, and were logged in general accordance with test procedure AS 1726-1993 by a suitably experienced representative from Douglas Partners. Representative soil samples were recovered from selected locations for subsequent laboratory testing.

DCP tests were carried out in accordance with AS 1289.6.3.2 to assess the density of the shallow soils.

Test locations were determined using hand held GPS and are shown on Drawing 1. Surface elevations at each test location were interpolated from a survey provided by ABN Group and are quoted in metres above Australian Height Datum (AHD).

4. Field Work Results

4.1 Ground Conditions

Detailed test pit logs of the ground conditions are presented in Appendix B, together with notes defining descriptive terms and classification methods used.

The ground conditions across the site generally consist of gravelly, sandy and clayey materials overlying weathered granitic bedrock.

A summary of the ground conditions encountered is given below, generally increasing in depth order:

- **Topsoil** – red-brown silty sand and silty clay topsoil to depths of between 0.05 m and 0.20 m.
- **Silty Sand/Clayey Silt**– generally medium dense/stiff to very stiff, red-brown silty sand with variable sand, silt and clay fractions to depths ranging from 0.15 m to 0.8 m.
- **Silty Clay/Sandy Clay/Clayey Sand –** stiff to hard, red-brown, clay and sandy clay from depths ranging between 0.1 m and 0.3 m and extending to depths ranging from 1.3 m and 1.6 m.
- **Sandy Gravel/Gravel/Clayey Gravel** – dense to very dense, red-brown and red-brown mottled off-white gravel with variable clay and sand fraction from depths ranging between 0.1 m and 1.6 m and extending to depths ranging from 1.4 m and 3.3 m.
- **Weathered Granite** – extremely low strength, extremely weathered granite excavated as gravel and sand with variable content of silt and clay, to test pit termination depths between 1.9 m and 3.3 m. Test pits were generally terminated due to machine refusal or slow digging within weathered granite.

4.2 Groundwater

No free groundwater was observed within any of the test pits excavated to depths of up to 3.3 m below surface level (RL 11.5 at TP9) on 5 and 6 May 2011.

The test pits were immediately backfilled following the investigation which precluded longer-term monitoring of groundwater levels.

5. Laboratory Testing

A geotechnical laboratory testing programme was carried out by a NATA registered laboratory on selected samples recovered from the test pits and comprised the determination of:

- The total soluble salt content and electrical conductivity of five samples.
- The particle size distribution of six samples.
- The Atterberg limits and linear shrinkage of three samples.
- The shrink-swell index on four samples.
- The Modified Maximum Dry Density (MMDD) of two samples.
- The four-day soaked California bearing ratio (CBR) of two samples.

The detailed test report sheets are given in Appendix B and the results are summarised in Table 1 and Table 2 (following page).

Table 1: Summary of Salinity Testing

Test	Depth (m)	Material	Conductivity (µS/cm)	Total Soluble Salts (mg/kg)
TP3	0.4	Clayey Gravel / Gravelly Clay	99	340
TP5	0.8	Gravelly Sandy Clay	68	230
TP9	0.4	Clayey Sand / Sandy Clay	47	160
TP10	0.9	Sandy Gravel	170	580
TP12	0.4	Clay	240	820

Table 2: Results of Laboratory Testing

Pit	Depth (m)	Fines (%)	d_{10} (mm)	d_{60} (mm)	LL (%)	PL (%)	PI	LS (%)	Iss (%)	OMC (%)	MMDD (t/m^3)	CBR (%)	Material
TP1	0.7	36	<0.0135	1.90	-	-	-	-	-	-	-	-	Sandy Clayey Gravel
TP2	0.3-0.6	-	-	-	-	-	-	-	0.9	-	-	-	Sandy Clay
TP3	0.3-0.6	-	-	-	-	-	-	-	1.3	-	-	-	Sandy Clay
TP3	0.4	58	<0.0135	0.09	-	-	-	-	-	-	-	-	Sandy Clay
TP5	0.8	47	<0.0135	0.60	28	17	11	4.0	-	-	-	-	Gravelly Sandy Clay
TP6	0.3-0.6	-	-	-	-	-	-	-	0.8	-	-	-	Clayey Gravel
TP9	0.4	43	<0.0135	0.25	38	16	22	9.0	-	9.4	2.21	4.5	Clayey Sand/ Sandy Clay
TP10	0.9	24	<0.0135	6.00	-	-	-	-	-	-	-	-	Sandy Gravel
TP12	0.4	80	<0.0135	<0.0135	61	23	38	14.5	-	16.9	1.81	1.5	Silty Clay
TP12	0.4-0.65	-	-	-	-	-	-	-	2.6	-	-	-	Silty Clay

Notes on Table 3:

-The % fines is the amount of particles smaller than 75 µm;

-A d_{10} of 0.17 mm means that 10% of the sample particles are finer than 0.17 mm;

-A d_{60} of 0.23 mm means that 60% of the sample particles are finer than 0.23 mm.

- LL: liquid limit
- PL: plastic limit
- PI: plasticity Index
- LS: linear shrinkage
- Iss: shrink-swell index
- MMDD: modified maximum dry density
- CBR: California Bearing Ratio
- OMC: optimum moisture content
- '-' means 'Not Tested'

6. Proposed Development

It is understood that the proposed development consists of the construction of a residential subdivision comprising 80 new lots together with public open space and associated pavements.

7. Comments

7.1 Site Classification

Current classification of the site in accordance with AS 2870-2011 was determined using the results of the field work and subsequent laboratory testing. Both an in-house computer program, REACTIVE, and the method presented in Kay (1990), were used to calculate the characteristic free surface movement (ys) for the site, based on procedures outlined in AS 2870-2011, a depth of suction depth of 4.0 m, the typical soil profiles revealed in the test pits and the results of laboratory testing.

The results of this assessment indicate that the test locations should be classified as either 'Class H1-D', 'Class M-D' or 'Class S' as detailed below in Table 3. The Karratha area is considered to be in a climatic zone where deep-seated movement, noted D, is anticipated. This should be taken into account for footing design.

Table 3: Site Classification at Test Locations

Test Location	Site Classification
TP1	M-D
TP2	M-D
TP3	H1-D
TP4	M-D
TP5	S
TP6	M-D
TP7	M-D
TP8	M-D
TP9	M-D
TP10	M-D
TP11	S
TP12	H1-D
TP13	S
TP14	M-D

7.2 Excavation Conditions and Rock

Weathered bedrock was encountered across the site. The rock was encountered as extremely low strength, extremely weathered rock, however the strength of the rock increased significantly with depth, and test pit refusal at depths ranging between 1.9 m and 3.3 m with backhoe was encountered across the majority of the site.

Based on the results of the investigation it is suggested that the soil and shallow rock should be readily excavatable for shallow service trenches and other small scale excavations with the use of conventional excavating equipment such as powerful excavators (minimum 30 tonne). It is considered that the use of rock breakers may be required in area where deep excavations into the bedrock are required. In this instance, excavation rates are likely to be slow.

7.3 Site Preparation

Prior to excavation of foundations, construction of roads and/or placement of fill, all deleterious material including topsoil and vegetation should be stripped from building envelopes and pavement areas and removed from site or reused for landscaping purposes, if applicable.

As noted in Section 2, gilgai soil was observed within two areas of the site (in the vicinity of TP3 and TP12, Refer to Drawing 1), and may possibly exist elsewhere on site. Owing to the presence of low density reactive soils within these areas, it is recommended that the subgrade beneath the proposed building envelopes and pavements be prepared as follows:

- excavation of the top 0.5 m of natural soil within the gilgai areas.
- replacement of the excavated soil in layers of loose lift thickness of less than 200 mm and conditioned to achieve a moisture content of up to 2% wetter than optimum (OMC) and compacted to target a dry density ratio of 98% relative to standard compaction.

Over compaction of reactive material should be avoided in order to minimise the risk of post construction movement from reactive clayey soils.

Across the remainder of the site it is recommended that the ground surface beneath building envelopes and pavement area be compacted to target a dry density ratio of 98% relative to standard compaction. The use of heavy non vibrating equipment is recommended on clayey ground. Care should be taken not to run heavy plant immediately adjacent to existing structures and services.

If the site is proposed to be filled, then imported filling could comprise material with no more than 5% per weight of particle less than 75 microns and no material with a nominal size greater than 150 mm. The filling should be placed within 2% of its optimum moisture content, in layers not exceeding 300 mm and compacted with a large roller to achieve a dry density ratio of not less than 98% relative to standard compaction. It is understood that sand material, as described above, may be of limited availability within Karratha, other materials could be suitable following approval by a geotechnical engineer.

As noted in Section 7.1, the clayey materials beneath the site are reactive to changes in soil moisture content. To avoid post construction swelling and shrinking, it is recommended that excessive drying and wetting of the exposed clayey materials be minimised. Excessive wetting of the base of the foundation excavations would also lead to softening of the foundation materials. Drying could be avoided by minimising the amount of time during which the base of the excavation is exposed and wetting could be avoided by adopting the drainage measures as outlined in Section 7.7.

It is recommended that earthworks be carried out during the dry period of the year in order to ease the handling, placement and compaction of the clayey materials.

Compaction control for clayey materials be carried out using a nuclear surface moisture-density gauge, in accordance with AS1289.5.8.1.

7.4 Earthworks Shrinkage Factors

It is estimated that clayey materials encountered within the site may have an earthworks shrinkage factor of approximately 0.9.

7.5 Earth Retaining Structures

Design of temporary and permanent retaining structures can be based on a bulk unit weight for the retained material of 20 kN/m^2 and an active earth pressure coefficient Ka of 0.33 in sand and Ka of 0.41 in clay assuming level backfill and adequate drainage. In addition to the soil pressure, wall design should also allow for external loads such as buildings and live loads.

7.6 Pavement Design

Laboratory testing results detailed in Section 5 indicate CBR values of 1.5% and 4.5% for soaked samples compacted to achieve a dry density ratio of not less than 95% relative to modified compaction and tested under a confining surcharge of 4.5 kg for silty clay and sandy clay subgrade.

Based on observations made in the field, the available laboratory testing results and the variability in ground conditions over the site, a subgrade CBR design value of 2% is recommended for gilgai soil areas and 4% for the remainder of the site for the design of pavement, provided the subgrade is compacted to achieve a dry density ratio of not less than 95% relative to modified compaction and suitably drained.

As recommended in Section 7.3, the subgrade beneath the proposed pavements in gilgai areas should be prepared as follows:

- excavation of the top 0.5 m of natural soil.
- replacement of the excavated soil in layers of loose lift thickness of less than 200 mm and conditioned to achieve a moisture content of up to 2% wetter than optimum (OMC) and compacted to target a dry density ratio of 98% relative to standard compaction.

The Shire of Roebourne require pavements within their jurisdiction to be designed in accordance with Austroads Guidelines where ground conditions are different to well drained sand soils. In accordance with Austroads 'Guide to Pavement Technology, Part 2: Pavement Structural Design' (2010) a design traffic load of 1x 10^5 ESAs, has been assumed for pavement thickness design.

The minimum standard pavement profile, as based on the Shire of Roebourne requirements is deemed suitable for this site. The profile consists of:

- Subgrade compacted to 98% relative to standard compaction (or that specified by the authority) to a minimum depth of 150 mm below the sub-grade surface.

- Sub base of a minimum 200 mm layer of local crusher dust material compacted to 95% relative to modified compaction (400 mm minimum in gilgai soils).
- Basecourse of a 200mm layer of proprietary produced crushed rock base compacted to 98% relative to modified compaction.
- Prime Coat.
- Primer seal.
- 25mm dense grade asphalt.

It is recommended that the basecourse be dried back to a moisture content of less than 85% prior to application of the asphalt surfacing.

In addition to the above, it is suggested that the pavement includes bituminous surfaced shoulders, in order to protect the shoulders from infiltration of run-off water.

It is recommended that subgrade be inspected by a suitably experienced geotechnical engineer prior to placement of basecourse to identify any unsuitable material and specific drainage measurements required. The long term performance of the pavement requires that suitable drainage be implemented to avoid saturation of the pavement layers. Saturation of the pavement would result in a decrease in the basecourse strength and could result in pavement failure. No water should be allowed to pond under the pavement.

7.7 Drainage and Reactive Materials

The clayey materials encountered across the site should be generally considered to be impervious for drainage purposes. Infiltrated water should be expected to pond at the base of natural sands or imported sand filling placed on underlying clayey materials. The implementation of a suitable drainage strategy is recommended to control this groundwater movement and so maintain site amenity and protect road subgrades. Such strategy could comprise shaping the clay subgrade in order to direct any perched water into a subsoil drainage network and then directing the water into a suitable outflow.

Some of the materials underlying the site are reactive and therefore may swell and shrink with moisture variation resulting in surface movement. It is recommended that particular attention be given to minimise moisture content changes within these clayey materials through the adoption of appropriate measures, such as ensuring that:

- The site is well drained, both during construction and throughout the life of structures on the site.
- Plumbing systems be maintained and repaired to avoid leaks beneath and around structures.
- No large trees are planted adjacent to structures.
- Irregular or excessive watering around the structures is avoided.

For further advice on protecting structures overlying clayey soils, reference should be made to the CSIRO note, entitled ‘Foundation Maintenance and Footing Performance: A Homeowner’s Guide’, which is attached in Appendix C of this report.

