

DEVELOPMENT PLAN REPORT

Portion of South Hedland - Western Edge

Part I – Statutory Provisions

Prepared by:

RPS

38 Station Street, SUBIACO WA 6008 PO Box 465, SUBIACO WA 6904

T: 618 9211 1111 F: 618 9211 1122

E: planning@rpsgroup.com.auW: www.rpsgroup.com.au

Report No: 2957.19

Version/Date: September 2012

Prepared for:

LANDCORP

3rd Floor

Westfarmers House

40 The Esplanade

PERTH WA 6000



Document Status

Document Status								
Version	Purpose of Document	Orig	Review	Review Date		RPS Release Approval	Issue Date	
Draft A	Internal Review	SD	SD	20.07.12				
Rev 0	Submission	SD	LR	28.09.12	28.09.12	28.09.12	02.10.12	



TABLE OF AMENDMENTS – DEVELOPMENT PLAN FOR PORTION OF SOUTH HEDLAND – WESTERN EDGE

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



CERTIFICATION OF DEVELOPMENT PLAN

IT IS HEREBY CERTIFIED THAT THE DEVELOPMENT PLAN FOR PORTION OF SOUTH HEDLAND – WESTERN EDGE WAS:

ENDORSED BY A RESOLUTION OF THE COUNCIL OF THE TOWN OF PORT HEDLAND ON
Director Planning and Development, Town of Port Hedland
and adopted by resolution of the western australian planning commission on
Being an officer of the Commission duly
Authorised by the Commission pursuant to
Section 16 of the Planning and Development Act 2005



TABLE OF CONTENTS

Page

1.0	DEVELOPMENT PLAN AREA	. I
2.0	DEVELOPMENT PLAN CONTENT	. I
3.0	INTERPRETATIONS	. I
4.0	OPERATION DATE	. 2
5.0	RELATIONSHIP TO THE SCHEME	. 2
6.0	PUBLIC OPEN SPACE PROVISION	. 2
7.0	RESIDENTIAL DENSITY	. 3
8.0	SUBDIVISION REQUIREMENTS	. 3
9.0	DEVELOPMENT REQUIREMENTS	. 3
10.0	OPERATION AND IMPLEMENTATION	. 3



1.0 DEVELOPMENT PLAN AREA

The Development Plan area relates to the area identified on the Development Plan (Ref: 2957.19-003b), and described as follows:

Lot	Plan	Certificate of Title
Whole of lot 5864	DP 218335	LR3145/829
Whole of lot 3259	DP 213764	LR3012/485
Whole of lot 450	DP 218335	Not issued.
Whole of lot 3257	DP 218335	LR3012/488
Whole of lot 5526	DP 215251	LR3008/466
Part of lot 344	DP 72901	LR3161/716
Part of lot 331	DP 72894	LR3161/417
Part of lot 307	DP 46147	LR3142/696
Part of lot 5157	DP 214217	LR3008/522
Part of lot 500	DP 63966	LR3156/935
Part of lot 6102	DP 221110	LR3120/428
Part of lot 310	DP 50269	LR3136/789
Part of lot 605	DP 71984	LR3161/585

2.0 DEVELOPMENT PLAN CONTENT

The Development Plan comprises the following sections:

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

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

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

The terms used in the Development Plan have the respective meaning given to them in the Town of Port Hedland Town Planning Scheme No. 5.



4.0 OPERATION DATE

The Development Plan will become operative following the endorsement of the Plan by the Town of Port Hedland and adoption of the Plan by the Western Australian Planning Commission pursuant to Clause 5.2 of Town Planning Scheme No. 5. 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

The provisions of this Development Plan are made pursuant to Clause 5.2, Clause 6.4 and Appendix 6 of the Town of Port Hedland Town Planning Scheme No. 5. The Development Plan is a Policy Statement and forms part of the Town of Port Hedland Land Use Planning Policy Manual.

The Town of Port Hedland Town Planning Scheme No. 5 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 as follows:

- land use permissibility within the nominated residential areas is to be in accordance with the 'Residential' zone provisions;
- land use permissibility within the commercial site is to be in accordance with the 'Commercial' zone provisions;
- land use permissibility within the nominated aged care / key worker accommodation site is to be in accordance with the 'Residential' zone provisions of the Town of Port Hedland Town Planning Scheme No.5, with a nominated residential density of R50/60; and
- land use permissibility within the education site is to be in accordance with the 'Education' zone provisions.

6.0 PUBLIC OPEN SPACE PROVISION

The Development Plan provides for public open space in association with multiple use corridors serving water management and open space functions.

The area of land provided for public open space is 4.46 hectares, and the area for multiple use corridors is 11.8 hectares.



7.0 RESIDENTIAL DENSITY

The residential areas of the Development Plan are coded R20, R30, R40, R50/60 as illustrated on the Development Plan.

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

8.0 SUBDIVISION REQUIREMENTS

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 I of State Planning Policy 3.1 – Residential Design Codes.

9.0 DEVELOPMENT REQUIREMENTS

Residential development is to comply with the provisions of State Planning Policy 3.1 – Residential Design Codes as required by section 6.2 of Town Planning Scheme No 5.

The Development Plan provides residential property directly adjacent to multiple use corridors and public open space. In these circumstances, development is to be regulated by Design Guidelines to ensure appropriate interface between the public and private realms.

10.0 OPERATION AND IMPLEMENTATION

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

Table I - Reports and Plans

Documentation	Approval Stage	Approving Authority		
Urban Water Management Plan	Prior to clearance of development and/or subdivision conditions	Town of Port Hedland & Department of Water		
Design Guidelines	Prior to development approval developments on applicable lots.	Town of Port Hedland.		



DEVELOPMENT PLAN

PORTION OF SOUTH HEDLAND - WESTERN EDGE, SOUTH HEDLAND

PROPOSED DEVELOPMENT PLAN
Western Edge, SOUTH HEDLAND

RPS Australia East Pty Ltd
ABN 44140292762
PO Box 465 SUBIACO WA 6904
38 Station Street SUBIACO WA 6008
T +61 8 9211 1111 W rpsgroup.com.au



DEVELOPMENT PLAN REPORT

Portion of South Hedland - Western Edge

Part 2 - Explanatory Report

Prepared by:

RPS

38 Station Street, SUBIACO WA 6008 PO Box 465, SUBIACO WA 6904

T: 618 9211 1111 F: 618 9211 1122

E: planning@rpsgroup.com.auW: www.rpsgroup.com.au

Report No: 2957.19

Version/Date: September 2012

Prepared for:

LANDCORP

3rd Floor Westfamers House 40 The Esplanade PERTH WA 6000



Document Status

Version	Purpose of Document	nent Orio Review 1					Issue Date
Draft A	Internal Review	SV	SD	20.07.12			
Rev 0	Submission	SD	LR	28.09.12	28.09.12	28.09.12	02.10.12



TAB	SLE O	F CONTENTS	Page			
1.0	PLAN	5				
1.1	Introd	Introduction and Purpose				
1.3	Land D	8				
	1.3.1	Location	8			
	1.3.2	Legal Description and Ownership	8			
	1.3.3	Historical Context	9			
	1.3.4	Current Land Use	13			
	1.3.5	Surrounding Land Use and Development Pattern	14			
	1.3.6	Port Hedland Housing Market	14			
1.4	Plannii	ng Framework	16			
	1.4.1	Regional and Local Strategic Plans	16			
	1.4.2	Statutory Zoning & Development Plan Areas	17			
	1.4.3	Policies	18			
2.0	SITE	CONDITIONS AND ENVIRONMENT	2 I			
2.1	Enviro	nmental Overview	21			
	2.1.1	Climate	21			
	2.1.2	Landform and Soils	21			
	2.1.3	Hydrology	22			
	2.1.4	Vegetation and Flora	23			
	2.1.5	Fauna and Habitat	23			
	2.1.6	Heritage and Cultural Significance	24			
3.0	PROF	POSED DEVELOPMENT PLAN	25			
3.1	Design	Philosophy	25			
3.2	Propos	sed Land Use	26			
	3.2.1	Distribution and Layout	26			
	3.2.2	Residential Density and Diversity	27			



	2 2 2	Duilt Form	20
	3.2.3	Built Form	
	3.2.4	Lot Layout, Orientation and Climatic Responsiveness	29
	3.2.5	Commercial Site	30
	3.2.6	Aged Care / Key Worker Accommodation Site	30
	3.2.7	Education Site	31
3.3	Mover	ment Network	31
	3.3.1	Existing/Surrounding Road Network	31
	3.3.2	Proposed Road Network	32
	3.3.3	Pedestrian and Cycle Movement	35
	3.3.4	Public Transport	35
3.4	Open	Space and Amenity	36
	3.4.1	Public Open Space Provision	36
	3.4.2	Landscape Amenity	39
	3.4.3	Streetscape Amenity	41
3.5	Urban	Water Management	41
	3.5.1	Key Principles and Objectives	41
	3.5.2	Stormwater Management	42
	3.5.3	LWMS Key Elements and Implementation	43
3.6	Emplo	oyment, Community Services and Facilities	45
3.7	Utiliti	es	46
	3.7.1	Sewerage	46
	3.7.2	Potable Water Supply	46
	3.7.3	Power	47
	3.7.4	Telecommunications	48
	3.7.5	Gas	48
3.8	Implei	mentation and Staging	48
4.0	•	ICLUSION	



TABLES

Table I:	Legal Description and Ownership	8
Table 2:	Structure Plan Summary Table	27
Table 3:	Residential Density and Diversity	28
Table 4:	Existing Road Hierarchy	32
Table 5:	Proposed Road Network Hierarchy and Function	33
Table 6:	Public Open Space Schedule	37
Table 7:	LWMS Key Principles and Objectives	42
Table 8:	Summary of Proposed Local Water Management Strategy	44
FIGURES		
Figure I:	Location Plan	10
Figure 2:	Local Context Plan	11
Figure 3:	Aerial Plan	12
Figure 4:	Scheme Map Amendments (Amendment 53)	19
Figure 5:	Development Plan Boundary Amendments (Amendment 53)	20
Figure 6:	Indicative Cross Section of District Distributor Road	34
Figure 7:	Indicative Cross Section of Neighbourhood Connector Road	34
Figure 8:	Indicative Cross Section of Local Access Street	35
Figure 9:	Public Open Space Provision	38
Figure 10:	Indicative Cross Section of a Multiple Use Corridor	40
Figure II:	Indicative Cross Section of a Multiple Use Corridor	40



APPENDICES

APPENDIX I Development Plan

APPENDIX 2 Environmental Assessment Report

APPENDIX 3 Aboriginal Heritage Survey Report

APPENDIX 4 Transport Assessment Report

APPENDIX 5 Landscape Concept Plan

APPENDIX 6 Local Water Management Strategy

APPENDIX 7 Engineering Servicing Report



1.0 PLANNING BACKGROUND

I.I Introduction and Purpose

This Development Plan report has been prepared on behalf of LandCorp for a portion of the project area generally referred to as 'South Hedland Western Edge'. The Development Plan area, made up of portions of eight lots, and five whole lots, is referred to in this report as the 'subject land'.

LandCorp is the Western Australian State Government's property developer operating under the Western Australian Land Authority Act 1992. Since its formation, LandCorp has delivered an extensive range of high quality urban, industrial and commercial/ tourism related land and infrastructure developments throughout regional Western Australia. In doing so, it has developed a reputation as a leading edge developer committed to more sustainable development through the integration of economic, environmental and social outcomes. Through strengthened links with the private sector via project partnering arrangements, LandCorp aims to unlock development benefits by matching complementary strengths with the public and private sectors.

Building on the vision set by the Pilbara Cities strategy, the South Hedland Western Edge project offers a unique opportunity to plan and deliver a family oriented master planned community, delivering diversity in accommodation types in a location where people will choose to live on a permanent and intergenerational basis. The wider South Hedland Western Edge area comprises potentially 226ha in area, and has been identified as having the capacity over time to deliver some 2,280 lots, a local commercial centre and accommodation to support a possible University/tertiary education campus. This is consistent with the following vision set for the area by Pilbara's Port City Growth Plan¹:

"South Hedland West (Western Edge) is South Hedland's newest land release area. It supports immediate and short term land supply, bringing a permanent population catchment to the west of the City. Densities are greatest in proximity to the City Centre, with more traditional home sites provided to the south west and south of the precinct."

To deliver this vision, the following South Hedland Western Edge key outcome areas and project objectives have been identified:

Housing

- 1. Optimise dwelling yields through a variety of medium and high density housing;
- 2. Encourage a greater permanent residential population within the catchment of the South Hedland city centre, supporting an increased level of services available to the community; and

¹ ToPH (2012), Pilbara's Port City Growth Plan, Town of Port Hedland, WA



3. Achieve built form that acknowledges the climatic conditions.

Amenity and Facilities

- 1. Provide safe public spaces that encourage public transport usage and pedestrian movement;
- 2. Provide for regional sport and recreation facilities, capable of hosting formalised sporting events;
- 3. Provide attractive open space areas for passive and informal active use;
- 4. Provide for public primary education services;
- 5. Facilitate effective public transport;
- 6. Provide linear open space, creating pedestrian corridors, view corridors towards South Creek, general open space amenity and water management areas;
- Achieve a balance of active and passive public open space in addition to the district open space provision; and
- 8. Create a sense of community through appropriate arrangement of activities, linkages and sight lines.

Environment

- I. Achieve sustainable water management outcomes and with regard to stormwater flows and the safe/appropriate location of urban development; and
- 2. Optimise relationship to the South Creek environment.

Movement Network

- 1. Strengthen the link between 'Western Edge' and Great Northern Highway/community activities to the west;
- 2. Provide linkages that will integrate with the long-term urban development area to the south; and
- 3. Design movement network to support roundabouts in-lieu of traffic light controlled intersections.

Implementation

- I. Achieve a 'fast-track' approvals process through shared objectives and support for early land release by key decision making agencies;
- 2. Facilitate the release of land to the private market to undertake subdivision and development where possible; and
- 3. Deliver housing and land turn-key packages within affordable price-points.

An amendment (Amendment 53) to the Town of Port Hedland's Town Planning Scheme No.5 (TPS5) is currently being progressed to rezone the entire South Hedland Western Edge area to 'Urban



Development' and realign the boundaries of 'Development Area South Hedland West'. The amendment has been initiated and adopted for final approval by the Town of Port Hedland.

To ensure continued supply of land in the South Hedland community, LandCorp has identified a 70ha parcel of land for early delivery to the market. It is crucial that the necessary planning for this land is progressed as a matter of priority to ensure subdivision and development occurs in a timely manner. Accordingly, the Development Plan (refer **Appendix I**) proposed by this report has been prepared to coordinate future subdivision and development in accordance with TPS5 requirements and the design elements outlined by Liveable Neighbourhoods².

In addition to Planning and Urban Design considerations, the preparation of the Development Plan has been informed by a number of technical and design investigations, including input from the following disciplines:

- **RPS Environment** environmental investigations
- RPS Economics market assessment
- Cossill & Webley civil infrastructure
- JDA local water management strategy
- UDLA landscape design
- Porter Engineering traffic and transportation
- Anthropos Australis heritage
- McMullen Nolan Group surveying

² WAPC (2007), Liveable Neighbourhoods, Western Australian Planning Commission, Perth



1.3 Land Description

1.3.1 Location

The subject land is located to the immediate west of the South Hedland City Centre area, and extends to the eastern boundary of the Boodarie Industrial Buffer Special Control Area as depicted on the Town of Port Hedland Town Planning Scheme No 5. The subject land also includes a portion of the Western Edge project area to the south of the existing South Hedland hospital site. (Refer Figure I - Location Plan, Figure 2 - Local Context Plan and Figure 3 - Aerial Plan).

The adjacent City Centre area is the key focus of retail, commercial, health and community activities within South Hedland. The centre is currently undergoing significant expansion consistent with the South Hedland Town Centre Development Plan (SHTCDP)³, which envisages the development of a new vibrant centre supported by commercial and retail development and increased housing diversity. The revitalised city centre is oriented around the new main street along Colebatch Way, with construction works well progressed. South Creek is situated to the immediate west of the subject land. The creek system is integral with local flood management and stormwater design for the subject land.

1.3.2 Legal Description and Ownership

The State of Western Australia is the proprietor of all lots within the subject land area, which are formally described as follows:

Table I: Legal Description and Ownership

Lot	Plan/Diagram	Certificate of Title	Primary Interest Holder	Purpose / Interests
Whole of lot 5864	DP 218335	LR3145/829	Town of Port Hedland	Reserve 36025 for drainage
Whole of lot 3259	DP 213764	LR3012/485	Unallocated Crown Land	Nil
Whole of lot 450	DP 218335	Not issued.	Unallocated Crown Land	Nil
Whole of lot 3257	DP 218335	LR3012/488	Unallocated Crown Land	Nil
Whole of lot 5526	DP 215251	LR3008/466	Minister for Water Resources	Pt Reserve 35380 for protection of rising main

³ ToPH (2008), South Hedland Town Centre Development Plan, Town of Port Hedland, WA



Lot	Plan/Diagram	Certificate of Title	Primary Interest Holder	Purpose / Interests
Part of lot 344	DP 72901	LR3161/716	Unallocated Crown Land	Authorisation Order (L856429); Notice of Intention to Take (L856430)
Part of lot 331	DP 72894	LR3161/417	Unallocated Crown Land	Nil
Part of lot 307	DP 46147	LR3142/696	Town of Port Hedland	Reserve 35654 for drainage
Part of lot 5157	DP 214217	LR3008/522	Minister for Water Resources	Part Reserve 35380 for protection of rising main
Part of lot 500	DP 63966	LR3156/935	Western Australian Land Authority	Leasehold (L781670)
Part of lot 6102	DP 221110	LR3120/428	Unallocated Crown Land	Nil
Part of lot 310	DP 50269	LR3136/789	Unallocated Crown Land	Subject to dealing
Part of lot 605	DP 71984	LR3161/585	Town of Port Hedland	Pt Reserve 36025 for drainage

1.3.3 Historical Context

The historical land uses for the subject land have been identified from analysis of historical imagery obtained from the Landgate Map viewer dating back to the year 1966. This imagery identifies that the entire extent of the area consisted of natural vegetation.

1983 aerial imagery shows that the subject land appears to have undergone a high disturbance event which appears to have resulted in the removal of the naturally occurring vegetation. The South Hedland town site has been developed directly to the east of the subject land. There has been removal of vegetation along the present day orientation of Forest Circle in the northern portion of the subject land area, and various unsealed tracks providing vehicular access to the west are present within the site.

Aerial imagery from 2009 shows that the extent of the vegetation coverage upon the subject land appears to have diminished, potentially indicating that the vegetation coverage is linked to specific seasonal influences and disturbance events, such as fire.

Further review of land tenure has also revealed the presence of a rising water main in the northern portion of the site (within Lot 5526 and part of Lot 5157) adjacent to the unconstructed Forrest Circle Road reserve.



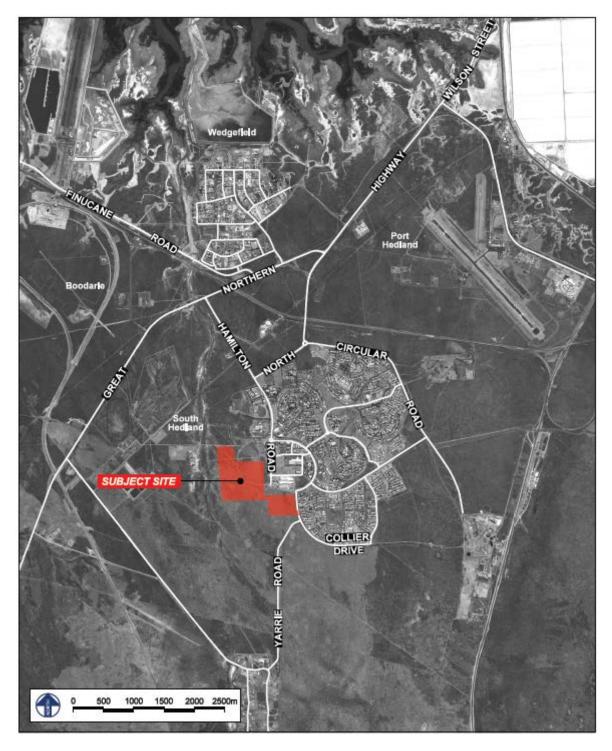


Figure I: Location Plan





Figure 2: Local Context Plan



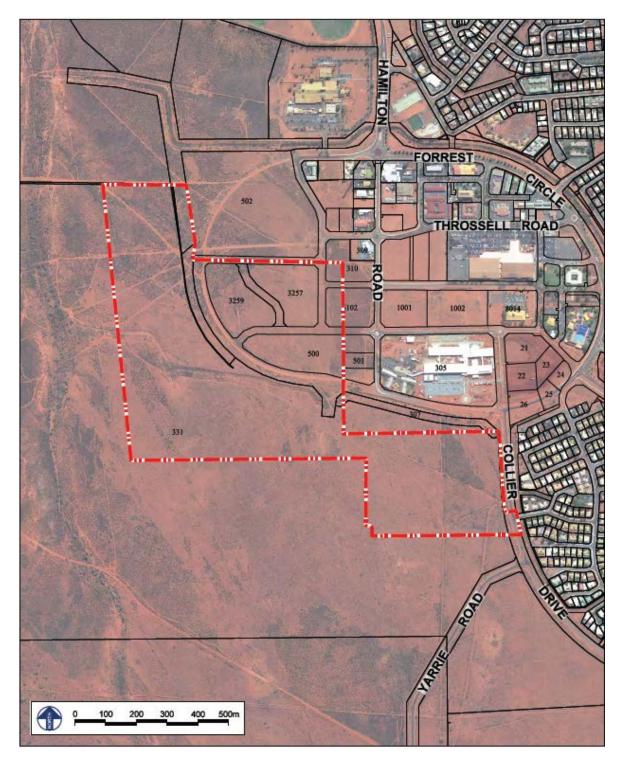


Figure 3: Aerial Plan



1.3.4 Current Land Use

The subject land is currently vacant, generally covered by native grassland vegetation, primarily Spinifex grasses (refer **Plate I**). Whilst there is no formal land use designation currently applicable to the subject land, it is used for informal pedestrian and vehicle access with a number of unsealed tracks and paths intersecting the site (refer **Plate 2**). Portions of the subject land have been used for uncontrolled tipping activities, with large amounts of household refuse being left on the site (refer **Plate 3**).

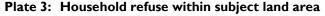
Plate I: Native grassland vegetation within subject land area



Plate 2: Unsealed access track within subject land area









1.3.5 Surrounding Land Use and Development Pattern

The area immediately to the east of Collier Drive as it abuts the subject land is developed for single residential purposes at R20 density. The balance of the surrounding land is presently undeveloped.

The South Hedland City Centre Master Plan (currently in draft form and intended to replace the existing Town Centre Development Plan) sets out development intentions for the area around Hamilton Street. This includes mixed use and medium to high density residential development ranging between R80 and R160. Land to the north of the subject site (around Throssell Road) is planned for residential development with housing densities ranging between R50 and R80.

A Concept Plan for the balance of the Western Edge project area anticipates residential development between R20 and R50/60. Details of the Concept Plan are described at Part 3.1.4 of this report.

1.3.6 Port Hedland Housing Market

The Port Hedland housing market is currently experiencing considerable stress, with robust demand growth from both residential and service populations outpacing delivery of new supply.

Increasing demand for residential property is being driven by significant regional economic growth associated with mining and export activity, with Port Hedland playing a key role as the international gateway for much of this mineral wealth. In the period 2008 to 2011, Port Hedland's Gross Regional Product (GRP) grew by 61.3%, whilst further economic growth will continue to be supported by considerable public and



private sector investment in infrastructure and property. This economic activity and investment will continue to support population growth over the coming decades and generate robust demand for housing.

In the period 2005 to 2011, median house prices in South Hedland increased from \$229,000 to \$800,000, representing an annual average growth rate of 19.6% per annum⁴. Similar to house prices, unit prices have also experienced strong growth, increasing from \$150,000 in 2005 to \$535,000 in 2011 (and currently at \$687,000 as at 19 June 2012). Rental costs have also increased considerably, with South Headland now achieving average rental rates of approximately \$1,752 per week⁵.

Given the constrained nature of Port Hedland in terms of geography and land use, South Hedland is expected to play a major role in accommodating the city's planned population growth (to 50,000 people by 2035). Analysis by RPS Economics suggests that to support such population growth, South Hedland will need to provide the following over the next two decades:

- 1,200 new high density apartments;
- 4,000 medium density apartments, townhouses, terrace houses and semi-detached product; and
- 5,150 detached houses (in addition to existing supply).

Given South Hedland's ability to provide more affordable housing products (relative to Port Hedland, which attracts significant price premiums compared to South Hedland), the South Hedland Western Edge project has the ability play a critical role in addressing local housing affordability concerns and providing a critical mass of supply.

While larger, more traditional products will continue to be required in the South Hedland market for lifestyle reasons, high infrastructure and land costs mean that a more efficient use of residential land will be required, increasing overall residential densities and dwelling yields. Whilst a significant proportion of new residential products in the Western Edge precinct should comprise three bedroom dwellings - to maximise flexibility of use for permanent residential, residential and corporate rentals and FIFO workers – such dwelling size can be delivered through a range of different built forms. Medium and high density attached and small lot detached product will be increasingly required and accepted in the market, as intra and interstate migrants to the area over the next decade transform local expectations of product type⁶.

The proposed Development Plan will facilitate subdivision and development to release critical additional housing stock, which in turn will assist in relieving the severe housing shortages and affordability issues currently being experienced throughout South Hedland and the broader Pilbara region.

⁴ RPData (2012), Unpublished Data, RPData, Brisbane

⁵ PDC (2012) Pilbara Housing and Land Snapshot June 2012, Pilbara Development Commission, Perth

⁶ RPS Economics (2012) Preliminary Residential Market Assessment, RPS, Perth



I.4 Planning Framework

1.4.1 Regional and Local Strategic Plans

1.4.1.1 Pilbara Planning and infrastructure Framework

The Pilbara Planning and Infrastructure Framework⁷ (PPIF) was published by the WA Planning Commission in February 2012. The PPIF defines a strategic direction for the future development of the Pilbara region over the next 25 years, and seeks to ensure that development and change in the Pilbara is achieved in a way that improves people's lives and enhances the character and environment of the region.

In summary, the Framework:

- Addresses the scale and distribution of future population growth and housing development, as well
 as identifying strategies for economic growth, environmental issues, transport, infrastructure,
 water resources, tourism and the emerging impacts of climate change.
- Sets out regional planning principles, together with goals, objectives and actions to achieve these. It
 represents an agreed 'whole of government' position on the broad future planning direction for
 the Pilbara, and will guide the preparation of local planning strategies and local planning schemes.
- Informs government on infrastructure priorities across the Pilbara and gives the private sector
 more confidence to invest in the region. The infrastructure priorities identified in the Framework
 have been determined, following extensive liaison with State Government agencies, local
 government and other key stakeholders.

Importantly, the PPIF sets a population target of 50,000 people for both Port Hedland and Karratha, reflecting their designation as Pilbara Cities. The South Hedland Western Edge project has the ability to accommodate significant additional population and contribute to the successful realisation of the Pilbara Cities population target of 50,000 people.

1.4.1.2 Pilbara's Port City Growth Plan

The Pilbara's Port City Growth Plan provides a strategic blueprint for the sustained growth of Port Hedland, building on its relative competitive advantages and an enviable platform of strong and sustained projected economic growth into the future. The Town of Port Hedland adopted the Growth Plan as the town's Local Planning Strategy in May 2012, subject to final endorsement by the WA Planning Commission.

⁷ WAPC (2012), *Pilbara Planning and Infrastructure Framework*, Western Australian Planning Commission, Perth



The Growth Plan advocates an urban development scenario whereby approximately two-thirds of new housing supply delivered over the next 20 years is provided in the existing South Hedland Townsite and immediate surrounds (with the remaining one-third provided in the East End of Port Hedland). In line with this spatial distribution pattern, the Growth Plan presents an activity centres framework which identifies South Hedland as the primary 'City Centre' for the region, supporting a concentration of significant retail offerings, commercial office space, major health facilities and personal services.

The Growth Plan designates a number of planning precincts, with the South Hedland Western Edge project area located within 'Precinct 10 – South Hedland West', described as follows:

"South Hedland West is South Hedland's newest land release area. It supports immediate and short term land supply, bringing a permanent population catchment to the west of the City. Densities are greatest in proximity to the City Centre, with more traditional home sites provided to the south west and south of the precinct".

The Growth Plan highlights that implementation of this precinct vision will require "immediate land release" on the western edge, with a "fast-track intervention approach to bring forward standard agency approval timeframes" and facilitate lot release within a two year timeframe. It also supports the preparation of a Structure Plan/Development Plan over priority development areas, consistent with the approach being taken by LandCorp for the South Hedland Western Edge project.

1.4.2 Statutory Zoning & Development Plan Areas

The subject land is currently zoned "Town Centre" and "Rural" under Town Planning Scheme No 5 (TPS5). The land is also partially covered by three Development Plan Areas as identified in Appendix 5 of TPS5:

- South Hedland West;
- South Hedland Town Centre; and
- South Hedland Entry.

Proposed Amendment 53 to TPS5 seeks to rezone the South Hedland Western Edge project area (including the subject land) to "Urban Development" zone under TPS5, and amend the boundaries of the Development Plan areas to correspond with the boundaries of the South Hedland Western Edge project. The Amendment has been initiated by the Town of Port Hedland and is subject to advertising for public comment prior to determination by the Town of Port Hedland and WA Planning Commission.

Proposed arrangements for Zoning and Development Plan boundaries under Amendment 53 are illustrated at Figure 4 – Scheme Map Amendments, and Figure 5 – Development Plan Boundary Amendments respectively.



The purpose of the 'Urban Development' zone is to "identify land where detailed planning and the provision of infrastructure is required prior to the further subdivision and development of land" as per Clause 6.4.1 of TPS5. TPS 5 requires the preparation of a Development Plan for all land zoned 'Urban Development' in accordance with the provisions of Clause 5.2 of the Scheme. Appendix 6 to TPS5 sets out matters required to be addressed by Development Plans in general.

The proposed Development Plan subject of this report has been prepared in accordance with the relevant Scheme provisions for the Urban Development zone and the preparation of Development Plans.

1.4.3 Policies

Liveable Neighbourhoods

Liveable Neighbourhoods is a WAPC 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 facilitating 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 South Hedland.

Liveable Neighbourhoods also provided guidance in relation to POS provision. Further comment in relation to these specific elements is further outlined in Part 3 of this report.