8. References

1. Australian Standard AS 1289.6.3.2-1999, Soil Strength and Consolidation Tests-Determination of the Penetration Resistance of a Soil – Dynamic Cone Penetrometer Test.
2. Australian Standard AS 1726-1996, Geotechnical Site Investigation.
3. Australian Standard AS 2870-2011, Residential Slabs and Footings.
4. Australian Standard AS 3798-2007, Guidelines on Earthworks for Commercial and Residential Developments.

9. Limitations

Douglas Partners (DP) has prepared this report for a project at Lot 504 corner Balmoral Road and Bowerbird Drive in Karratha, WA in accordance with DP's proposal dated 13 April 2011 and acceptance received from Mr Luke May of ABN Group on behalf of Chenin Grove Pty Ltd on 15 April 2011. This report is provided for the exclusive use of ABN Group on behalf of Chenin Grove Pty Ltd for this project only and for the purposes described in the report. It should not be used by or relied upon for other projects or purposes on the same or other site or by a third party. In preparing this report DP has necessarily relied upon information provided by the client and/or their agents.

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

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

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

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

Douglas Partners Pty Ltd

Appendix A

About this Report
Drawings
Results of Field Work

About this Report

Douglas Partners

Introduction

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

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

Copyright

Borehole and Test Pit Logs

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

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

Groundwater

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

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

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

Reports

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

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

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

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

About this Report

Site Anomalies

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

Information for Contractual Purposes

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

Site Inspection

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

Sampling Methods

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Sampling

Sampling is carried out during drilling or test pitting to allow engineering examination (and laboratory testing where required) of the soil or rock.

Disturbed samples taken during drilling provide information on colour, type, inclusions and, depending upon the degree of disturbance, some information on strength and structure.

Undisturbed samples are taken by pushing a thin-walled sample tube into the soil and withdrawing it to obtain a sample of the soil in a relatively undisturbed state. Such samples yield information on structure and strength, and are necessary for laboratory determination of shear strength and compressibility. Undisturbed sampling is generally effective only in cohesive soils.

Test Pits

Test pits are usually excavated with a backhoe or an excavator, allowing close examination of the in-situ soil if it is safe to enter into the pit. The depth of excavation is limited to about 3 m for a backhoe and up to 6 m for a large excavator. A potential disadvantage of this investigation method is the larger area of disturbance to the site.

Large Diameter Augers

Boreholes can be drilled using a rotating plate or short spiral auger, generally 300 mm or larger in diameter commonly mounted on a standard piling rig. The cuttings are returned to the surface at intervals (generally not more than 0.5 m) and are disturbed but usually unchanged in moisture content. Identification of soil strata is generally much more reliable than with continuous spiral flight augers, and is usually supplemented by occasional undisturbed tube samples.

Continuous Spiral Flight Augers

The borehole is advanced using 90-115 mm diameter continuous spiral flight augers which are withdrawn at intervals to allow sampling or in-situ testing. This is a relatively economical means of drilling in clays and sands above the water table. Samples are returned to the surface, or may be collected after withdrawal of the auger flights, but they are disturbed and may be mixed with soils from the sides of the hole. Information from the drilling (as distinct from specific sampling by SPTs or undisturbed samples) is of relatively low reliability, due to the remoulding, possible mixing or softening of samples by groundwater.

Non-core Rotary Drilling

The borehole is advanced using a rotary bit, with water or drilling mud being pumped down the drill rods and returned up the annulus, carrying the drill cuttings. Only major changes in stratification can be determined from the cuttings, together with some information from the rate of penetration. Where drilling mud is used this can mask the cuttings and reliable identification is only possible from separate sampling such as SPTs.

Continuous Core Drilling

A continuous core sample can be obtained using a diamond tipped core barrel, usually with a 50 mm internal diameter. Provided full core recovery is achieved (which is not always possible in weak rocks and granular soils), this technique provides a very reliable method of investigation.

Standard Penetration Tests

Standard penetration tests (SPT) are used as a means of estimating the density or strength of soils and also of obtaining a relatively undisturbed sample. The test procedure is described in Australian Standard 1289, Methods of Testing Soils for Engineering Purposes - Test 6.3.1.

The test is carried out in a borehole by driving a 50 mm diameter split sample tube under the impact of a 63 kg hammer with a free fall of 760 mm. It is normal for the tube to be driven in three successive 150 mm increments and the 'N' value is taken as the number of blows for the last 300 mm. In dense sands, very hard clays or weak rock, the full 450 mm penetration may not be practicable and the test is discontinued.

The test results are reported in the following form.

- In the case where full penetration is obtained with successive blow counts for each 150 mm of, say, 4, 6 and 7 as:

  4,6,7
  N=13

- In the case where the test is discontinued before the full penetration depth, say after 15 blows for the first 150 mm and 30 blows for the next 40 mm as:

  15, 30/40 mm

The results of the SPT tests can be related empirically to the engineering properties of the soils.

Dynamic Cone Penetrometer Tests / Perth Sand Penetrometer Tests

Dynamic penetrometer tests (DCP or PSP) are carried out by driving a steel rod into the ground using a standard weight of hammer falling a specified distance. As the rod penetrates the soil the number of blows required to penetrate each successive 150 mm depth are recorded. Normally there is a depth limitation of 1.2 m, but this may be extended in certain conditions by the use of extension rods. Two types of penetrometer are commonly used.

- Perth sand penetrometer - a 16 mm diameter flat ended rod is driven using a 9 kg hammer dropping 600 mm (AS 1289, Test 6.3.3). This test was developed for testing the density of sands and is mainly used in granular soils and filling.
- Cone penetrometer - a 16 mm diameter rod with a 20 mm diameter cone end is driven using a 9 kg hammer dropping 510 mm (AS 1289, Test 6.3.2). This test was developed initially for pavement subgrade investigations, and correlations of the test results with California Bearing Ratio have been published by various road authorities.

Soil Descriptions

Douglas Partners

Description and Classification Methods

The methods of description and classification of soils and rocks used in this report are based on Australian Standard AS 1726, Geotechnical Site Investigations Code. In general, the descriptions include strength or density, colour, structure, soil or rock type and inclusions.

Soil Types

Soil types are described according to the predominant particle size, qualified by the grading of other particles present:

Type	Particle size (mm)
Boulder	>200
Cobble	63 - 200
Gravel	2.36 - 63
Sand	0.075 - 2.36
Silt	0.002 - 0.075
Clay	<0.002

The sand and gravel sizes can be further subdivided as follows:

Type	Particle size (mm)
Coarse gravel	20 - 63
Medium gravel	6 - 20
Fine gravel	2.36 - 6
Coarse sand	0.6 - 2.36
Medium sand	0.2 - 0.6
Fine sand	0.075 - 0.2

The proportions of secondary constituents of soils are described as:

Term	Proportion	Example
And	Specify	Clay (60%) and Sand (40%)
Adjective	20 - 35%	Sandy Clay
Slightly	12 - 20%	Slightly Sandy Clay
With some	5 - 12%	Clay with some sand
With a trace of	0 - 5%	Clay with a trace of sand

Definitions of grading terms used are:

- Well graded - a good representation of all particle sizes
- Poorly graded - an excess or deficiency of particular sizes within the specified range
- Uniformly graded - an excess of a particular particle size
- Gap graded - a deficiency of a particular particle size with the range

Cohesive Soils

Cohesive soils, such as clays, are classified on the basis of undrained shear strength. The strength may be measured by laboratory testing, or estimated by field tests or engineering examination. The strength terms are defined as follows:

Description	Abbreviation	Undrained shear strength (kPa)
Very soft	vs	<12
Soft	s	12 - 25
Firm	f	25 - 50
Stiff	st	50 - 100
Very stiff	vst	100 - 200
Hard	h	>200

Cohesionless Soils

Cohesionless soils, such as clean sands, are classified on the basis of relative density, generally from the results of standard penetration tests (SPT), cone penetration tests (CPT) or dynamic penetrometers (PSP). The relative density terms are given below:

Relative Density	Abbreviation	SPT N value	CPT qc value (MPa)
Very loose	vl	<4	<2
Loose	l	4 - 10	2 -5
Medium dense	md	10 - 30	5 - 15
Dense	d	30 - 50	15 - 25
Very dense	vd	>50	>25

Soil Descriptions

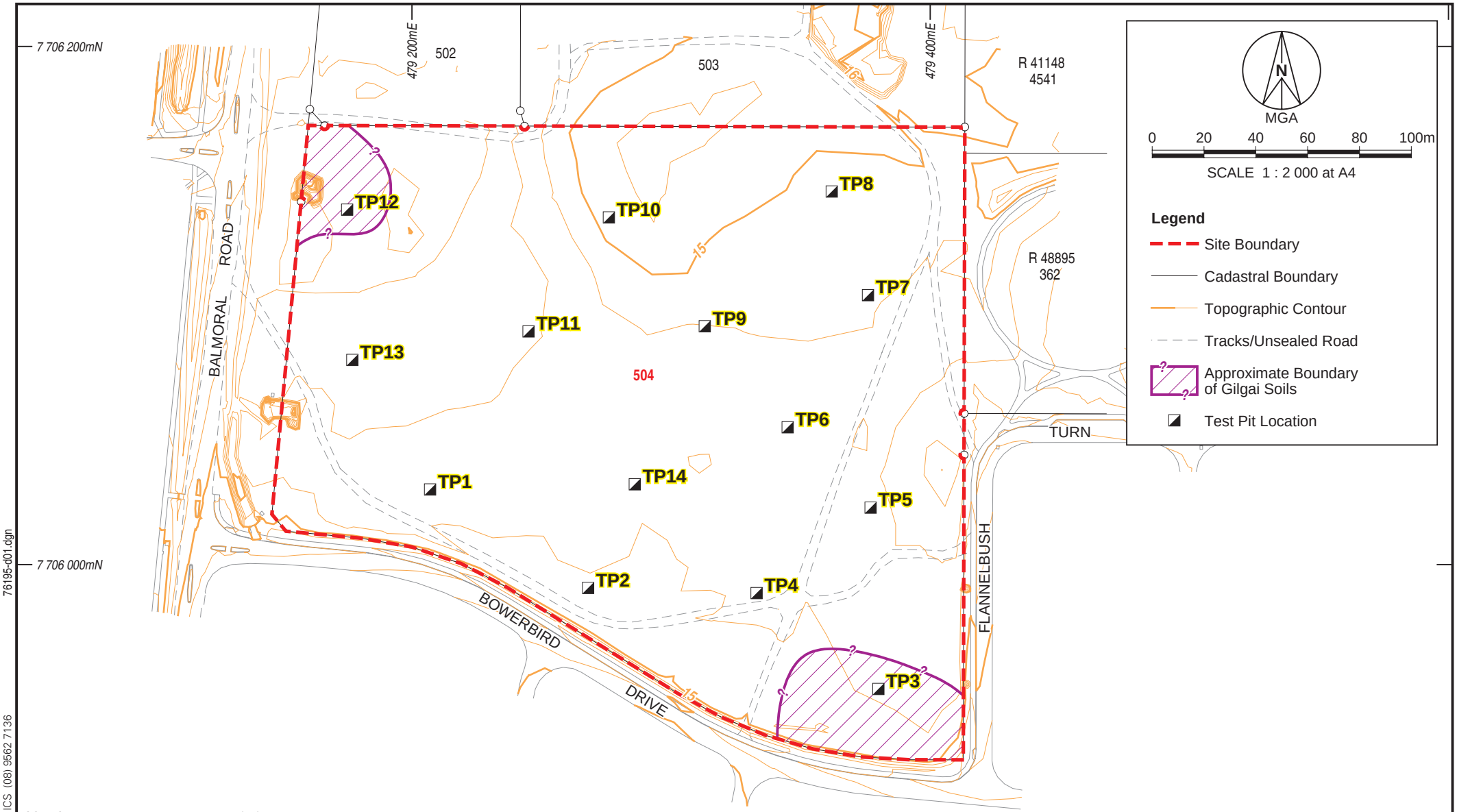
Soil Origin

It is often difficult to accurately determine the origin of a soil. Soils can generally be classified as:

- Residual soil - derived from in-situ weathering of the underlying rock;
- Transported soils - formed somewhere else and transported by nature to the site; or
- Filling - moved by man.

Transported soils may be further subdivided into:

- Alluvium - river deposits
- Lacustrine - lake deposits
- Aeolian - wind deposits
- Littoral - beach deposits
- Estuarine - tidal river deposits
- Talus - scree or coarse colluvium
- Slopewash or Colluvium - transported downslope by gravity assisted by water. Often includes angular rock fragments and boulders.



SOURCE: Whelans, Dwg No. 13325 002, 11/06/2010.

76195-d01.dgn

PINPOINT CARTOGRAPHICS (08) 9562 7136

Douglas Partners
Geotechnics / Environment / Groundwater

CLIENT: Chenin Grove Pty Ltd

OFFICE: Perth

DATE: 12 May 2011

Location of Tests
Lot 504 Cnr Balmoral Road and Bowerbird Drive
Karratha

PROJECT No.: 76195

DRAWING No.: 1

REVISION: A

TEST PIT LOG

CLIENT: Chenin Grove Pty Ltd
PROJECT: Lot 504 cnr Balmoral Road and Bowerbird Drive
LOCATION: Karratha, WA

SURFACE LEVEL: 14.7 m AHD* **PIT No:** TP1
EASTING: **PROJECT No:** 76195
NORTHING: **DATE:** 5/5/2011
DIP/AZIMUTH: 90°/-- **SHEET** 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
14	0.15	CLAYEY SILT - red-brown, slightly gravelly clayey silt with some rootlets, moist.							
		CLAYEY GRAVEL - dense, red-brown, fine to coarse sized, clayey gravel with some sand and trace of cobbles of granite, moist.							
	0.5	CLAYEY GRAVEL - dense to very dense, red-brown mottled light yellow-brown, fine to coarse sized, clayey gravel with some sand and some cobbles of granite, dry to moist.		D	0.7				
13	1.9	SILTY SAND - dense, grey mottled red-brown, fine to coarse grained, slightly clayey silty sand with some gravel, dry to moist (extremely weathered rock). Gravel is granite.		D	2.2				
12	2.6	Pit discontinued at 2.6m (Due to Slow Digging)							

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20; 1, 2, 3

RIG: Backhoe with 600 mm toothed bucket
LOGGED: CE
SURVEY DATUM:

WATER OBSERVATIONS: No free groundwater observed

REMARKS: * Surface level interpolated from survey provided by client.

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo Ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U,	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▽	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

TEST PIT LOG

CLIENT: Chenin Grove Pty Ltd
PROJECT: Lot 504 cnr Balmoral Road and Bowerbird Drive
LOCATION: Karratha, WA

SURFACE LEVEL: 14.9 m AHD*
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

PIT No: TP2
PROJECT No: 76195
DATE: 5/5/2011
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.2	TOPSOIL - loose, red-brown, fine to medium grained, slightly gravelly clayey silty topsoil with some rootlets, moist.							
		SANDY CLAY - stiff to very stiff, red-brown, sandy clay with some fine to coarse sized gravel, dry to moist.			0.3				
				B	0.4				
		- gravel content increased with depth.		U					
					0.6				
14	0.8	CLAYEY GRAVEL - dense to very dense, red-brown mottled light yellow-brown, fine to coarse sized, clayey gravel with some sand, dry to moist.							
	1			D	1.2				1
	1.5	SANDY CLAYEY GRAVEL - dense to very dense, red-brown mottled blue-grey and off-white, fine to coarse sized, sandy clayey gravel, dry to moist.							
13	2								2
	2.1	Pit discontinued at 2.1m (Due to Slow Digging)							
12	3								3

RIG: Backhoe with 600 mm toothed bucket

LOGGED: CE

SURVEY DATUM:

WATER OBSERVATIONS: No free groundwater observed

REMARKS: * Surface level interpolated from survey provided by client.

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U,	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▽	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

TEST PIT LOG

CLIENT: Chenin Grove Pty Ltd
PROJECT: Lot 504 cnr Balmoral Road and Bowerbird Drive
LOCATION: Karratha, WA

SURFACE LEVEL: 14.8 m AHD*
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

PIT No: TP3
PROJECT No: 76195
DATE: 5/5/2011
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.1	TOPSOIL - red-brown, silty clayey topsoil with some rootlets.							
		SILTY CLAY - soft, red-brown, silty clay with some sand, moist.							
	0.3	SANDY CLAY - very stiff to hard, red-brown, clay with trace of fine sized gravel, moist.		D U	0.3 0.4 0.6		pp >400 kPa		
					0.8		pp >400 kPa		
14	1				1.0		pp >400 kPa		1
	1.3	SANDY GRAVEL/GRAVELLY SAND - dense to very dense, red-brown mottled blue-grey and off-white, fine to coarse sized, sandy gravel/gravelly sand with a trace of clay and with some cobble of granite, dry to moist.							
13	1.9	Pit discontinued at 1.9m (Due to Slow Digging/Refusal)							
	2								2
12	3								3

RIG: Backhoe with 600 mm toothed bucket
LOGGED: CE
SURVEY DATUM:

WATER OBSERVATIONS: No free groundwater observed

REMARKS: * Surface level interpolated from survey provided by client.

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U,	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▽	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

TEST PIT LOG

CLIENT: Chenin Grove Pty Ltd
PROJECT: Lot 504 cnr Balmoral Road and Bowerbird Drive
LOCATION: Karratha, WA

SURFACE LEVEL: 14.8 m AHD* **PIT No:** TP4
EASTING: **PROJECT No:** 76195
NORTHING: **DATE:** 5/5/2011
DIP/AZIMUTH: 90°/-- **SHEET** 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
14	0.15	CLAYEY SILT - red-brown, fine to medium grained, slightly gravelly clayey silt with some rootlets, moist.							
		CLAYEY GRAVEL/GRAVELLY CLAY - dense/stiff to very stiff, red-brown, fine to coarse sized, clayey gravel/gravelly clay with some sand, moist.							
	0.8	CLAYEY GRAVEL - dense to very dense, red-brown, fine to coarse sized, slightly sandy clayey gravel with some silt, dry to moist.		B	0.9				
13	1.6	SANDY GRAVEL - dense to very dense, red-brown mottled blue-grey and off-white, fine to coarse sized, sandy gravel with some clay, dry to moist.							
12	2.6	Pit discontinued at 2.6m (Due to Slow Digging)							

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20; 1, 2, 3

RIG: Backhoe with 600 mm toothed bucket
LOGGED: CE
SURVEY DATUM:

WATER OBSERVATIONS: No free groundwater observed

REMARKS: * Surface level interpolated from survey provided by client.

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo Ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▽	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Chenin Grove Pty Ltd
PROJECT: Lot 504 cnr Balmoral Road and Bowerbird Drive
LOCATION: Karratha, WA

SURFACE LEVEL: 14.7 m AHD* **PIT No:** TP5
EASTING: **PROJECT No:** 76195
NORTHING: **DATE:** 5/5/2011
DIP/AZIMUTH: 90°/-- **SHEET** 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
14	0.2	TOPSOIL - red-brown, silty clayey topsoil with some rootlets.							
		GRAVELLY SANDY CLAY - very stiff to hard, red-brown, fine to coarse sized, gravelly sandy clay, moist.							
		- becoming mottled off-white/yellow-brown from 0.7 m.		D	0.8				
13	1.6	- clay content decreased with depth.							
		SANDY GRAVEL - dense to very dense, dark red-brown, fine to coarse sized, sandy gravel with some clay, dry to moist. Sand is fine to coarse grained.		D	2.0				
12	3.0	- becoming mottled green from 2.9 m.							
		Pit discontinued at 3.0m (Target)							

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20; 1, 2, 3

RIG: Backhoe with 600 mm toothed bucket
LOGGED: CE
SURVEY DATUM:

WATER OBSERVATIONS: No free groundwater observed

REMARKS: * Surface level interpolated from survey provided by client.

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U,	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▽	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Chenin Grove Pty Ltd
PROJECT: Lot 504 cnr Balmoral Road and Bowerbird Drive
LOCATION: Karratha, WA

SURFACE LEVEL: 14.7 m AHD* **PIT No:** TP6
EASTING: **PROJECT No:** 76195
NORTHING: **DATE:** 5/5/2011
DIP/AZIMUTH: 90°/-- **SHEET** 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
		TOPSOIL - red-brown, silty clayey topsoil with some rootlets.							
	0.2	CLAYEY SILT - red-brown, clayey silt with some sand and some fine sized gravel, moist.			0.3				
	0.35	CLAYEY GRAVEL - dense, red-brown, fine to coarse sized, clayey gravel with some sand, moist.		U					
14	0.6	SILTY GRAVELLY SAND - dense to very dense, red-brown mottled yellow-brown/off-white, fine to medium grained, silty gravelly sand with some clay, dry to moist. Gravel is fine to coarse sized.			0.6				
	1								1
13		- becoming coarse grained, mottled green from 1.8 m.							
	2								2
	2.6	Pit discontinued at 2.6m (Due to Slow Digging)							
12	3								3

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20

RIG: Backhoe with 600 mm toothed bucket

LOGGED: CE

SURVEY DATUM:

WATER OBSERVATIONS: No free groundwater observed

REMARKS: * Surface level interpolated from survey provided by client.

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo Ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U,	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Chenin Grove Pty Ltd
PROJECT: Lot 504 cnr Balmoral Road and Bowerbird Drive
LOCATION: Karratha, WA

SURFACE LEVEL: 14.8 m AHD*
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

PIT No: TP7
PROJECT No: 76195
DATE: 5/5/2011
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
14	0.15	SILTY SAND - red-brown, fine to medium grained, silty sand with some clay, moist.							
		GRAVELLY SANDY CLAY - very stiff to hard, red-brown , fine to coarse sized, gravelly sandy clay, dry to moist.							
		- becoming mottled off-white from 0.3 m.							
	1								1
	1.4	CLAYEY SAND - dense to very dense, red-brown mottled off-white, fine to coarse sized, slightly gravelly clayey sand, dry to moist.		D	1.5				
13	2								2
		- clay content decreased with depth to GRAVELLY SAND from 2.5 m.							
12	3								3
	3.0	Pit discontinued at 3.0m (Target)							

RIG: Backhoe with 600 mm toothed bucket
LOGGED: CE
SURVEY DATUM:

WATER OBSERVATIONS: No free groundwater observed

REMARKS: * Surface level interpolated from survey provided by client.

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U,	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▽	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Chenin Grove Pty Ltd
PROJECT: Lot 504 cnr Balmoral Road and Bowerbird Drive
LOCATION: Karratha, WA

SURFACE LEVEL: 14.9 m AHD*
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

PIT No: TP8
PROJECT No: 76195
DATE: 5/5/2011
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per mm)
	0.1	SANDY GRAVEL - red-brown, fine to coarse grained, subangular sandy gravel, moist. gravel is granite.							
		GRAVEL - medium dense, red-brown, fine to coarse sized, slightly clayey gravel with some sand, moist.							
	0.3	GRAVEL - dense, red-brown, fine to coarse sized, gravel with some sand, some clay and some silt, moist.		D	0.5				
14	1								1
	1.4	CLAYEY GRAVEL - dense to very dense, red-brown mottled yellow-brown/off-white, fine to medium sized, clayey gravel with some sand and with a trace of silt, dry to moist.							
13	2								2
		- becoming coarse grained, mottled green from 1.8 m.							
12	3								3
	3.0	Pit discontinued at 3.0m (Target)							

RIG: Backhoe with 600 mm toothed bucket
LOGGED: CE
SURVEY DATUM:

WATER OBSERVATIONS: No free groundwater observed

REMARKS: * Surface level interpolated from survey provided by client.

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo Ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U,	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▽	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Chenin Grove Pty Ltd
PROJECT: Lot 504 cnr Balmoral Road and Bowerbird Drive
LOCATION: Karratha, WA

SURFACE LEVEL: 14.8 m AHD*
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

PIT No: TP9
PROJECT No: 76195
DATE: 5/5/2011
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.1	TOPSOIL - red-brown, silty clayey topsoil with some rootlets.							
14		CLAYEY SAND/SANDY CLAY - dense/very stiff to hard, red-brown, clayey sand/sandy clay with some fine sized gravel, moist.		B	0.4				
					0.6		pp>400 kPa		
		- gravel content increased to slightly gravelly sandy clay with depth.			0.8		pp>400 kPa		
1								1	
	1.4	GRAVELLY SAND - dense to very dense, red-brown mottled yellow-brown and off-white, fine to coarse grained, gravelly sand with some clay, dry to moist.							
13									
2								2	
12									
3								3	
	3.3	Pit discontinued at 3.3m (Target)							

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20

RIG: Backhoe with 600 mm toothed bucket
LOGGED: CE
SURVEY DATUM:

WATER OBSERVATIONS: No free groundwater observed

REMARKS: * Surface level interpolated from survey provided by client.

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo Ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U,	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	⫧	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Chenin Grove Pty Ltd
PROJECT: Lot 504 cnr Balmoral Road and Bowerbird Drive
LOCATION: Karratha, WA

SURFACE LEVEL: 15.1 m AHD* **PIT No:** TP10
EASTING: **PROJECT No:** 76195
NORTHING: **DATE:** 5/5/2011
DIP/AZIMUTH: 90°/-- **SHEET** 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
15		SANDY GRAVEL - dense to very dense, red-brown, fine to medium sized, slightly clayey sandy gravel with some silt, moist.							5 10 15 20
	0.4	SANDY GRAVEL - dense to very dense, red-brown mottled yellow-brown/off-white, fine to medium sized, slighlty clayey sandy gravel with some silt, moist.		D	0.9				
14	1								1
13	2								2
12	3								3
	3.0	Pit discontinued at 3.0m (Target)							

RIG: Backhoe with 600 mm toothed bucket
LOGGED: CE
SURVEY DATUM:

WATER OBSERVATIONS: No free groundwater observed

REMARKS: * Surface level interpolated from survey provided by client.