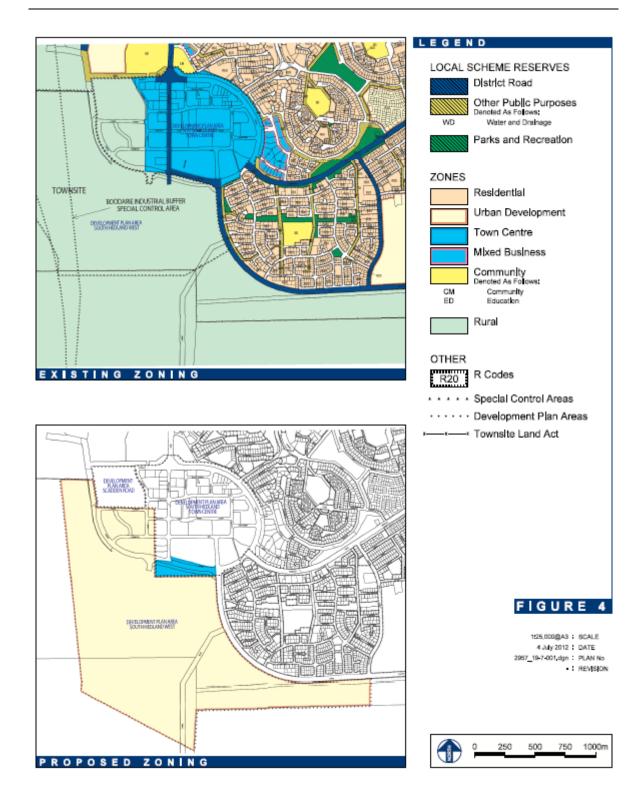


Figure 4: Scheme Map Amendments (Amendment 53)



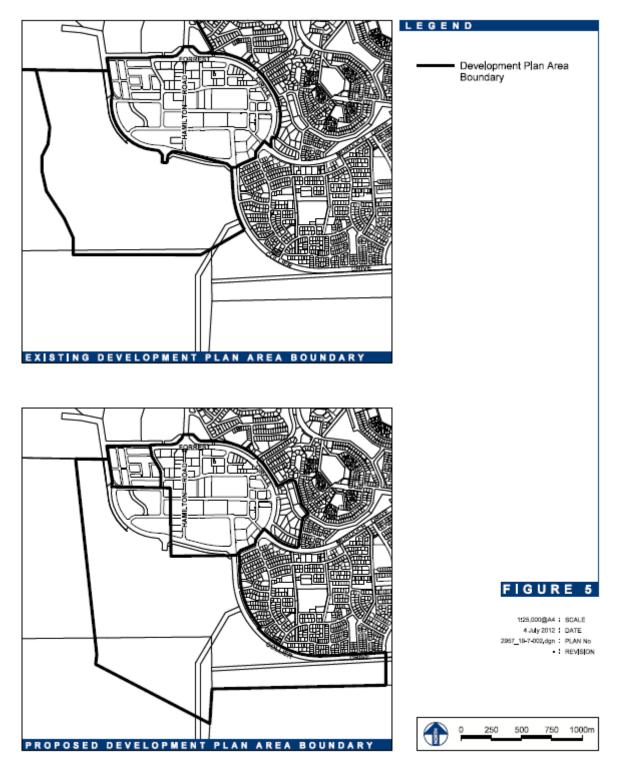


Figure 5: Development Plan Boundary Amendments (Amendment 53)



2.0 SITE CONDITIONS AND ENVIRONMENT

2.1 Environmental Overview

An Environmental Assessment Report (EAR) has been prepared for the subject land in support of Scheme Amendment 53. The purpose of the EAR was to ascertain the current environmental factors in relation to the whole Western Edge project area, including the subject land. Following initiation of Amendment 53 by the Town of Port Hedland, the Environmental Protection Authority (EPA) considered the Amendment under Section 48A of the *Environmental Protection Act 1986*. The EPA determined that the Amendment is not to be formally assessed, noting that the site is degraded with the same vegetation and habitat being abundant in the surrounding areas. The EPA notice in this regard was issued on 4 June 2012, reference identification A491717.

A summary description of site conditions is provided below. The full EAR report and subsequent EPA notice is provided at **Appendix 2** for further information.

2.1.1 Climate

Port Hedland experiences a hot, semi-arid climate. Summers (October to April) are very hot with an average maximum temperature of 31.8 °C to an average monthly maximum of 26.8 °C (Bureau of Meteorology 2011).

Most of the annual rainfall occurs during the summer period from scattered thunderstorms and the occasional tropical cyclone. A secondary peak in the rainfall occurs in May as a result of rainfall events caused by tropical cloud bands which intermittently affect he area mostly in May and June. These events can also produce low maximum temperatures particularly away from the coast. Thunderstorms average 20-30 per annum over most of the area but 15-20 is more common near the coast (Bureau of Meteorology 2011). Winds in the Port Hedland area are characterised by dominant westerly winds occurring throughout summer and prevailing easterly winds in the winter.

2.1.2 Landform and Soils

The natural topography of the subject land displays little variation in relief sloping from approximately 13m Australian Height Datum (AHD) in the south-eastern portion of the land through to approximately 10m AHD approaching the north-western boundary.

The subject land is situated within the De Grey Roebourne Zone, the natural geology of which can be described as consisting of alluvial plains and sand plains (and some flood plains and stony plains) on alluvial and marine deposits over rocks fo the northern Pilbara Craton (Tille 2006).



2.1.3 Hydrology

2.1.3.1 Surface Water

There are no surface water features within the subject land area, however, South Creek is located approximately 400m west of the subject land (refer **Plate 4**). South Creek is dry for the majority of the year, however, it does cater for significant run-off after heavy rainfall. Stormwater from South Hedland town site drains west across the subject site (via a defined drainage line) into South Creek, and from there, northwards into Stingray Creek.

Plate 4: South Creek



2.1.3.2 Ground Water

There are no long term groundwater monitoring bores within the South Hedland area, and hence, no data record to indicate seasonal variability. Five monitoring bores were installed within the South Hedland Western Edge project area in March 2012, with bore depth between 1.7m and 3.4m. No water has been encountered in any of the bores between late March and early May 2012.

As South Hedland is located in close proximity to the Indian Ocean, and given the direction of surface water flows of South Creek, it is anticipated that groundwater flow will generally be north towards the ocean.



2.1.4 Vegetation and Flora

A Level I Flora and Vegetation Survey, comprising a desktop assessment and two field surveys, was undertaken for the South Hedland Western Edge project area in February 2012. Desktop assessment and database searches identified no threatened or priority species, and no Threatened Ecological Communities (TECs) or Priority Ecological Communities (PEC) occurring within the subject land area.

Field survey results confirmed no occurrences of Threatened Rare Flora species as listed by the Department of Environment and Conservation (DEC) or species of national conservation significance listed under the *Environmental Protection and Biodiversity Conservation (EPBC) Act 1999*. The majority of vegetation on the subject land is considered to be in 'Excellent' to 'Very Good' condition, with some isolated areas being degraded or completely degraded.

One Priority flora species, Heliotropium muticum (PI) was identified in the Western Edge project area during the field survey and subsequent targeted grid searches. However, vegetation types associated with the occurrence of this species are not restricted to the subject land, and are considered common in the Port Hedland hinterlands. It is therefore unlikely that the subject land would be considered significant habitat upon which Heliotropium muticum (PI) is dependent upon for survival. This was acknowledged in the EPA's determination of proposed Amendment 53, which noted that "the same vegetation and habitat is abundant in the surrounding areas".

2.1.5 Fauna and Habitat

A Level I Fauna Survey, including desktop review and a field survey, was undertaken for the South Hedland Western Edge project area in February 2012. The survey found:

- No recorded occurrences of threatened species within the subject land.
- Two migratory bird species protected under the EPBC Act and two Priority 4 bird species under the Wildlife Conservation Act 1950 recorded by the field survey.
- Given the proximity of the subject land to the existing South Hedland town site it is likely that the fauna of conservation significance may avoid the subject land.
- Although the subject land may contain habitat which could potentially be utilised by the
 conservation significant species, it is unlikely that this would be considered significant habitat upon
 which the species are dependent upon for survival.
- Federal referral under the EPBC Act is not required for the South Hedland Western Edge project.



2.1.6 Heritage and Cultural Significance

2.1.6.1 Aboriginal Heritage

A search of the Department of Indigenous Affairs (DIA) Aboriginal Heritage Inquiry System has revealed no recorded Aboriginal heritage sites within the subject land area. Furthermore, Aboriginal Heritage Surveys (refer **Appendix 3**) carried out for the subject land area in 2011 ('Area A') and 2012 ('Area C') made the following conclusions and recommendations:

- There are no Aboriginal archaeological or ethnographic sites located within the survey area, which was disturbed by vehicular and recent human activity;
- Given the potential for sub-surface Aboriginal cultural material, including skeletal, to be disturbed,
 Two Marapikurrinya Pty Ltd nominated Marapikurrinya Heritage Monitors are to be engaged by during initial ground disturbing activity associated with proposed works; and
- If any Aboriginal cultural material, including skeletal, is found during ground disturbing activity, then
 works stop (in accordance with an agreed Stop Work Procedure) and the Marapikurrinya people
 are consulted.

2.1.6.2 European Heritage

There are no recorded places of European Heritage significance within the subject land area.



3.0 PROPOSED DEVELOPMENT PLAN

3.1 Design Philosophy

The design of the Western Edge Development Plan (**Appendix I**) has been driven by contemporary planning principles focused on creating sustainable communities, enhancing connectivity/permeability and climate responsive design, consistent with the WA Planning Commission's *Liveable Neighbourhoods* operational policy. It acknowledges the unique site context, its location adjacent to the South Hedland City Centre, and the various opportunities and constraints as identified in Section 2.

Key design elements of the South Hedland Western Edge Development Plan include:

- A mix of medium and low density residential land uses, with highest densities located in close
 proximity to the City Centre to capitalise on enhanced amenity and service provision;
- Road spacing and residential cell design aimed at providing flexibility in ultimate built form
 development outcomes, such as single-detached residential dwellings, townhouses, grouped
 dwellings and multiple-unit dwellings of various sizes and tenure types;
- Maximisation of the north-south and east-west orientation of lots to encourage the use of passive solar design principles in dwelling design;
- Extension of key functional road linkages from the City Centre (namely Hamilton Road, Collier
 Drive, McLarty Boulevard and Colebatch Way), and provision of a 'modified grid' internal street
 layout to maximise connectivity and permeability throughout the site for vehicles, pedestrians and
 cyclists;
- Development setbacks of approximately 400m to South Creek (also consistent with the future planned odour buffer for the South Hedland wastewater treatment plant), formally designated by the ultimate extension of North Circular Road around the Western Edge project area;
- A network of multiple-use corridors traversing the site in north-south and east-west alignments,
 providing both public open space areas (active and passive) and functional stormwater drainage
 swales, designed in accordance with the principles of Better Urban Water Management as they apply
 to the region and landscaped to the highest standards to maximise local amenity, safety and
 encourage local community activity;
- Identification of a commercial development site in the western portion of the Development Plan area, potentially providing some localised small scale retail/commercial or community activities;
- Provision for a potential tertiary education site straddling the Western Edge and City Centre precincts, consistent with Pilbara's Port City Growth Plan objectives; and
- Provision for a potential aged care/key worker village development site south of the new Hedland Health Campus, providing for the co-location of complementary land uses (and potential interim use for key worker accommodation to relieve acute accommodation shortages in the short term).



The proposed Development Plan (as part of the wider Western Edge Precinct vision) sets a framework for development that is highly complementary and integrated with planned revitalisation of the adjacent City Centre precinct, responding to extremely strong demand for residential accommodation and the need for greater variety in housing products and tenure options. The plan seeks to set a new standard for urban development and community building in South Hedland, responding to lessons learned from the original 'Radburn' townsite designs.

The following sections of this report provide further commentary on the design rationale for the Development Plan with regard to land use designation and dwelling provision, movement networks, public open space and amenity, urban water management and the provision of necessary community facilities and utilities services.

3.2 Proposed Land Use

3.2.1 Distribution and Layout

The South Hedland Western Edge precinct is planned to form a major residential expansion area immediately west/southwest of the existing South Hedland townsite and City Centre precinct, and accordingly, the predominant land use component of the proposed Development Plan is for residential development. Approximately 25ha or 36% of the total development plan area has been identified for residential land use at a range of medium and low densities, with highest densities proposed in close proximity to the City Centre which will offer significant local services, employment opportunities and transport links. Lowest residential densities are provided in the western portions of the Development Plan area, furthest from the City Centre and offering traditional greenfield residential development opportunities (notwithstanding the ability to achieve alternate built form and tenure types at these lower densities).

In addition to residential land uses, the Development Plan also identifies the provision of multiple-use corridors (offering active and passive open space areas along with functional stormwater drainage swales), a commercial site, potential tertiary education/university site, and an aged care site (capable of interim development/use as key worker accommodation). The land use composition of the Development Plan is summarised in the following table:



Table 2: Structure Plan Summary Table

Item	Area / Provision
Development Plan Area (total)	68.51 ha
Residential Land (excluding aged care/key worker site)	25.43ha
Commercial Site	0.27 ha
Education Site (portion of)	0.85 ha
Aged Care / Key Worker Site	5.9 ha
Sewer Pump Station Site	0.16 ha
Active Open Space (neighbourhood parks)	4.46 ha
Passive Open Space (multi-use corridors)	11.8 ha
Road Reserves	19.57 ha
Estimated Maximum No. Residential Dwellings ¹	832 dwellings
Estimated No. Aged Care/Key Worker Units	318 units
Total No. Dwelling Units (Residential and Aged Care/Key Worker) ¹	1150 dwelling units
Estimated Maximum Residential Population ²	2,780 people

^{1.} Assumes a mix of grouped dwelling and multiple dwelling development scenarios.

3.2.2 Residential Density and Diversity

The Development Plan provides for a range of lot types and residential densities including:

- Medium density 'Residential R50/60' in the eastern portions of the subject site immediately adjacent to the City Centre precinct and the aged care/key worker village site;
- Medium density 'Residential R40' at high amenity locations in the eastern portion of the site;
- Medium density 'Residential R30' in the eastern portion of the site and high amenity areas in the western portion; and
- Low density 'Residential R20' lots in the western portion of the site.

^{2.} Estimated residential population assumes 2.9 persons per dwelling unit and a 83.4% occupancy rate (as per 2011 Census⁸).

⁸ ABS (2011), South Hedland (SSC) Basic Community Profile, cat. No. 2001.0, Australian Bureau of Statistics, Canberra.



Land use permissibility within the nominated residential areas is to be in accordance with the 'Residential' zone provisions of the Town of Port Hedland Town Planning Scheme No.5.

A breakdown of estimated lot and dwelling yields based on proposed residential densities is provided in the following table (note that the proposed aged care/key worker site is dealt with under section 3.2.5 of this report and is therefore not included in the lot/dwelling calculations below).

Table 3: Residential Density and Diversity

Density, Product Types	Area (ha)	Estimated No. Lots ¹	Estimated No. Dwelling Units ²
Residential R20			
Single Residential	11.42	228	228
Grouped Dwellings		0	0
Multiple Dwellings	0	0	0
Residential R30			
Single Residential	8.23	274	274
Grouped Dwellings		0	0
Multiple Dwellings	0	0	0
Residential R40			
Single Residential	3.63	165	165
Grouped Dwellings	0.77	0	15
Multiple Dwellings	0.77	9	36
Residential R50/60			
Single Residential	0	0	0
Grouped Dwellings	4.00	7	28
Multiple Dwellings	1.38	7	86
Total Dwellings	25.43	674	832
Average Density - (dwellings per h	a)		33

- 1. Lot estimates based on preliminary concept designs.
- 2. Dwelling unit estimates assume a mix of grouped and multiple dwelling types, with yields calculated based on land areas, and assuming:
 - I dwelling per single residential lot;
 - Application of R-Codes minimum average site area requirements for R30, R40 and R50/60 grouped dwelling sites; and
 - Minimum dwelling foorspace of 70m² and plot ratio of 0.6 for R40 and R50/60 multiple dwelling sites.



As illustrated above, the Development Plan provides for an average residential density of 33 dwellings per hectare of zoned/nominated residential land, which complies with the guideline densities specified in Liveable Neighbourhoods (Element 1, R17 recommends 30 to 40 dwellings per hectare for areas within 400m of town centres). The net residential density potentially achieved by the Development Plan is 12 dwellings per hectare of total site area (68.51ha).

3.2.3 Built Form

It is anticipated that the majority of residential product ultimately built in the Development Plan area (and the wider South Hedland Western Edge precinct) will comprise single residential dwellings, delivered either via traditional construction methods or though modular unit construction (of a suitably high quality consistent with the project vision and objectives). In addition to single residential built form typologies, a number of multiple/grouped dwelling sites are to be provided in the R30, R40 and R50/60 coded areas, providing opportunities for a wide range of built form outcomes including duplex, triplex, townhouse and large multi-unit developments.

To ensure appropriate built form outcomes with regard to land use interface, building treatments, access arrangements and/or other specific design requirements, a set of residential design guidelines are to be established for the Western Edge precinct and adopted as a Local Planning Policy under part 5 of Town Planning Scheme No. 5 for those properties immediately adjacent open space reserves. Having regard for the provisions of the Development Plan and TPS5, the Design Guidelines will provide a further degree of design guidance and development control to facilitate a high standard of sustainable building and amenity in the area.

3.2.4 Lot Layout, Orientation and Climatic Responsiveness

The Development Plan achieves the residential density and diversity requirements of Liveable Neighbourhoods by providing for a range of dwelling types and sizes from traditional low density R20 lots to higher density residential R50/R60 dwelling units.

A high degree of flexibility in ultimate lot configuration and built form outcomes is encouraged through the design of residential cells to accommodate a variety of subdivision configurations and lot sizes. In higher density areas, the provision of suitably sized grouped and multiple dwelling sites will provide for flexibility in ultimate built form outcomes. In lower density R20 and R30 areas, a standard set of lot configurations have been used to inform cell depths and road spacing. These lots have been sized to ensure they are capable of accommodating two and three module pre-fabricated construction forms (typically 12m frontages in R30 areas catering for two-module units, and 16m frontages in R20 areas for three-module dwellings), thereby providing significant opportunities for lower-cost development and ultimately more affordable housing.



The alignment and orientation of residential development cells ensures that all future residential lots will orient north south or east west, facilitating climate responsive design (Liveable Neighbourhoods Element 3, R18). The majority of residential development cells have been designed consistent with Liveable Neighbourhoods requirements (Appendix 2 Phase 8), with dimensions generally between 70m-120m x 120m-240m, with smaller cells typically in close proximity to the City Centre (and coded R40).

No direct lot frontage is provided to North Circular Road, to limit both visual impact and traffic conflicts (LN E3 R30), with access to these properties provided via internal access streets. Direct access to the two connector roads is also minimised in proximity to the intersection with North Circular Road.

3.2.5 Commercial Site

A 'commercial' site of approximately 0.27ha is provided in the western portion of the subject land area, at the south eastern corner of the proposed intersection of North Circular Road and McLarty Boulevard (extension). The intent of the commercial site is to provide a location where in addition to (or instead of) residential land use (being a discretionary use under TPS5), the site is capable of accommodating a range of local service/retail/commercial land uses appropriate in scale to support local community needs (whilst not undermining South Hedland City Centre's role as the primary provider of local retail, commercial and community services). Such uses may include (but not limited to) shop, office, child care service, place of public worship etc.

Land use permissibility within the commercial site is to be in accordance with the 'Commercial' zone provisions of the Town of Port Hedland Town Planning Scheme No.5.

3.2.6 Aged Care / Key Worker Accommodation Site

The Development Plan identifies the location of a large single site approximately 5.904ha in the easternmost portion of the subject land, immediately west of Collier Drive and south of the recently completed Hedland Health Campus. Concept planning has identified this site as potentially suitable for an aged care development given its proximity to, and potential operational synergies with, the Hedland Health Campus. In the short term, however, the site is capable of being developed in a residential village format for the purpose of providing affordable accommodation for key workers in a location close to the City Centre. Services and built form provided in the short term could ultimately be retrofitted to cater for an aged care / supported living arrangement.

Land use permissibility within the nominated aged care / key worker accommodation site is to be in accordance with the 'Residential' zone provisions of the Town of Port Hedland Town Planning Scheme No.5, with a nominated residential density of R50/60.



3.2.7 Education Site

A site of approximately 0.85ha is provided in the north east of the Development Plan area, immediately adjacent to the South Hedland City Centre precinct (between proposed extensions of McLarty Boulevard and Colebatch Way). This site has been identified as being potentially suitable for development (as part of a wider site extending east to Hamilton Road) for tertiary education purposes, such as a university or specialised training centre. This is consistent with the vision established by the Pilbara's Port City Growth Plan, which identifies the land as a potential tertiary education facility / centre for excellence precinct (refer specific Growth Plan commentary and plans for Precinct 10 – South Hedland West and Precinct 11 – City Centre).

Land use permissibility within the education site is to be in accordance with the 'Education' zone provisions of the Town of Port Hedland Town Planning Scheme No.5.

3.3 Movement Network

A detailed Transport Assessment Report (TAR) has been prepared by Porter Consulting Engineers for the South Hedland Western Edge project area. The TAR assesses the impacts of the proposed development on the adjacent road network, and provides advice on the proposed internal road configuration, pedestrian and cycle links, and opportunities for public transport provision. The following provides a summary of the TAR findings with regard to the proposed Development Plan area, with the full report provided at **Appendix 4**.

3.3.1 Existing/Surrounding Road Network

Access to the subject land is currently provided via the following existing constructed roads:

- Hamilton Road (extending south from the City Centre);
- Collier Drive (extending south from the City Centre and along the eastern boundary of the subject land);
- Forrest Circle (south of the City Centre area);

A number of unconstructed road reserves also bound and traverse the subject land, including North Circular Road, which effectively forms the western extent of the proposed development plan area.

The existing road network hierarchy is described as follows:



Table 4:	Existing Road	Hierarchy
----------	---------------	-----------

Road	MRWA Rural Road Hierarchy classification	Equivalent MRWA Metropolitan Road Category	Geometry	Desirable Maximum Volume ADT (veh/day)
Hamilton Road	Rural Local Distributor	Neighbourhood Connector A	Undivided two-way carriageway	7,000 - 15,000
Collier Drive	Rural Local Distributor	Neighbourhood Connector B	Undivided two-way carriageway	3,000 - 7,000
Forrest Circle	Rural Local Distributor	District Distributor	Median-divided two-way carriageway	15,000-35,000

3.3.2 Proposed Road Network

The proposed Development Plan seeks to provide a permeable, legible and integrated movement network, with a clear hierarchy of operation to ensure the efficient movement of vehicles within and through the subject land area. The proposed road network is generally described as follows:

- Hamilton Road to be extended southwards into the Development Plan area, effectively forming a
 key north-south link (along with Collier Drive) between the City Centre and the South Hedland
 Western Edge precinct.
- Collier Drive intersection with Wambiri Street to be modified to a 4-way roundabout, linking in
 with a new subdivision road extending west into the subject land. (Future stages of the South
 Hedland Western Edge project will require realignment of Collier Drive south of Wambiri Street
 to a north-south alignment).
- North Circular Road ultimately constructed within its current reserve alignment, effectively
 forming the western boundary of the Development Plan area and acting as a major arterial link into
 the wider regional road network.
- McLarty Boulevard (formerly Rason Court), Colebatch Way and a new local access road are to be
 extended west from Hamilton Road and provide direct east-west linkages between the City
 Centre and subject land.
- A 'modified grid' network of internal local access roads, of varying reserve widths (typically between 15m and 18m) sufficient to accommodate a 6m-7m carriageway, service trenching, street trees and pedestrian and cyclist paths in accordance with Liveable Neighbourhoods standards.

Estimated traffic generation rates and arrangements for operation of the proposed road network have been assessed and detailed in the TAR. Whilst the road network of the proposed development area (forming the first stage of the wider Western Edge project area) will operate in a satisfactory manner and is not projected to have an undue impact on the surrounding regional and local road environment, full



development of the wider Western Edge area will necessitate further upgrades to key linkages. With specific regard to North Circular Road, whilst not essential to the delivery and immediate function of the proposed development area, it will form a key functional component of the wider South Hedland Western Edge project area and is required to facilitate increased traffic volumes generated by subsequent project stages.

The proposed road network has been designed and assessed in a manner consistent with Main Roads WA (Metropolitan Functional Road Hierarchy) and WA Planning Commission (Liveable Neighbourhoods) standards. The following table provides a summary of the proposed network hierarchy and function:

Table 5: Proposed Road Network Hierarchy and Function

Road	Type / Classification	Responsible Authority	Characteristics
North Circular Road	District Distributor	Main Roads	Reserve Width: 40m
		WA	Speed Limit: 80km/h
			Design : Median-divided, two-way single carriageway. Limited intersections and no development frontage/access.
			Capacity: 15,000 - 35,000 veh/day
			Intersections: Median/islands at 3-way intersections, roundabouts at 4-way intersections.
Hamilton Road	Neighbourhood	Local	Reserve Width: 20m
(southern extension)	Connector Type A	Government	Speed Limit: 50km/h
McLarty Blvd (western Extension)			Design : Median-divided two-way single carriageway with cycle lanes
New E-W road (extended west from			Capacity: 7,000 veh/day
Wambiri Street intersection)			Intersections: Median/islands at 3-way major intersections, roundabouts at 4-way intersections. Spacing of no less than 40m.
All other roads	Local Access	Local	Reserve Width: 15-18m
	Streets (various types)	Government	Speed Limit: 50km/h
	7,5-20		Design : Undivided two-way single carriageway. Optional on-street parking depending on configuration.
			Capacity: Less than 3,000 veh/day
			Intersections: Give way/stop control at intersections, roundabouts at major 4-way intersections. Spacing of no less than 20m.



The following selection of cross sections is provided below to illustrate the nature of various proposed road types. Note that the full range of cross-sections for all road types is provided at **Appendix 4**.

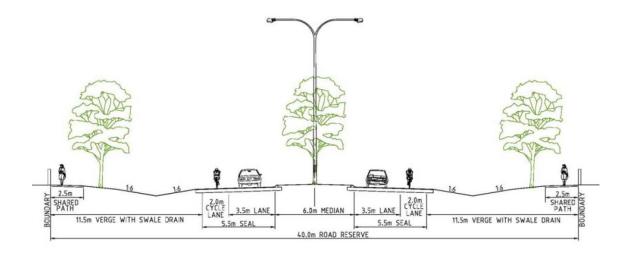


Figure 6: Indicative Cross Section of District Distributor Road⁹

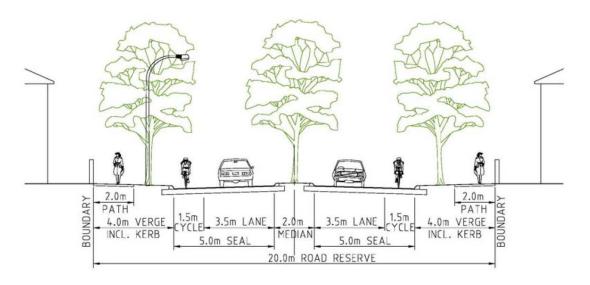


Figure 7: Indicative Cross Section of Neighbourhood Connector Road 10

⁹ Porter Consulting Engineers (2012), South Hedland Western Edge Land Development Transport Assessment, Porter Consulting Engineers, Perth

¹⁰ Porter Consulting Engineers (2012), South Hedland Western Edge Land Development Transport Assessment, Porter Consulting Engineers, Perth

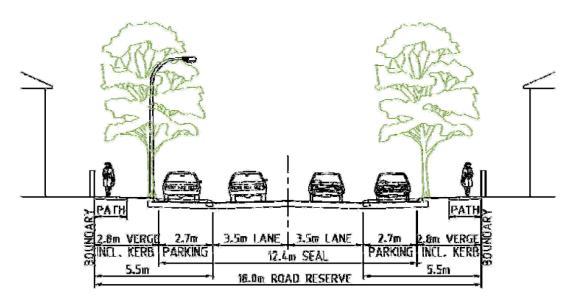


Figure 8: Indicative Cross Section of Local Access Street¹¹

3.3.3 Pedestrian and Cycle Movement

Liveable Neighbourhoods recommend provision of a footpath along every street with a developed frontage. Footpaths should have a minimum width of 1.5m on residential access streets and 2.0m in the vicinity of schools, commercial centres and other activity centres.

Proposed neighbourhood connector roads are expected to provide I.5m dedicated cycle paths, whilst the local access streets in the network will have low daily traffic volumes suitable for on-road cycling. Informal on-street parking will, however, create some interference for on-road cycling but typically this will occur on very low traffic volume roads where the opportunity for conflict should be low.

The TAR provided at **Appendix 4** includes diagrams showing where pedestrian footpaths and cycle paths are recommended. Regional paths and shared paths are also shown, indicating connection with the Town of Port Hedland's existing and proposed path network.

3.3.4 Public Transport

Hedland Bus Lines provide public transport on behalf of the Public Transport Authority for the South Hedland Town Bus Service and School Pick-up and Drop-off Service.

¹¹ Porter Consulting Engineers (2012), South Hedland Western Edge Land Development Transport Assessment, Porter Consulting Engineers, Perth



The proposed revitalisation and development of the South Hedland City Centre as a major activity centre, along with the proposed subdivision and development of the South Hedland Western Edge precinct, will significantly improve the viability of increased public transport provision and patronage in the town. In this regard, the extension of bus services from the City Centre to service the South Hedland Western Edge precinct is proposed (refer TAR plans/diagrams provided at **Appendix 4**).

3.4 Open Space and Amenity

3.4.1 Public Open Space Provision

The amount and distribution of open space throughout the Development Plan area is largely dictated by the functional stormwater management requirements of the land, which has necessitated the provision of a series of open drainage swales throughout the site. This drainage network has been designed to form a series of landscaped corridors, which serve a dual function both in terms of stormwater conveyance and passive open space provision (consistent with Liveable Neighbourhoods Element 4 and Element 7 which require the integration of urban water management features into public open space). These 'multiple use corridors' (MUCs) are a key feature of the Development Plan, influencing not only the design and provision of public open space, but the overall layout and function of the urban development area as a whole.

In addition to the MUCs, which fulfil a 'passive open space' and landscape amenity role in addition to their drainage functionality, further provision for active open space is also identified in the development plan through a series of neighbourhood parks. These neighbourhood parks have been located in areas that are highly accessible, and co-located with MUCs to seamlessly integrate both passive and active open spaces.