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U,	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Chenin Grove Pty Ltd
PROJECT: Lot 504 cnr Balmoral Road and Bowerbird Drive
LOCATION: Karratha, WA

SURFACE LEVEL: 14.6 m AHD*
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

PIT No: TP11
PROJECT No: 76195
DATE: 5/5/2011
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
14	0.05	TOPSOIL - red-brown, silty clayey topsoil with some rootlets.							
		CLAYEY SAND - medium dense to dense, red-brown, fine to medium grained, clayey sand, moist.							
	0.5	GRAVEL - dense, red-brown, fine to coarse sized, gravel with some sand and some silt, moist.							
	0.8	GRAVELLY CLAYEY SAND - dense to very dense, red-brown mottled yellow-brown and off-white, fine to coarse grained, gravelly clayey sand, dry to moist.		D	1.2				
1									1
13									
2									2
12		- becoming dark red-brown from 2.5 m.							
3	3.0	Pit discontinued at 3.0m (Target)							3

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20

RIG: Backhoe with 600 mm toothed bucket
LOGGED: CE
SURVEY DATUM:

WATER OBSERVATIONS: No free groundwater observed

REMARKS: * Surface level interpolated from survey provided by client.

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U,	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▽	Water level	V	Shear vane (kPa)

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Geotechnics / Environment / Groundwater

TEST PIT LOG

CLIENT: Chenin Grove Pty Ltd
PROJECT: Lot 504 cnr Balmoral Road and Bowerbird Drive
LOCATION: Karratha, WA

SURFACE LEVEL: 14.3 m AHD*
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

PIT No: TP12
PROJECT No: 76195
DATE: 5/5/2011
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
14	0.1	TOPSOIL - red-brown, silty clayey topsoil with some rootlets.							
		SILTY CLAY - stiff, red-brown, slighlty sandy silty clay with a trace of gravel, moist.		B	0.4				
				U	0.65		pp>400 kPa		
13	1.6	SAND - dense to very dense, red-brown mottled yellow-brown and off-white, fine to coarse grained, slightly silty sand with some clay, dry to moist.							
12		- clay content varied through layer to slightly clayey sand.							
		- becoming mottled blue-grey from 2.6 m.							
11	2.8	Pit discontinued at 2.8m (Due to Slow Digging)							

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20; 1, 2, 3

RIG: Backhoe with 600 mm toothed bucket
LOGGED: CE
SURVEY DATUM:

WATER OBSERVATIONS: No free groundwater observed

REMARKS: * Surface level interpolated from survey provided by client.

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo Ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U,	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▽	Water level	V	Shear vane (kPa)

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Geotechnics / Environment / Groundwater

TEST PIT LOG

CLIENT: Chenin Grove Pty Ltd
PROJECT: Lot 504 cnr Balmoral Road and Bowerbird Drive
LOCATION: Karratha, WA

SURFACE LEVEL: 14.5 m AHD*
EASTING:
NORTHING:
DIP/AZIMUTH: 90°/--

PIT No: TP13
PROJECT No: 76195
DATE: 6/5/2011
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.1	TOPSOIL - red-brown, silty clayey topsoil with some rootlets.							
		GRAVEL - dense, red-brown, fine to medium sized, slightly silty gravel with some clay, moist.		D	0.6				
	0.8	GRAVEL - dense to very dense, red-brown mottled yellow-brown/off-white, fine to coarse sized, slightly clayey gravel with some silt, moist.							
		- gravel size increased with depth							
		- clay content decreased to slightly silty gravel with some clay from 1.9 m.		D	1.9				
		- becoming mottled blue-grey, with some gravel of weathered granite from 2.4 m.							
	3.0	Pit discontinued at 3.0m (Target)							

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20

RIG: Backhoe with 600 mm toothed bucket
LOGGED: CE
SURVEY DATUM:

WATER OBSERVATIONS: No free groundwater observed

REMARKS: * Surface level interpolated from survey provided by client.

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U,	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	⫧	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Chenin Grove Pty Ltd
PROJECT: Lot 504 cnr Balmoral Road and Bowerbird Drive
LOCATION: Karratha, WA

SURFACE LEVEL: 14.8 m AHD* **PIT No:** TP14
EASTING: **PROJECT No:** 76195
NORTHING: **DATE:** 6/5/2011
DIP/AZIMUTH: 90°/-- **SHEET** 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.1	TOPSOIL - red-brown, silty clayey topsoil with some rootlets.							
		CLAYEY SILT - loose to medium dense, red-brown, clayey silt with some sand and a trace of gravel, moist.		D	0.3				
	0.5	GRAVEL - dense to very dense, red-brown mottled off-white, fine to medium sized, slightly silty gravel with some clay and some coarse sized gravel, dry to moist.		D	0.9				
14	1								
	1.2	CLAYEY SAND - dense to very dense, red-brown mottled blue-grey and off-white, fine to coarse sized, sandy clayey gravel, dry to moist. Gravel is extremely to moderately weathered granite.		D	1.3				
	1.5	GRAVEL - dense to very dense, red-brown mottled blue-grey, fine to medium sized, slightly sandy gravel, dry to moist.							
13	2	- becoming mottled green/yellow from 2.0 m.							
	2.5	Pit discontinued at 2.5m (Due to Slow Digging)							
12	3								

RIG: Backhoe with 600 mm toothed bucket
LOGGED: CE
SURVEY DATUM:

WATER OBSERVATIONS: No free groundwater observed

REMARKS: * Surface level interpolated from survey provided by client.

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

Appendix B

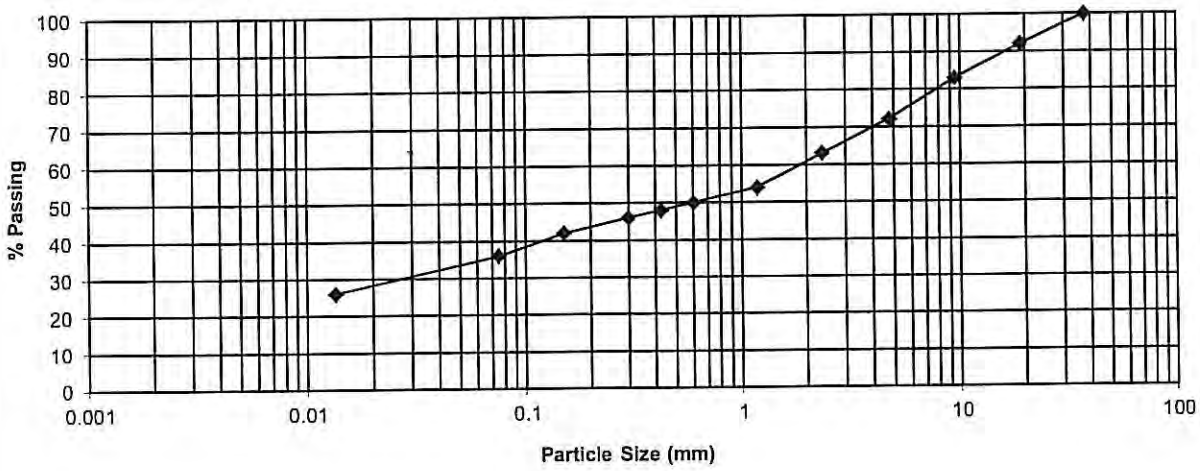
Geotechnical Laboratory Testing

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:	**60017**
Report No:	**60017-P11/1323**
Sample No:	**P11/1323**
Issue Date:	**27 May 2011**
Sample Location:	**TP 1**
Depth (m):	**0.7**

Client: **Chenin Grove Pty Ltd**
Project: **Lot 504 Corner Balmoral Road & Bowerbird Drive**
Location: **Karratha WA**



SIEVE ANALYSIS WA 115.1

Sieve Size (mm)	% Passing
75.0	
37.5	100
19.0	92
9.5	83
4.75	72
2.36	63
1.18	54
0.600	50
0.425	48
0.300	46
0.150	42
0.075	36
0.0135	26

Plasticity Index tests
Australian Standard 1289.

Liquid Limit 3.1.1	na	%
Plastic Limit 3.2.1		%
Plasticity Index 3.3.1		%
Linear Shrinkage 3.4.1		%

Cracked ☐

Curled ☐

Client address: 36 O'Malley Street, Osborne Park

Sampling Procedure: Tested as received

NATA WORLD RECOGNISED ACCREDITATION

Approved signature

Kevin M Jones

TRICON TESTING
Geotechnical Engineering Laboratory
5 / 8 Corbusier Place, Balcatta, WA 6021 ABN 12 529 845 438
tricontest@optusnet.com.au Ph: (08) 9240 1444 Fax: (08) 9240 1044

REPORT CERTIFICATE

Determination of the Shrinkage Index of a Soil
Shrink-Swell Index
-according to AS 1289.7.1.1 - 2003

CLIENT : Douglas Partners Pty Ltd (Job # 76195) **JOB NO :** 1011422
PROJECT : Lot 504 Cnr Balmoral Rd & Bowerbird Drive (Chenin Grove Ltd) **Lab No. :** TT 06422001
LOCATION : Karratha **Date Tested :** May - June 2011
Sample Id : TP 2, Depth : 0.3 - 0.6m

SAMPLE DETAILS

Sample Description : Dark Reddish Brown, Clayey Gravelly Sand

Sample Type : nom. 48mm Ø tube sample

SWELL SPECIMEN		SHRINKAGE SPECIMEN	
Dry Density - Initial :	1.655 t/m^3	**Moisture Content** - Initial :	8.6 %
Moisture Content - Initial :	8.7 %	**Length / Diameter Ratio** :	1.32
Moisture Content - Final :	14.3 %	**Extent of Soil Crumbling** :	Nil
Overburden Pressure Used :	25 kPa	**Extent of Cracking** :	Hairline only
Significant Inert Inclusions :	Nil	**Significant Inert Inclusions** :	Nil

SHRINK-SWELL INDEX

I_{ss} : **0.9** % Vertical Strain per pF change in Total Suction

Notes : Sample supplied by Client

Authorised Signatory : DIGITAL COPY
(S. Brodie)

Date : 14/06/2011
Form No AS1289711sw 06/1 R

TRICON

TRICON TESTING
Geotechnical Engineering Laboratory
5 / 8 Corbusier Place, Balcatta, WA 6021 ABN 12 529 845 438
tricontest@optusnet.com.au Ph: (08) 9240 1444 Fax: (08) 9240 1044

REPORT CERTIFICATE

Determination of the Shrinkage Index of a Soil
Shrink-Swell Index
-according to AS 1289.7.1.1 - 2003

CLIENT : Douglas Partners Pty Ltd (Job # 76195) **JOB NO :** 1011422
PROJECT : Lot 504 Cnr Balmoral Rd & Bowerbird Drive (Chenin Grove Ltd) **Lab No. :** TT 06422002
LOCATION : Karratha **Date Tested :** May - June 2011
Sample Id : TP 3, Depth : 0.3 - 0.6m

SAMPLE DETAILS

Sample Description : Dark Reddish Brown, Clayey Sand

Sample Type : nom. 48mm Ø tube sample

SWELL SPECIMEN		SHRINKAGE SPECIMEN	
Dry Density - Initial :	1.645 t/m^3	**Moisture Content** - Initial :	14.1 %
Moisture Content - Initial :	12.7 %	**Length / Diameter Ratio** :	1.34
Moisture Content - Final :	16.7 %	**Extent of Soil Crumbling** :	Nil
Overburden Pressure Used :	25 kPa	**Extent of Cracking** :	Hairline only
Significant Inert Inclusions :	Nil	**Significant Inert Inclusions** :	Nil

SHRINK-SWELL INDEX

I_{ss} : **1.3** % Vertical Strain per pF change in Total Suction

Notes : Sample supplied by Client

Authorised Signatory : DIGITAL COPY (S. Brodie)

Date : 14/06/2011

Form No AS1289711sw 06/1 R

TRICON

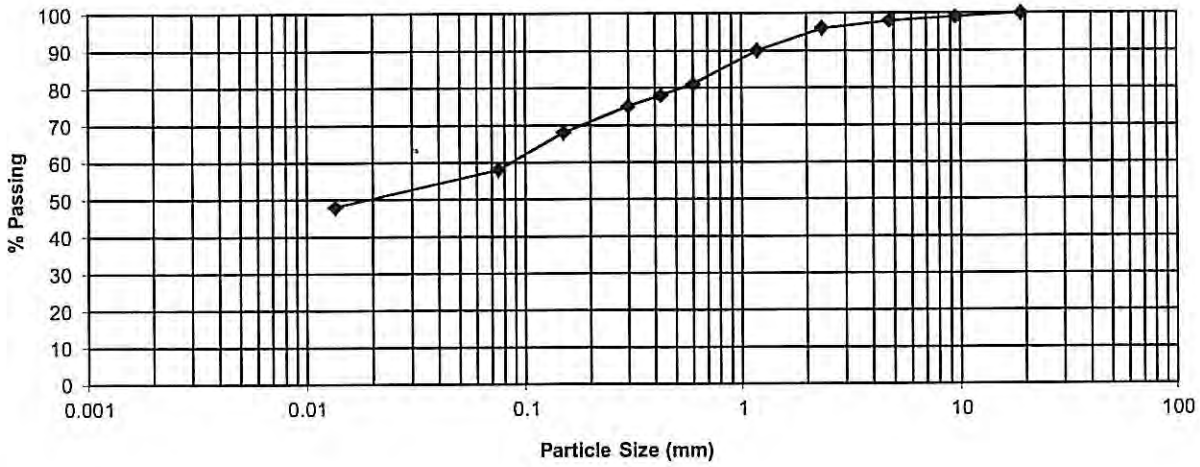
Particle Size Distribution & Plasticity Index tests

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:	**60017**
Report No:	**60017-P11/1321**
Sample No:	**P11/1321**
Issue Date:	**27 May 2011**

Client: **Chenin Grove Pty Ltd**
Project: **Lot 504 Corner Balmoral Road & Bowerbird Drive**
Location: **Karratha WA**

Sample Location: **TP 3**
Depth (m): **0.4**



SIEVE ANALYSIS WA 115.1

Sieve Size (mm)	% Passing
75.0	
37.5	
19.0	100
9.5	99
4.75	98
2.36	96
1.18	90
0.600	81
0.425	78
0.300	75
0.150	68
0.075	58
0.0135	48

Plasticity Index tests
Australian Standard 1289.

Liquid Limit 3.1.1	na	%
Plastic Limit 3.2.1		%
Plasticity Index 3.3.1		%
Linear Shrinkage 3.4.1		%

Cracked ☐

Curled ☐

Client address: 36 O'Malley Street, Osborne Park

Sampling Procedure: Tested as received

NATA WORLD RECOGNISED ACCREDITATION

Approved signature

Kevin M Jones

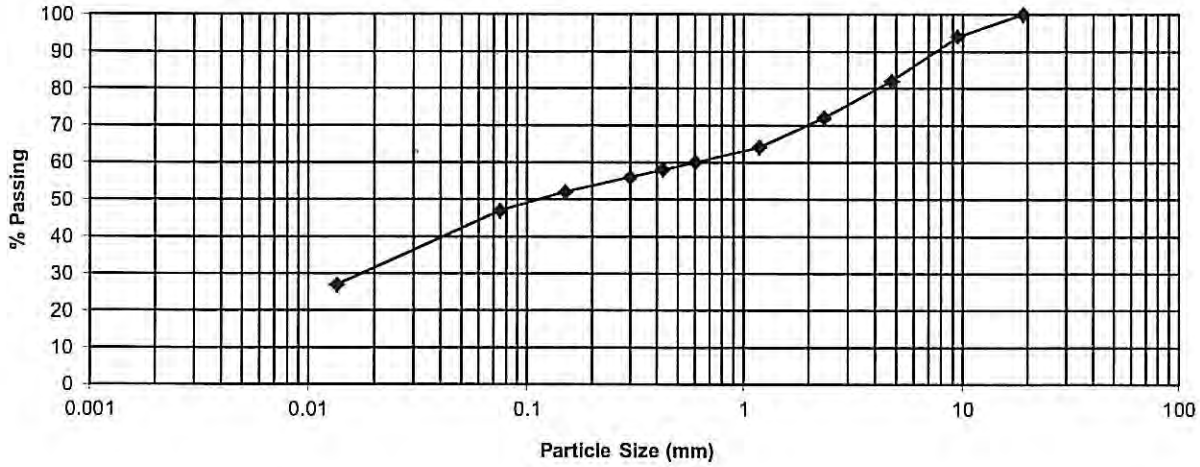
Particle Size Distribution & Plasticity Index tests

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:	**60017**
Report No:	**60017-P11/1320**
Sample No:	**P11/1320**
Issue Date:	**27 May 2011**

Client: **Chenin Grove Pty Ltd**
Project: **Lot 504 Corner Balmoral Road & Bowerbird Drive**
Location: **Karratha WA**

Sample Location: **TP 5**
Depth (m): **0.8**



SIEVE ANALYSIS WA 115.1

Sieve Size (mm)	% Passing
75.0	
37.5	
19.0	100
9.5	94
4.75	82
2.36	72
1.18	64
0.600	60
0.425	58
0.300	56
0.150	52
0.075	47
0.0135	27

Plasticity Index tests
Australian Standard 1289.

Liquid Limit 3.1.1	28	%
Plastic Limit 3.2.1	17	%
Plasticity Index 3.3.1	11	%
Linear Shrinkage 3.4.1	4.0	%

Cracked ☑
Curled ☐

Client address: 36 O'Malley Street, Osborne Park

Sampling Procedure: Tested as received

NATA WORLD RECOGNISED ACCREDITATION

Approved signature

Kevin M Jones

TRICON TESTING
Geotechnical Engineering Laboratory
5 / 8 Corbusier Place, Balcatta, WA 6021 ABN 12 529 845 438
tricontest@optusnet.com.au Ph: (08) 9240 1444 Fax: (08) 9240 1044

REPORT CERTIFICATE

Determination of the Shrinkage Index of a Soil
Shrink-Swell Index
-according to AS 1289.7.1.1 - 2003

CLIENT : Douglas Partners Pty Ltd (Job # 76195) **JOB NO :** 1011422
PROJECT : Lot 504 Cnr Balmoral Rd & Bowerbird Drive (Chenin Grove Ltd) **Lab No. :** TT 06422003
LOCATION : Karratha **Date Tested :** May - June 2011
Sample Id : TP 6, Depth : 0.3 - 0.6m

SAMPLE DETAILS

Sample Description : Dark Reddish Brown/ Off White (mottled), Clayey Sandy Gravel

Sample Type : nom. 48mm Ø tube sample

SWELL SPECIMEN		SHRINKAGE SPECIMEN	
Dry Density - Initial :	1.666 t/m^3	**Moisture Content** - Initial :	7.8 %
Moisture Content - Initial :	7.7 %	**Length / Diameter Ratio** :	1.35
Moisture Content - Final :	14.5 %	**Extent of Soil Crumbling** :	Nil
Overburden Pressure Used :	25 kPa	**Extent of Cracking** :	Hairline only
Significant Inert Inclusions :	Nil	**Significant Inert Inclusions** :	Nil

SHRINK-SWELL INDEX

I_{ss} : **0.8** % Vertical Strain per pF change in Total Suction

Notes : Sample supplied by Client

Authorised Signatory : DIGITAL COPY _____
(S. Brodie)

Date : 14/06/2011
Form No AS1289711sw 06/1 R

TRICON

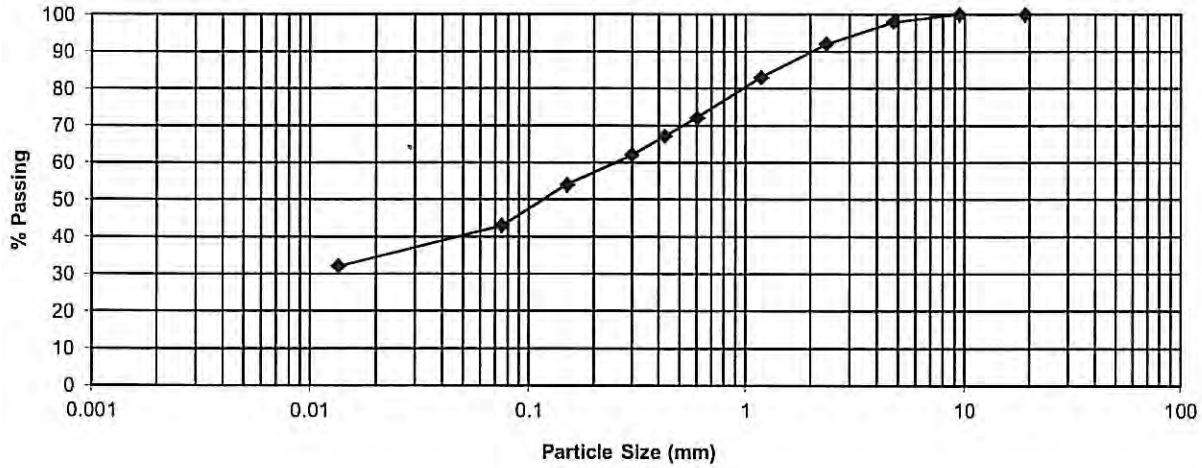
Particle Size Distribution & Plasticity Index tests

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:	**60017**
Report No:	**60017-P11/1319**
Sample No:	**P11/1319**
Issue Date:	**27 May 2011**

Client: **Chenin Grove Pty Ltd**
Project: **Lot 504 Corner Balmoral Road & Bowerbird Drive**
Location: **Karratha WA**

Sample Location: **TP 9**
Depth (m): **0.4**



SIEVE ANALYSIS WA 115.1

Sieve Size (mm)	% Passing
75.0	
37.5	
19.0	100
9.5	100
4.75	98
2.36	92
1.18	83
0.600	72
0.425	67
0.300	62
0.150	54
0.075	43
0.0135	32

Plasticity Index tests
Australian Standard 1289.

Liquid Limit 3.1.1	38	%
Plastic Limit 3.2.1	16	%
Plasticity Index 3.3.1	22	%
Linear Shrinkage 3.4.1	9.0	%
Cracked	☑	
Curled	☑	

Client address: 36 O'Malley Street, Osborne Park

Sampling Procedure: Tested as received

Approved signature

Kevin M Jones

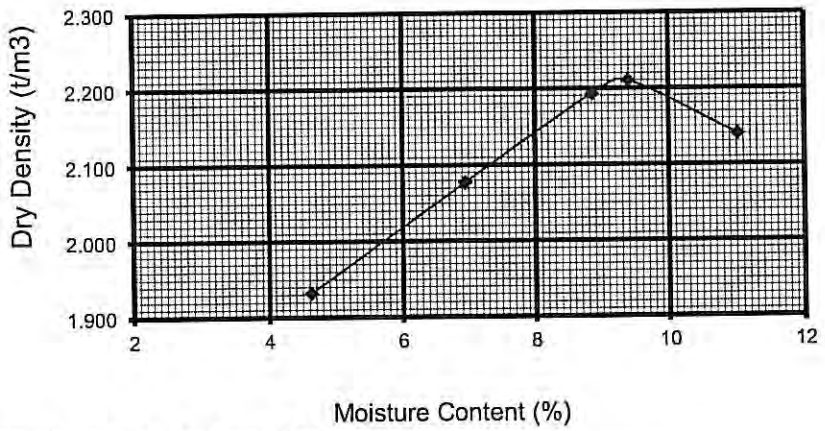
Mining &
Civil
Geotest Pty Ltd
Unit 1/1 Pusey Road, JANDAKOT WA 6164
Ph (08) 9414 8022
Fax (08)9414 8011
Email kevin@mcgeotest.com.au

Maximum Dry Density (AS 1289.5.2.1) & California Bearing Ratio (AS 1289.6.1.1) Test Report

Certificate No:	60017-P11/1319	**Client:**	Chenin Grove Pty Ltd
Sample No:	P11/1319	**Project:**	Karratha WA
Location:	Lot 504,Cnr Balmoral Rd & Bowerbird D	**Date of issue:**	27 May 2011
	TP 9, 0.4m	**Job No:**	60017

Maximum Dry Density t/m^3:	2.210	**Conditions at Test**	
Optimum Moisture Content %:	9.4	Soaking Period (Days)	4
Desired Conditions:	95/100	Surcharge (kg)	4.5
Compactive Effort		Entire Moisture Content %	15.2
Mass of hammer kg	4.9	Entire Moisture Ratio %	161.9
Number of layers	5	Top 30mm Moisture Content %	16.5
Number of blows/layer	25	Top 30mm Moisture Ratio %	175.8
Conditions after Compaction		Swell %	3.5
Dry Density t/m^3	2.109	C.B.R. at 5.0 mm Penetration %	4.5
Moisture Content %	9.4	**Conditions after Soaking**	
Density Ratio %	95.4	Dry Density t/m^3	2.035
Moisture Ratio %	100.0	Moisture Content %	14.0
Soaked / Unsoaked	Soaked	Dry Density Ratio %	92.0
		Moisture Ratio %	149.0

Comments:



Client address: 36 O'Malley St, Osborne Park

ASMDD-CBR June 2009

Approved Signature Kevin M Jones

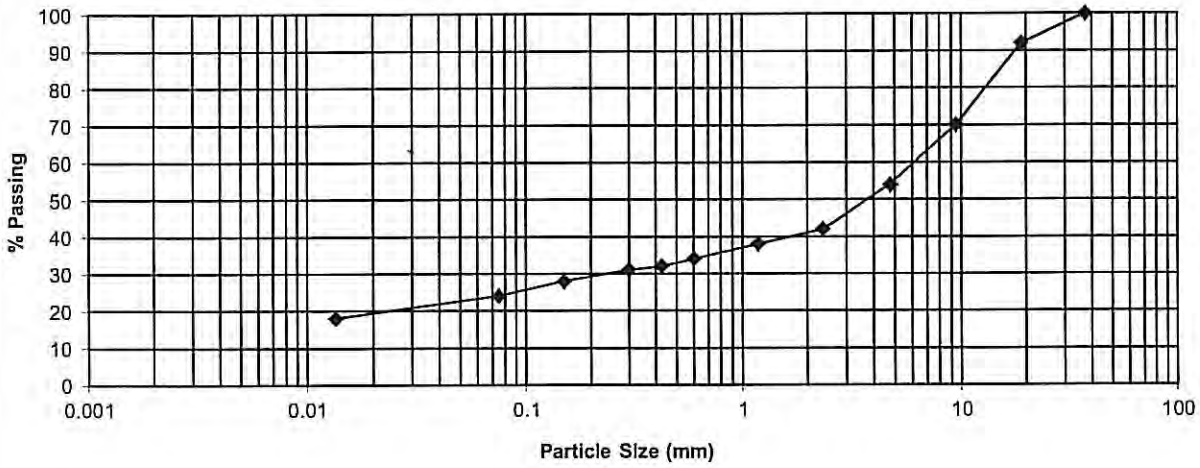
Particle Size Distribution & Plasticity Index tests

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:	**60017**
Report No:	**60017-P11/1322**
Sample No:	**P11/1322**
Issue Date:	**27 May 2011**

Client: **Chenin Grove Pty Ltd**
Project: **Lot 504 Corner Balmoral Road & Bowerbird Drive**
Location: **Karratha WA**

Sample Location: **TP 10**
Depth (m): **0.9**



SIEVE ANALYSIS WA 115.1

Sieve Size (mm)	% Passing
75.0	
37.5	100
19.0	92
9.5	70
4.75	54
2.36	42
1.18	38
0.600	34
0.425	32
0.300	31
0.150	28
0.075	24
0.0135	18

Plasticity Index tests
Australian Standard 1289.