Key features of the proposed active and passive public open space network include:

- Neighbourhood parks incorporating formal play areas, shade structures, seating and picnic facilities, along with grassed open space areas for active and passive recreation;
- Strong path networks linking areas of open space and amenity with residential and non-residential development areas, via a network of connected multiple use corridors;
- Hard-stand areas incorporating local concrete and aggregates, with further rest areas and exercise stations consisting of local gravels or compacted/stabilised sands;
- Opportunities for the provision of public art, developed in collaboration with the local community;
- Integration of best practice urban water management in accordance with the Local Water Management Strategy, including water wise irrigation techniques and extensive use of low water consuming native plant species; and
- Maximisation of passive surveillance opportunities along MUCs and overlooking neighbourhood parks to minimise anti-social behaviour.



Liveable Neighbourhoods requires that "a minimum contribution of 10 percent of the gross subdivisible area must be given up free of cost by the subdivider and may comprise a minimum of eight percent active and passive recreational purposes with the remaining two percent comprises restricted use public open space uses...". The following uses are identified as types of restricted POS that can contribute towards 2% of the total requirement:

- natural areas and cultural features;
- urban water management measures such as swales and or detention areas;
- artificial lakes/permanent drainage ponds; and
- natural wetlands.

Areas of proposed unrestricted and restricted POS are clearly demarcated on **Figure 9**. MUCs are classified as restricted POS, and attract a partial credit for all areas between the 1:1 year and 1:5 year ARI stormwater levels (with areas below the 1:1 year ARI level attracting no credit). Neighbourhood parks are located above the 1:5 year ARI level and therefore attract a full credit as unrestricted POS in accordance with Liveable Neighbourhoods. The following POS schedule provides a summary of POS provision in accordance with Liveable Neighbourhoods requirements:

Table 6: Public Open Space Schedule

	Deducted	Provided	Balance
Site area			68.51
Deductions			
Education Site	0.85		
Sewer Pump Station	0.16		
MUC dedicated drainage areas (1 in 1 year ARI event area)	3.84		
Total	4.85		
Gross Subdivisible Area			63.66
Public open space required @ 10%			6.37
May comprise			
minimum 80% unrestricted POS		5.09	
maximum 20% restricted POS		1.28	
Unrestricted POS provision			
Neighbourhood Parks		4.46	
Multi Use Corridors (Above 1:5 ARI)		6.07	
Total		10.53	
Restricted POS provision			
		1.89 (actual) 1.28 (max	
Multi Use Corridors (Between 1:1 and 1:5 ARI)		allowable)	
Total		1.28	
TOTAL CREDITABLE POS PROVISION			11.81





Figure 9: Public Open Space Provision



Public Open Space arrangements were discussed with the Town of Port Hedland in a meeting held on 3 May 2012. In this meeting it was agreed that the concept of multi-use corridors offers beneficial open space amenity, and should be considered within the overall contribution towards POS requirements.

3.4.2 Landscape Amenity

The South Hedland Western Edge project presents a unique opportunity to learn from the negative historic aspects of the existing South Hedland townsite, and establish a vibrant and sustainable urban community where open space amenity responds to the local cultural, social and environmental context and defines a unique sense of place within the Pilbara landscape. UDLA, on behalf of LandCorp, has prepared a Landscape Report in support of the Development Plan (provided at **Appendix 5**), which focuses on the treatment of contemporary public open space, including multi-functional corridors and pedestrian scaled streetscapes that complement the development's future built form.

In presenting a plan for the provision of high quality and amenity open space, the landscape concept seeks to address and respond to the following matters:

- Urban water management best practice (complementing the provisions of the Local Water Management Strategy);
- Opportunities presented through the use of multi-use corridors and linked neighbourhood parks, to address a new form of open space amenity and improve connectivity and movement throughout the area:
- Open space amenity within walkable catchments for residents;
- Improved streetscape typologies, though increased use of street trees and vertical treatments;
- Water conservation and irrigation strategy for water wise landscapes;
- Use of exotic shade trees mixed with local endemic vegetation;
- Weed and pest management;
- Use of shade and shelter to respond to unique climatic conditions;
- Opportunities to design safe places through passive surveillance and lighting; and
- The creation of community spaces, recognising cultural and social diversity and heritage through art and interpretation opportunities.

With specific regard to the MUCs, it is acknowledged that the design and treatment of these corridors and drainage swales is not only important in a functional stormwater management sense, but is also crucial in providing a high level of local amenity and maximising their potential to be used for a variety of passive local open space functions. Given the extent and prominence of these corridors, they will more often than not form a key element of the local streetscape and play a major part in the everyday lives of future residents, The Landscape Report included at **Appendix 5** provides further detail with regard to design approach



taken for these corridors, although the following figures provide an indication of key features and treatments:

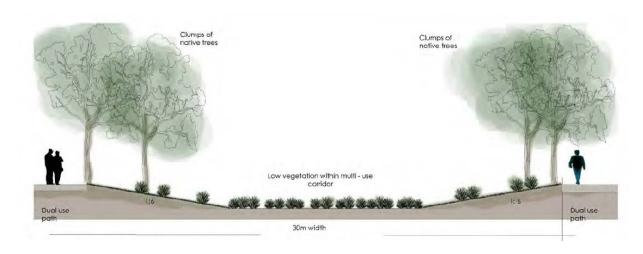


Figure 10: Indicative Cross Section of a Multiple Use Corridor¹²

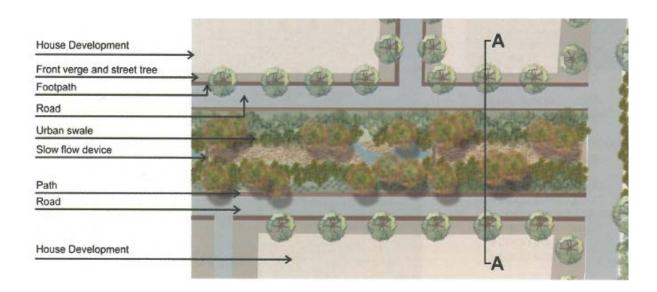


Figure II: Indicative Cross Section of a Multiple Use Corridor¹³

¹² JDA (2012), South Hedland Western Edge Local Water Management Strategy (LWMS), JDA, Perth ¹³ UDLA (2012), South Hedland Western Edge Local Development Plan Landscape Report, ULDA, Perth



3.4.3 Streetscape Amenity

Given local climatic conditions, the provision of shade along pedestrian corridors and local streets is an essential element of the proposed development. Shade trees along road verges adjacent to footpaths will provide relief from the Pilbara sun and a sense of scale to the otherwise sparsely vegetated landscape. Street tree planting along major roads will be used to formalise the corridor, delineate the road hierarchy and provide a strong vertical element to the relatively flat topography of the site. Further details on tree species and streetscape amenity is provided at **Appendix 5**.

3.5 Urban Water Management

In accordance with the WA Planning Commissions Guidelines for Better Urban Water Management ¹⁴, a Local Water Management Strategy (LWMS) has been prepared by JDA Consultant Hydrologists on behalf of LandCorp for the whole of the South Hedland Western Edge precinct (refer **Appendix 6**). LWMS preparation has been informed by liaison and discussion with the Department of Water (DoW), Water Corporation (WC) and the Town of Port Hedland, along with consideration of the following key documents:

- Town Planning Flood Study for South Hedland (Wyche, 1975);
- South Hedland Town Centre Drainage Design (PWD, 1976);
- South Hedland Flood Study (GHD, 2011);
- South Hedland Town Centre East Precinct: LWMS (JDA, 2011);
- Port Hedland Coastal Vulnerability Study (Cardno, 2011);
- State Planning Policy 2.9 Water Resources; and
- Stormwater Management Manual for WA;

3.5.1 Key Principles and Objectives

In Port Hedland, surface water runoff issues are primarily linked to erosion and sedimentation, as well as management and protection for 100 year ARI events. Peak flow rates do not need to be detained to pre development peak flow, but the velocity of the post development flow should to be minimised to prevent erosion. Following a meeting with the DoW to discuss the approach to water management in South Hedland Town Centre and surrounds, the following key design principles and objectives were established to underpin preparation of the LWMS:

¹⁴ WAPC (2008), Better Urban Water Management, Western Australian Planning Commission, Perth



Table 7: LWMS Key Principles and Objectives

Category	Principles	Design Objectives
Water Supply and Conservation	 Consider all potential water sources in water supply planning. Integration of water and land use planning Sustainable and equitable use of all water sources having consideration of the needs of all users, including community, industry and environment Maximise the reuse of stormwater 	 Minimise the use of potable water where drinking water quality is not essential, particularly ex-building use. Apply water wise landscaping measures to swales in road reserve to reduce/avoid irrigation.
Surface Water Flows and velocity	 Protect development from flooding and waterlogging Implement economically viable stormwater systems Retain natural drainage systems and protect and/or improve ecosystem health (For the Pilbara, reduce the stormwater velocity to prevent export of sediments). Ensure that stormwater management recognises and maintains social, aesthetic, and cultural values Where there are identified impacts on significant ecosystems, maintain or restore desirable environmental flows and/or hydrological cycles consistent with DoW's requirements. 	 Use swales through the development to disperse flow throughout the development with the aim to minimise velocity. Swales sized to minimum 10yr ARI, with larger events flowing along road reserve. For South Creek flood management, finished floor levels are a minimum of 0.5 m above the 100 year ARI flood level in South Creek for a 100 m wide corridor adjacent to South Creek. For local flood management, lot levels have minimum 100 yr ARI protection, with 0.3 m freeboard above kerb height.
Groundwater Levels	Protect development from waterlogging	Protect development from waterlogging
Water Quality	Where development is associated with an ecosystem dependent upon a particular hydrologic regime, minimise discharge or pollutants to shallow groundwater and receiving waterway and maintain water quality in specified environment	 No sensitive ecosystems in vicinity. The receiving environment is South Creek which discharges to the intratidal zone prior to discharging to the ocean. (Note nutrients are not a problem in the Pilbara).

3.5.2 Stormwater Management

The management of surface water runoff and regional/local flooding is a significant consideration for development in South Hedland, and as such has been given due consideration in the LWMS. To provide adequate flood protection for the proposed development, the LWMS recommends that minimum floor levels are to be set at 0.5 m above the 100 year ARI flood level (including impact of fill). To inform this process, flood mapping has been carried out by JDA and is and presented in the LWMS (refer **Appendix** 6). Preliminary estimates suggest that on average across the Western Edge precinct, approximately 0.6m fill will be required to meet minimum floor level requirements and provide adequate flood protection. The



impact of this fill on stormwater flows into South Creek has been considered in the LWMS and confirmed to be within acceptable limits, presenting no undue risk to other existing developed areas.

Local stormwater management is proposed to be undertaken consistent with water sensitive design practices and meet key objectives and criteria as detailed above. The stormwater drainage system is to be designed using a major/minor approach, with the minor drainage system designed as a swale and road drainage system capable of carrying runoff generated by low frequency ARI storms, less than 5 year ARI. The major drainage system is defined as the arrangement of roads and drainage reserves to provide safe passage of stormwater runoff from extreme events which exceeds the capacity of the minor system, directing it into South Creek. The drainage swales will provide some attenuation of peak surface water flows, and some water quality treatment for the proposed development prior to discharge from the Study Area.

Due to the large rainfall intensity and volumes experienced in the North West Region of WA, conveyance of stormwater is via overland flow paths and open drainage systems, rather than underground pipe systems. All stormwater swales areas are proposed to be ephemeral and no open water body lakes are proposed, consistent with the DoW's current policy.

With regard to the Development Plan, the functional alignment of drainage swales has dictated the design and layout of various public open space / multi-use corridors through the subject land area, which are generally aligned in a N-S and E-W grid layout to maximise the efficient movement of stormwater through the site. Further detail on proposed drainage swale locations and flow directions is contained in the LWMS provided at **Appendix 6**,

3.5.3 LWMS Key Elements and Implementation

The following table provides an overall summary of key elements of the proposed water management strategy for the Study Area, with an assessment of the strategy in relation to DoW principle objectives for stormwater management in Western Australia.



Table 8: Summary of Proposed Local Water Management Strategy

Principle	Key LWMS Elements
Water Quantity To maintain the total water cycle balance within development areas relative to the pre-development conditions.	 Maintain flow paths for existing catchments Maintain or reduce 100 year ARI peak flood levels from the Study Area
Water Quality To maintain or improve the surface and groundwater quality within development areas relative to pre-development conditions.	 Maintain 1 in 1 year ARI event post development discharge volume and peak flow rates relative to pre-development conditions Application of source controls – including street sweeping, native plantings. Application of structural controls – retention/detention areas, swales.
Water Conservation To maximise the reuse of stormwater	 Encourage implementation of water efficiency and demand management measures in and ex-building. Use of native plantings in swale and drainage areas to minimise irrigation
Economic Viability To implement stormwater systems that are economically viable in the long term	Use of proven structural WSUD technology Use of source control techniques to minimise cost of nutrient management
Public Health To minimise the public risk, including risk of injury or loss of life to the community	Design in accordance with relevant design standards, best management practices, council regulations and government agency requirements.
Protection of Property To protect the built environment from flooding and waterlogging	Identification of 100 year ARI flood levels for Study Area Protection of downstream areas by restricting stormwater discharge to existing levels for storm events up to 100 year ARI
Social Values To ensure that social aesthetic and cultural values are recognised and maintained when managing stormwater	 Use of swales within public areas for stormwater conveyance Integration of drainage and POS functions
Development To ensure the delivery of best practice stormwater management through planning and development of high quality developed areas in accordance with sustainability and precautionary principles.	Urban water management in accordance with Better Urban Water Management (WAPC, 2008) Development of the LWMS in accordance with government agency guidelines and best management practice recommendations

In addition to the Local Water Management Strategy, preparation of an Urban Water Management Plan (UWMP) will be required to facilitate subdivision of the subject land. UWMP preparation will be the responsibility of the developer, and will need to address the following matters:

 Detailed stormwater management design including the size, location and design of swales, integrating major and minor flood management capability, landscape plants for the swales as related



to stormwater function, specific details of local geotechnical investigations and their impact on stormwater design;

- Detail measures to reduce velocity of stormwater discharge to prevent erosion and sediment transportation.
- Management of groundwater levels, and if any proposed dewatering is necessary;
- Agreed/approved measures to achieve water conservation and efficiencies of use including sources
 of water for non-potable uses and detailed designs, controls, management and operation of any
 proposed system;
- Management of sub-divisional works (management of soil/sediment including dust).

Following construction, initial operation and maintenance of the stormwater management system will be the responsibility of the developer. This operation and maintenance responsibility will then ultimately transfer to the Town of Port Hedland.

3.6 Employment, Community Services and Facilities

The subject land enjoys close proximity to South Hedland City Centre, identified as the primary activity centre within the wider Town of Port Hedland municipality by the Pilbara's Port City Growth Plan. The City Centre will provide significant employment opportunities for future residents, in addition to local opportunities already available in traditional mining, logistics and associated industries. Residents will also benefit from the concentration of existing and future retail activity, community facilities and services in the City Centre precinct. Furthermore, residential development of the Western Edge area will support the City Centre's ongoing revitalisation and stimulate further economic activity by centralising it within a larger population catchment.

Liaison with the Department of Education and Training has identified that capacity remains within existing South Hedland primary and secondary school network to accommodate the residential development of the subject land area. However, additional population and associated education demand generated by subsequent stages of the South Hedland Western Edge project will necessitate provision of another primary school, which has been reflected in wider concept planning for the Western Edge precinct.

The location of a potential tertiary education facility partially within the subject land also represents a significant opportunity to improve the education and training offering for future residents within the Development Plan area and beyond.



3.7 Utilities

A Servicing & Infrastructure Report has been prepared by Cossill & Webley on behalf of LandCorp to accompany the Development Plan, and is provided at **Appendix 7**. The Servicing and Infrastructure report serves to provide initial advice on the presence of existing service infrastructure, development constraints and servicing requirements for development of the subject land. A summary of key the report findings and key utilities infrastructure requirements is provided below.

3.7.1 Sewerage

The Water Corporation is currently reviewing their conceptual sewerage catchment planning in response to the Pilbara Port City Grown Plan and significant projected population growth in the town. Verbal advice has confirmed that the Water Corporation have no objections to the current proposed rezoning of the subject land to support future residential development.

The subject land is located within the current Water Corporation planning catchment boundary, and will gravitate to a proposed Type 180 pump station to be located in the northern extent of the Development Plan area. Completion of the pump station is anticipated to occur in late 2013 - early 2014, at which time the station will discharge to the existing South Hedland Wastewater Treatment Plan west of the Site. A recent review of odour contours for the South Hedland Wastewater Treatment Plant has confirmed that the odour buffer does not impact on the subject land.

The new pump station will be fully funded by Water Corporation utilising their own design and procurement processes. Its location has been determined, fixed and is noted on the proposed Development Plan. The Water Corporation has also requested that additional land be set aside to the west of the pump station site to incorporate storage tanks and a future Type 350 pump station. This area is shown as POS on the proposed Development Plan, with the extent of land required pending further planning and design by the Water Corporation.

Development of the subject land will require construction of prefunded sewer mains with a nominal size of DN600mm (subject to design). Further investigation is required with Water Corporation to determine the ultimate extents of prefunded infrastructure within the development area.

3.7.2 Potable Water Supply

The Water Corporation are currently reviewing their water capacity constraints for the East Pilbara Water Supply Scheme. Verbal advice has confirmed that the Water Corporation have no objections to the current proposed rezoning of the subject land to support future residential development.



The East Pilbara Water Supply Scheme is under extreme pressure and is not able to immediately service the extent of the site. In response to this challenge, the Water Corporation is planning for major infrastructure upgrades and new assets to facilitate servicing of the planned growth of Port and South Hedland.

Port and South Hedland water supply is currently sourced from the Yule & De Grey borefields located tens of kilometres from the town, and it is understood that the Water Corporation has recently received an increase in its groundwater allocation to provide for the planned expansion of the region. The ability of the Corporation to meet water supply demands will however be influenced by proposed development densities and staging/delivery timeframes. In this regard, the Water Corporation will be consulted to confirm that the proposed demand can be supplied from their planned source upgrades and to confirm the timing of any trunk mains that may be required.

There is existing water supply reticulation mains in the adjoining and nearby developments and the ability to extend these mains to service initial phases of development would be subject to further investigation.

3.7.3 **Power**

The existing South Hedland Town Centre and surrounds is currently serviced from the Murdoch Zone substation located in Murdoch Drive near Demarchi Road. It is understood that the Murdoch Zone substation is supplied from the Alinta Gas 66KVA overhead transmission line that traverses the area south of the proposed development plan area and through the planned Department of Housing land south of Murdoch Drive near the Outer Ring Road in the south-east corner of the existing South Hedland Townsite.

It is understood that the Murdoch Zone substation is running near capacity at Summer Peak Loads and any significant new development may require an upgrade of this facility. In order to understand any capacity constraints to service the Site, Horizon Power will need to complete a detailed HV System Study. It is understood that representations have been made by government Agencies (Pilbara Cities, LandCorp & Department of Housing) and their representatives to progress this investigation and study.

LandCorp is aware of preliminary discussions held with Horizon Power to provide an overall plan for the servicing of South Hedland and understand this may include a new substation site in the Western or Northern area of the townsite. It is possible that an area within the wider South Hedland Western Edge precinct may be required to serve as a substation. In this regard, is anticipated that satisfactory and timely planning by Horizon Power will be critical to the servicing of the proposed Development Plan area.



3.7.4 Telecommunications

The subject land area currently sits beyond NBN Co's National Broadband Network footprint, but NBN Co officers have confirmed that it is likely that the inclusion of these areas can be treated as an extension to LandCorp's South Hedland Town Centre redevelopment and would hence be included in the NBN rollout.

The current design practice for road reserves, pavement and verge provisions will make adequate allowance for services including broadband in accordance with the agreed Utilities Service Providers handbook. There will be some local land requirements for equipment sites, similar to current provisions which will be accommodated at detailed subdivision stage

3.7.5 Gas

South Hedland is not currently provided with a reticulated gas supply network.

3.8 Implementation and Staging

LandCorp intends to deliver the South Hedland Western Edge project via a Development Agreement arrangement with a private sector partner, to be selected through an Expression of Interest (EoI) process. On execution of the Development Agreement with LandCorp, the successful Proponent is to progressively plan, develop, subdivide and sell residential lots and potentially any built form products. Given the entire Western Edge project is to be delivered via a single Public/Private Sector development partnership, rather than across multiple/fragmented private landholdings, no development contribution arrangement will be required to finance infrastructure delivery.

LandCorp is pursuing a two-phase project delivery model for the South Hedland Western Edge Project, with the subject Development Plan area relating to 'Phase I' and the larger 'Phase 2' area to follow in due course. The internal staging within the phases is yet to be identified. These staging arrangements are expected to be identified by the selected private sector development partner in collaboration with LandCorp, informed by further discussion with utilities providers with regard to servicing capacity and logical sequencing arrangements.



4.0 CONCLUSION

The Development Plan, prepared on behalf of LandCorp, illustrates the preferred development option for Phase I of the South Hedland Western Edge precinct, which has been identified as a priority development area capable of supplying additional housing supply in the short term.

The proposed Development Plan has been prepared in accordance with the requirements of Town Planning Scheme No.5 and the design elements outlined by Liveable Neighbourhoods, and provides a framework for the development for a high quality residential development, demonstrating urban design excellence and consistency with sustainability principles. Furthermore, it responds to the direction set by the Pilbara's Port City Growth Plan by providing for short term residential expansion to the west of the existing South Hedland Townsite, providing both residential property market relief and supporting the continued revitalisation of the City Centre.

Following adoption of the Development Plan by the Town of Port Hedland and WA Planning Commission, subdivision applications will be lodged with the WA Planning Commission to facilitate staged development of the land to progress through lot construction, clearance, sale and built form development.



APPENDIX I

Development Plan

PROPOSED DEVELOPMENT PLAN
Western Edge, SOUTH HEDLAND

RPS Australia East Pty Ltd
ABN 44140292762
PO Box 465 SUBIACO WA 6904
38 Station Street SUBIACO WA 6008
T +61 8 9211 1111 W rpsgroup.com.au



APPENDIX 2

Environmental Assessment Report



ENVIRONMENTAL ASSESSMENT REPORT

South Hedland Western Edge Precinct – Amendment to Town Planning Scheme No. 5

Prepared by:

RPS

38 Station Street, SUBIACO WA 6008 PO Box 465, SUBIACO WA 6904

T: 618 9211 1111 F: 618 9211 1122

E: environment@rpsgroup.com.au

W: rpsgroup.com.au

Report No: L1142601

Version/Date: Rev 0, April 2012

Prepared for:

LANDCORP

Level 6 Wesfarmers House 40 The Esplanade

PERTH WA 6000



Document Status

Version	Purpose of Document	Orig	Review	Review Date	Format Review	RPS Release Approval	Issue Date
Draft A	Draft for Client Review	GilGla	GrePur	13.04.12	DC 13.04.12		
Rev 0	Final for Issue	GilGal	GrePur	24.04.12	SN 26.04.12	G. Purser	26.04.12

Disclaimer

This document is and shall remain the property of RPS. The document may only be used for the purposes for which it was commissioned and in accordance with the Terms of Engagement for the commission. Unauthorised copying or use of this document in any form whatsoever is prohibited.



SUMMARY

Overview

The town of Port Hedland is located in the Pilbara region of Western Australia. Port Hedland's initial growth in the 1960s was driven by the iron ore industry resulting in major changes to the town, which previously supported fledgling pastoral and pearling pursuits. The transformation of the town's natural harbour into Australia's largest tonnage export port has been a key economic driver in the evolution of Port Hedland into a strategic regional centre.

The town of Port Hedland, which includes the satellite town of South Hedland, is presently facing significant ongoing growth pressures as a result of the exploration, mining and export of minerals and wealth in the Pilbara. With further growth forecast for Port Hedland, chiefly driven by the Pilbara Cities goal to build the population of Port Hedland into a city of 50,000 people by 2031, there is a strong local demand for residential subdivisions to provide affordable housing.

Preliminary Environmental Report

RPS Environment and Planning Pty Ltd (RPS) has been commissioned by the Western Australian Land Authority (trading as 'LandCorp') to provide an Environment Assessment Report (EAR) for the parcels of land that comprise the South Hedland Western Edge Precinct (the subject land), a 222.55 ha extent on interior land to the south-west of South Hedland.

The subject land is currently identified as being subject to three zonings under the Town of Port Hedland's Town Planning Scheme No. 5 (TPS No. 5). The majority of the subject land is zoned 'Rural' with a small portion of land enclosed within the subject land being zoned 'Commercial' and 'District Road' (Department of Planning 2010).

A Scheme Amendment has been proposed to rezone the subject land from 'Rural', 'Commercial' and 'District Road' to 'Urban Development' to facilitate the progressive subdivision and development of a future urban area to the west and south of the existing South Hedland town site. This EAR has been prepared to support the proposed rezoning of the subject land.

To assist in fulfilling the scope of services for the commissioned work, RPS subcontracted MJ and AR Bamford Consulting Ecologists (Bamford) to undertake al Level I Fauna Survey for the initial investigation area, which was an approximate I65ha portion of the subject land. After the Level I Fauna Survey the extent of the investigation area was increased from I65ha to 222.55 ha. As a result of the increase in the size of the investigation area, RPS undertook a targeted search for conservation significant fauna over the remaining extent of the subject land which had not been included in the initial Level I Fauna Survey undertaken by Bamford. The targeted search was undertaken for an area of land totalling approximately 57.55 ha and identified three burrows, which were thought to be mammalian in their origin.



As a result of undertaking the targeted search for conservation significant fauna, an additional search was undertaken by Bamford to determine if any conservation significant fauna were presently using burrows that were identified within the search area.

RPS undertook a Level I Flora and Vegetation Survey over the entire extent of the subject land. The Level I Flora and Vegetation identified the presence of Priority I species, *Heliotropium muticum* (PI), upon the subject land.

Targeted searches were consequentially undertaken by RPS to determine the relative distribution of *Heliotropium muticum* (PI) within the subject land and its regional distribution in relation to the Port Hedland hinterland.

Key Findings

Level I Flora and Vegetation Survey

- No Threatened Flora species were identified as occurring within the subject land.
- No Threatened Ecological Communities (TEC) or Priority Ecological Communities (PEC) were identified as occurring within the subject land.
- The majority of the subject land is considered to be in 'Excellent' to 'Very Good' condition.
- Heliotropium muticum (PI) was identified as occurring within the subject land.

Heliotropium muticum (PI)

- Vegetation types associated with the occurrence of Heliotropium muticum (PI) are not restricted to the subject land.
- Distribution of Heliotropium muticum (P1) is considered to be wide spread and adequately represented in the Port Hedland hinterlands.
- It is considered unlikely that the subject land would be considered significant habitat upon which Heliotropium muticum (PI) is dependent upon for survival.

Level I Fauna Survey and Targeted Searches

- No Threatened species were recorded within the subject land.
- Two migratory bird species protected under the Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) and two Priority 4 bird species under the Wildlife Conservation Act 1950 were recorded by the field investigation.



- Given the proximity of the subject land to the existing South Hedland town site it is likely that the fauna of conservation significance may avoid the subject land.
- Although the subject land may potentially contain habitat which could potentially be utilised by the identified species of conservation significance fauna, it is considered unlikely to be considered significant habitat upon which any of these species are dependent upon for survival.
- Referral to the Department of Sustainability, Environment, Water, Population and Communities (SEWPaC) under the EPBC Act will not to be required for this proposal.

Potential Contamination

Uncontrolled tipping activities has led to large amounts of household refuse being placed within the subject land therefore there is potential for some contamination to be present.

Management of Impacts

A summary of the management measures which should be considered when preparing the Development Plan for the South Hedland Western Edge Precinct is provided in Table 4. The implementation of these management measures will ensure that potential impacts to the environmental values of the subject land are managed to ensure that proposed future development of the subject land meets the objectives of the EPA.

Conclusions

Through addressing the identified key environmental factors when preparing the Development Plan, this environmental assessment of the proposed amendment to TPS No. 5 for the South Hedland Western Edge Precinct concludes that the potential environmental impacts identified in this report can be managed in accordance with the objectives of the EPA to prevent significant impacts on the environmental values of the subject land.



This page is intentionally blank.