Liquid Limit 3.1.1	na	%
Plastic Limit 3.2.1		%
Plasticity Index 3.3.1		%
Linear Shrinkage 3.4.1		%
Cracked	☐	
Curled	☐	

Client address: 36 O'Malley Street, Osborne Park

Sampling Procedure: Tested as received

NATA WORLD RECOGNISED ACCREDITATION

Approved signature

Kevin M Jones

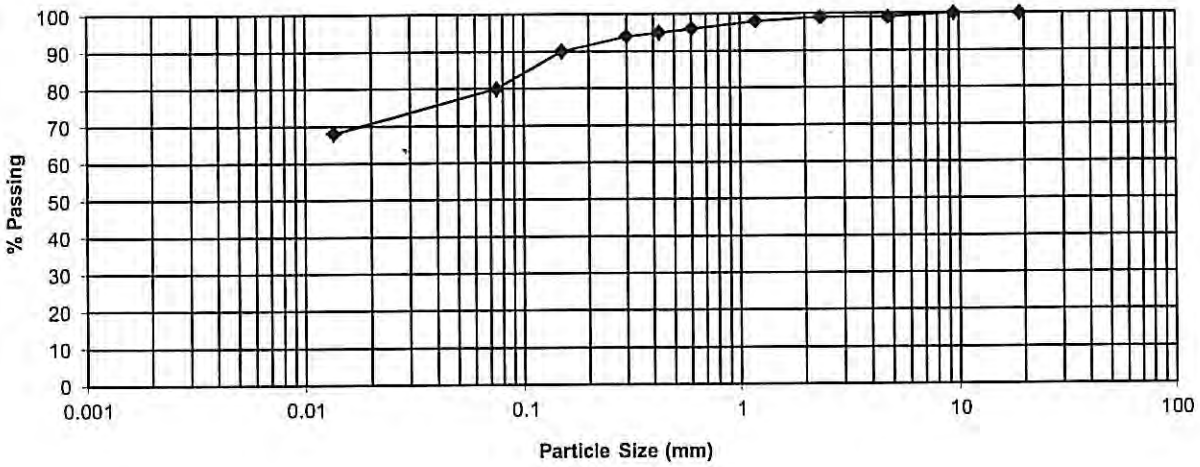
Particle Size Distribution & Plasticity Index tests

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:	**60017**
Report No:	**60017-P11/1318**
Sample No:	**P11/1318**
Issue Date:	**27 May 2011**

Client: **Chenin Grove Pty Ltd**
Project: **Lot 504 Corner Balmoral Road & Bowerbird Drive**
Location: **Karratha WA**

Sample Location: **TP 12**
Depth (m): **0.4**



SIEVE ANALYSIS WA 115.1

Sieve Size (mm)	% Passing
75.0	
37.5	
19.0	100
9.5	100
4.75	99
2.36	99
1.18	98
0.600	96
0.425	95
0.300	94
0.150	90
0.075	80
0.0135	68

Plasticity Index tests
Australian Standard 1289.

Liquid Limit 3.1.1	61	%
Plastic Limit 3.2.1	23	%
Plasticity Index 3.3.1	38	%
Linear Shrinkage 3.4.1	14.5	%
Cracked	☑	
Curled	☑	

Client address: 36 O'Malley Street, Osborne Park

Sampling Procedure: Tested as received

NATA WORLD RECOGNISED ACCREDITATION

Approved signature

Kevin M Jones

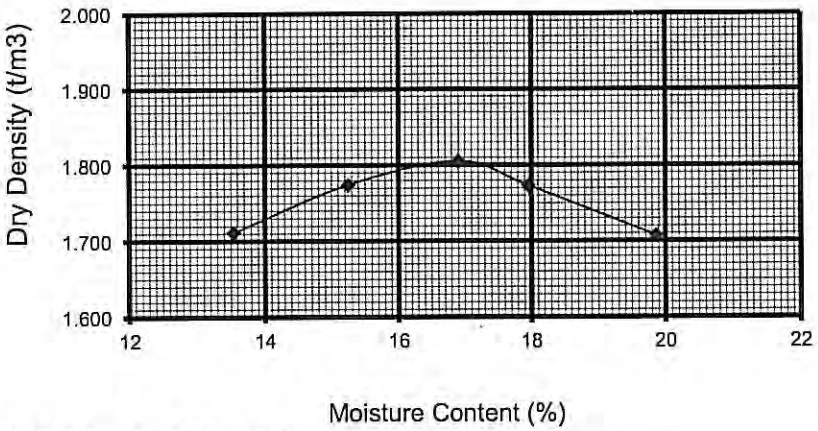
Mining &
Civil
Geotest Pty Ltd
Unit 1/1 Pusey Road, JANDAKOT WA 6164
Ph (08) 9414 8022
Fax (08)9414 8011
Email kevin@mcgeotest.com.au

Maximum Dry Density (AS 1289.5.2.1) & California Bearing Ratio (AS 1289.6.1.1) Test Report

Certificate No:	60017-P11/1318	**Client:**	Chenin Grove Pty Ltd
Sample No:	P11/1318	**Project:**	Karratha WA
Location:	Lot 504,Cnr Balmoral Rd & Bowerbird D	**Date of issue:**	27 May 2011
	TP 12, 0.4m	**Job No:**	60017

Maximum Dry Density t/m^3:	1.805	**Conditions at Test**	
Optimum Moisture Content %:	16.9	Soaking Period (Days)	4
Desired Conditions:	95/100	Surcharge (kg)	4.5
Compactive Effort		Entire Moisture Content %	26.3
Mass of hammer kg	4.9	Entire Moisture Ratio %	155.8
Number of layers	5	Top 30mm Moisture Content %	38.1
Number of blows/layer	30	Top 30mm Moisture Ratio %	225.4
Conditions after Compaction		Swell %	10.5
Dry Density t/m^3	1.710	C.B.R. at 2.5 mm Penetration %	1.5
Moisture Content %	17.1	**Conditions after Soaking**	
Density Ratio %	94.7	Dry Density t/m^3	1.546
Moisture Ratio %	101.2	Moisture Content %	27.4
Soaked / Unsoaked	Soaked	Dry Density Ratio %	85.7
		Moisture Ratio %	153.1

Comments:



Client address: 36 O'Malley St, Osborne Park

ASMDD-CBR June 2009

Approved Signature Kevin M Jones

TRICON TESTING
Geotechnical Engineering Laboratory
5 / 8 Corbusier Place, Balcatta, WA 6021 ABN 12 529 845 438
tricontest@optusnet.com.au Ph: (08) 9240 1444 Fax: (08) 9240 1044

REPORT CERTIFICATE

Determination of the Shrinkage Index of a Soil
Shrink-Swell Index
-according to AS 1289.7.1.1 - 2003

CLIENT : Douglas Partners Pty Ltd (Job # 76195) **JOB NO :** 1011422
PROJECT : Lot 504 Cnr Balmoral Rd & Bowerbird Drive (Chenin Grove Ltd) **Lab No. :** TT 06422004
LOCATION : Karratha **Date Tested :** May - June 2011
Sample Id : TP 12, Depth : 0.4 - 0.65m

SAMPLE DETAILS

Sample Description : Dark Brown, Silty Clay

Sample Type : nom. 48mm Ø tube sample

SWELL SPECIMEN		SHRINKAGE SPECIMEN	
Dry Density - Initial :	1.485 t/m^3	**Moisture Content** - Initial :	21.4 %
Moisture Content - Initial :	21.5 %	**Length / Diameter Ratio** :	1.36
Moisture Content - Final :	24.6 %	**Extent of Soil Crumbling** :	Nil
Overburden Pressure Used :	25 kPa	**Extent of Cracking** :	Hairline only
Significant Inert Inclusions :	Nil	**Significant Inert Inclusions** :	Nil

SHRINK-SWELL INDEX

I_{ss} : **2.6** % Vertical Strain per pF change in Total Suction

Notes : Sample supplied by Client

Authorised Signatory : DIGITAL COPY
(S. Brodie)

Date : 14/06/2011
Form No AS1289711sw 06/1 R

TRICON

mpl Laboratories
Part of the Envirolab Group ENVIROLAB GROUP

16 - 18 Hayden Court, Myaree, Western Australia 6154
PO Box 4023 Myaree BC, Western Australia 6960
Tel: +61 8 9317 2505 / Fax: +61 8 9317 4163
email: laboratory@mpl.com.au
www.envirolabservices.com.au
Envirolab Services (WA) Pty Ltd ABN 53 140 099 207

CERTIFICATE OF ANALYSIS 111441

Client:
Mining and Civil Geotest Pty Ltd
Unit 1, Pusey rd
Jandakot
WA 6164

Attention: Caroline Engel

Sample log in details:

Your Reference:	**Lot 504, Cnr Balmoral & Bowerbird**
No. of samples:	5 Soils
Date samples received:	20/5/11
Date completed instructions received:	20/5/11
Location:	

Analysis Details:
Please refer to the following pages for results, methodology summary and quality control data.
Samples were analysed as received from the client. Results relate specifically to the samples as received.
Results are reported on a dry weight basis for solids and on an as received basis for other matrices.
Please refer to the last page of this report for any comments relating to the results.

Report Details:

Date results requested by:	27/05/11
Date of Preliminary Report:	Not issued
Issue Date:	31/05/11

NATA accreditation number 2901. This document shall not be reproduced except in full.
This document is issued in accordance with NATA's accreditation requirements.
Accredited for compliance with ISO/IEC 17025.
Tests not covered by NATA are denoted with *.

Results Approved By:

Todd Lee
Laboratory Manager

Miscellaneous Inorg - soil						
Our Reference:	UNITS	111441-1	111441-2	111441-3	111441-4	111441-5
Your Reference	----------	1318	1319	1320	1321	1322
Sample location	----------	TP12	TP9	TP5	TP3	TP10
Depth		0.4	0.4	0.8	0.4	0.9
Type of sample		soil	soil	soil	soil	soil
Date prepared	-	24/05/11	24/05/11	24/05/11	24/05/11	24/05/11
Date analysed	-	25/05/11	25/05/11	25/05/11	25/05/11	25/05/11
Electrical Conductivity soil	µS/cm	240	47	68	99	170
Estimated Salinity*	mg/kg	820	160	230	340	580

Method ID	Methodology Summary
INORG-002	Conductivity and Salinity - measured using a conductivity cell and dedicated meter, in accordance with APHA 21st ED 2510 and Rayment & Higginson.

QUALITY CONTROL Miscellaneous Inorg - soil	UNITS	PQL	METHOD	Blank	Duplicate Sm#	Duplicate results Base II Duplicate II %RPD	Spike Sm#	Spike % Recovery
Date prepared	-			24/05/11	111441-1	24/05/11 || 24/05/11	LCS	24/05/11
Date analysed	-			25/05/11	111441-1	25/05/11 || 25/05/11	LCS	25/05/11
Electrical Conductivity soil	µS/cm	1	INORG-002	<1.0	111441-1	240 || 240 || RPD: 0	LCS	100%
Estimated Salinity*	mg/kg	5	INORG-002	[NT]	111441-1	820 || 820 || RPD: 0	[NR]	[NR]

Report Comments:
This report R01 replaces report R00 due to addition of sample location IDs as per client request. All results remain unchanged.

Australian Drinking Water Guidelines recommend that Thermotolerant Coliform & E.coli levels are less than 1cfu/100mL. The recommended maximums are taken from "Australian Drinking Water Guidelines", published by NHMRC& ARMC 2004.

Asbestos was analysed by Approved Identifier: Not applicable for this job
Airborne fibres were analysed by Approved Counter: Not applicable for this job

INS: Insufficient sample for this test; NT: Not tested; PQL: Practical Quantitation Limit; <: Less than; >: Greater than
RPD: Relative Percent Difference; NA: Test not required; LCS: Laboratory Control Sample; NR: Not requested
NS: Not specified; NEPM: National Environmental Protection Measure
DOL: Sample rejected due to particulate overload

Quality Control Definitions
Blank: This is the component of the analytical signal which is not derived from the sample but from reagents, glassware etc, can be determined by processing solvents and reagents in exactly the same manner as for samples.
Duplicate: This is the complete duplicate analysis of a sample from the process batch. If possible, the sample selected should be one where the analyte concentration is easily measurable.
Matrix Spike: A portion of the sample is spiked with a known concentration of target analyte. The purpose of the matrix spike is to monitor the performance of the analytical method used and to determine whether matrix interferences exist.
LCS (Laboratory Control Sample): This comprises either a standard reference material or a control matrix (such as a blank sand or water) fortified with analytes representative of the analyte class. It is simply a check sample.
Surrogate Spike: Surrogates are known additions to each sample, blank, matrix spike and LCS in a batch, of compounds which are similar to the analyte of interest, however are not expected to be found in real samples.

Laboratory Acceptance Criteria
Duplicate sample and matrix spike recoveries may not be reported on smaller jobs, however were analysed at a frequency to meet of exceed NEPM requirements. All samples are tested in batches of 20. The duplicate sample RPD a matrix spike recoveries for the sample batch were within laboratory acceptance criteria.

Duplicates: <5xPQL - any RPD is acceptable; >5xPQL - 0-50% RPD is acceptable.
Matrix Spike and LCS: Generally 70-130% for inorganics/metals; 60-140% for organics and 10-140% for SVOC and Speciated Phenols is acceptable.
Surrogates: 60-140% is acceptable for general organics and 10-140% for SVOC and Speciated Phenols.

Appendix C

CSIRO Notes on Foundation Maintenance and Footing Performance

Foundation Maintenance and Footing Performance:
A Homeowner's Guide

CSIRO

BTF 18
replaces
Information
Sheet 10/91

Buildings can and often do move. This movement can be up, down, lateral or rotational. The fundamental cause of movement in buildings can usually be related to one or more problems in the foundation soil. It is important for the homeowner to identify the soil type in order to ascertain the measures that should be put in place in order to ensure that problems in the foundation soil can be prevented, thus protecting against building movement.

This Building Technology File is designed to identify causes of soil-related building movement, and to suggest methods of prevention of resultant cracking in buildings.

Soil Types

The types of soils usually present under the topsoil in land zoned for residential buildings can be split into two approximate groups – granular and clay. Quite often, foundation soil is a mixture of both types. The general problems associated with soils having granular content are usually caused by erosion. Clay soils are subject to saturation and swell/shrink problems.

Classifications for a given area can generally be obtained by application to the local authority, but these are sometimes unreliable and if there is doubt, a geotechnical report should be commissioned. As most buildings suffering movement problems are founded on clay soils, there is an emphasis on classification of soils according to the amount of swell and shrinkage they experience with variations of water content. The table below is Table 2.1 from AS 2870, the Residential Slab and Footing Code.

Causes of Movement

Settlement due to construction

There are two types of settlement that occur as a result of construction:

- Immediate settlement occurs when a building is first placed on its foundation soil, as a result of compaction of the soil under the weight of the structure. The cohesive quality of clay soil mitigates against this, but granular (particularly sandy) soil is susceptible.
- Consolidation settlement is a feature of clay soil and may take place because of the expulsion of moisture from the soil or because of the soil's lack of resistance to local compressive or shear stresses. This will usually take place during the first few months after construction, but has been known to take many years in exceptional cases.

These problems are the province of the builder and should be taken into consideration as part of the preparation of the site for construction. Building Technology File 19 (BTF 19) deals with these problems.

Erosion

All soils are prone to erosion, but sandy soil is particularly susceptible to being washed away. Even clay with a sand component of say 10% or more can suffer from erosion.

Saturation

This is particularly a problem in clay soils. Saturation creates a bog-like suspension of the soil that causes it to lose virtually all of its bearing capacity. To a lesser degree, sand is affected by saturation because saturated sand may undergo a reduction in volume – particularly imported sand fill for bedding and blinding layers. However, this usually occurs as immediate settlement and should normally be the province of the builder.

Seasonal swelling and shrinkage of soil

All clays react to the presence of water by slowly absorbing it, making the soil increase in volume (see table below). The degree of increase varies considerably between different clays, as does the degree of decrease during the subsequent drying out caused by fair weather periods. Because of the low absorption and expulsion rate, this phenomenon will not usually be noticeable unless there are prolonged rainy or dry periods, usually of weeks or months, depending on the land and soil characteristics.

The swelling of soil creates an upward force on the footings of the building, and shrinkage creates subsidence that takes away the support needed by the footing to retain equilibrium.

Shear failure

This phenomenon occurs when the foundation soil does not have sufficient strength to support the weight of the footing. There are two major post-construction causes:

- Significant load increase.
- Reduction of lateral support of the soil under the footing due to erosion or excavation.
- In clay soil, shear failure can be caused by saturation of the soil adjacent to or under the footing.

GENERAL DEFINITIONS OF SITE CLASSES

Class	Foundation
A	Most sand and rock sites with little or no ground movement from moisture changes
S	Slightly reactive clay sites with only slight ground movement from moisture changes
M	Moderately reactive clay or silt sites, which can experience moderate ground movement from moisture changes
H	Highly reactive clay sites, which can experience high ground movement from moisture changes
E	Extremely reactive sites, which can experience extreme ground movement from moisture changes
A to P	Filled sites
P	Sites which include soft soils, such as soft clay or silt or loose sands; landslip; mine subsidence; collapsing soils; soils subject to erosion; reactive sites subject to abnormal moisture conditions or sites which cannot be classified otherwise

Tree root growth
Trees and shrubs that are allowed to grow in the vicinity of footings can cause foundation soil movement in two ways:

- Roots that grow under footings may increase in cross-sectional size, exerting upward pressure on footings.
- Roots in the vicinity of footings will absorb much of the moisture in the foundation soil, causing shrinkage or subsidence.

Unevenness of Movement

The types of ground movement described above usually occur unevenly throughout the building's foundation soil. Settlement due to construction tends to be uneven because of:

- Differing compaction of foundation soil prior to construction.
- Differing moisture content of foundation soil prior to construction.

Movement due to non-construction causes is usually more uneven still. Erosion can undermine a footing that traverses the flow or can create the conditions for shear failure by eroding soil adjacent to a footing that runs in the same direction as the flow.

Saturation of clay foundation soil may occur where subfloor walls create a dam that makes water pond. It can also occur wherever there is a source of water near footings in clay soil. This leads to a severe reduction in the strength of the soil which may create local shear failure.

Seasonal swelling and shrinkage of clay soil affects the perimeter of the building first, then gradually spreads to the interior. The swelling process will usually begin at the uphill extreme of the building, or on the weather side where the land is flat. Swelling gradually reaches the interior soil as absorption continues. Shrinkage usually begins where the sun's heat is greatest.

Effects of Uneven Soil Movement on Structures

Erosion and saturation
Erosion removes the support from under footings, tending to create subsidence of the part of the structure under which it occurs. Brickwork walls will resist the stress created by this removal of support by bridging the gap or cantilevering until the bricks or the mortar bedding fail. Older masonry has little resistance. Evidence of failure varies according to circumstances and symptoms may include:

- Step cracking in the mortar beds in the body of the wall or above/below openings such as doors or windows.
- Vertical cracking in the bricks (usually but not necessarily in line with the vertical beds or perpends).

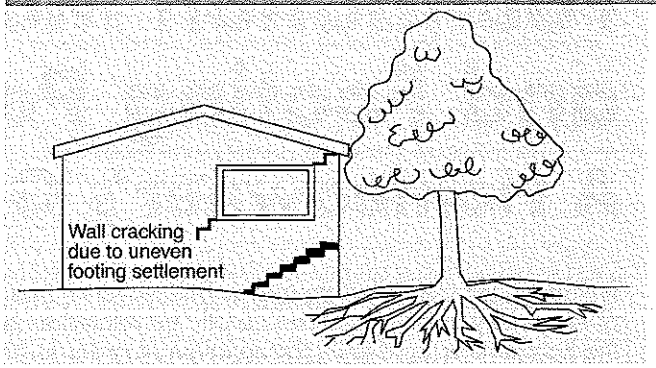
Isolated piers affected by erosion or saturation of foundations will eventually lose contact with the bearers they support and may tilt or fall over. The floors that have lost this support will become bouncy, sometimes rattling ornaments etc.

Seasonal swelling/shrinkage in clay
Swelling foundation soil due to rainy periods first lifts the most exposed extremities of the footing system, then the remainder of the perimeter footings while gradually permeating inside the building footprint to lift internal footings. This swelling first tends to create a dish effect, because the external footings are pushed higher than the internal ones.

The first noticeable symptom may be that the floor appears slightly dished. This is often accompanied by some doors binding on the floor or the door head, together with some cracking of cornice mitres. In buildings with timber flooring supported by bearers and joists, the floor can be bouncy. Externally there may be visible dishing of the hip or ridge lines.

As the moisture absorption process completes its journey to the innermost areas of the building, the internal footings will rise. If the spread of moisture is roughly even, it may be that the symptoms will temporarily disappear, but it is more likely that swelling will be uneven, creating a difference rather than a disappearance in symptoms. In buildings with timber flooring supported by bearers and joists, the isolated piers will rise more easily than the strip footings or piers under walls, creating noticeable doming of flooring.

Trees can cause shrinkage and damage



As the weather pattern changes and the soil begins to dry out, the external footings will be first affected, beginning with the locations where the sun's effect is strongest. This has the effect of lowering the external footings. The doming is accentuated and cracking reduces or disappears where it occurred because of dishing, but other cracks open up. The roof lines may become convex.

Doming and dishing are also affected by weather in other ways. In areas where warm, wet summers and cooler dry winters prevail, water migration tends to be toward the interior and doming will be accentuated, whereas where summers are dry and winters are cold and wet, migration tends to be toward the exterior and the underlying propensity is toward dishing.

Movement caused by tree roots
In general, growing roots will exert an upward pressure on footings, whereas soil subject to drying because of tree or shrub roots will tend to remove support from under footings by inducing shrinkage.

Complications caused by the structure itself
Most forces that the soil causes to be exerted on structures are vertical – i.e. either up or down. However, because these forces are seldom spread evenly around the footings, and because the building resists uneven movement because of its rigidity, forces are exerted from one part of the building to another. The net result of all these forces is usually rotational. This resultant force often complicates the diagnosis because the visible symptoms do not simply reflect the original cause. A common symptom is binding of doors on the vertical member of the frame.

Effects on full masonry structures
Brickwork will resist cracking where it can. It will attempt to span areas that lose support because of subsided foundations or raised points. It is therefore usual to see cracking at weak points, such as openings for windows or doors.

In the event of construction settlement, cracking will usually remain unchanged after the process of settlement has ceased.

With local shear or erosion, cracking will usually continue to develop until the original cause has been remedied, or until the subsidence has completely neutralised the affected portion of footing and the structure has stabilised on other footings that remain effective.

In the case of swell/shrink effects, the brickwork will in some cases return to its original position after completion of a cycle, however it is more likely that the rotational effect will not be exactly reversed, and it is also usual that brickwork will settle in its new position and will resist the forces trying to return it to its original position. This means that in a case where swelling takes place after construction and cracking occurs, the cracking is likely to at least partly remain after the shrink segment of the cycle is complete. Thus, each time the cycle is repeated, the likelihood is that the cracking will become wider until the sections of brickwork become virtually independent.

With repeated cycles, once the cracking is established, if there is no other complication, it is normal for the incidence of cracking to stabilise, as the building has the articulation it needs to cope with the problem. This is by no means always the case, however, and monitoring of cracks in walls and floors should always be treated seriously.

Upheaval caused by growth of tree roots under footings is not a simple vertical shear stress. There is a tendency for the root to also exert lateral forces that attempt to separate sections of brickwork after initial cracking has occurred.

The normal structural arrangement is that the inner leaf of brickwork in the external walls and at least some of the internal walls (depending on the roof type) comprise the load-bearing structure on which any upper floors, ceilings and the roof are supported. In these cases, it is internally visible cracking that should be the main focus of attention, however there are a few examples of dwellings whose external leaf of masonry plays some supporting role, so this should be checked if there is any doubt. In any case, externally visible cracking is important as a guide to stresses on the structure generally, and it should also be remembered that the external walls must be capable of supporting themselves.

Effects on framed structures
Timber or steel framed buildings are less likely to exhibit cracking due to swell/shrink than masonry buildings because of their flexibility. Also, the doming/dishing effects tend to be lower because of the lighter weight of walls. The main risks to framed buildings are encountered because of the isolated pier footings used under walls. Where erosion or saturation cause a footing to fall away, this can double the span which a wall must bridge. This additional stress can create cracking in wall linings, particularly where there is a weak point in the structure caused by a door or window opening. It is, however, unlikely that framed structures will be so stressed as to suffer serious damage without first exhibiting some or all of the above symptoms for a considerable period. The same warning period should apply in the case of upheaval. It should be noted, however, that where framed buildings are supported hy strip footings there is only one leaf of brickwork and therefore the extetnally visible walls are the supporting structure fot the building. In this case, the subfloor masonry walls can be expected to behave as full btickwork walls.

Effects on brick veneer structures
Because the load-bearing structute of a brick veneer building is the frame that makes up the interior leaf of the external walls plus perhaps the internal walls, depending on the type of roof, the building can be expected to behave as a framed sttucture, except that the external masonry will behave in a similar way to the external leaf of a full masonry structure.

Water Service and Drainage

Where a water service pipe, a sewer or stormwater drainage pipe is in the viciniry of a building, a water leak can cause erosion, swelling or saturation of susceptible soil. Even a minuscule leak can be enough to saturate a clay foundarion. A leaking tap near a building can have the same effect. In addition, trenches containing pipes can become watercourses even though backfilled, particularly where broken rubble is used as fill. Water that runs along these trenches can be responsible for serious erosion, interstrata seepage into subfloor areas and saturation.