L1142601, Rev 0, April 2012 Page iv



TABLE OF CONTENTS

Page

SUMI	MARY	•••••••••••••••••••••••••••••••••••••••	·····
1.0	INTR	RODUCTION	I
1.1	Backg	ground	I
1.2	Objec	ctive	I
1.3	Metho	odology and Scope	I
2.0	PLAN	NNING CONTEXT	3
2.1	Strate	egic Planning	3
	2.1.1	State Planning Strategy	
	2.1.2	Draft Pilbara Planning and Infrastructure Framework	
	2.1.3	Port Hedland Regional Hotspots Land Supply Update	3
	2.1.4	Draft Pilbara's Port City Growth Plan	
2.2	Statu	tory Planning	4
	2.2.1	Town of Port Hedland Town Planning Scheme No. 5	
3.0	EXIS	TING ENVIRONMENT	5
3.1	Locat	ion	5
3.2	Clima	ate and Weather	5
3.3	Land	Uses	6
	3.3.1	Historic Land Uses	<i>6</i>
	3.3.2	Existing Land Uses	<i>6</i>
	3.3.3	Surrounding Land Uses	9
3.4	Topog	graphy	9
3.5	Geolo	ogy	10
3.6	Hydro	ology	10
	3.6.1	Surface Water	10
	3.6.2	Groundwater	10
3.7	Veget	tation and Floratation and Flora	I I
	3.7.1	Regional Vegetation	
	3.7.2	Level I Flora and Vegetation Survey	1
	3.7.3	Conclusions	21



ıarge	eted Flora Searches for Heliotropium muticum (PI)	
3.8.1	Background	21
3.8.2	Targeted Search of the Subject Land	21
3.8.3	Targeted Search of the Port Hedland Hinterlands	22
3.8.4	Discussion	22
3.8.5	Conclusions	23
Fauna	and Habitat	24
3.9.1	Desktop Assessment	24
3.9.2	Field Survey	24
3.9.3	Targeted Fauna Searches	29
3.9.4	Conclusions	30
Acid S	Sulfate Soils	31
Poten	tial Contamination	31
Herita	age	31
3.12.1	Aboriginal Heritage	31
		32
	POSED SCHEME AMENDMENT	
	·	33
PROF	POSED SCHEME AMENDMENT	33
PROF	POSED SCHEME AMENDMENT	33
PROF POTI Hydro	POSED SCHEME AMENDMENT ENTIAL IMPLICATIONS FOR DEVELOPMENT	333535
PROF POTI Hydro 5.1.1	POSED SCHEME AMENDMENT ENTIAL IMPLICATIONS FOR DEVELOPMENT blogy	33353535
PROF POTI Hydro 5.1.1 5.1.2 5.1.3	POSED SCHEME AMENDMENT ENTIAL IMPLICATIONS FOR DEVELOPMENT Dlogy EPA Objective Potential Impacts	3335353535
PROF POTI Hydro 5.1.1 5.1.2 5.1.3	POSED SCHEME AMENDMENT ENTIAL IMPLICATIONS FOR DEVELOPMENT Plogy	333535353535
PROF POTI Hydro 5.1.1 5.1.2 5.1.3 Flora	POSED SCHEME AMENDMENT ENTIAL IMPLICATIONS FOR DEVELOPMENT Dlogy	333535353535
PROF POTI Hydro 5.1.1 5.1.2 5.1.3 Flora 5.2.1	POSED SCHEME AMENDMENT ENTIAL IMPLICATIONS FOR DEVELOPMENT Dlogy	
PROF POTI Hydro 5.1.1 5.1.2 5.1.3 Flora 5.2.1 5.2.2 5.2.3	POSED SCHEME AMENDMENT ENTIAL IMPLICATIONS FOR DEVELOPMENT Dlogy EPA Objective Potential Impacts Management Measures and Vegetation EPA Objective Potential Impacts	333535353535363636
PROF POTI Hydro 5.1.1 5.1.2 5.1.3 Flora 5.2.1 5.2.2 5.2.3	POSED SCHEME AMENDMENT ENTIAL IMPLICATIONS FOR DEVELOPMENT Dlogy	333535353535363636
PROF POTI Hydro 5.1.1 5.1.2 5.1.3 Flora 5.2.1 5.2.2 5.2.3 Fauna	POSED SCHEME AMENDMENT ENTIAL IMPLICATIONS FOR DEVELOPMENT Dlogy EPA Objective Potential Impacts Management Measures and Vegetation EPA Objective Potential Impacts Management Measures	
PROF POTI Hydro 5.1.1 5.1.2 5.1.3 Flora 5.2.1 5.2.2 5.2.3 Fauna 5.3.1	POSED SCHEME AMENDMENT ENTIAL IMPLICATIONS FOR DEVELOPMENT Diogy	
PROF POTI Hydro 5.1.1 5.1.2 5.1.3 Flora 5.2.1 5.2.2 5.2.3 Fauna 5.3.1 5.3.2 5.3.3	POSED SCHEME AMENDMENT ENTIAL IMPLICATIONS FOR DEVELOPMENT Dlogy EPA Objective Potential Impacts Management Measures and Vegetation EPA Objective Potential Impacts Management Measures	
PROF POTI Hydro 5.1.1 5.1.2 5.1.3 Flora 5.2.1 5.2.2 5.2.3 Fauna 5.3.1 5.3.2 5.3.3	POSED SCHEME AMENDMENT ENTIAL IMPLICATIONS FOR DEVELOPMENT Diogy EPA Objective Potential Impacts Management Measures and Vegetation EPA Objective Potential Impacts Management Measures EPA Objective Potential Impacts EPA Objective Potential Impacts Management Measures	3335353535363636363637
PROF POTI Hydro 5.1.1 5.1.2 5.1.3 Flora 5.2.1 5.2.2 5.2.3 Fauna 5.3.1 5.3.2 5.3.3 Poten	POSED SCHEME AMENDMENT ENTIAL IMPLICATIONS FOR DEVELOPMENT Dlogy	



5.5	Herit	age	38
	5.5.1	EPA Objective	38
	5.5.2	Potential Impacts	38
	5.5.3	Management Measures	38
5.6	Envir	onmental Management Summary	38
6.0	CON	ICLUSIONS	41
7.0	REFE	ERENCES	43



TABLES

(contained withi	n report text)	Page
Table I:	Vegetation Types Recorded in the Subject Land	17
Table 2:	Vegetation Condition Rating Scale (Keighery 1994)	20
Table 3:	Species of Fauna that could Potentially Occur within the Subject Land	26
Table 4:	Summary of Management Actions	39

FIGURES

(compiled at rear of report)

Figure 1: Site Location

Figure 2: Zoning under Town of Port Hedland Town Planning Scheme No. 5

Figure 3: Historical Imagery

Figure 4: Topography

Figure 5: Geology

Figure 6: Beard Vegetation Association

Figure 7: Vegetation Types

Figure 8: Vegetation Condition

Figure 9: Location and Likely Occurrences of Heliotropium muticum (P1) recorded within

the Subject Land

Figure 10: Search Areas and Locations of Heliotropium muticum (PI) in the Port Hedland

hinterland

Figure 11: Potential Mammal Burrows

Figure 12: Acid Sulfate Soils



PLATES

(contained within	report text)	Page
Plate 1:	Typical extent of native grassland vegetation	7
Plate 2:	Unsealed access track and overhead power cables upon the subject land.	8
Plate 3:	Household refuse	8
Plate 4:	Created drainage line	9
Plate 5:	South Creek creek bed in February 2012	10
Plate 6:	Heliotropium muticum (PI)	15
Plate 7:	Grassland habitat consisting of patchy mosaic vegetation reflecting varying degrees of fire age	
Plate 8:	Potential mammal burrow	30

APPENDICES

APPENDIX I: EPBC Act Protected Matters Search Tool

APPENDIX 2: Flora Species Recorded by Level 1 Flora and Vegetation Survey

APPENDIX 3: Vegetation Classifications for the Pilbara

APPENDIX 4: Level I Fauna Survey

APPENDIX 5: Inspection of Animal Burrows at South Hedland



This page is intentionally blank.

L1142601, Rev 0, April 2012

Page x



1.0 INTRODUCTION

I.I Background

RPS Environment and Planning Pty Ltd (RPS) has been commissioned by the Western Australian Land Authority (trading as 'LandCorp') to provide an Environment Assessment Report (EAR) for the parcels of land that comprise the South Hedland Western Edge Precinct (the subject land), a 222.55 ha extent on interior land to the south-west of South Hedland (Figure 1).

The subject land is currently identified as being subject to three zonings under TPS No. 5. The majority of the subject land is zoned 'Rural' with a small portion of land enclosed within the subject land being zoned 'Commercial' and 'District Road' (Department of Planning 2010) (Figure 2).

A Scheme Amendment has been proposed to rezone the subject land from 'Rural', 'Commercial' and 'District Road' to 'Urban Development' to facilitate the progressive subdivision and development of a future urban area to the west and south of the existing South Hedland town site. This EAR has been prepared to support the proposed rezoning of the subject land.

1.2 Objective

The objective of this report is to identify the potential impacts to the environment posed by the development of the subject land and identify management actions aimed at facilitating the rezoning of the subject land in accordance with the Environmental Protection Authority's (EPA) objectives.

In order to deliver this report, RPS followed this approach:

- Described the existing natural environment of the subject land.
- Identified the key environmental constraints to the development opportunities.
- Identified potential management actions required to facilitate the development opportunities.

1.3 Methodology and Scope

This EAR addresses the following key environmental factors:

- topography
- land system



- geology
- hydrology
- native vegetation
- fauna
- acid sulfate soils
- contamination
- heritage.

The identified environmental factors have been validated and refined through:

- Meeting with officers from the Office of the Environmental Protection Authority (OEPA) on 10 January 2012 to determine the level of assessment required by the OEPA for the Flora and Vegetation survey and the Fauna survey in order to meet the objectives of the EPA for the proposal.
- Undertaking of Level 1 Flora and Vegetation survey and Level 1 and targeted Fauna surveys
- Meeting with the OEPA on 14 March 2012 to discuss the findings of the field surveys.
- Undertaking of targeted flora and fauna searches.

RPS undertook a Level I Flora and Vegetation Survey for the entire extent of the subject land.

Additional targeted searches were undertaken by RPS to determine the relative distribution of Priority I species, *Heliotropium muticum* (PI), within the subject land and its regional distribution in the hinterlands surrounding Port Hedland.

To assist in fulfilling the scope of services for the commissioned work, RPS subcontracted MJ and AR Bamford Consulting Ecologists (Bamford) to undertake a Level I Fauna Survey for a portion of the subject land, totalling approximately 165 ha.

RPS performed a targeted search for conservation significant fauna for the remaining extent of the subject land, totalling approximately 57.55 ha and identified three burrows.

Bamford was commissioned to undertake an additional search to determine if any conservation significant fauna were presently using burrows that were identified by the targeted search for conservation significant fauna.



2.0 PLANNING CONTEXT

The proposed amendment to TPS No. 5 for the South Hedland Western Edge Precinct is subject to the direction provided by the following key strategic planning documents.

2.1 Strategic Planning

2.1.1 State Planning Strategy

The State Planning Strategy (Western Australian Planning Commission [WAPC] 1997) provides the basis for long-term State and regional land use planning and coordinates a whole of government approach to planning. The State Planning Strategy aims to shape and manage the direction and form of development where it is most achievable and where there is the strongest case for government action to protect strategic assets (Department of Planning 1997). The State Planning Strategy identifies the Pilbara region as a key population and economic growth area.

2.1.2 Draft Pilbara Planning and Infrastructure Framework

The Draft Pilbara Planning and Infrastructure Framework (WAPC 2011a) defines a strategic direction for the future development of the Pilbara region spanning over the next 25 years. The Draft Pilbara Planning and Infrastructure Framework aims to address the scale and distribution of future population growth and housing development as well as identifying strategies for economic growth, environmental issues, transport, infrastructure, water resources, tourism and the emerging impacts of climate change (WAPC 2011a). Additionally the Draft Pilbara Planning and Infrastructure Framework sets out regional planning principles, goals, objectives and actions to achieve the above set outcomes that will guide the preparation of Local Planning Strategies and Local Planning Schemes.

2.1.3 Port Hedland Regional Hotspots Land Supply Update

As part of its Urban Development Program, the WAPC prepares a series of regional hotspot reports on major resource centres. The Port Hedland Regional Hotspots Land Supply Update (WAPC 2011b) identifies that Port Hedland's greatest current challenges are developing land, housing and infrastructure to keep pace with rapid population and employment growth. Additionally, the Port Hedland Regional Hotspots Land Supply Update outlines key economic, employment, population and housing demand considerations.



2.1.4 Draft Pilbara's Port City Growth Plan

The Draft Pilbara's City Growth Plan (Town of Port Hedland 2011) provides a high level strategic blueprint to facilitate that sustained growth of Port Hedland into Pilbara's Port City with a population of up to 50,000 persons. The Draft Pilbara's City Growth Plan identifies and presents an activities centres framework which identifies South Hedland as the primary City centre for the region supporting a concentration of significant retail offerings, commercial office space, major health facilities and personal services.

The subject land is contained within Precinct 10 of the Draft Pilbara's City Growth Plan. The vision for Precinct 10 is as follows:

South Hedland West is South Hedland's newest land release area. It supports immediate and short term land supply, bring a permanent population catchment to the west of the City. Densities are greater in proximity to the City Centre, with more traditional home sites provided to the south west and south of the precinct.

(Town of Port Hedland 2011).

2.2 Statutory Planning

The proposed amendment to TPS No. 5 for the South Hedland Western Edge Precinct is regulated by the Town of Port Hedland's statutory planning instruments.

2.2.1 Town of Port Hedland Town Planning Scheme No. 5

Under the Town of Port Hedland Town Planning Scheme No. 5 (Department of Planning 2011) the subject land is identified as being subject to three zonings. The majority of the subject land is zoned 'Rural' with a small portion of land enclosed within the subject land being zoned 'Commercial' and 'District Road' (Department of Planning 2010) (Figure 2).

A Scheme Amendment has been proposed to rezone the subject land from 'Rural', 'Commercial' and 'District Road' to 'Urban Development' to facilitate the progressive subdivision and development of a future urban area to the west and south of the existing South Hedland town site.



3.0 EXISTING ENVIRONMENT

3.1 Location

The subject land is located within the municipality of the Town of Port Hedland. The subject land is situated approximately 10 km south of the Port Hedland Central Business District and lies immediately to south west of the existing South Hedland town site (Figure 1). Port Hedland is situated in the Pilbara region of Western Australia and is located about 1600 km north of Perth.

The significant mineral, oil and gas reserves of the Pilbara region are the driving forces behind the region, and Western Australia's, strong economic growth. Additionally tourism, agriculture and aquaculture industries all feature prominently in the local regional economy (Pilbara Development Commission 2009). On the back of regional mining, oil, gas and export activities Port Hedland's economy has grown 61.3% over the last three years with significant additional growth projected as a direct result of expected long term global demand for steel and iron (Town of Port Hedland 2011).

The subject land is comprised of numerous different parcels of land and totals 222.55 hectares (ha) in extent. The subject land is separated from existing urban development of the South Hedland town site to the north by Collier Drive and Forest Circle. To the west, south and east the subject land is bordered by rural land. The western boundary of the subject land is the extent of the Boodarie Industrial Buffer Special Control Area (Department of Planning 2011).

3.2 Climate and Weather

Port Hedland experiences a hot, semi-arid climate. Summers (October to April) are very hot with an average maximum temperature of 31.8 °C and daily maximum of up to 35.2 °C in March, which is the hottest month. Winters are generally mild with temperatures ranging from an average monthly minimum of 17.2 °C to an average monthly maximum of 26.8 °C (Bureau of Meteorology 2011).

Most of the annual rainfall occurs during the summer period from scattered thunderstorms and the occasional tropical cyclone. A secondary peak in the rainfall occurs in May as a result of rainfall events caused by tropical cloud bands which intermittently affect the area mostly in May and June. These events can also produce low maximum temperatures particularly away from the coast. Thunderstorms average 20–30 per annum over most of the area but 15–20 is more common near the coast (Bureau of Meteorology 2011). Winds in the Port Hedland area are characterised by dominant westerly winds occurring throughout summer and prevailing easterly winds in the winter.



Port Hedland has been severely impacted by several severe tropical cyclones in the last thirty years. Cyclones are most common in the Port Hedland region between February and March which can result in extreme rainfall events (Bureau of Meteorology 2011).

3.3 Land Uses

3.3.1 Historic Land Uses

The historic land uses for the subject land have been identified from analysis of historical imagery obtained from the Landgate Map viewer dating back to the year 1966 (Figure 3).

The 1966 image identifies that the entire extent of the subject land consisted of natural vegetation.

The 1983 image shows that the entire extent of the subject land appears to have undergone a high disturbance event which appears to have resulted in the removal of the naturally occurring vegetation. The South Hedland town site has been developed directly to the east of the subject land. There has been removal of vegetation undertaken along the present day orientation of Forest Circle in the north of the subject land and various unsealed tracks which provide vehicular access to the west are present within the subject land.

The 2004 image shows that vegetation appears to be covering small areas of the subject land and Yarrie Road appears to have been formalised by a bitumen road.

The 2009 image shows that the extent of the vegetation coverage upon the subject land appears to have diminished from the 2004 extent potentially indicating that the vegetation coverage is linked to specific seasonal influences and disturbance events, such as fire.

3.3.2 Existing Land Uses

The subject land is currently vacant and comprised almost entirely of native grassland vegetation (Plate I).



Plate I: Typical extent of native grassland vegetation

From the site visits undertaken for the Level I Flora and Vegetation and Level I Fauna Surveys from the 30 January to I February 2012, RPS has identified that the existing land uses of the subject land are predominantly for access, infrastructure provision, recreation, water conveyance and maintenance of the local hydrological function.

The subject land does not have a perimeter fence or gates across the existing unsealed tracks to restrict access. This allows local residents to access the subject land in order to undertake a variety of activities.

RPS identified from visual observations that the subject land was used for transportation both as means of getting from one location to another and by four wheel drive enthusiasts for recreational driving. Overhead power cables traverse the subject land in an east-west direction in the southern sections of the subject land (Plate 2).

L1142601, Rev 0, April 2012



Plate 2: Unsealed access track and overhead power cables upon the subject land

Portions of the subject land have been used for uncontrolled tipping activities, which has lead to large amounts of household refuse being placed within the subject land (Plate 3).



Plate 3: Household refuse

Additionally due to the lack of controlled access and existing local amenity, the subject land is used by local dog walkers and as a location for informal community gatherings.



A created drainage line traverses the subject land in a south-westerly direction which provides the functions of conveying storm water flows and assisting in the maintenance of the existing local hydrological regimes (Plate 4).



Plate 4: Created drainage line

3.3.3 Surrounding Land Uses

The South Hedland town site is situated directly to the north of the subject land. South Hedland is recognised as the hub for regional government public sector and business activity (Town of Port Hedland 2011). The South Hedland town site supports a range of land uses including 'Commercial' and 'Parks and Recreation', however the majority of land in South Hedland supports 'Residential' use.

3.4 Topography

The natural topography of the subject land displays little variation in relief sloping from about 14 m Australian Height Datum (AHD) in the south east through to approximately 10 m AHD in the north west (Figure 4).



3.5 Geology

The subject land is situated within the De Grey Roebourne Lowlands Zone the natural geology of which can be described as consisting of alluvial plains and sand plains (and some flood plains and stony plains) on alluvial and marine deposits over rocks of the northern Pilbara Craton (Tille 2006) (Figure 5).

3.6 Hydrology

3.6.1 Surface Water

There are no streams, creeks or any other natural watercourses within the subject land.

South Creek is located approximately 400 m west of the subject land (Plate 5). South Creek is dry for the majority of the year, however, significant run-off is generated after heavy rainfall. Stormwater naturally drains from the South Hedland town site into the created drainage line which traverses the subject land in a south-westerly direction and runs into South Creek, which then flows northward into the coastal estuary of Stingray Creek.



Plate 5: South Creek creek bed in February 2012

3.6.2 Groundwater

As South Hedland is located in close proximity to the Indian Ocean, and given the direction of surface water flows of South Creek, it is anticipated groundwater flow will generally be south to north towards the ocean.



3.7 Vegetation and Flora

3.7.1 Regional Vegetation

Port Hedland is situated within the Interim Biogeographical Regionalisation of Australia region of Pilbara 4, and more specifically, is within the costal subregion of Roebourne.

The Roebourne subregion is described as:

Quaternary alluvial plains with a grass savannah of mixed bunch and hummock grasses, and dwarf Shrub Steppe of Acacia translucens or A. pyrifolia and A. inaequilatera. Resistant linear ranges of basalts occur across the coastal plains. These uplands are dominated by *Triodia* hummock grasslands. Ephemeral drainage lines support Eucalyptus woodlands. Samphire, Sporobolus grasslands and mangal occur on the marine alluvial flats and river deltas (DEC 2002).

Figure 6 identifies that the Beard Vegetation Association: 589 - Mosiac: Short bunch grassland — savannah/grass plain (Pilbara)/Hummock grasslands, grass steppe; soft spinifex vegetation complex, naturally occurs over the extent of the subject land.

A Biodiversity Audit of WA (Department of Conservation and Land Management [CALM] 2002) for the Roebourne subregion identifies that the Beard Vegetation Association: 589 - Mosiac: Short bunch grassland — savannah/grass plain (Pilbara)/Hummock grasslands, grass steppe; soft spinifex has medium priority for reservation.

CALM (2002) identifies that a substantial amount (approximately 13,758.3 ha) of Beard Vegetation Association 589 - Mosiac: Short bunch grassland - savannah/grass plain (Pilbara)/Hummock grasslands, grass steppe; soft spinifex is contained in reservation estates within the Pilbara 4 region.

3.7.2 Level I Flora and Vegetation Survey

RPS undertook a Level I Flora and Vegetation Survey in line with EPA Guidance Statement No. 51 – Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment in Western Australia (EPA 2004a) and Terrestrial Biological Surveys as an Element of Biodiversity Protection, Position Statement No. 3 (EPA 2002).

RPS undertook a desktop assessment and two field surveys of the subject land. An approximate extent of 165 ha of the subject land was surveyed from 6 to 8 February 2012 and a smaller extent of approximately 57.55 ha was surveyed on 28 February 2012. The undertaking of two separate field surveys being undertaken was due to the size of the investigation area being increased.

3.7.2.1 Desktop Assessment

Threatened Flora

A search was undertaken on 23 February 2011 of the DEC's Threatened (Declared Rare) Flora database, Declared Rare and Priority Flora List and the Western Australian Herbarium Specimen database for threatened and priority species collected within a buffer of greater than five kilometre radius of the subject land. There were no threatened or priority species identified as occurring within the subject land.

A search using SEWPaC's *Protected Matters Search Tool*, undertaken on 23 November 2011, identified that there were no known occurrences of Threatened Flora protected under the EPBC Act identified within the subject land or within a surrounding five km radius buffer (Appendix 1).

Threatened Ecological Communities

A search was undertaken on 23 February 2011 of the DEC's *Threatened and Priority Ecological Communities* database and identified that there were no known occurrences of TECs or Priority Ecological Communities (PECs) within a buffer of greater than a five kilometre radius of the subject land.

A search using SEWPaC's *Protected Matters Search Tool*, undertaken on 23 November 2011, identified that there were no known occurrences of Threatened Ecological Communities (TECs) protected under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) identified within the subject land or within a surrounding five kilometre radius buffer (Appendix 1).

3.7.2.2 <u>Field Survey - Methodology</u>

The field survey was undertaken to provide a description of the dominant vegetation types present, vegetation condition and flora species present at the time of the survey within the subject land. Additionally, the survey was also conducted to determine whether any of the conservation significant species identified from the desktop assessment actually occur or are likely to occur in the subject land. This was based on a combination of sampling using relevès as well as intensively traversing the subject land.

Forty four relevè sites were selected within representative vegetation types in the subject land. Locations were selected to ensure that an adequate representation of the major vegetation types and flora present was sampled. This was done using recent colour aerial photography and by ground-truthing on foot. A targeted search by foot of the entire subject land for any Threatened Rare Flora or Priority listed species was also undertaken.

-

¹ Relevès are often used in flora and vegetation surveys to ascertain vegetation types and boundaries by recording the dominant plant species present including height and percentage



Flora Identification

Species that were well known to the survey botanist were identified in the field, while species that were unknown were collected and assigned a unique number to facilitate tracking. All plant species collected during the field program were dried and frozen in accordance with the requirements of the Western Australian Herbarium. Plant species were identified using local and regional flora keys and comparisons with named species held at the Western Australian Herbarium. Plant taxonomists who are considered to be an authority on a particular plant group were consulted, when necessary.

The conservation status of all recorded flora was compared against the current lists available on *FloraBase* (DEC 2012a).

Limitations

Complete flora and vegetation surveys can require multiple surveys, at different times of year, and over a period of a number of years, to enable observation of all species present. Some flora species, such as annuals, are only available for collection at certain times of the year, and others are only identifiable at particular times (such as when they are flowering). Additionally, climatic and stochastic events (such as fire) may affect the presence of plant species. Species that have a very low abundance in the area are more difficult to locate, due to above factors.

Flora composition changes over time, with flora species having specific growing periods, especially annuals and ephemerals (some plants lasting for a markedly brief time, some only a day or two). Therefore the results of future botanical surveys in this location may differ from the results of this field survey. As the survey was conducted only once rather than several times over the course of a year some annual, ephemeral condition-specific species may be present that were not recorded in the survey.

The subject land covers approximately 222.55 hectares. The large scale of this survey meant that sampling was conducted using relevès uniformly selected across the subject land, opportunistic collections of flora species and targeted searches based on intensive survey in habitats considered to support conservation significant species were undertaken. The majority of species would have been identified using these techniques; however, it is possible that species with a low abundance in the subject land were not observed.

The flora surveys were also restricted to predominantly flowering, vascular plants. Fungi and nonvascular plants (e.g. alga, mosses and liverworts) were not systematically searched for, as the information available on these plants is generally limited.



3.7.2.3 Field Survey - Results

A total of 121 plant taxa (including subspecies and varieties) representing 74 genera and 34 plant families were recorded in the subject land. This total is comprised of 116 native species and five introduced (exotic) species. The vegetation of the subject land is considered to be of moderate diversity.

A total of eight taxa in the collection could not be identified to species level due to the absence of adequate flowering parts and/or fruiting bodies. A further two taxa were unable to be identified to the subspecies level. Specimens that could not be accurately determined were compared to all conservation significant species identified from the database searches and contained within the morphological types held by the Western Australian Herbarium. None of these specimens matched any of the conservation significant species identified from the desktop assessment.

A complete list of flora species recorded from the subject land has been provided in Appendix 2.

Threatened and Priority Flora

No Threatened Rare Flora species listed by the DEC (2010) or species of national conservation significance listed under the EPBC Act (SEWPC 2009) were recorded by the field survey.

One Priority flora species, *Heliotropium muticum* (PI), was recorded during the 2012 survey (Figure 7). This species was recorded at relevè sites II, I2, I5, 38, 39, 41 and was collected at two other locations within the subject land; 665765 E 7741614 N and 666014 E 7741565 N (GDA datum). A total of I8 plants were recorded by the Level I field survey.



Plate 6: Heliotropium muticum (PI)

There are currently seven collection records of *Heliotropium muticum* (PI) retained at the Western Australian Herbarium. The records indicate that the distribution of *Heliotropium muticum* (PI) is rare and predominately restricted to the Port Hedland area however this species has been recorded at two locations approximately 20 km south of the Whim Creek Hotel.

Habitat for this species is not considered to be limited to the subject land and is common in the Port Hedland hinterlands.

Introduced Flora

A total of five introduced species (weeds) were recorded during the flora survey; *Cenchrus ciliaris, *Cynodon dactylon, *Aerva javonica, * Stylosanthes hamata and *Citrullus colocynthis. None of these species are listed as Declared Plant species pursuant to Section 37 of the Agricultural and Related Resources Protection Act 1976 (WA).

Vegetation Types

Five distinct vegetation types were recorded during the field survey (Figure 8). The vegetation types were described using a vegetation classification for the Pilbara biogeographic region based on Specht's (1970) Structural Formations in Australia with modification by Aplin (1979) and Trudgen (2002) (Appendix 3).

Vegetation structure across the subject land has been visibly impacted by frequently occurring fires over the last five years. Consequently, the distribution and therefore percentage foliar cover of taller native shrub species such as *Dolichandrone heterophylla* and *Acacia sericophylla* may have been under-represented at the time of this survey.

L1142601, Rev 0, April 2012 Page 15



Table I describes the five vegetation types that have been identified as occurring upon the subject land.



Table I: Vegetation Types Recorded in the Subject Land

Vegetation Type	Vegetation Description	Site Photo	Relevè
>	Low to Low Open Shrubland of Acacia stellaticeps, Bonamia spp., Ptilotus astrolasius and Hybanthus aurantiacus over Closed to Open Tussock Grassland of Triodia epactia, Eriachne obtusa, Aristida holathera var. holathera, Chrysopogon fallax and Paraneurachne muelleri.		1, 9, 18- 20, 33- 37, 39, 42-43
٧2	Shrubland of <i>Acacia stellaticeps</i> over Low Open Shrubland of <i>Acacia stellaticeps</i> , <i>Bonamia</i> spp. with Tussock Grassland to Open Tussock Grassland of <i>Triodia lanigera</i> , <i>Aristida</i> spp. and Scattered Herbs of <i>Cassytha capillaris</i> .		2 and 36

Vegetation Type	Vegetation Description	Site Photo	Re	Relevè
٨3	High Open Shrubland to Scattered Tall Shrubs of <i>Dolichandrone</i> heterophylla and or Low Shrubland to Low Scattered Shrubs of <i>Acacia</i> stellaticeps, Ptilotus astrolasius and Bonamia spp. with Tussock to Open Tussock Grassland of <i>Triodia</i> schinzii over Scattered Herbs of Mollugo molluginis.		4-7 14 17 29 29	4-7, 13- 14, 16- 17, 21- 24, 27, 29-30,
4\	Low to Low Open Shrubland of Acacia stellaticeps, Sida cardiophylla, Ptilotus astrolasius, Corchorus incanus subsp. incanus, Bonamia rosea and Hybanthus aurantiacus over a mosaic Tussock to Open Tussock Grassland dominated by either Triodia epactia, Triodia schinzii or Eriachne obtusa with Triodia lanigera, Chrysopogon fallax, Aristida holathera var. holathera over Scattered Herbs/Sedges of Bonamia alatisemina, Mollugo molluginis and Cyperus? blakeanus; with Scattered Tall Shrubs of Acacia colei var. colei and Acacia tumida var. pilbarensis on moister soils in lower lying depressions.		3, 8 112, 25, 28, 40, 40,	3, 8, 10- 12, 15, 25-26, 40-41, 44

Vegetation Type	Vegetation Type Vegetation Description	Site Photo	Relevè
9/	Low Open Shrubland of Neptunia? dimorphantha with Tussock to Open Tussock Grassland of Triodia epactia and or Eriachne flaccida over Very Open Sedges of Cyperus iria and Very Open Herbs of Marsilea sp., Goodenia lamprosperma and Peplidium aithocheilum.		31 and 32



Vegetation Condition

The vegetation condition of the site was assessed using the vegetation condition rating scale developed by Keighery (1994) that recognises the intactness of vegetation, which is defined by the following:

- Completeness of structural levels.
- Extent of weed invasion.
- Historical disturbance from tracks and other clearing or dumping.
- The potential for natural or assisted regeneration.

The scale consists of six rating levels as outlined below in Table 2.

Table 2: Vegetation Condition Rating Scale (Keighery 1994)

Vegetation Condition Rating	Vegetation Condition	Description
1	Pristine or Nearly So.	No obvious signs of disturbance.
2	Excellent	Vegetation structure intact, disturbance affecting individual species, and weeds are non-aggressive species.
3	Very Good	Vegetation structure altered, obvious signs of disturbance.
4	Good	Vegetation structure significantly altered by very obvious signs of multiple disturbances retains basic vegetation structure or ability to regenerate it.
5	Degraded	Basic vegetation structure severely impacted by disturbance. Scope for regeneration but not in a state approaching good condition without intensive management.
6	Completely Degraded	The structure of the vegetation is no longer intact and the area is completely or almost without native species.

The condition of the vegetation in the subject land ranged from 'Excellent' to 'Completely Degraded', however the majority of the vegetation was considered 'Excellent' to 'Very Good' in condition (Figure 9).

There are some isolated areas within the subject land that have been invaded by *Cenchrus ciliaris (Buffel Grass). This species is a common pastoral weed in northern Western Australia and can reduce native species abundance and diversity by aggressively competing with available plant resources (space, sunlight and water).

Vegetation structure over the subject land has been visibly impacted by frequent fires that have occurred over the last five years; the age of burns across the majority of the subject land is one to three years. Despite frequent burn regimes, the majority of the vegetation on the subject land remains structurally intact and has responded favorably to fire without aggressive incursions of weed species such as *Cenchrus ciliaris and *Aerva javanica (Kapok Bush). As a result the condition of the vegetation over the majority of the subject land was rated as 'Excellent' to 'Very Good'.



3.7.3 Conclusions

- No Threatened Flora species were identified as occurring within the subject land.
- Heliotropium muticum (P1) was identified as occurring within the subject land.
- No TECs or PECs were identified as occurring within the subject land.
- The majority of the subject land is considered to be in 'Excellent' to 'Very Good' condition.

3.8 Targeted Flora Searches for Heliotropium muticum (PI)

3.8.1 Background

According to specimen records contained in the Western Australian Herbarium collection, it appears that the occurrence of *Heliotropium muticum* (PI) is correlated with the Uaroo Land System. The subject land is located within the Uaroo Land System which is characterised by broad, level sandy surfaced plains, minor pebbly plains and tracts receiving sheet flow which support shrubby hard and soft spinifex grasslands (Van Vreeswyk et al. 2004). The Uaroo Land System is considered to be very common and has a distribution of approximately 768,100 ha throughout the Pilbara biogeographic region (BHP 2011).

Additionally, *Heliotropium muticum* (PI) appears to respond positively to fire. Frequent fires have occurred on the subject land in the last five years however the average age of fire on the majority of the site was estimated to be one to three years.

3.8.2 Targeted Search of the Subject Land

Heliotropium muticum (PI) was recorded at eight locations within the subject land by the Level I Flora and Vegetation Survey. Based on the outcomes of the survey RPS initiated a targeted flora grid search on 29 February 2012. The subject land was grid searched east to west by foot at 30 metre intervals, to determine the abundance and distribution of Heliotropium muticum (PI) within the subject land.

A total of 206 plants of *Heliotropium muticum* (PI) were recorded within the subject land. The majority of these occurrences were recorded in the north western extent of the subject land (Figure 9).

Approximately 25% of the search area was surveyed. Based on information including soil composition, species composition at sampling sites, floristic community structure and fire age patterns, the likelihood of occurrence of *Heliotropium muticum* (PI) within the subject land was mapped (Figure 9).



3.8.2.1 <u>Limitations of Surveys</u>

The targeted flora search was limited by time and by the extensive distribution and abundance of *Heliotropium muticum* (PI) which determined the extent of coverage achieved during the survey of the subject land.

3.8.3 Targeted Search of the Port Hedland Hinterlands

On 14 March 2012, RPS met with the OPEA officers to discuss the South Hedland Western Edge Precinct project. During this meeting the results of the *Heliotropium muticum* (PI) targeted flora search were considered by the OPEA. It was suggested by the officers that RPS undertake an additional search for this species outside of the subject land in order to determine the significance of the population of *Heliotropium muticum* (PI) identified as occurring within the subject land on a regional scale. On this advice, RPS conducted a targeted search for *Heliotropium muticum* (PI) between the 27 and 28 March 2012 within the Port Hedland hinterlands.

The search area focused on the Port Hedland hinterlands contained within the Uaroo Land System, locations with recent fire disturbance history of between one to three years in age and the known locations where *Heliotropium muticum* (PI) has been previously documented as occurring².

A total of 1299 plants of *Heliotropium muticum* (PI) were recorded during the targeted search (Figure 10).

3.8.3.1 <u>Limitations of Search</u>

The main limiting factor of the targeted search was restricted access to areas due to the land coming under private ownership. The majority of the locations sourced from the desktop assessment, where *Heliotropium muticum* (PI) has been previously recorded, could not be accessed during the search.

3.8.4 Discussion

The occurrence of *Heliotropium muticum* (PI) seems to be associated with the Uaroo Land System. This land system is common and wide spread in the Port Hedland area and therefore well represented at a local scale.

The distribution and abundance of Heliotropium muticum (PI) in the Port Hedland hinterland is more widespread than currently indicated from the collection records contained at the Western Australian Herbarium. The results of the targeted search of the Port Hedland hinterland support this view. Furthermore, the results confirm that the population of Heliotropium muticum (PI) recorded within the subject land is not the only significant concentration of Heliotropium muticum (PI) in the Port Hedland hinterland and therefore may be considered to be not as significant as initially suspected.

² There are seven collection records of *Heliotropium muticum* (PI) retained at the Western Australian Herbarium.



Approximately 25% of the subject land was surveyed during the targeted search of the subject land. Based on the outcomes of the search and the mapping of likelihood of occurrence of the target species, it is more than likely that the total population of *Heliotropium muticum* (PI) present within the subject land is between 400-600 plants. In perspective, the frequency of occurrence of *Heliotropium muticum* (PI) at other locations was significantly higher in comparison. A total of 1021 plants were recorded from seven separate search areas contained within a small area of land.

This small area of land appears to have been subjected to several fire regimes over the last four years and this has resulted in a patchy mosaic consisting of different aged vegetation. Plate 7 shows vegetation in the foreground has been burnt between one to two years ago with vegetation in the background burnt between three to five years previously. The area burnt between three to five years at this particular location was approximately 50 m x 20 m and contained approximately 148 Heliotropium muticum (PI) plants.



Plate 7: Grassland habitat consisting of patchy mosaic vegetation reflecting varying degrees of fire age

3.8.5 Conclusions

- Vegetation types associated with the occurrence of Heliotropium muticum (PI) are not restricted to the subject land.
- Distribution of Heliotropium muticum (PI) is considered to be wide spread and adequately represented in the Port Hedland hinterlands.
- It is considered unlikely that the subject land would be considered significant habitat upon which *Heliotropium muticum* (PI) is dependent upon for survival.



3.9 Fauna and Habitat

Bamford undertook a Level I Fauna Survey in line with the objectives of EPA Guidance Statement No. 56 - Terrestrial Fauna Survey for Environmental Impact Assessment in Western Australia (EPA 2004b) for the subject land. The Level I Fauna Survey included a field survey of the subject land which was undertaken between the 6 and 8 February 2012 for approximately 165 ha of the subject land.

The key objectives of the survey were to determine the fauna values of the subject land and the potential impacts of the proposed residential development. A copy of the report; South Hedland – Western Edge Precinct, Fauna Assessment (Bamford 2012a) is provided in Appendix 4.

RPS undertook a targeted search for conservation significant fauna for the remaining extent of the subject land, totalling approximately 57.55 ha. The targeted search was undertaken on 28 February 2012. The provision of separate Level I Fauna Survey and a targeted search was due to the size of the investigation area being increased.

3.9.1 Desktop Assessment

A desktop review involved state and Commonwealth database searches and results of regional studies. The review revealed that 210 species of vertebrate fauna could potentially occur within the subject land. The list of vertebrate fauna included eight frogs, 62 reptiles, 32 mammals and 108 birds. Of these, 15 species (one reptile, 10 birds and four mammals) are fauna protected under either the EPBC Act or the Wildlife Conservation Act 1950 (Bamford 2012a).

3.9.2 Field Survey

The field survey undertaken between 6 February and 8 February 2012 used the following fauna identification techniques:

- recording vegetation and soil types.
- opportunistic observations.
- camera trapping.
- bat detecting.
- searching for evidence of significant species.

3.9.2.1 Habitat Types

Bamford (2012a) identifies that the habitat type within the subject land as grassland mosaic.



3.9.2.2 Protected Fauna

Using the results of the desktop assessment and field survey, Bamford (2012a) identifies species of fauna that are recognised as protected under the Wildlife Conservation Act 1950 and / or under the EPBC Act and that could potentially occur in the subject land (Table 3).

Table 3 identifies that 10 species of conservation significant vertebrate fauna species (two mammals and eight birds) could potentially occur within the subject land due to the presence of suitable habitat.



Table 3: Species of Fauna that could Potentially Occur within the Subject Land

Species	Common Name	Conservation Significance under Wildlife Conservation Act 1950	Conservation Significance under EPBC Act	Habitat Description	Likelihood of Occurrence
Reptiles					
Rhinonicteris aurantia (Pilbara form)	Pilbara Leaf- nosed Bat	Schedule 1	Vulnerable	The Pilbara Leaf-nosed Bat is restricted in distribution to the Pilbara. The Pilbara Leaf-nosed Bat is known to roost in the mines of the eastern Pilbara, in the Hamersley Range and in the sandstone formations south of the Hamersley Range. The Pilbara Leaf-nosed Bat has been observed foraging over the following habitats: • Triodia hummock grasslands covering low rolling hills and shallow gullies, with scattered Eucalyptus camaldulensis along the creeks. • Small watercourses amongst granite boulder terrain and around nearby rock piles. • Pools and low shrubs in ironstone gorges. • Low shrubs and around pools in gravelly watercourses with Melaleuca leucodendron (SEWPAC 2012).	Bamford (2012a) identifies that the Pilbara Leafnosed Bat is known to occur approximately 25 km from the subject land and could commute to the subject land to forage, however given that the habitat of subject land does not match the known foraging habitat of the Pilbara Leaf-nosed Bat it is considered unlikely that the Pilbara Leaf-nosed Bat is a regular visitor to the subject land. Given the distance of the known occurrence of Pilbara Leaf-nosed Bat to the subject land and the lack of known foraging habitat in the subject land it is considered extremely unlikely that the subject land would contain habitat upon which this species is dependent.
<i>Macroderma</i> gigas	Ghost Bat	Priority 4		The Ghost Bat is widespread across northern Australia and a population is known to occur in the Pilbara. In arid environments Ghost Bats are mainly found near rocky outcrops and roost in small colonies in caves, mines and rock clefts. The Ghost Bat generally forages within one to two km of a roost site (The IUCN Red List of Threatened Species 2012).	Bamford (2012a) identifies that the Ghost Bat is known to occur approximately 25 km from the subject land and could commute to the subject land to forage, however given that Ghost Bats generally forage within one to two km of their roost site it is considered unlikely that the Ghost Bat is a regular visitor to the subject land. Given the distance of the known occurrence of Ghost Bat to the subject land and the similarity of habitat in the Port Hedland hinterlands it is considered unlikely that the subject land would contain habitat which this species is dependent upon.

Page 26 L1142601, Rev 0, April 2012



Species	Common	Conservation Significance under Wildlife Conservation Act 1950	Conservation Significance under EPBC Act	Habitat Description	Likelihood of Occurrence
Birds					
Falco peregrines	Peregrine Falcon	Schedule 4	1	Peregrine Falcons are widespread across most habitats in Australia and generally prefer coastal and inland cliffs or open woodlands near water.	Bamford (2012a) identifies that there is habitat available in the subject land which potentially could support hunting behaviour of the Peregrine Falcon. Given the similarity of habitat in the Port Hedland hinterlands it is unlikely that there is any habitat within the subject land upon which this species is entirely dependent.
Ardeotis australis	Australian Bustard	Priority 4	-	Australian Bustards are tall birds that live on open grassy plains and low shrubby areas in northern Australia.	Bamford (2012a) identifies that there were remains of at least two birds found within the subject land. It is considered that there is habitat available in the subject land which, potentially, could support the Australian Bustard. Given the similarity of habitat in the Port Hedland hinterlands it is considered unlikely that the subject land would contain habitat which this species is dependent upon.
Falco hypoleucos	Grey Falcon	Priority 4		The Grey Falcon is infrequently seen over much of arid and semi-arid Australia and favours timbered lowland plains that are crossed by treelined watercourses. The Grey Falcon is also known to frequent grassland and woodland habitats (Bird Life International 2012).	Bamford (2012a) identifies that the Grey Falcon may periodically utilise the subject land for hunting. Given the similarity of habitat in the Port Hedland hinterlands it is considered unlikely that the subject land would contain habitat which this species is dependent upon.
Heteromunia pectoralis	Pictorella Mannikin	Priority 4	-	The Pictorella Mannikin is usually found near water in acacia shrublands that have a grassy understorey and in the <i>Triodia</i> hummock grasslands of northern Australia.	Bamford (2012a) identifies that although the Pictorella Mannikin was recorded during the field investigation, the subject land is considered to be outside of their normal distribution. Given that subject land is considered to be outside the normal distribution of the Pictorella Mannikin it is considered extremely unlikely that the subject land would contain habitat which this species is dependent upon.

Page 27 L1142601, Rev 0, April 2012



Species	Common Name	Conservation Significance under Wildlife Conservation Act 1950	Conservation Significance under EPBC Act	Habitat Description	Likelihood of Occurrence
Apus pacificus	Fork-tailed Swift	-	Migratory	In Western Australia, they are known to occur from Eyre Bird observatory to Denmark. They are widespread in coastal and sub coastal areas between Augusta and Carnarvon, including some on near shore and offshore islands. The Forktailed Swift prefers habitat in coastal areas. They prefer cliffs and beaches and sometimes they are also found in treeless grassland and sand plains.	Bamford (2012a) identifies that there is habitat available in the subject land which potentially could support the Fork-tailed Swift. Given the wide variety of habitats which support Fork-tailed Swift it is considered unlikely that the subject land would contain habitat which this species is dependent upon.
Glareola maldivarum	Oriental Pratincole		Migratory	The Oriental Pratincole prefers open plains, flood plains or short grasslands, often occurring near terrestrial wetlands. It also occurs on the coast, inhabiting beaches, mudflats and islands.	Bamford (2012a) identifies that large flocks of Oriental Pratincole were recorded during the field investigation flying over the subject land and considers that the Oriental Pratincole may periodically utilise the subject land. The subject land may potentially provide habitat for the Oriental Pratincole, however is extremely unlikely to be considered significant habitat which this species is dependent upon given that the large flocks recorded by Bamford (2012a) were not observed utilising the subject land and that similar habitat is available in the Port Hedland hinterlands.
Hirundo rustica	Barn Swallow	-	Migratory	The Barn Swallows non breeding range occurs along the north coast of Australia. The preferred habitat includes open country with low vegetation, such as pasture, meadows and farmland preferably with nearby water.	Bamford (2012a) identifies the Barn Swallow is a species which occasionally reaches the north-west of Australia. The subject land may potentially provide habitat for the Barn Swallow however is extremely unlikely to be considered significant habitat which this species is dependent upon.
Merops ornatus	Rainbow Bee-eater	1	Migratory	The Rainbow Bee-eater is most often found in open forests, woodlands and shrublands, and cleared areas, usually near water. It can be found on farmland with remnant vegetation and in orchards and vineyards. It will use disturbed sites such as quarries, cuttings and mines to build its nesting tunnels.	Bamford (2012a) identifies that there is habitat available in the subject land which potentially could support breeding behaviour of the Rainbow Beeeater. The Rainbow Bee-eater is generally wide spread and while the subject land may potentially provide habitat for the Rainbow Bee-eater it is extremely unlikely to be considered significant habitat which this species is dependent upon.

Schedule 1 = Rare or likely to become extinct Schedule 4 = Other specially protected fauna Priority 4 = Taxa in need of monitoring

Table 3 assesses the likelihood of occurrence of the 10 identified conservation significant vertebrate fauna species and identifies that, although the subject land may potentially contain habitat which could be utilised by these species, it is considered unlikely to be considered significant habitat upon which any of the identified species is dependent upon for survival.

Table 3 notes that the type of habitat found within the subject land is similar to those found within the Port Hedland hinterland that surrounds the subject land. This statement is qualified by the extensive nature of the vegetation association and land system that comprise the subject land within the Pilbara biogeographic region:

- Section 3.7 identifies that the Beard Vegetation Association 589 Mosiac: Short bunch grassland savannah/grass plain (Pilbara)/Hummock grasslands, grass steppe; soft Spinifex, of which the subject land is comprised has approximately 13, 760 ha presently retained in reservation estates within the Pilbara 4 region.
- Section 3.8 identifies that subject land is located within the Uaroo Land System. The Uaroo Land System is considered to be very common and has a distribution of approximately 768,100 ha throughout the Pilbara biogeographic region.

3.9.3 Targeted Fauna Searches

RPS undertook a targeted search for conservation significant fauna for the remaining extent of the subject land, totalling approximately 57.55 ha. The targeted search was undertaken on 28 February 2012. Given that the habitat in the extended area, of 57.55 ha, is homogenous with the initial area where the Level I Fauna Survey was undertaken, it was determined that a targeted fauna search was the appropriate investigation required to capture any significant fauna or habitat values that may be present within the extended area.

No species of conservation significant fauna were directly identified by RPS, however three burrows, suspected to be mammalian in origin, were identified within the search area (Plate 8; Figure 11).



Plate 8: Potential mammal burrow

Bamford was commissioned by RPS to undertake an additional search to determine if any conservation significant fauna were presently using burrows that were identified by the targeted search for conservation significant fauna. The additional search was undertaken was undertaken because the burrows had some resemblance to those of the Greater Bilby, *Macrotis lagotis*, a species of high conservation significance which known to occur in the Pilbara

The additional search was undertaken on 20 April 2012. A copy of the report; *Inspection of Animal Burrows at South Hedland* (Bamford 2012b) is provided in Appendix 5.

3.9.3.1 Results

The three burrows previously recorded on the 28 February 2012 by RPS were successfully re-located by Bamford and additional burrows of a similar nature were also located.

Bamford (2012b) identified that all the burrows located were foraging burrows of a large monitor lizard.

3.9.4 Conclusions

- No Threatened species were recorded within the subject land.
- Two migratory bird species protected under the EPBC Act and two Priority 4 bird species under the Wildlife Conservation Act 1950 were recorded by the Level I Field Survey.
- Given the proximity of the subject land to the existing South Hedland town site it is likely that the fauna of conservation significance may avoid the subject land.

L1142601, Rev 0, April 2012 Page 30



- Table 3 identifies that although the subject land may potentially contain habitat which could potentially be utilised by the identified species of conservation significance fauna, it is considered unlikely to be considered significant habitat upon which any of these species are dependent upon for survival.
- Referral to SEWPAC under the EPBC Act will not to be required for this proposal.

3.10 Acid Sulfate Soils

Acid Sulfate Soils (ASS) are naturally occurring soils, sediments and peats that contain fine-grained metal sulphides, typically pyrite, which are formed under saturated, anoxic/reducing conditions (MPL Laboratories 2010). In an undisturbed state below the watertable, these soils are benign and non-acidic. However, if the soils are exposed to the atmosphere by drainage, excavation or lowering of the water table, the sulphides may react with oxygen to form sulphuric acid. Where these materials have oxidised, they commonly have a mottled appearance (orange/red or buttery yellow discolouration) due to the presence of oxidised iron minerals (MPL Laboratories 2010).

The subject land is mapped by the DEC as being of no known risk of encountering ASS within 3 m of the soil's natural surface (Figure 12).

3.11 Potential Contamination

A search of the DEC's Contaminated Sites Database was undertaken on 11 January 2012 and no matches were recorded for the subject land or directly adjacent lands.

Given that the subject land is vacant land comprised predominantly of native vegetation contamination is unlikely to be present over the majority of the subject land. However given that uncontrolled tipping activities has led to large amounts of household refuse being placed within the subject land there is potential for some contamination to have occurred.

3.12 Heritage

3.12.1 Aboriginal Heritage

The Aboriginal Heritage Act 1972 defines Aboriginal Heritage Sites and provides for the preservation of places and objects customarily used by or traditionally important to Aboriginals, and prohibits the concealment, destruction or alteration of any Aboriginal Heritage Sites.

An Aboriginal site may:



- Exist in any area of Western Australia.
- Not have been recorded in the register of Aboriginal Sites or elsewhere.
- Not have been identified in previous heritage surveys or reports on that area but remains fully protected under the Act.

A search of the Department of Indigenous Affair's (DIA) Aboriginal Heritage Inquiry System was undertaken on 12 January 2011 and no matches were recorded for the subject land or lands directly adjacent to the subject land.

3.12.2 European Heritage

A search of the Heritage Council of Western Australia's Places Database was undertaken on 12 January 2012 and no matches were found for the subject land. The Places Database allows members of the general public to search for places or sites listed on the State Register of Heritage Places. The State Register of Heritage Places is managed by the Heritage Council of Western Australia (Government of Western Australia 2010).

L1142601, Rev 0, April 2012



4.0 PROPOSED SCHEME AMENDMENT

The subject land is currently identified as being subject to three zonings under TPS No. 5. The majority of the subject land is zoned 'Rural' with a small portion of land enclosed within the subject land being zoned 'Commercial' and 'District Road' (Department of Planning 2010).

A Scheme Amendment has been proposed to rezone the subject land from 'Rural', 'Commercial' and 'District Road' to 'Urban Development' to facilitate the progressive subdivision and development of a future urban area to the west and south of the existing South Hedland town site.

The proposed scheme amendment also introduces consequential rationalisation of the boundary between the proposed 'Urban Development' zone and the 'Commercial' zone including the creation of the Development Plan Area corresponding with an approved Development Plan.

The proposed 'Urban Development' zone along with corresponding Development Plan Area designations will ensure a coordinated approach to planning across the area as a whole and ultimately enable the release of land for much needed urban development.

L1142601, Rev 0, April 2012



This page is intentionally blank.



5.0 POTENTIAL IMPLICATIONS FOR DEVELOPMENT

In response to the existing environmental values of the subject land, this section identifies the likely impacts and proposes subsequent potential management measures to minimise and mitigate any impacts to the environment resulting from future development of the subject land. The proposed management measures should be considered when preparing the Development Plan.

5.1 Hydrology

5.1.1 EPA Objective

To maintain the quantity and quality of water so that existing and potential environmental values, including ecosystem maintenance, are protected.

5.1.2 Potential Impacts

Surface water flows and groundwater of the subject land have the potential to be impacted by a variety of activities including:

- Groundwater level changes that occur as a result of a change in land use.
- Removal of vegetation and installation of impervious surfaces that lead to an increase in run-off during rainfall events.
- Urbanisation will result in an increase in the potential for urban generated pollutants, such as nutrients, hydrocarbons, metals and sediment, being discharged, via run-off and influencing the soil profile and ultimately, into the groundwater.
- Nutrient loading to the surface water and groundwater.
- Stormwater drainage which facilitates the transportation of nutrients (through surface run-off) and potential contaminants (e.g. litter) through the subject land.

5.1.3 Management Measures

To ensure that the quantity of the existing surface water and groundwater flows is maintained the following water management actions are required as a matter of planning compliance:

- Local Water Management Strategy (LWMS) will be required to support a Development Plan.
- Urban Water Management Plan (UWMP) will be required to support subdivision activities.



5.2 Flora and Vegetation

5.2.1 EPA Objective

To maintain the abundance, diversity, geographic distribution and productivity of flora at species and ecosystem levels through the avoidance or management of adverse impacts and improvement in knowledge.

5.2.2 Potential Impacts

The potential impacts to native vegetation within the subject land from a proposed Development Plan include:

- Removal of vegetation within the subject land.
- Degradation of retained vegetation through further uncontrolled public access and increased weed invasion.
- Further disturbance to vegetation from fire.

5.2.3 Management Measures

In response to the proposed removal of vegetation which will result from the implementation of a Development Plan the following management measures should be considered:

- Retention of the existing vegetation along the created drainage line and within areas identified for the purposes of drainage should be considered as part of the Development Plan.
- Minimise soil disturbance during clearing and practice standard vehicle hygiene to ensure exotic species do not become established within the subject land whist undertaking construction activities.

5.3 Fauna

5.3.1 EPA Objective

To maintain the abundance, diversity, geographic distribution and productivity of fauna at species and ecosystem levels through the avoidance or management of adverse impacts and improvement in knowledge.



5.3.2 Potential Impacts

The threatening process in general to fauna and habitat which are relevant to the subject land include:

- Loss of habitat through clearing.
- Habitat fragmentation.
- Land clearing and vehicle movement may result in death or injury of fauna as a result of collisions.
- Habitat degradation due to weed invasion.
- Species interactions, including predation and competition.
- Disturbance of fauna from light spill, noise and human disturbance.
- Changes in fire regime.

5.3.3 Management Measures

In response to the proposed removal of vegetation which will result from the implementation of a Development Plan the following management measures should be considered:

- Retention of the existing drainage systems into the design of the Development Plan should be considered
- Staging of any proposed vegetation clearing works and implementation of clearing methods designed to maximise the survival of fauna individuals on the subject land during construction.

5.4 Potential Contamination

5.4.1 EPA Objective

To ensure previous land uses within and surrounding the subject land, do not impact on proposed development of the subject land.

5.4.2 Potential Impacts

Development of the subject land will result in the reduction and / or removal of many potentially contaminating activities including fly / uncontrolled tipping. Due to existing land uses within the subject land it is likely that some degree of potential contamination exists.



5.4.3 Management Measures

To quantify the extent of any potential existing contamination occurring within the subject land, and determine specific management actions, a Preliminary Site Investigation (PSI) for contamination should to be undertaken. The PSI will be untaken according to the methodology detailed in the DEC Contaminated Sites Management Series Guidelines. This involves interviews with the previous land owners, inspection of salient facilities on the property, and general observations made during other site investigations.

5.5 Heritage

5.5.1 EPA Objective

To ensure that changes to the biophysical environment do not adversely affect historical and cultural associations and comply with relevant heritage legislation.

5.5.2 Potential Impacts

It is considered that there is a very low risk that Aboriginal objects maybe either identified or unearthed during development activities.

5.5.3 Management Measures

Should any Aboriginal objects be identified or unearthed during development activities then under the *Aboriginal Heritage Act 1972* the findings must be reported to the DIA and development activities should be ceased.

5.6 Environmental Management Summary

Table 4 summarises the management measures that should be considered when preparing the Development Plan in order to manage the environmental values of the subject land in accordance with the objectives of the EPA.



Table 4: Summary of Management Actions

Environmental Factor	EPA Objective	Potential Impacts	Management Measures	Timing
Hydrology	To maintain the quantity and quality of water so that existing and potential environmental values, including ecosystem maintenance, are protected.	 Groundwater level changes can occur as a result of a change in land use. Removal of vegetation and installation of impervious surfaces can lead to an increase in runoff during rainfall events. Urbanisation can result in an increase in the potential for urban generated pollutants, such as nutrients, hydrocarbons, metals and sediment, being discharged, via run-off and influencing the soil profile and ultimately, into the groundwater. Nutrient loading to the groundwater and surface water can occur. Stormwater drainage can facilitate the transportation of nutrients (through surface run-off) and potential contaminants (e.g. litter) through the subject land. 	 Implementation of LWMS. Implementation of UWMP. 	Development Plan (LWMS); Prior to Subdivision (UWMP)
Vegetation and Flora	To maintain the abundance, diversity, geographic distribution and productivity of flora at species and ecosystem levels through the avoidance or management of adverse impacts and improvement in knowledge.	 Removal of vegetation within the subject land Degradation of retained vegetation through uncontrolled public access and weed invasion. Disturbance to vegetation from fire. 	 Retention of existing vegetation within drainage network. Employ construction management actions. 	Development Plan; Prior to Subdivision
Fauna and Habitat	To maintain the abundance, diversity, geographic distribution and productivity of fauna at species and ecosystem levels through the avoidance or management of adverse impacts and improvement in knowledge.	 Loss of habitat through clearing. Habitat fragmentation. Land clearing and vehicle movement may result in death or injury of fauna as a result of collisions. Habitat degradation due to weed invasion. Species interactions, including predation and competition. Disturbance of fauna from light spill, noise and human disturbance. Changes in fire regime. 	 Retention of the existing drainage systems. Employ construction management actions. 	Development Plan; Prior to Subdivision

Page 39 L1142601, Rev 0, April 2012

Environmental Factor	Environmental EPA Objective Factor	Potential Impacts	Management Measures Timing	Timing
Contamination	Contamination To ensure previous land uses within and surrounding the subject land, do not impact on proposed development of the subject land.	 Potential contamination. 	Undertaking of a PSI Prior to for contamination. Subdivis	Prior to Subdivision
Heritage	To ensure that changes to the biophysical environment do not adversely affect historical and cultural associations and comply with relevant heritage legislation.	 Aboriginal objects are either identified or unearthed during development activities. 	Report findings to the During DIA and cease development activities	During Construction

Page 40



6.0 CONCLUSIONS

Through addressing the identified key environmental factors when preparing the Development Plan, this environmental assessment of the proposed amendment to TPS No. 5 for the South Hedland Western Edge Precinct concludes that the potential environmental impacts identified in this report can be managed in accordance with the objectives of the EPA to prevent significant impacts on the environmental values of the subject land.



This page is intentionally blank.