Pipe leakage and trench water flows also encourage tree and shrub toots to the source of water, complicaring and exacerbating the problem.
Poor roof plumbing can result in large volumes of rainwater being concentrated in a small area of soil:

- Incorrect falls in roof guttering may result in overflows, as may gutters blocked with leaves etc.
- Corroded guttering or downpipes can spill water to ground.
- Downpipes not positively connected to a proper stormwater collection system will direct a concentration of water to soil that is directly adjacent to footings, sometimes causing large-scale problems such as erosion, saturation and migration of water under the building.

Seriousness of Cracking

In general, most cracking found in masonry walls is a cosmetic nuisance only and can be kept in repair or even ignored. The table below is a reproduction of Table C1 of AS 2870.

AS 2870 also publishes figures relating to cracking in concrete floors, however because wall cracking will usually reach the critical point significantly earlier than cracking in slabs, this table is not reproduced here.

Prevention/Cure

Plumbing
Where building movemenr is caused by water service, roof plumbing, sewer or stormwater failute, the remedy is to repair the problem. It is prudent, however, to consider also rerouting pipes away from the building where possible, and relocating taps to positions where any leakage will not direct water to the building vicinity. Even where gully traps are present, there is sometimes sufficient spill to create erosion or saturation, particularly in modern installations using smaller diameter PVC fixtures. Indeed, some gully traps are not situated directly under the taps that are installed to charge them, with the result that water from the tap may enter the backfilled trench that houses the sewer piping. If the trench has been poorly backfilled, the water will eithet pond or flow along the bottom of the trench. As these trenches usually run alongside the foorings and can be at a similar depth, it is not hard to see how any water that is thus directed into a trench can easily affect the foundation's ability to support footings or even gain entry to the subfloor area.

Ground drainage
In all soils there is the capaciry for water to travel on the surface and below it. Surface water flows can be established by inspection during and after heavy or prolonged rain. If necessary, a grated drain system connected to the stormwater collection system is usually an easy solution.

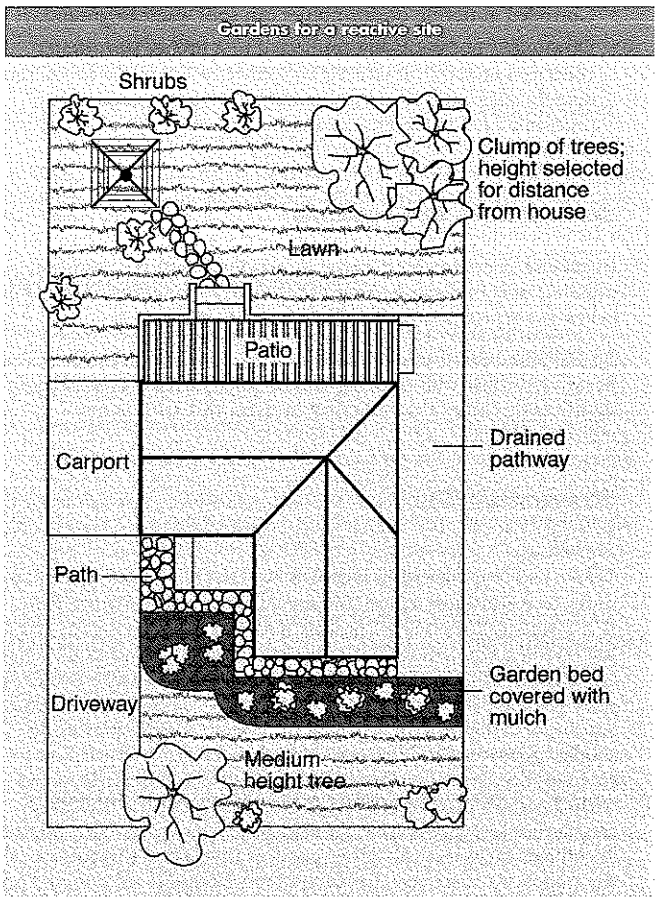
It is, however, sometimes necessary when attempring to prevent water migration that testing be carried out to establish watertable height and subsoil water flows. This subject is referred to in BTF 19 and may properly be regarded as an area for an expert consultant.

Protection of the building perimeter
It is essential to remember that the soil that affects footings extends well beyond the actual building line. Watering of garden planrs, shrubs and trees causes some of rhe most serious water problems.

For this reason, particularly where problems exist or are likely to occur, it is recommended that an apron of paving be insralled around as much of the building perimeter as necessary. This paving

CLASSIFICATION OF DAMAGE WITH REFERENCE TO WALLS

Description of typical damage and required repair	Approximate crack width limit (see Note 3)	Damage category
Hairline cracks	<0.1 mm	0
Fine cracks which do not need repair	<1 mm	1
Cracks noticeable but easily filled. Doors and windows stick slightly	<5 mm	2
Cracks can be repaired and possibly a small amount of wall will need to be replaced. Doors and windows stick. Service pipes can fracture. Weathertightness ofren impaired	5–15 mm (or a number of cracks 3 mm or more in one group)	3
Extensive repair work involving breaking-out and replacing sections of walls, especially over doors and windows. Window and door frames distort. Walls lean or bulge noriceably, some loss of bearing in beams. Service pipes disrupted	15–25 mm but also depend on number of cracks	4



should extend outwards a minimum of 900 mm (more in highly reactive soil) and should have a minimum fall away from the building of 1:60. The finished paving should be no less than 100 mm below brick vent bases.

It is prudent to relocate drainage pipes away from this paving, if possible, to avoid complications from future leakage. If this is not practical, earthenware pipes should be replaced by PVC and backfilling should be of the same soil type as the surrounding soil and compacted to the same density.

Except in areas where freezing of water is an issue, it is wise to remove taps in the building area and relocate them well away from the building – preferably not uphill from it (see BTF 19).

It may be desirable to install a grated drain at the outside edge of the paving on the uphill side of the building. If subsoil drainage is needed this can be installed under the surface drain.

Condensation

In buildings with a subfloor void such as where bearers and joists support flooring, insufficient ventilation creates ideal conditions for condensation, particularly where there is little clearance between the floor and the ground. Condensation adds to the moisture already present in the subfloor and significantly slows the process of drying out. Installation of an adequate subfloor ventilation system, either natural or mechanical, is desirable.

Warning: Although this Building Technology File deals with cracking in buildings, it should be said that subfloor moisture can result in the development of other problems, notably:

- Water that is transmitted into masonry, metal or timber building elements causes damage and/or decay to those elements.
- High subfloor humidity and moisture content create an ideal environment for various pests, including termites and spiders.
- Where high moisture levels are transmitted to the flooring and walls, an increase in the dust mite count can ensue within the living areas. Dust mites, as well as dampness in general, can be a health hazard to inhabitants, particularly those who are abnormally susceptible to respiratory ailments.

The garden

The ideal vegetation layout is to have lawn or plants that require only light watering immediately adjacent to the drainage or paving edge, then more demanding plants, shrubs and trees spread out in that order.

Overwatering due to misuse of automatic watering systems is a common cause of saturation and water migration under footings. If it is necessary to use these systems, it is important to remove garden beds to a completely safe distance from buildings.

Existing trees

Where a tree is causing a problem of soil drying or there is the existence or threat of upheaval of footings, if the offending roots are subsidiary and their removal will not significantly damage the tree, they should be severed and a concrete or metal barrier placed vertically in the soil to prevent future root growth in the direction of the building. If it is not possible to remove the relevant roots without damage to the tree, an application to remove the tree should be made to the local authority. A prudent plan is to transplant likely offenders before they become a problem.

Information on trees, plants and shrubs

State departments overseeing agriculture can give information regarding root patterns, volume of water needed and safe distance from buildings of most species. Botanic gardens are also sources of information. For information on plant roots and drains, see Building Technology File 17.

Excavation

Excavation around footings must be properly engineered. Soil supporting footings can only be safely excavated at an angle that allows the soil under the footing to remain stable. This angle is called the angle of repose (or friction) and varies significantly between soil types and conditions. Removal of soil within the angle of repose will cause subsidence.

Remediation

Where erosion has occurred that has washed away soil adjacent to footings, soil of the same classification should be introduced and compacted to the same density. Where footings have been undermined, augmentation or other specialist work may be required. Remediation of footings and foundations is generally the realm of a specialist consultant.

Where isolated footings rise and fall because of swell/shrink effect, the homeowner may be tempted to alleviate floor bounce by filling the gap that has appeared between the bearer and the pier with blocking. The danger here is that when the next swell segment of the cycle occurs, the extra blocking will push the floor up into an accentuated dome and may also cause local shear failure in the soil. If it is necessary to use blocking, it should be by a pair of fine wedges and monitoring should be carried out fortnightly.

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Distributed by

CSIRO PUBLISHING PO Box 1139, Collingwood 3066, Australia

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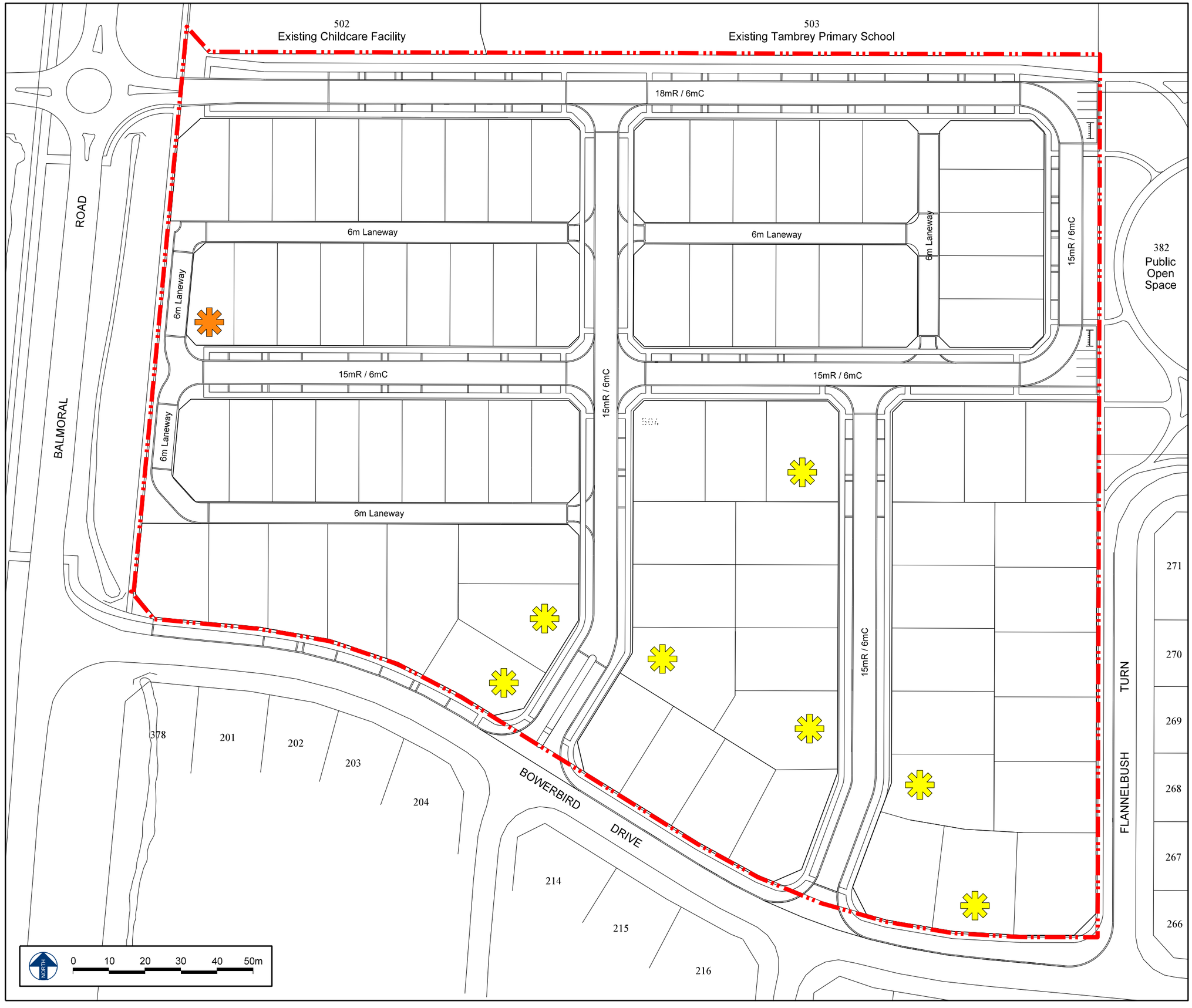
APPENDIX 8

Outdoor Living Areas

APPENDIX 8: OUTDOOR LIVING AREAS

Lot 504 Nickol,
TAMBREY



LEGEND

- Development Plan Boundary
- Cottage Lot - The Minimum Depth of the Outdoor Living Area shall be 2.8m
- Traditional Lot - The Minimum Width of the Outdoor Living Area shall be 4.0m

Note:
Requirements for all other lots shall be in accordance with the dimensions outlined in Section 9.2 (b) of the report.

ABN Developments : CLIENT
1:1,000@A3 : SCALE
27 February 2012 : DATE
3789-5-007.dgn : PLAN No
- : REVISION
F.V. : PLANNER
R.F. : DRAWN
N.T. : CHECKED

Base data supplied by Whelans and Simon Youngleson Architects. Accuracy +/- 4m. Projection KAR94.

Areas and dimensions shown are subject to final survey calculations. All carriageways are shown for illustrative purposes only and are subject to detailed engineering design.

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