7.0 REFERENCES

- Alpine, T.E.H. (1979). *The Flora*. In O'Brien, B.J. (Ed.) *Environment and Science*. Nedlands: Western Australia.
- Beard, J.S. (1990). Plant Life of Western Australia. Perth: Western Australia.
- BHP (2011). Section 5: Existing Terrestrial Environment. Accessed 12 January 2012 http://www.bhpbilliton.com/home/aboutus/regulatory/Documents/perSection5ExistingTerrestrialEnvironment.pdf
- BirdLife International (2012). Species factsheet: Falco hypoleucos. Accessed 11 April 2012 http://www.birdlife.org
- Bureau of Meteorology (2011). Climate Port Hedland. Accessed 12 January 2012 http://www.bom.gov.au/wa/port_hedland/climate.shtml
- Department of Agriculture and Food Western Australia (2011). Declared Plants lists. Accessed 10 April 2012 http://www.agric.wa.gov.au/objtwr/imported_assets/content/pw/weed/decp/dec_plants_list.pdf
- Department of Conservation and Land Management (2002). A Biodiversity Audit of Western Australia's 53 Biogeographic Subregions in 2002, Perth, Western Australia.
- Department of Environment and Conservation (2010). Current list of Threatened Ecological Communities. Accessed March 2012 http://www.dec.wa.gov.au/content/view/852/2010/
- Department of Environment and Conservation (2012a). Florabase the Western Australian Herbarium. Accessed March 2012 http://florabase.calm.wa.gov.au.
- Department of Environment and Conservation (2012b). Priority Ecological Communities List. Accessed March 2012 http://www.dec.wa.gov.au/content/view/849/2017/
- Department of Planning (1997). State Planning Strategy. Accessed on the 13 January 2012 http://www.planning.wa.gov.au/dop_pub_pdf/SPSreport.pdf
- Department of Planning (2011). Town of Port Hedland Town Planning Scheme No. 5. Accessed on the 12 January 2012 http://online.planning.wa.gov.au/lps/localplanning schemes.asp?f=Port Hedland Town of (Scheme 5)
- Department of Sustainability, Environment, Water, Population and Communities (2009). EPBC Act List of Threatened Flora. Accessed 12 April 2012 http://www.environment.gov.au/cgi-bin/sprat/public/publicthreatenedlist.pl?wanted=flora
- Department of Sustainability, Environment, Water, Population and Communities (2012). *Rhinonicteris aurantia (Pilbara form)* in Species Profile and Threats Database. Accessed 11 April 2012 http://www.environment.gov.au/sprat.
- Environmental Protection Authority (2002). Terrestrial Biological Surveys as an Element of Biodiversity Protection: Position Statement No. 3. Perth: Western Australia



- Environmental Protection Authority (2004a). Guidance Statement No. 51 Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment in Western Australia. Perth Western Australia.
- Environmental Protection Authority (2004b). Guidance Statement No.56 Terrestrial Fauna Surveys for Environmental Impact Assessment in Western Australia. Perth: Western Australia.
- Government of Western Australia (2010). Quick Search Places Database. Accessed 12 January 2012 http://register.heritage.wa.gov.au/index.html
- Keighery, B.J. (1994). Bushland Plant Survey: a Guide to Plant Community Survey for the Community. Nedlands: Western Australia.
- M.J. & A. R. Bamford Consulting Ecologists (2012a). South Hedland Western Edge Precinct. Perth: Western Australia.
- M.J. & A. R. Bamford Consulting Ecologists (2012b). South Hedland Western Edge Precinct. Perth: Western Australia.
- MPL Laboratories (2010). Acid Sulfate Soils WA. Accessed 12 January 2012 http://www.envirolabservices.com.au/downloads/editor/fact-sheet-acid-sulfate-soils.pdf
- Pilbara Development Commission (2009). Industry. Accessed 12 January 2012 http://www.pdc.wa.gov.au/regional-information/industry.aspx
- Specht, R.L. (1970). Vegetation. In: G. W. Leeper (ed.) The Australian Environment 4th edn, pp. 44-67. CSIRO & Melbourne University Press, Melbourne.
- The IUCN Red List of Threatened Species (2012). Macroderma gigas. Accessed 11 April 2012 http://www.iucnredlist.org/apps/redlist/details/12590/0
- Tille, P. (2006). Soil-landscapes of Western Australia's Rangelands and Arid Interior. Accessed 12 January 2012 http://www.asris.csiro.au/downloads/state_agencies/tr2007_slwarai_ptille_nomaps.pdf
- Town of Port Hedland (2011). Pilbara's Port City Growth Plan. Accessed 12 January 2012 http://www.porthedland.wa.gov.au/Councillnitiative/pilbaras-port-city-growth-plan
- Trudgen, M.E. (2002). A Flora, Vegetation and Floristic Survey of the Burrup Peninsula, Some Adjoining Areas and Part of the Dampier Archipelago, with Comparisons to the Floristics on then Adjoining Mainland. Unpublished Report prepared by M.E. Trudgen and Associates for the Department of Mineral and Petroleum Resources, Perth W.A
- Van Vreeswyk, A.M.E., Payne, A.L., Leighton, K.A. and Hennig, P. (2004). An inventory and condition survey of the Pilbara region, Western Australia. Department of Agriculture, Western Australia Technical Bulletin No. 92.
- WAPC (2011a). Draft Pilbara Planning and Infrastructure Framework. Accessed 13 January 2012 http://www.planning.wa.gov.au/dop_pub_pdf/pilbara_doc_secs_1-3.pdf
- WAPC (2011b). Port Hedland Regional Hotspots Land Supply Update. Accessed 13 January 2012 http://www.planning.wa.gov.au/dop_pub_pdf/port_headland_2011_report.pdf.

FIGURES

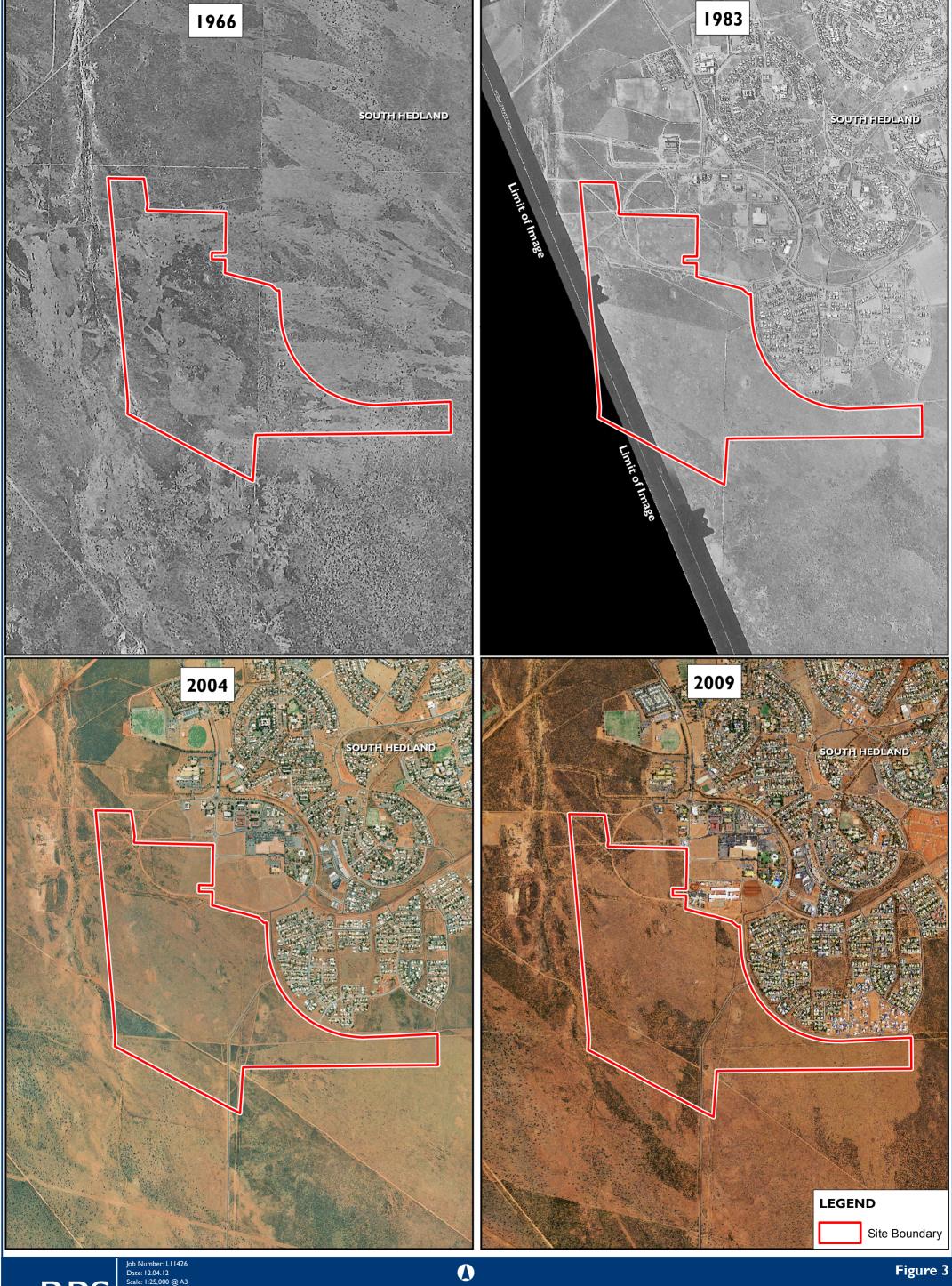
PPS

Job Number: L11426
Date: 12.04.12
Scale: 1:100,000 @ A3
Revision: A
Drafted by: MA
Source: Orthophoto - L

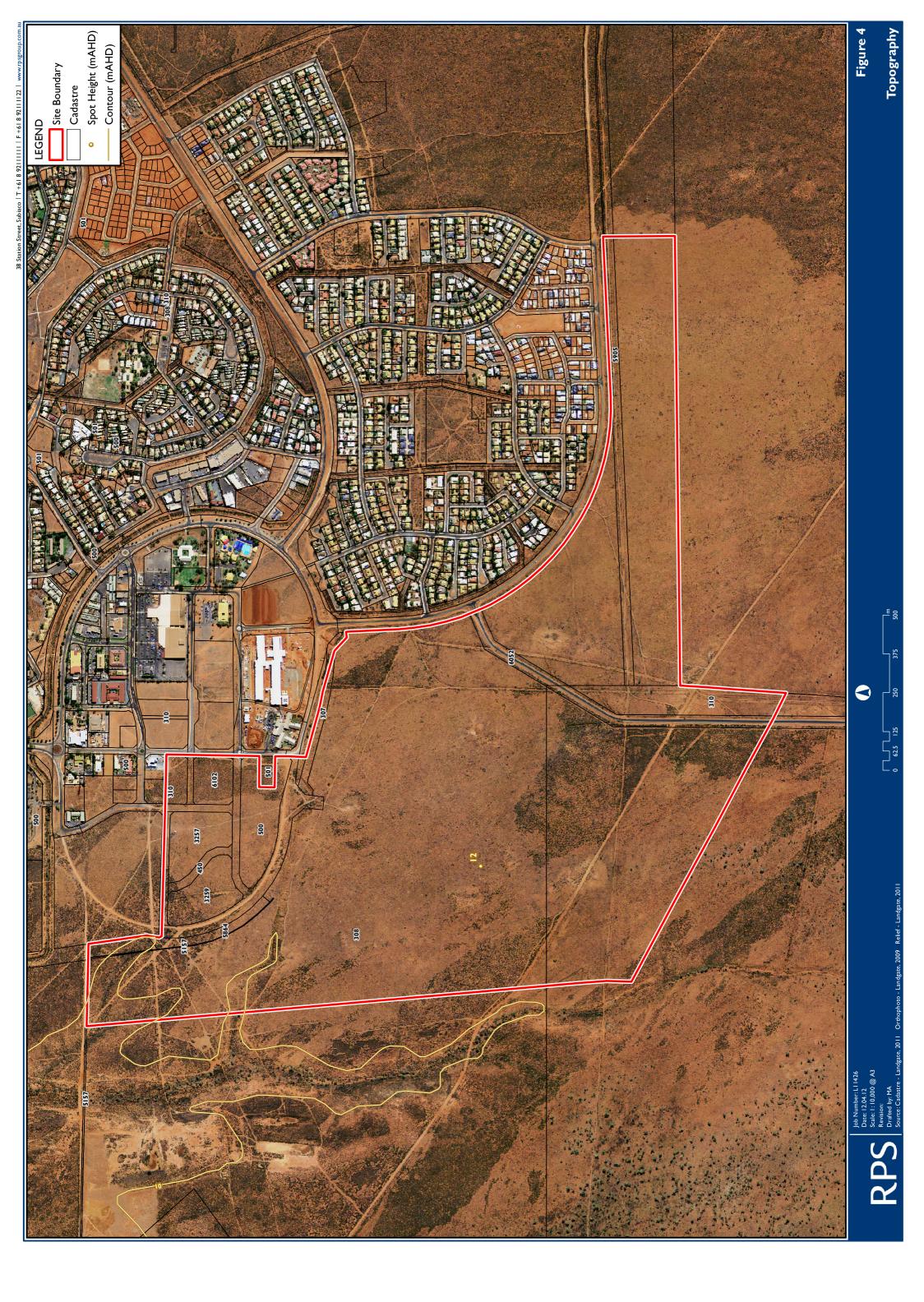
(A) | (A) |

LEGEND



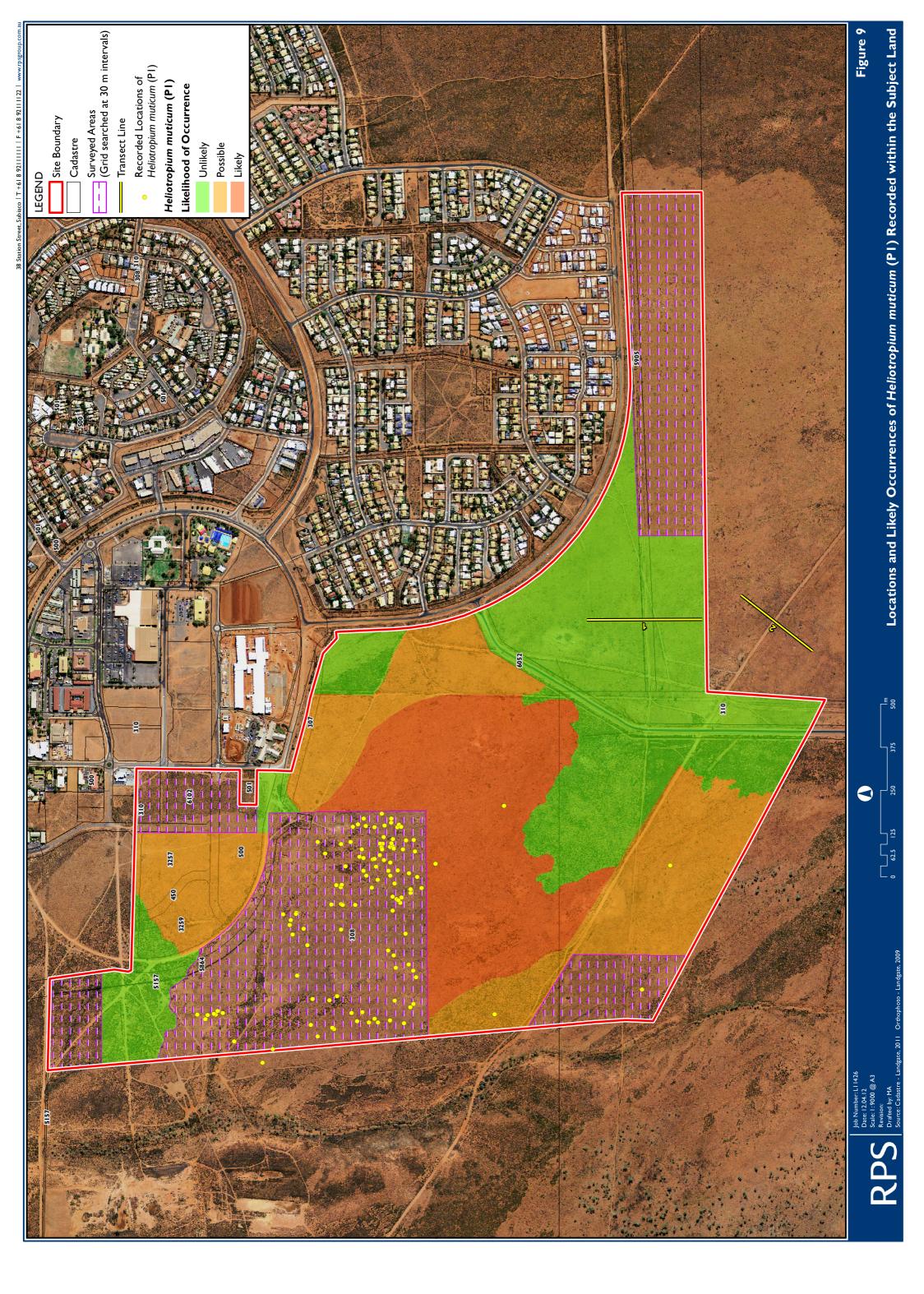


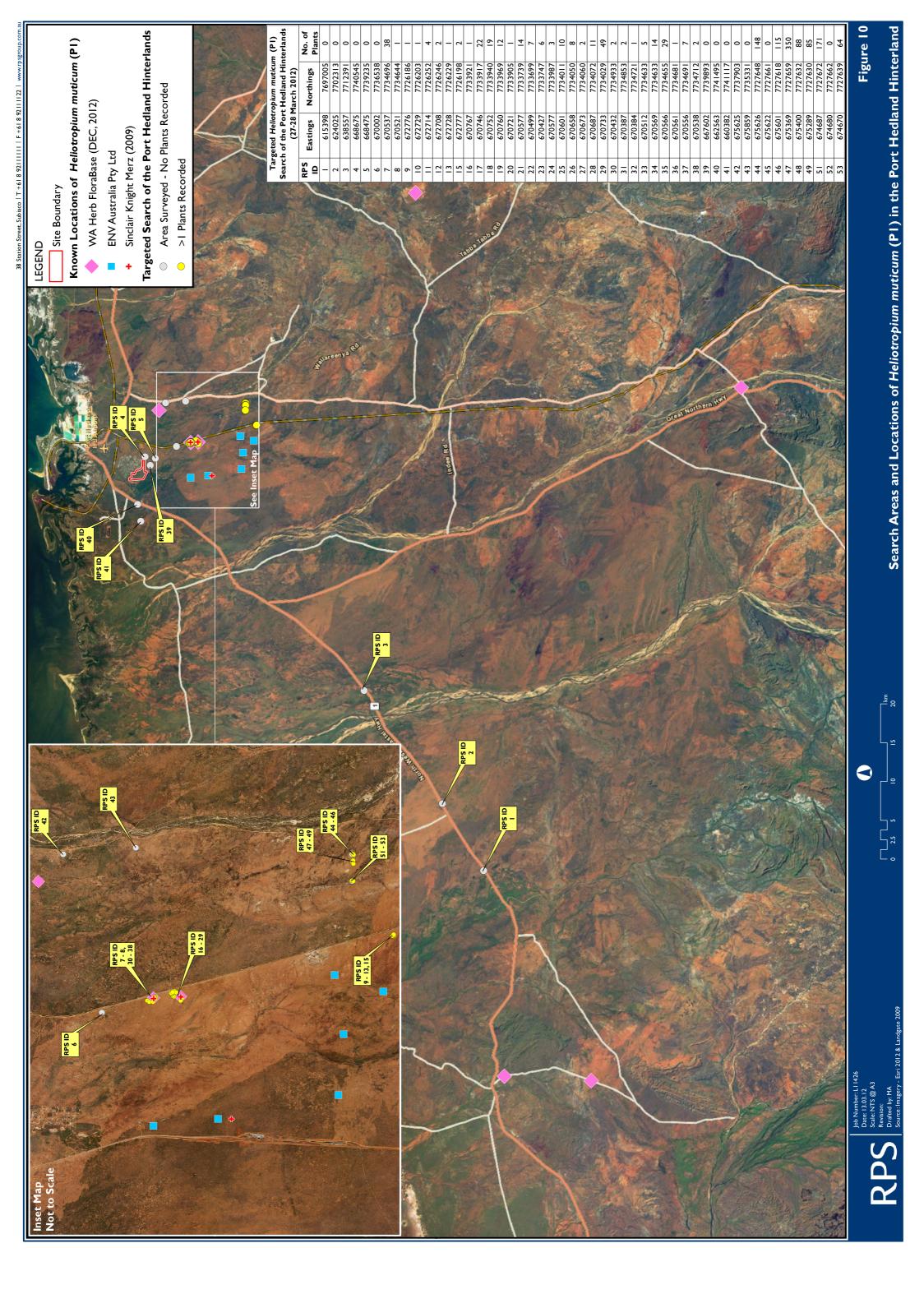
0 0.125 0.25





Scale: 19,000 @ A3
Revision:
Drafted by: MA
Source: Cadastre - Landgate, 2011 O







APPENDIX I

EPBC Act Protected Matters Search Tool

EPBC Act Protected Matters Report

This report provides general guidance on matters of national environmental significance and other matters protected by the EPBC Act in the area you have selected.

Information on the coverage of this report and qualifications on data supporting this report are contained in the caveat at the end of the report.

Information about the EPBC Act including significance guidelines, forms and application process details can be found at http://www.environment.gov.au/epbc/assessmentsapprovals/index.html

Report created: 23/11/11 18:38:45

<u>Summary</u>

Details

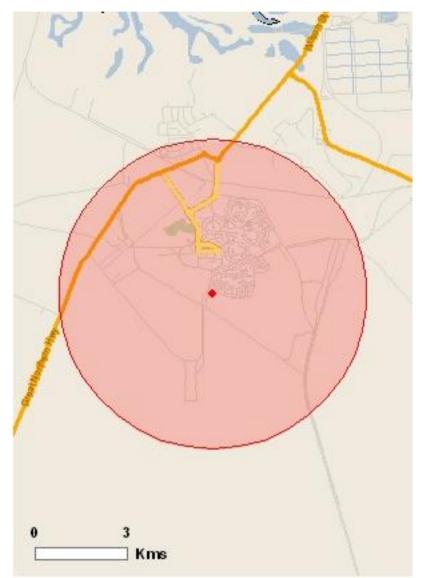
Matters of NES

Other Matters Protected by the EPBC Act

Extra Information

Caveat

Acknowledgements



This map may contain data which are ©Commonwealth of Australia (Geoscience Australia), ©PSMA 2010

Coordinates
Buffer: 5.0Km



Summary

Matters of National Environment Significance

This part of the report summarises the matters of national environmental significance that may occur in, or may relate to, the area you nominated. Further information is available in the detail part of the report, which can be accessed by scrolling or following the links below. If you are proposing to undertake an activity that may have a significant impact on one or more matters of national environmental significance then you should consider the Administrative Guidelines on Significance - see http://www.environment.gov.au/epbc/assessmentsapprovals/guidelines/index.html

World Heritage Properties:	None
National Heritage Places:	None
Wetlands of International	None
Great Barrier Reef Marine Park:	None
Commonwealth Marine Areas:	None
Threatened Ecological Communities:	None
Threatened Species:	3
Migratory Species:	10

Other Matters Protected by the EPBC Act

This part of the report summarises other matters protected under the Act that may relate to the area you nominated. Approval may be required for a proposed activity that significantly affects the environment on Commonwealth land, when the action is outside the Commonwealth land, or the environment anywhere when the action is taken on Commonwealth land. Approval may also be required for the Commonwealth or Commonwealth agencies proposing to take an action that is likely to have a significant impact on the environment anywhere.

The EPBC Act protects the environment on Commonwealth land, the environment from the actions taken on Commonwealth land, and the environment from actions taken by Commonwealth agencies. As heritage values of a place are part of the 'environment', these aspects of the EPBC Act protect the Commonwealth Heritage values of a Commonwealth Heritage place and the heritage values of a place on the Register of the National Estate. Information on the new heritage laws can be found at http://www.environment.gov.au/heritage/index.html

This part of the report summarises other matters protected under the Act that may relate to the area you nominated. Approval may be required for a proposed activity that significantly affects the environment on Commonwealth land, when the action is outside the Commonwealth land, or the environment anywhere when the action is taken on Commonwealth land. Approval may also be required for the Commonwealth or Commonwealth agencies proposing to take an action that is likely to have a significant impact on the environment anywhere.

A permit may be required for activities in or on a Commonwealth area that may affect a member of a listed threatened species or ecological community, a member of a listed migratory species, whales and other cetaceans, or a member of a listed marine species. Information on EPBC Act permit requirements and application forms can be found at http://www.environment.gov.

Commonwealth Lands:	1
Commonwealth Heritage Places:	None
Listed Marine Species:	8
Whales and Other Cetaceans:	None
Critical Habitats:	None
Commonwealth Reserves:	None

Extra Information

This part of the report provides information that may also be relevant to the area you have

Place on the RNE:	None
State and Territory Reserves:	None
Regional Forest Agreements:	None
Invasive Species:	4
Nationally Important Wetlands:	None

Details

Matters of National Environmental Significance

Threatened Species		[Resource Information]
Name	Status	Type of Presence
MAMMALS		
Dasyurus hallucatus		
Northern Quoll [331]	Endangered	Species or species habitat likely to occur within area

Name Status Type of Presence **Macrotis lagotis** Greater Bilby [282] Vulnerable Species or species habitat likely to occur within area Rhinonicteris aurantia (Pilbara form) Pilbara Leaf-nosed Bat [82790] Vulnerable Species or species habitat likely to occur within area Migratory Species [Resource Information] Species is listed under a different scientific name on the EPBC Act - Threatened Species list. **Threatened** Type of Presence Name Migratory Marine Birds Apus pacificus Fork-tailed Swift [678] Species or species habitat may occur within area Ardea alba Great Egret, White Egret [59541] Species or species habitat may occur within area Ardea ibis Cattle Egret [59542] Species or species habitat may occur within area Migratory Terrestrial Species Haliaeetus leucogaster White-bellied Sea-Eagle [943] Species or species habitat likely to occur within area Hirundo rustica Barn Swallow [662] Species or species habitat may occur within area Merops ornatus Rainbow Bee-eater [670] Species or species habitat may occur within area Migratory Wetlands Species Ardea alba Great Egret, White Egret [59541] Species or species habitat may occur within area Ardea ibis Cattle Egret [59542] Species or species habitat may occur within area Charadrius veredus Oriental Plover, Oriental Dotterel [882] Species or species habitat may occur within area Glareola maldivarum Oriental Pratincole [840] Species or species habitat may occur within area Other Matters Protected by the EPBC Act Commonwealth Lands [Resource Information] The Commonwealth area listed below may indicate the presence of Commonwealth land in this

[Resource Information]

vicinity. Due to the unreliability of the data source, all proposals should be checked as to whether it impacts on a Commonwealth area, before making a definitive decision. Contact the State or Territory government land department for further information.

Name

Commonwealth Land -

Listed Marine Species

Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name Threatened Type of Presence

Name	Threatened	Type of Presence
Birds	Tilleateried	Type of Freserice
Apus pacificus		
Fork-tailed Swift [678]		Species or species habitat may occur within area
Ardea alba		
Great Egret, White Egret [59541] Ardea ibis		Species or species habitat may occur within area
		Charles ar anasias
Cattle Egret [59542]		Species or species habitat may occur within area
<u>Charadrius veredus</u>		
Oriental Plover, Oriental Dotterel [882]		Species or species habitat may occur within area
Glareola maldivarum		
Oriental Pratincole [840]		Species or species habitat may occur within area
Haliaeetus leucogaster		
White-bellied Sea-Eagle [943]		Species or species habitat likely to occur within area
Hirundo rustica		
Barn Swallow [662]		Species or species habitat may occur within area
Merops ornatus		
Rainbow Bee-eater [670]		Species or species habitat may occur within

Extra Information

Invasive Species [Resource Information]

area

Weeds reported here are the 20 species of national significance (WoNS), along with other introduced plants that are considered by the States and Territories to pose a particularly significant threat to biodiversity. The following feral animals are reported: Goat, Red Fox, Cat, Rabbit, Pig, Water Buffalo and Cane Toad. Maps from Landscape Health Project, National Land and Water Resouces Audit,

		, , , , , , , , , , , , , , , , , , ,
Name	Status	Type of Presence
Mammals		
Felis catus		
Cat, House Cat, Domestic Cat [19]		Species or species habitat likely to occur within area
Sus scrofa		
Pig [6]		Species or species habitat likely to occur within area
<u>Vulpes vulpes</u>		
Red Fox, Fox [18]		Species or species habitat likely to occur within area
Plants		
Cenchrus ciliaris		
Buffel-grass, Black Buffel-grass [20213]		Species or species habitat likely to occur

Name Status Type of Presence within area

Coordinates

-20.42187 118.60059

Caveat

The information presented in this report has been provided by a range of data sources as acknowledged at the end of the report.

This report is designed to assist in identifying the locations of places which may be relevant in determining obligations under the Environment Protection and Biodiversity Conservation Act 1999. It holds mapped locations of World Heritage and Register of National Estate properties, Wetlands of International Importance, Commonwealth and State/Territory reserves, listed threatened, migratory and marine species and listed threatened ecological communities. Mapping of Commonwealth land is not complete at this stage. Maps have been collated from a range of sources at various

Not all species listed under the EPBC Act have been mapped (see below) and therefore a report is a general guide only. Where available data supports mapping, the type of presence that can be determined from the data is indicated in general terms. People using this information in making a referral may need to consider the qualifications below and may need to seek and consider other

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

For species where the distributions are well known, maps are digitised from sources such as recovery plans and detailed habitat studies. Where appropriate, core breeding, foraging and roosting areas are indicated under 'type of presence'. For species whose distributions are less well known, point locations are collated from government wildlife authorities, museums, and non-government organisations; bioclimatic distribution models are generated and these validated by experts. In some cases, the distribution maps are based solely on expert knowledge.

Only selected species covered by the following provisions of the EPBC Act have been mapped:

- migratory and
- marine

The following species and ecological communities have not been mapped and do not appear in reports produced from this database:

- threatened species listed as extinct or considered as vagrants
- some species and ecological communities that have only recently been listed
- some terrestrial species that overfly the Commonwealth marine area
- migratory species that are very widespread, vagrant, or only occur in small numbers

The following groups have been mapped, but may not cover the complete distribution of the species:

- non-threatened seabirds which have only been mapped for recorded breeding sites
- seals which have only been mapped for breeding sites near the Australian continent

Such breeding sites may be important for the protection of the Commonwealth Marine environment.

Acknowledgements

This database has been compiled from a range of data sources. The department acknowledges the following custodians who have contributed valuable data and advice:

- -Department of Environment, Climate Change and Water, New South Wales
- -Department of Sustainability and Environment, Victoria
- -Department of Primary Industries, Parks, Water and Environment, Tasmania
- -Department of Environment and Natural Resources, South Australia
- -Parks and Wildlife Service NT, NT Dept of Natural Resources, Environment and the Arts
- -Environmental and Resource Management, Queensland
- -Department of Environment and Conservation, Western Australia
- -Department of the Environment, Climate Change, Energy and Water
- -Birds Australia
- -Australian Bird and Bat Banding Scheme
- -Australian National Wildlife Collection
- -Natural history museums of Australia
- -Museum Victoria
- -Australian Museum
- -SA Museum
- -Queensland Museum
- -Online Zoological Collections of Australian Museums

- -Queensland Herbarium
- -National Herbarium of NSW
- -Royal Botanic Gardens and National Herbarium of Victoria
- -Tasmanian Herbarium
- -State Herbarium of South Australia
- -Northern Territory Herbarium
- -Western Australian Herbarium
- -Australian National Herbarium, Atherton and Canberra
- -University of New England
- -Ocean Biogeographic Information System
- -Australian Government, Department of Defence
- -State Forests of NSW
- -Other groups and individuals

The Department is extremely grateful to the many organisations and individuals who provided expert advice and information on numerous draft distributions.

Please feel free to provide feedback via the Contact Us page.

© Commonwealth of Australia

Department of Sustainability, Environment, Water, Population and Communities

GPO Box 787

Canberra ACT 2601 Australia

+61 2 6274 1111

APPENDIX 2

Flora Species Recorded by Level I Flora and Vegetation Survey

Family	Name
Amaranthaceae	*Aerva javanica
Amaranthaceae	Ptilotus astrolasius
Amaranthaceae	Ptilotus exaltatus
Amaranthaceae	Ptilotus fusiformis
Amaranthaceae	Ptilotus polystachyus
Apocynaceae	Carissa lanceolata
Asteraceae	Pluchea tetranthera
Asteraceae	Pterocaulon serrulatum
Asteraceae	Pterocaulon sphaeranthoides
Bignoniaceae	Dolichandrone heterophylla
Boraginaceae	Ehretia saligna var. saligna
Boraginaceae	Heliotropium muticum (P1)
Byblidaceae	Byblis liniflora
Caryophyllaceae	Polycarpaea longiflora
Caryophyllaceae	Polycarpaea sp.
Cleomaceae	Cleome uncifera subsp. uncifera
Cleomaceae	Cleome viscosa
Convolvulaceae	Bonamia ? rosea
Convolvulaceae	Bonamia alatisemina
Convolvulaceae	Bonamia linearis
Convolvulaceae	Bonamia media
Convolvulaceae	Bonamia rosea
Convolvulaceae	Evolvulus alsinoides var. villosicalyx
Convolvulaceae	Ipomoea muelleri
Cucurbitaceae	*Citrullus colocynthis
Cucurbitaceae	Cucumis maderaspatanus
Cyperaceae	Bulbostylis barbata
Cyperaceae	Cyperus ? blakeanus
Cyperaceae	Cyperus iria
Cyperaceae	Fimbristylis dichotoma
Euphorbiaceae	Adriana tomentosa var. tomentosa
Euphorbiaceae	Euphorbia alsiniflora
Euphorbiaceae	Euphorbia australis
Euphorbiaceae	Phyllanthus maderaspatensis
Fabaceae	Acacia ancistrocarpa
Fabaceae	Acacia bivenosa
Fabaceae	Acacia colei var. colei
Fabaceae	Acacia inaequilatera
Fabaceae	Acacia sericophylla
Fabaceae	Acacia stellaticeps
Fabaceae	Acacia trachycarpa
Fabaceae	Acacia tumida
Fabaceae	Acacia tumida var. pilbarensis
Fabaceae	Crotalaria ? ramosissima
	Crotalaria medicaginea

COUNTS Taxa 121 Genera 74 Family 34 weeds 5

Fabaceae	Crotalaria medicaginea var. neglecta
Fabaceae	Desmodium filiforme
Fabaceae	Glycine sp.
Fabaceae	Indigofera monophylla
Fabaceae	Leptosema anomalum
Fabaceae	Neptunia ? dimorphantha
Fabaceae	Neptunia sp.
Fabaceae	Rhynchosia minima
Fabaceae	Senna artemisioides subsp. oligophylla
Fabaceae	Senna artemisioides subsp. oligophylla x helmsii
Fabaceae	Senna notabilis
Fabaceae	Senna symonii
Fabaceae	*Stylosanthes hamata
Fabaceae	Tephrosia leptoclada
Fabaceae	Tephrosia rosea
Fabaceae	Tephrosia sp. D Kimberley Flora (R.D. Royce 1848)
Fabaceae	Zornia muelleriana subsp. congesta
Goodeniaceae	Goodenia forrestii
Goodeniaceae	
	Goodenia lamprosperma
Goodeniaceae	Goodenia microptera
Goodeniaceae	Goodenia sp.
Gyrostemonaceae	Codonocarpus cotinifolius
Lauraceae	Cassytha capillaris
Malvaceae	Corchorus elachocarpus
Malvaceae	Corchorus incanus subsp. incanus
Malvaceae	Gossypium australe
Malvaceae	Hibiscus brachychlaenus
Malvaceae	Hibiscus leptocladus
Malvaceae	Keraudrenia nephrosperma
Malvaceae	Sida cardiophylla
Malvaceae	Sida clementii
Malvaceae	Sida rohlenae subsp. rohlenae
Malvaceae	Sida sp.
Malvaceae	Triumfetta ? chaetocarpa
Malvaceae	Waltheria indica
Marsileaceae	Marsilea sp.
Meliaceae	Owenia reticulata
Menispermaceae	Tinospora smilacina
Molluginaceae	Mollugo molluginis
Myrtaceae	Corymbia ? candida
Myrtaceae	Corymbia sp.
Myrtaceae	Eucalyptus victrix
Nyctaginaceae	Boerhavia coccinea
Phrymaceae	Peplidium aithocheilum
Plantaginaceae	Stemodia lathraia
Poaceae	Aristida contorta
Poaceae	Aristida holathera var. holathera

Poaceae	Aristida latifolia
Poaceae	*Cenchrus ciliaris
Poaceae	Chrysopogon fallax
Poaceae	*Cynodon dactylon
Poaceae	Dactyloctenium radulans
Poaceae	Digitaria brownii
Poaceae	Eragrostis eriopoda
Poaceae	Eriachne flaccida
Poaceae	Eriachne helmsii
Poaceae	Eriachne obtusa
Poaceae	Eulalia aurea
Poaceae	Paraneurachne muelleri
Poaceae	Triodia epactia
Poaceae	Triodia lanigera
Poaceae	Triodia schinzii
Poaceae	Triodia secunda
Polygalaceae	Polygala linariifolia
Proteaceae	Grevillea pyramidalis
Proteaceae	Grevillea wickhamii
Proteaceae	Hakea lorea subsp. lorea
Rubiaceae	Synaptantha tillaeacea var. tillaeacea
Santalaceae	Santalum sp.
Solanaceae	Solanum ? lasiophyllum
Solanaceae	Solanum diversiflorum
Solanaceae	Solanum phlomoides
Thymelaeaceae	Pimelea ammocharis
Violaceae	Hybanthus aurantiacus
Zygophyllaceae	Tribulopis angustifolia
Zygophyllaceae	Tribulus occidentalis

APPENDIX 3

Vegetation Classifications for the Pilbara

Vegetation Classifications for the Pilbara based on Specht (1970) with modification by Aplin (1979) & Trudgen (2002)

Life form	Canopy Cover				
Height Class	100 - 70%	70 - 30%	30 - 10%	10 - 2%	< 2%
Trees > 30 m	High Closed Forest	High Open Forest	High Woodland	High Open Woodland	Scattered Tall Trees
Trees 10-30 m	Closed Forest	Open Forest	Woodland	Open Woodland	Scattered Trees
Trees < 10 m	Low Closed Woodland	Low Open Forest	Low Woodland	Low Open Woodland	Scattered Low Trees
Shrubs > 2 m	Closed Scrub	Open Scrub	High Shrubland	High Open Shrubland	Scattered Tall Shrubs
Shrubs 1-2 m	Closed Heath	Open Heath	Shrubland	Open Shrubland	Scattered Shrubs
Shrubs < 1 m	Low Closed Heath	Low Open Heath	Low Shrubland	Low Open Shrubland	Low Scattered Shrubs
Hummock Grass Tussock Grass	Closed Hummock Grassland	Hummock Grassland Tussock Grassland	Open Hummock Grassland Open Tussock Grassland	Very Open Hummock Grassland	Scattered Hummock Grass Scattered Tussock Grass
Bunch Grass	Closed Tussock Grassland	Bunch Grassland	Open Bunch Grassland	Very Open Tussock Grassland	Scattered Bunch Grass
	Closed Bunch Grassland			Very Open Bunch Grassland	
Sedges	Closed Sedges	Sedges	Open Sedges	Very Open Sedges	Scattered Sedges
Herbs	Closed Herbs	Herbs	Open Herbs	Very Open Herbs	Scattered Herbs

Page 3-1

APPENDIX 4

Level I Fauna Survey

South Hedland – Western Edge Precinct

Fauna Assessment



Desert Spadefoot *Notaden nichollsi*, found whilst spotlighting in Area A of the Western Edge Precinct. Photo (B. Metcalf)

Prepared for: RPS Group

38 Station Street

Subiaco WA 6008

Prepared by: Brenden Metcalf and Mike Bamford

M.J. & A.R. Bamford Consulting Ecologists

23 Plover Way

Kingsley WA 6026



5th March 2012

EXECUTIVE SUMMARY

With the expansion of mining operations throughout the Pilbara region, Landcorp has initiated the release of several land packages around South Hedland township to accommodate some of the region's increasing housing requirements. The Western Edge Precinct consists of two blocks (totalling ~165ha) abutting the western and southern edges of the existing South Hedland township. The proposed development of the South Hedland – Western Edge Precinct is subject to environmental impact assessment, and as part of this process Bamford Consulting Ecologists was commissioned by RPS to undertaken fauna investigations for impact assessment. BCE uses an impact assessment process with the following components:

- The identification of fauna values:
 - o Assemblage characteristics: uniqueness, completeness and richness;
 - o Species of conservation significance;
 - o Recognition of ecotypes or vegetation/substrate associations (VSAs) that provide habitat for fauna, particularly those that are rare, unusual and/or support significant fauna;
 - o Patterns of biodiversity across the landscape;
 - o Ecological processes upon which the fauna depend.
- The review of impacting processes such as:
 - o Habitat loss leading to population decline;
 - o Habitat loss leading to population fragmentation;
 - Degradation of habitat due to weed invasion leading to population decline;
 - Ongoing mortality from operations;
 - o Species interactions including feral and overabundant native species;
 - o Hydrological change;
 - o Altered fire regimes; and
 - o Disturbance (dust, light, noise).
- The recommendation of actions to mitigate impacts.

The fauna investigations were based on a desktop review of data to produce a list of expected species and a three day site visit (February 2012) enabling the consultant to make fauna observations, identify Vegetation and Substrate Associations (VSAs) that provide habitat for fauna, and place the results of the desktop review into the perspective of the study area.

The desktop assessment identified 210 vertebrate fauna species that may occur in the project area, including eight frog, 62 reptile, 108 bird and 32 mammal species. Two frogs, two reptiles, 28 bird and seven mammal species were found during field investigations. Key fauna values are:

<u>Fauna assemblage</u> – Incomplete, with loss of some conservation significant mammals and other species susceptible to ongoing disturbance associated with feral predators and human activity. Assemblage is primarily Eremaean with Torresian influences.

<u>Significant species</u> – including one frog, one reptile, 10 birds and five mammals, with limited potential for short range endemic (SRE) invertebrates. Some of the significant fauna species are expected to use habitats similar to those encountered within the study area, but may avoid the study area itself due to ongoing human activities and the close proximity of the residential area e.g. Greater Bilby, Crest-tailed Mulgara. Other species are expected only as vagrants or occasional visitors e.g. Oriental Pratincole, Pictorella Mannikin. There is limited potential for SRE invertebrates within the study area; these species are often associated with isolated, mesic habitats, whereas the study area supports a widespread, homogenous xeric habitat.

<u>Vegetation and Substrate Associations</u> – largely uniform across the site (mosaic of tussock and hummock grasslands, with or without an overstorey of open shrubs on red to orange calcareous sands). A modified drainage lines (flowing out of South Hedland) crosses through Area A, and a minor drainage line passes to the southwest of the site.

<u>Key ecological processes</u> - main processes affecting the fauna assemblage within the site include local hydrology, altered fire regimes, firewood collection and fauna interactions (feral predators e.g. cats, foxes).

The impact assessment found that the main concerns were the impacts of human disturbance and feral predators being driven into adjacent areas as a result of this development, resulting in a gradual decline in the fauna assemblage of those areas. However it is not expected that conservation significant fauna species will be significantly impacted by this process.

CONTENTS

1	Intr	oduc	tion	1
	1.1	Bac	kground	1
	1.2	Ger	neral Approach to Fauna Impact Assessment	1
	1.3	Des	cription of Project	2
	1.4	Des	scription of Project Area	2
2	Met	hods		5
	2.1	Ove	erview	5
	2.2	Des	ktop Assessment	6
	2.2	.1	Sources of information	6
T	able 1	Тур	es of records held on database, areas searched and their source location	n. 7
	2.2.	.2	Nomenclature and taxonomy	7
	2.3	Fiel	d Investigations	8
	2.3	.1	Overview of field investigations	8
	2.3	.2	Personnel	9
	2.4	Ana	llysis and interpretation of data	9
	2.4	.1	Interpretation of species lists	9
	2.4	.2	Analysis of bat recordings	9
	2.5	Sur	vey limitations	10
	2.6	Imp	pact Assessment	11
3	Res	ults.		13
	3.1	Fau	ına assemblage	13
	3.2	Spe	cies of conservation significance	13
	3.2	.1	Conservation significance level 1	13
	3.2	.2	Conservation significance level 2	14
	3.2	.3	Conservation significance level 3	15
	3.2	.4	Summary of species of conservation significance	15
	3.3	Veg	etation and Substrate Associations	17
	3.4	Key	ecological processes in the project area	19
	3.5	Sur	nmary of fauna values	19
4	Imp	act a	assessment	21

4	4.1	Loss of habitat leading to population decline	. 21
4	4.2	Loss of habitat leading to population fragmentation	. 21
4	4.3	Degradation of habitat due to weed invasion	. 21
4	4.4	Ongoing mortality	. 21
4	4.5	Species interactions	. 21
4	4.6	Hydrological change	. 22
4	4.7	Altered fire regimes	. 22
4	4.8	Disturbance	. 22
4	4.9	Summary of impacts	. 22
5	Reco	ommendations	. 24
6	Refe	rences	. 25
TA	BLES		
Ta	ble 1.	Types of records held on database, areas searched and their source location	
Ta	ble 2.	Details of motion-camera locations and recording periods	
Та	ble 3.	Details of Anabat locations and recording periods 8	
Та	ble 4.	Survey limitations as outlined by EPA (2004)10	
Ta	ble 5.	Assessment criteria of impacts upon fauna12	
Ta	ble 6.	Composition of vertebrate fauna assemblage recorded and/or expected to occur within the study area	
Ta	ble 7.	Conservation status of significant fauna species expected to occur in the study (based on desktop review and field investigation). See Appendix for descriptions of conservation significance levels. Species recorded are indicated and the predicted status of each species in the project is also given (as per Section 2.4.1)	
Ta	ble 8.	Summary assessment of impacting processes and the possible effects of the proposed development upon fauna values	
Ta	ble 9.	Summary of possible impacts upon key fauna values23	
Ta	ble 10). Call characteristics of microbat species recorded from the study area. Presented as an average (± standard deviation)	

FIGURES

Figure 1. The South Hedland - Western Edge Precinct; "Area A" to the west and "Area B" to the south
Figure 2. IBRA Subregions in Western Australia. Note South Hedland lies in the Roebourne (Pilbara 4) subregion
Figure 3. Small ephemeral pool amongst mosaic grasslands in Area B17
Figure 4. Mosaic grasslands with powerline overhead in Area B
Figure 5. Minor drainage line with low shrubland, east of the study areas 18
Figure 6. Riparian woodland along drainage line east of the study areas 18
Figure 7. Samples of Anabat calls recorded from microbats within the study area. Calls presented with pulses at f6 expansion and time between calls compressed
APPENDICES
Appendix 1. Explanation of fauna values28
Appendix 2. Explanation of threatening processes
Appendix 3. Categories used in the assessment of conservation status35
Appendix 4. Ecological and threatening processes identified under legislation and in the literature
Appendix 5. Species lists derived from database searches and field investigations. 39
Appendix 6. Field data on fauna46
Appendix 7. Annotated species list for fauna assessment of the South Hedland – Western Edge Precinct

1 Introduction

1.1 Background

With the expansion of mining operations throughout the Pilbara region, Landcorp has initiated the release of several land packages around the South Hedland township to accommodate some of the region's increasing housing requirements. The Western Edge Precinct consists of two blocks (totalling ~165ha) abutting the western and southern edges of the existing South Hedland township. The proposed development of the South Hedland – Western Edge Precinct is subject to environmental impact assessment, and as part of this process Bamford Consulting Ecologists was commissioned by RPS to undertaken fauna investigations.

1.2 General Approach to Fauna Impact Assessment

The purpose of impact assessment is to provide government agencies with the information they need to decide upon the significance of impacts of a proposed development. BCE uses an impact assessment process with the following components:

- The identification of fauna values:
 - o Assemblage characteristics: uniqueness, completeness and richness;
 - o Species of conservation significance;
 - o Recognition of ecotypes or vegetation/substrate associations (VSAs) that provide habitat for fauna, particularly those that are rare, unusual and/or support significant fauna;
 - o Patterns of biodiversity across the landscape;
 - o Ecological processes upon which the fauna depend.
- The review of impacting processes such as:
 - Habitat loss leading to population decline;
 - o Habitat loss leading to population fragmentation;
 - o Degradation of habitat due to weed invasion leading to population decline;
 - o Ongoing mortality from operations;
 - o Species interactions including feral and overabundant native species;
 - o Hydrological change;
 - o Altered fire regimes; and
 - o Disturbance (dust, light, noise).
- The recommendation of actions to mitigate impacts.

Descriptions and background information on these values and processes can be found in Appendices 1 to 4. Based on this impact assessment process, the objectives of investigations are to: identify fauna values; review impacting processes with respect to these values and the proposed development; and provide recommendations to mitigate these impacts. Methods for investigations into the South Hedland – Western Edge Precinct are outlined in Section 3.

1.3 Description of Project

Landcorp has initiated the release of several areas of land adjacent to the South Hedland township. This project concerns the Western Edge Precinct which consists of two blocks totalling 165.08ha (see Figure 1), to be developed for residential purposes: Area "A" (115.41ha) and Area "B" (49.67ha).

1.4 Description of Project Area

The South Hedland – Western Edge Precinct project area lies in the Roebourne subregion of the Pilbara Bio-geographic regions as classified by the Interim Biogeographical Regionalisation for Australia (EA 2000; McKenzie *et al.* 2003, see Figure 2). The general features of this region are summarised by Kendrick and Stanley (2001) as:

"Quaternary alluvial and older colluvial coastal and subcoastal plains with a grass savannah of mixed bunch and hummock grasses, and dwarf shrub steppe of *Acacia stellaticeps* or *A. pyrifolia* and *A. inaequilatera*. Uplands are dominated by *Triodia* hummock grasslands. Ephemeral drainage lines support *Eucalyptus victrix* or *Corymbia hamersleyana* woodlands... ... Climate is arid (semi-desert) tropical with highly variable rainfall, falling mainly in summer. Cyclonic activity is significant, with several systems affecting the coast and hinterland annually" (pg 581, McKenzie *et al.* 2003).

The site lies between Turner River to the west (~15km) and Beebingarra Creek to the east (~8km), with a small un-named drainage line abutting the western boundary of the site.

Kendrick and Stanley (2001) provide information on significant fauna and ecosystems in the subregions, and this information is included in the results of the literature review.

South Hedland – Western Edge Precinct; Fauna Assessment

Figure 1. The South Hedland - Western Edge Precinct; "Area A" to the west and "Area B" to the south.



Figure 2. IBRA Subregions in Western Australia. Note South Hedland lies in the Roebourne (Pilbara 4) subregion.

2 Methods

2.1 Overview

The methods used in these investigations are based upon the general approach to fauna investigations for impact assessment as outlined in Section 1.2 and with reference to Appendices 1 to 4. Thus, the impact assessment process involves the identification of fauna values, review of impacting processes and preparation of mitigation recommendations.

In addition, the approach to fauna impact assessment was carried out with reference to guidelines and recommendations set out by the Western Australian Environmental Protection Authority (EPA) on fauna surveys and environmental protection, and Commonwealth biodiversity legislation ((EPA 2002; EPA 2004b). The EPA proposes two levels of investigation that differ in the approach to field investigations, Level 1 being a review of data and a site reconnaissance to place data into the perspective of the site, and Level 2 being a data review and intensive field investigations (eg. trapping and other intensive sampling). The level of assessment recommended by the EPA is determined by the size and location of the proposed disturbance, the sensitivity of the surrounding environment in which the disturbance is planned, and the availability of pre-existing data.

The South Hedland – Western Edge Precinct is a relatively small project area (~165ha), in a locally disturbed area adjacent to an existing development (South Hedland). The site supports relatively uniform Vegetation/Soil Associations i.e. a mosaic of hummock/tussocks grassland with scattered shrubs over red/orange calcareous sands; with a modified minor drainage line passing through the area and another slightly higher order drainage line passing to the south-west of the site. A range of fauna studies has previously been conducted throughout the biogeographic sub-region, providing adequate background information on species likely to occur in the area, particularly conservation significant species. On the 10th January 2012, RPS held a meeting with the Office of the Environmental Protection Authority (OEPA) to determine the level of assessment that would be required for technical investigations proposed to be undertaken as part of the project. At the meeting the OEPA confirmed that the required level of specificity for the Fauna Survey was Level 1.

The following approach and methods is divided into three groupings that relate to the stages and the objectives of impact assessment:

- Desktop assessment. The purpose of the desktop review is to produce a species list that can be considered to represent the vertebrate fauna assemblage of the project area based on unpublished and published data using a precautionary approach.
- Field investigations. The purpose of the field investigations is to gather information on this assemblage: confirm the presence of as many species as possible (with an emphasis on species of conservation significance), place the list generated by the desktop review into the context of the environment

of the project area, collect information on the distribution and abundance of this assemblage, and develop an understanding of the project area's ecological processes that maintain the fauna. Note that field investigations cannot confirm the presence of an entire assemblage, or confirm the absence of a species. This requires far more work than is possible in the EIA process. For example, in an intensive trapping study, How and Dell (1990) recorded in any one year only about 70% of the vertebrate species found over three years. In a study spanning over two decades, Bamford (2010) has found that the vertebrate assemblage varies over time and space, meaning that even complete sampling at a set of sites only defines the assemblage of those sites at the time of sampling.

• Impact assessment. Determine how the fauna assemblage may be affected by the proposed development based on the interaction of the project with a suite of ecological and threatening processes.

2.2 Desktop Assessment

2.2.1 Sources of information

Information on the fauna assemblage of the project area was drawn from a wide range of sources. These included state and federal government databases and results of regional studies. Databases accessed were the DEC Naturemap (incorporating the Western Australian Museum's FaunaBase and the DEC Threatened and Priority Fauna Database), Birds Australia's Atlas Database (BA), the EPBC Protected Matters Search Tool and the BCE database (Table 1). Kendrick and Stanley (2001) provided information on significant species and ecosystems in each bioregion. Information from the above sources was supplemented with species expected in the area based on general patterns of distribution. Sources of information used for these general patterns were:

- Frogs: Tyler & Doughty (2009);
- Reptiles: Storr et al. (1983); Storr et al. (1990); Storr et al. (1999); Storr et al. (2002) and Wilson & Swan (2008);
- Birds: Blakers *et al.* (1984); Johnstone and Storr (1998, 2004) and Barrett *et al.* (2003); and
- Mammals: Menkhorst & Knight (2001); Churchill (2008); and Van Dyck and Strahan (2008).

Table 1. Types of records held on database, areas searched and their source location.

Database	Type of records held on database	Area searched
NatureMap (DEC 2011)	Records in the WAM and DEC databases. Includes historical data and records on Threatened and Priority species in WA.	Based on a central location with a 40km buffer: 20.4°S, 119°E;
Birds Australia Atlas Database	Records of bird observations in Australia, 1998-2011.	One degree square containing: 20.4°S, 119°E
EPBC Protected Matters Search Tool	Records on matters of national environmental significance protected under the EPBC Act, including threatened species and conservation estate.	Based on a central location with a 10km buffer: 20.4°S, 119°E;

2.2.2 Nomenclature and taxonomy

As per the recommendations of EPA (2004a), the nomenclature and taxonomic order presented in this report are based on the Western Australian Museum's (WAM) *Checklist of the Vertebrates of Western Australia* 2008. The authorities used for each vertebrate group are: amphibians and reptiles (Aplin & Smith 2001), birds (Christidis & Boles 2008; Johnstone 2001), and mammals (How *et al.* 2001). English names of species, where available, are used throughout the text; Latin species names are presented with corresponding English names in tables in the appendices.

2.3 Field Investigations

2.3.1 Overview of field investigations

A three day site reconnaissance was conducted in early $(6^{th} - 8^{th})$ February 2012. During this site reconnaissance the site was traversed both by vehicle and foot to investigate the range of vegetation/soil associations available to fauna within the area. Activities undertaken during the site reconnaissance included:

- Recording vegetation and soil types throughout the study area
- Opportunistic observations on fauna (particularly birds);
- Motion-sensitive cameras set at four locations (see Table 2);
- Bat detectors set at two locations (see Table 3); and
- Searching for evidence of significant fauna (such as Mulgara and Greater Bilby).

Table 2. Details of motion-camera locations and recording periods.

Camera	Location & Description	Start-End Date
BCE01	50 K 665928 7742299; amongst stand of tall shrubs adjacent to several areas highly disturbed by human activity, in Area A.	6 th – 8 th Feb 2012
BCE03	50 K 665886 7741917; looking across a small ephemeral pool surrounded by Spinifex grassland, in Area A.	6 th - 7 th Feb 2012
BCE04	50 K 667529 7740839; amongst stand of low shrubs along powerline track within Area B.	6 th – 8 th Feb 2012
BCE01	50 K 665667 7740992; looking across a semi-permanent pool of creek to the south-west of the study area, west of Area A.	7 th – 8 th Feb 2012

Table 3. Details of Anabat locations and recording periods.

Start – End Date	Location & Description
6 th -7 th Feb 2012	50 K 666622 7740667; at the junction of the powerline track and Yarrie Rd. in an area of Spinifex grassland.
7th-8th Feb 2012	50 K 665667 7740992; at a semi-permanent, Eucalypt lined pool of the creek south-west of the study area, west of Area A.

2.3.2 Personnel

Personnel involved in the reconnaissance survey were:

- Brenden Metcalf (B.Sc. Hons. Env. Sc.); and
- Giles Glasson (B.Sc. (Env. Sc), Post. Grad. Dip.(Env.Mgt).

The report was reviewed by Dr Mike Bamford (B.Sc. Hons. Ph.D.)

2.4 Analysis and interpretation of data

2.4.1 Interpretation of species lists

Species lists generated from the review of sources of information are generous as they include records drawn from a large region and possibly from environments not represented in the project area. Therefore, some species that were returned by one or more of the data searches have not been included in this assessment because their ecology, or the environment within the project area, meant that it was highly unlikely that these species would be present. In general, however, species returned by the desktop review process are considered to be potentially present in the project area whether or not they were recorded during field surveys. This is because fauna are highly mobile, often seasonal and difficult to observe. This is particularly important for significant species that are often rare and hard to find.

Interpretation of species lists generated through the desktop review included assigning an expected status within the project area to species of conservation significance. This is particularly important for birds that may naturally be migratory or nomadic, and for some mammals that can also be mobile. The status categories used are:

- Resident: species with a population permanently present in the project area;
- Regular migrant or visitor: species that occur within the project area regularly in at least moderate numbers, such as part of annual cycle;
- Irregular Visitor: species that occur within the project area irregularly such as nomadic and irruptive species. The length of time between visitations could be decades but when the species is present, it uses the project area in at least moderate numbers and for some time;
- Vagrant: species that occur within the project area unpredictably, in small numbers and/or for very brief periods. Therefore, the project area is unlikely to be of important for the species; and
- Locally extinct: species that has not been recently recorded in the local area and therefore is almost certainly no longer present in the project area.

2.4.2 Analysis of bat recordings

Bat recordings were made with passive Anabat II Detectors (Titley, Australia), connected to a CFZCAIM. Calls were downloaded from the CFZCAIM and analysed

using the AnalookW (Corben, 2006, www.hoarybat.com) and Analyze (Jolly, 1997) software. Characteristics used in call analysis included:

Fmax Maximum call frequency (kHz)

Fmin Maximum call frequency (kHz)

Fc Characteristic frequency (kHz)

Fpeak Frequency with peak number of cycles (kHz)

DUR Duration of call (ms)

2.5 Survey limitations

The EPA Guidance Statement 56 (EPA 2004a) outlines a number of limitations that may arise during surveying. These survey limitations are discussed in the context of the BCE fauna survey at the project area in Table 4.

Table 4. Survey limitations as outlined by EPA (2004).

EPA Limitation	BCE Comment
Level of survey.	Level 1 – project area was relatively small (~165ha), previously disturbed, adjacent to an existing development and vegetation/soil associations were relatively uniform and widespread.
Competency/experience of the consultant(s) carrying out the survey.	The authors have had extensive experience in conducting fauna assessments.
Scope. (What faunal groups were sampled and were some sampling methods not able to be employed because of constraints?)	Survey focussed on assessing vegetation/soil associations for likely presence of fauna species, but bird surveys were conducted.
Proportion of fauna identified, recorded and/or collected.	All vertebrate fauna observed were identified.
Sources of information e.g. previously available information (whether historic or recent) as distinct from new data.	Sources include previous reports on the fauna of the region (BCE) and databases (Naturemap, BA, DEC and EPBC).
The proportion of the task achieved and further work which might be needed.	Level 1 Survey complete.
Timing/weather/season/cycle.	Reconnaissance survey in February following a cyclonic rainfall event one week prior, which may have increased local abundance of some species.
Disturbances (e.g. fire, flood, accidental human intervention etc.), which affected results of survey.	No disturbances affected the survey, but ongoing human activity throughout the site limited the extent of some survey activities e.g. spotlighting.
Intensity. (In retrospect, was the intensity adequate?)	Survey intensity adequate to record conservation significant fauna and habitats.
Completeness (e.g. was relevant area fully surveyed).	Project area was fully surveyed to the extents of a Level 1 survey.
Resources (e.g. degree of expertise available in animal identification to taxon level).	All vertebrate species identified to species (sometimes sub-species) level. All staff are competent to conduct animal identification to taxon level.
Remoteness and/or access problems.	No difficulties with access were encountered.

EPA Limitation	BCE Comment
Availability of contextual (e.g. biogeographic) information on the region.	Extensive regional information was available and was consulted.

2.6 Impact Assessment

While some impacts are unavoidable during a development, of concern are long-term, deleterious impacts upon biodiversity. This is reflected in documents such as the Significant Impact Guidelines provided by the Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC) (see Appendix 4). Significant impacts may occur if:

- There is direct impact upon a VSA and the VSA is rare, a large proportion of the VSA is affected and/or the VSA supports significant fauna.
- There is direct impact upon conservation significant fauna.
- Ecological processes are altered and this affects large numbers of species or large proportions of populations, including significant species.

The impact assessment process therefore involves reviewing the fauna values identified through the desktop assessment and field investigations with respect to the project and impacting processes. The severity of impacts on the fauna assemblage and conservation significant fauna can then be quantified on the basis of predicted population change (Table 5).

The presentation of this assessment follows the general approach to impact assessment as given in Section 1.2, but modified to suit the characteristics of the site and the field investigations for the Western Edge Precinct proposal. Key components to the general approach to impact assessment are addressed as follows:

Fauna values

This section presents the results of the desktop and field investigations in terms of key fauna values (described in detail in Appendix 1):

- Assemblage characteristics (uniqueness, completeness and richness) based upon desktop assessment, reconnaissance and some information from the intensive study;
- Species of conservation significance based upon desktop assessment and reconnaissance;
- o Recognition of ecotypes or vegetation/substrate associations (VSAs) based upon desktop assessment and reconnaissance;
- o Patterns of biodiversity across the landscape based upon desktop assessment and reconnaissance for general patterns;
- o Ecological processes upon which the fauna depend based upon desktop assessment and reconnaissance.

Impact assessment

This section reviews impacting processes (as described in detail in Appendix 2) with respect to the project and examines the potential effect of these impacts upon biodiversity of the alignment. It thus expands upon the Project Description

(Section 1.3) and discusses the contribution of the project to impacting processes, and the consequences of this with respect to biodiversity. A major component of impact assessment is consideration of threats to species of conservation significance as these are a major and sensitive element of biodiversity. Therefore, the impact assessment includes the following:

- Review of impacting processes; will the proposal result in:
 - o Habitat loss leading to population decline, especially for significant species;
 - o Habitat loss leading to population fragmentation, especially for significant species;
 - o Weed invasion occur and lead to habitat degradation;
 - o Ongoing mortality;
 - o Species interactions that adversely affect native fauna, particularly significant species;
 - o Hydrological change;
 - o Altered fire regimes; and
 - o Disturbance (dust, light, noise).
- Summary of impacts upon significant species, and other fauna values.

The impact assessment concludes with recommendations based upon predicted impacts and designed to mitigate these.

Table 5. Assessment criteria of impacts upon fauna.

Impact Category	Observed Impact
Negligible	Effectively no population decline; at most few individuals impacted and any decline in population size within the normal range of annual variability.
Minor	Short-term population decline (recovery after end of project) within project area, no change in viability of conservation status of population. Where environment permanently altered, no change in viability or conservation status of population
Moderate	Permanent population decline, change in viability or conservation status of population considered unlikely
Major	Permanent population decline resulting in change in viability or conservation status of population
Critical	Taxon extinction

3 Results

3.1 Fauna assemblage

The desktop study identified 210 vertebrate fauna species as potentially occurring in the project area (see Table 6 and Appendix 5). Species extinct in the region are listed separately under Appendix 5. The presence of 39 species was confirmed during field investigations (indicated in Appendix 1; see also field results in Appendix 6, including results of bat surveys and from motion-sensitive cameras, and annotated species list from field investigations in Appendix 7). The assemblage includes at least 18 species of conservation significance, which are discussed further in Section 3.2. Conservation significant invertebrate species are also considered in Section 3.2.

The assemblage of the project area is expected to be quite incomplete, with the area impacted by feral predators and ongoing human activity causing significant disturbance. Similar vegetation/soil associations in undisturbed areas of the bioregion are likely to support a much more intact assemblage with greater likelihood of conservation significant species still occurring.

Table 6. Composition of vertebrate fauna assemblage recorded and/or expected to occur within the study area.

Taxon	Number of species	Number Recorded		ficant faxpected		Introduced species
	expected		CS1	CS2	CS3	expected
Frogs	8	2	-	-	1	0
Reptiles	62	2	1	-	-	2
Birds	108	28	5	5	-	1
Mammals	32	7	3	2	-	4
Total	210	39	9	7	1	7

3.2 Species of conservation significance

Details on species of conservation significance are presented in Table 6. The list includes one frog, one reptile, 10 birds and 5 mammal species. With the vegetation/substrate associations of the study area being relatively homogenous and widespread, it is considered unlikely that the area would support short-range endemic invertebrates. Of the conservation significant vertebrate species present, some are known to utilise similar areas elsewhere, but may avoid the study area due to the high level of disturbance. Others may only occasionally be present or occur only as vagrants, but some are expected to be resident or regularly present, with some of these recorded during field investigations. Further information on these is presented below.

3.2.1 Conservation significance level 1

<u>Woma</u>. May have historically occurred within the study area but considered unlikely now, due to impacts of feral predators and human activity.

<u>Fork-tailed Swift</u>. Likely to occur regularly but a largely aerial species mostly independent of terrestrial ecosystems.

<u>Peregrine Falcon</u>. May periodically utilise the study area for hunting; likely to breed only where there are very large trees that provide hollows, or old nests of other species (eg Australian Raven).

<u>Oriental Pratincole</u>. Large flocks (200+ birds) observed flying over the study area during the site visit. Although none was seen utilising the site, it is possible they would do so periodically.

<u>Rainbow Bee-eater</u>. Summer breeding visitor to the study area. May construct nesting burrows on the edge of tracks.

<u>Barn Swallow</u>. A migrant species that occasionally reaches north-western Australia.

<u>Crest-tailed Mulgara.</u> May have historically occurred within the study area but considered unlikely now, due to impacts of feral predators and human activity.

<u>Greater Bilby</u>. May have historically utilised the study area but considered unlikely now, due to impacts of feral predators and human activity.

Pilbara Leaf-nosed Bat. Possibly forages over the study area on a regular basis, but unlikely to roost/breed within it. Known records from ~25km south (Naturemap, 2012) suggest it could commute to the study area from nearby roost sites.

3.2.2 Conservation significance level 2

<u>Grey Falcon.</u> May periodically utilise the study area for hunting. Often associated with drainage lines such as the one west of the study area.

<u>Australian Bustard</u>. Remains of at least two birds found along the powerline track traversing the southern portion of "Area A".

<u>Bush Stone-curlew.</u> Likely to be resident within the broader area, but may avoid the study area due to ongoing disturbance.

Star Finch. May utilise the nearby riparian habitats.

<u>Pictorella Mannikin</u>. Several seen during the site visit, but considered to be outside of their normal distribution.

<u>Brush-tailed Mulgara</u>. May have historically occurred within the study area but considered unlikely now, due to impacts of feral predators and human activity.

Ghost Bat. Possibly forages over the study area on a regular basis, but unlikely to roost/breed within it. Known records from ~25km south (Naturemap, 2012) suggest it could commute to the study area from nearby roost sites

3.2.3 Conservation significance level 3

Glandular Frog. Has a limited distribution within the north-coastal area of the Pilbara. There is potential habitat along creeklines south of the study area.

3.2.4 Summary of species of conservation significance

Significant species expected to occur within the study area include a number of particular interest. These are:

- Greater Bilby. This species is known to utilise drainage lines, such as the nearby Turner River and Beebingarra Creek, to move through the landscape.
 It may have historically utilised the study area for foraging, but is now unlikely due to the ongoing disturbances at the site.
- Crest-tailed and Brush-tailed Mulgara. It is likely that only one of these species occurred within the study area, and whichever species was present, it is now locally extinct. There are conflicting reports on the species of Mulgara in the Pilbara, with Woolley (2005) and DSEWPAC (2011) suggesting that only the Brush-tailed Mulgara occurs throughout the Pilbara region, but with a recent record of the Crest-tailed Mulgara in the eastern Pilbara (Phoenix Environmental 2011).
- Ghost Bat and Pilbara Leaf-nosed Bat. Both of these species are known to occur ~25km south of the study area (Naturemap, 2012) and could commute to the study area to forage.

South Hedland – Western Edge Precinct; Fauna Assessment

investigation). See Appendix for descriptions of conservation significance levels. Species recorded are indicated and the predicted Table 7. Conservation status of significant fauna species expected to occur in the study (based on desktop review and field status of each species in the project is also given (as per Section 2.4.1).

	CONSERVATION STATUS		3	CS1		CS2	CS3	PREDICTED STATUS IN PROJECT AREA
COMMON NAME	SPECIES NAME	EPBC	WA Act	JAMBA	CAMBA			
FROGS								
Glandular Frog	Uperoleia glandulosa						×	Resident
REPTILES								
Woma	Aspidites ramsayi		S4					Resident (probably locally extinct)
BIRDS								
Fork-tailed Swift	Apus pacificus	Migrant	Migrant	Migrant	Migrant			Regular migrant
Peregrine Falcon	Falco peregrinus		S4					Resident
Grey Falcon	Falco hypoleucos					P4		Resident
Australian Bustard	Ardeotis australis					P4		Regular visitor
Bush Stone-curlew	Burhinus grallarius					P4		Resident (possibly locally extinct)
Oriental Pratincole	Glareola maldivarum	Migrant	Migrant	Migrant	Migrant			Recorded - Regular migrant
Rainbow Bee-eater	Merops ornatus	Migrant	Migrant	Migrant	Migrant			Recorded - Regular migrant
Barn Swallow	Hirundo rustica	Migrant	Migrant	Migrant	Migrant			Irregular migrant
Star Finch	Neochmia ruficauda					P4		Resident
Pictorella Mannikin	Heteromunia pectoralis					P4		Recorded - Vagrant?
MAMMALS								
Brush-tailed Mulgara	Dasycercus blythi					P4		Former Resident? (locally extinct?)
Crest-tailed Mulgara	Dasycercus cristicauda	ΛN	S1 - VU					Former Resident? (locally extinct?)
Greater Bilby	Macrotis lagotis	۸n	S1 – VU					Former Resident (locally extinct?)
Ghost Bat	Macroderma gigas					P4		Possible foraging visitor
Pilbara Leaf-nosed Bat	Rhinonicteris aurantia	۸n	S1 - VU					Possible foraging visitor

3.3 Vegetation and Substrate Associations

The South Hedland – Western Edge Precinct covers an area of largely homogenous vegetation/substrate types (VSAs), which are well represented in less disturbed locations across the Roebourne subregion. Two VSAs were recognised within and adjacent to the study area and are described below

<u>Grassland mosaic</u> (Figure 3 and Figure 4). This was the dominant VSA within the study area, consisting of hummock and tussock grasslands, with or without an overstorey of open to very open shrubland, over red to orange calcareous sands.

• Conservation significance: Historically these areas would have supported a diverse fauna assemblage, which is now expected to be depauperate due to the ongoing disturbances to the area e.g. feral predators and human activity.

<u>Riparian woodlands</u> (Figure 5 and Figure 6). Although not actually present within the Precinct area, riparian areas off to the west and south-west of "Area A", would contribute to the fauna assemblage of the study area. They include Eucalypt woodlands and tall shrublands along minor drainage lines.

• Conservation significance: Expected to support a greater diversity of fauna species than the surrounding landscape, possibly also acting as a corridor for the movement of some species throughout the landscape. Development of the Western Edge Precinct will impact these areas by driving ongoing human disturbances into adjacent areas.

Both of these VSAs are well represented within the region, the "Grassland mosaic" more so than the "Riparian woodlands".

Figure 3. Small ephemeral pool amongst mosaic grasslands in Area B.



Figure 4. Mosaic grasslands with powerline overhead in Area B.



Figure 5. Minor drainage line with low shrubland, east of the study areas.



Figure 6. Riparian woodland along drainage line east of the study areas.



3.4 Key ecological processes in the project area

The South Hedland – Western Edge Precinct lies in a region of generally low relief, but the nature of the landscape and the fauna assemblage do indicate some of the ecological processes that may be important. These include:

<u>Local hydrology</u>. There is modified drainage line flowing through Area A, draining away from the South Hedland township. This flows into an existing minor drainage line west of the study areas. Any development of the area will likely impact the surface flow of water through the landscape, but is unlikely to be overly detrimental to VSA's within the area.

<u>Fire</u>. Fire has affected large areas of native vegetation within the study area, possibly removing much of the overstorey species from the study areas, thereby creating the existing grassland mosaic. Ongoing human activities within the study area include the regular burning of small fires, particularly in Area A. It is possible that some of the small fires escape leading to larger burns impacting larger portions of the landscape; such fires are likely to have contributed to the decline and local extinction of some mammal and bird species (Burbidge and McKenzie 1989).

The collection of firewood for regular small fires would also reduce the availability of micro-habitats for a range of vertebrate fauna species.

<u>Feral predators</u>. Feral predators are a major factor in the decline and local extinction of some mammal and bird species (Burbidge and McKenzie 1998). Foxes and feral cats will have impacted native fauna, but feral pigs, utilising some of the larger drainage lines nearby, may also have had some impact through transmission of diseases (see Appendix 2).

<u>Habitat degradation due to weed invasion</u>. The study area shows some signs of weed invasion e.g. Buffel grass *Cenchrus ciliaris*, which is likely to continue affecting adjacent areas once the Western Edge Precinct has been developed. This will be an ongoing impact to native fauna within the area.

3.5 Summary of fauna values

Fauna values within the South Hedland – Western Edge Precinct can be summarised as follows:

<u>Fauna assemblage</u> – Incomplete, with loss of some conservation significant mammals and other species susceptible to ongoing disturbance associated with feral predators and human activity. Assemblage is primarily Eremaean with Torresian influences. The composition of the assemblage is typical of a large region of semi-arid spinifex grasslands.

<u>Significant species</u> – including one frog, one reptile, 10 birds and five mammals, with limited potential for short range endemic (SRE) invertebrates. Some of the

significant fauna species are expected to use habitats similar to those encountered within the study area, but may avoid the study area itself due to ongoing human activities and the close proximity of the residential area e.g. Greater Bilby, Cresttailed Mulgara. Other species are expected only as vagrants or occasional visitors e.g. Oriental Pratincole, Pictorella Mannikin. There is limited potential for SRE invertebrates within the study area; these species are often associated with isolated, mesic habitats, whereas the study area supports a widespread, homogenous xeric habitat.

<u>Vegetation and Substrate Associations</u>. Only two VSAs recognised: grassland mosaic and riparian woodland, of which the latter is outside the study area. The grassland mosaic is probably a result of areas fire history, but regardless, is well represented outside the study area.

<u>Patterns of biodiversity</u>. The nearby riparian woodlands are expected to support a higher diversity of fauna species than the grassland mosaics.

<u>Key ecological processes</u>. Main processes affecting the fauna assemblage along the alignment include local hydrology, fire, fauna interactions/feral predators and habitat degradation due to weed invasion.

4 Impact assessment

As outlined in section 1.3, this project involves the development of two areas of land on the western and southern edge of the South Hedland township. The extent to which this development will impact fauna values of the study area are discussed below. Impacting processes are discussed below and summarised in Table 8. Impacts on key fauna values are summarised in Table 8. Impact categories as per Table 5.

4.1 Loss of habitat leading to population decline

The area of habitat loss is relatively small (~165ha) and given the disturbed condition of the area involved and the broad representation of similar environments across the surrounding landscape, its impact will be minimal. Therefore, population declines due to direct habitat loss are expected to be Negligible. Little or no effect of habitat loss upon significant species is expected.

4.2 Loss of habitat leading to population fragmentation

The grassland mosaic that covers the study area is widespread outside, therefore fauna species will easily be able to utilise adjacent, undeveloped areas to move through the landscape. Additionally, the study areas abut the existing South Hedland township on their eastern/northern sides, again limiting the extent of any population fragmentation.

Of some concern may be indirect impacts to nearby drainage lines that may act as corridors, allowing the movement of fauna through the landscape.

4.3 Degradation of habitat due to weed invasion

Weed invasion has already occurred along the exposed sections of the study areas e.g. roadsides and the edge of tracks, an issue exacerbated by ongoing human disturbance. Further development of the study area is likely to increase weed density and encourage their establishment in adjacent areas. Impact of weed invasion is likely to be Minor where it impacts adjacent, previously undisturbed areas.

4.4 Ongoing mortality

Initial development of the project is likely to remove the majority of fauna species from the study area, limiting the extent of any ongoing mortality.

4.5 Species interactions

Species interactions include effects of feral species, especially predators but also feral herbivores. In the current study this is includes foxes, feral cats and dogs. All three, but particularly the former two, are expected to have already impacted the fauna values of the study area. The development of the project may allow these species to access other nearby areas that have previously had little impact.

Feral pigs, although not expected to occur in the study area, may have had some indirect impact on the study area's fauna assemblage e.g. through disease transmission (Phillips *et. al.* 2009; Dept. of Environment and Heritage, 2005). However this is unlikely to alter as a result of the proposed development.

Overall the species interactions associated with the development are expected to have a Minor impact.

4.6 Hydrological change

A modified drainage line passes through Area A and will need to be retained in some manner to allow for drainage of both the site and part of the South Hedland township. Any development along the western edge of Area A will need to accommodate water levels within the nearby minor drainage line. Assuming these existing drainage lines are recognised and the development adapted where necessary, hydrological impacts are expected to be Minor.

4.7 Altered fire regimes

Although difficult to confirm, it is expected that the dominant grassland mosaic VSA of the study area is at least partially the result of regular fires resulting in the loss of the overstorey species. The fire regime that has operated over the site probably already extends into adjacent areas, so there is likely to be little change in the fire regime as a result of the development.

4.8 Disturbance

The study areas, particularly Area A, have suffered extensively from ongoing disturbances, particularly human activities e.g. regular small fires, rubbish dumping, creation of numerous vehicle tracks. Development of the study areas is likely to drive these activities into other adjacent areas. This gradual impact is expected to have a Minor impact on the fauna values of adjacent areas.

4.9 Summary of impacts

Impacts are summarised on Tables 8 and 9. As a result of the previously disturbed nature of the study area, all processes are expected to have only negligible or minor impacts. Impacts are generally considered to be only Negligible or Minor, even upon the majority of significant species (see Table 5) because of the relatively small area involved and the existing level of disturbance.

Table 8. Summary assessment of impacting processes and the possible effects of the proposed development upon fauna values.

Impacting process	Impact	
Habitat loss leading to population decline	Negligible . Only a small area of previously disturbed habitat loss with no impact upon significant species anticipated. Similar environments and fauna assemblages expected in adjacent areas.	
Population fragmentation and disruption of movement and gene flow due to habitat fragmentation	Negligible to Minor. Limited fragmentation or disruption of movement is anticipated as the area is relatively small and the dominant VSA is widespread. No impact upon significant species anticipated.	
Increased mortality leading to population decline; e.g. due to ongoing roadkill	Negligible . The area has already been heavily disturbed, with those species susceptible to roadkill or other ongoing mortality already expected to have declined within the study area.	
Habitat degradation due to weed invasion	Minor. Adjacent undisturbed areas may suffer from weed invasion as a result of the development. The study area already suffers from weed invasion along exposed section e,g, roadsides.	
Hydrological change	Minor. Existing drainage will need to be accommodated within the proposal, but not expected to significantly impact fauna.	
Species interactions due to feral species	Minor . These species would have already impacted fauna within the study area and surrounds. The development is not expected to alter the existing impacts.	
Changes in fire regime	Negligible . The study area appears to have experienced regular fires resulting in a change in vegetation structure, but development of the project area is unlikely to result in significant changes in fire regime around the study area.	
Effects of disturbance, dust and light	Negligible. As the project area has already suffered from human disturbance, the development is unlikely to significantly alter these impacts.	

Table 9. Summary of possible impacts upon key fauna values.

Fauna Value	Impacts from proposal	Significance of impacts
Fauna assemblage	Small loss of previously disturbed habitat.	Negligible
Significant species	Small loss of previously disturbed habitat; few significant species present and/or reliant on project area, with similar environments extensive nearby.	Negligible
VSAs	Small loss of widespread VSA.	Negligible

5 Recommendations

Recommendations for the minimisation of impacts can be drawn from the review of impacting processes.

- Habitat loss leading to population decline. Minimise where possible. Clear towards areas of native vegetation (to displace mobile fauna towards cover). Avoid fragmentation of the study area where possible during clearing.
- Degradation of habitat due to weed invasion. Vehicle hygiene to minimise transport of weeds into uncontaminated areas. Clearly delineate clearing boundaries.
- Species interactions. Changes in the abundance of predators and the vulnerability of species such as Mulgara and Bush Stone-curlew are the main concern. Fauna in adjacent areas would benefit from control of Foxes and Feral Cats during and after the development.
- Hydrological change. Accommodate existing drainage lines, within and adjacent to the project area, into the design of the development.
- Altered fire regimes. A reduction in the frequency of fires in surrounding areas through education and management would reduce the impacts of regular burning such as the loss of overstorey species.
- Disturbance. As a precaution, light, noise and dust should be minimised during development. Discourage human activity within adjacent areas, thereby reducing the extent and severity of habitat disturbance.

6 References

- Aplin, K. P. and Smith, L. A. (2001). Checklist of the frogs and reptiles of Western Australia. Records of the Western Australian Museum Supplement 63: 51–74.
- Bamford, M., Bancroft, W. And Sibbel, N. (2010). Twenty years and two transects; spatial and temporal variation in local patterns of biodiversity. Paper at Ecol. Soc. Aust Conference, Canberra.
- Barrett, G., Silcocks, A., Barry, S., Cunnningham, R. and Poulter, R. (2003). The New Atlas of Australian Birds. Royal Australasian Ornithologists Union, Melbourne.
- Birdata (2011). Birds Australia Birdata Database. Accessed 03/02/2012 from: http://www.birdata.com.au
- Blakers, M., Davies, S.J.J.F. and Reilly, P.N. (1984). The Atlas of Australian Birds. Royal Australasian Ornithologists Union. Melbourne University Press.
- Burbidge, A.A. and McKenzie, N.L. (1989). Patterns in the Modern Decline of Western Australia's Vertebrate Fauna; Causes and Conservation Implications. *Biol. Cons.* **50**: 143-198.
- Calver, M., Lymbery, A., McComb, J. and Bamford, M. (2009). Environmental Biology. Cambridge University Press, Melbourne.
- Christidis, L. and Boles, W.E. (2008). Systematics and taxonomy of Australian birds. CSIRO Publishing, Melbourne.
- Churchill, S. (2008). Australian Bats. 2nd Ed. Jacana Books, Allen & Unwin, Sydney.
- Clevenger, A. P. and Waltho, N. (2000). Factors Influencing the Effectiveness of Wildlife Underpasses in Banff National Park, Alberta, Canada. *Conservation Biology* **14**: 1-11
- Cogger, H.G., E.E. Cameron, R.A. Sadlier & P. Eggler (1993). The Action Plan for Australian Reptiles. [Online]. Canberra, ACT: Australian Nature Conservation Agency.

 http://www.environment.gov.au/biodiversity/threatened/action/reptiles/index.html.
- Department of Environment and Conservation. (2011). NatureMap Threatened and Priority Fauna Database, Accessed 03/02/2012. http://www.naturemap.wa.gov.au
- Department of Environment and Heritage. (2005). Threat Abatement Plan for Predation, Habitat Destruction, Competition and Disease Transmission by Feral Pigs. Canberra, ACT.
- Dufty, A.C. (1989). Some Population characteristics of *Perameles gunnii* in Victoria. *Wildlife Research*: **18** (3) 355 365.

- Environmental Protection Authority. (2002). Terrestrial Biological Surveys as an Element of Biodiversity Protection. Position Statement No. 3. Environmental Protection Authority, Perth, Western Australia.
- Environmental Protection Authority. (2004). Guidance for the assessment of environmental factors: Terrestrial fauna surveys for environmental impact assessment in Western Australia. No. 56. Environmental Protection Authority, Perth, Western Australia.
- Environment Australia. (2000). Revision of the Interim Biogeographic Regionalisation for Australia (IBRA) and Development of Version 5.1 Summary Report. Environment Australia, Department of Environment and Heritage, Canberra, Australian Capital Territory.
- Harvey, M. (2002). Short-range Endemism amongst the Australian fauna: examples from non-marine environments. *Invertebrate Systematics*, 16: 555-570.
- How, R.A. and Dell, J. (1990). Vertebrate fauna of Bold Park, Perth. West. Aust. Nat. 18: 122-131.
- How, R.A., Cooper, N.K. and Bannister, R.L. (2001). Checklist of the mammals of Western Australia. Records of the Western Australian Museum Supplement No. 63, 91-98.
- Johnstone, R.E. and Storr, G.M. (1998). Handbook of Western Australian Birds Vol 1 Non-passerines (Emu to Dollarbird). Western Australian Museum, Perth.
- Johnstone, R.E. and Storr, G.M. (2004). Handbook of Western Australian Birds. Vol 2: Passerines (Blue-winged Pitta to Goldfinch). Western Australian Museum, Perth.
- Jones, M.E. (2000). Road upgrade, road mortality and remedial measures: impacts on a population of eastern quolls and Tasmanian devils. *Wildlife Research* **27**: 289 296
- Kendrick, P. and Stanley, F. (2001). Pilbara 4 (PIL4 Roebourne Synopsis). In "Bioregional Summary of the 2002 Biodiversity Audit for Western Australia". The National Land and Water Resources Audit and the Western Australian Department of Conservation and Land Management, Perth, Western Australia.
- Mace, G. and Stuart, S. (1994). Draft IUCN Red List Categories, Version 2.2. Species; Newsletter of the Species Survival Commission. IUCN The World Conservation Union. No. 21-22: 13-24.
- Maxwell, S., Burbidge, A.A and Morris, K. D., Eds (1996). The 1996 Action Plan for Australian Marsupials and Monotremes. Wildlife Australia, Canberra.
- Menkhorst, P. and Knight, F. (2004). A Field Guide to the Mammals of Australia. Oxford University Press, Melbourne.
- Phillips, N.D., La, T., Adams, P.J., Harland, B., Fenwick, S.G. and Hampson, D.J. (2009). Detection of *Brachyspira hyodysenteriae*, *Lawsonia intracellularis* and *Brachyspira pilosicoli* in feral pigs. *Veterinary Microbiology*, **134** (3-4): 294-299.

- Phoenix Environmental (2011). Level 1 fauna habitat assessment and targeted mulgara survey for the FerrAus Pilbara Project. Unpublished report for FerrAus Ltd.
- Rich, C. and Longcore, T. (2006). Ecological Consequences of Artificial Night Lighting. Island Press.
- Scheick, B.K. and Jones, M.D. (1999). Locating Wildlife Underpasses Prior To The Expansion Of Highway 64, In North Carolina. In Proceedings of the International Conference on Wildlife 1999.
- Storr, G.M. (1984). Birds of the Pilbara Division, Western Australia. *Records of the Western Australian Museum Suppl.* No. 16.
- Storr, G.M., Smith, L.A. and Johnstone, R.E. (1983). Lizards of Western Australia. II. Dragons and Monitors. W.A. Museum, Perth.
- Storr, G.M., Smith, L.A. and Johnstone, R.E. (1990). Lizards of Western Australia. III. Geckoes and Pygopodids. W.A. Museum, Perth.
- Storr, G.M., Smith, L.A. and Johnstone, R.E. (1999). Lizards of Western Australia. I. Skinks. Revised Edition. W.A. Museum, Perth.
- Storr, G.M., Smith, L.A. and Johnstone, R.E. (2002). Snakes of Western Australia. W.A. Museum, Perth.
- Tyler, M. J. and Doughty P. (2009). Field Guide to Frogs of Western Australia. Western Australian Museum, Perth, W.A.
- Van Dyck, S. and Strahan, R. (2008). The Mammals of Australia. Third Edition. New Holland Publishers, Sydney.
- Woolley, P. A. 2005. The species of *Dasycercus* Peters, 1875 (Marsupialia: Dasyuridae). *Memoirs of Museum Victoria* 62(2): 213-221.

Appendix 1. Explanation of fauna values.

Fauna values are the features of a site and its fauna that contribute to biodiversity, and it is these values that are potentially at threat from a development proposal. Fauna values can be examined under the five headings outlined below. It must be stressed that these values are interdependent and should not be considered equal, but contribute to an understanding of the biodiversity of a site. Understanding fauna values provides opportunities to predict and therefore mitigate impacts.

Assemblage characteristics.

<u>Uniqueness</u>. This refers to the combination of species present at a site. For example, a site may support an unusual assemblage that has elements from adjacent biogeographic zones, it may have species present or absent that might be otherwise expected, or it may have an assemblage that is typical of a very large region. For the purposes of impact assessment, an unusual assemblage has greater value for biodiversity than a typical assemblage.

<u>Completeness</u>. An assemblage may be complete (ie. has all the species that would have been present at the time of European settlement), or it may have lost species due to a variety of factors. Note that a complete assemblage, such as on an island, may have fewer species than an incomplete assemblage (such as in a species-rich but degraded site on the mainland).

<u>Richness</u>. This is a measure of the number of species at a site. At a simple level, a species rich site is more valuable than a species poor site, but value is also determined, for example, by the sorts of species present.

Vegetation/substrate associations (VSAs)

VSAs combine broad vegetation types, the soils or other substrate with which they are associated, and the landform. In the context of fauna assessment, VSAs are the environments that provide habitats for fauna. The term habitat is widely used in this context, but by definition an animal's habitat is the environment that it utilises (Calver et al. 2009), not the environment as a whole. Habitat is a function of the animal and its ecology, rather than being a function of the environment. For example, a species may occur in eucalypt canopy or in leaf-litter on sand, and that habitat may be found in only one or in several VSAs. VSAs are not the same as vegetation types since these may not incorporate soil and landform, and recognise floristics to a degree that VSAs do not. Vegetation types may also not recognise minor but often significant (for fauna) structural differences in the environment. VSAs also do not necessarily correspond with soil types, but may reflect some of these elements.

Because VSAs provide the habitat for fauna, they are important in determining assemblage characteristics. For the purposes of impact assessment, VSAs can also provide a surrogate for detailed information on the fauna assemblage. For example, rare, relictual or restricted VSAs should

automatically be considered a significant fauna value. Impacts may be significant if the VSA is rare, a large proportion of the VSA is affected and/or the VSA supports significant fauna. The disturbance of even small amounts of habitat in a localised area can have significant impacts to fauna if rare or unusual habitats are disturbed.

Patterns of biodiversity across the landscape

This fauna value relates to how the assemblage is organised across the landscape. Generally, the fauna assemblage is not distributed evenly across the landscape or even within one VSA. There may be zones of high biodiversity such as particular environments or ecotones (transitions between VSAs). There may also be zones of low biodiversity. Impacts may be significant if a wide range of species is affected even if most of those species are not significant *per se*.

Species of conservation significance

Species of conservation significance are of special importance in impact assessment. The conservation status of fauna species in Australia is assessed under Commonwealth and State Acts such as the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and the *Western Australian Wildlife Conservation Act 1950* (Wildlife Conservation Act). In addition, the Western Australian DEC recognises priority levels, while local populations of some species may be significant even if the species as a whole has no formal recognition. Therefore, three broad levels of conservation significance can be recognised and are used for the purposes of this report and are outlined below. A full description of the conservation significance categories, schedules and priority levels mentioned below is provided in Appendix 3.

<u>Conservation Significance (CS) 1:</u> Species listed under State or Commonwealth Acts.

Species listed under the EPBC Act are assigned to categories recommended by the International Union for the Conservation of Nature and Natural Resources (IUCN) and reviewed by Mace and Stuart (1994), or are listed as migratory. Migratory species are recognised under international treaties such as the China Australia Migratory Bird Agreement (CAMBA), the Japan Australia Migratory Bird Agreement (JAMBA), the Republic of South Korea Australia Migratory Bird Agreement (ROKAMBA), and/or the Bonn Convention (The Convention on the Conservation of Migratory Species of Wild Animals). The Wildlife Conservation Act uses a series of Schedules to classify status, but also recognizes the IUCN categories.

<u>Conservation Significance (CS) 2:</u> Species listed as Priority by the DEC but not listed under State or Commonwealth Acts.

In Western Australia, the DEC has produced a supplementary list of Priority Fauna, being species that are not considered threatened under the Wildlife Conservation Act but for which the DEC feels there is cause for concern. Some Priority species are also assigned to the Conservation Dependent category of the IUCN.

<u>Conservation Significance (CS) 3:</u> Species not listed under Acts or in publications, but considered of at least local significance because of their pattern of distribution.

This level of significance has no legislative or published recognition and is based on interpretation of distribution information, but is used here as it may have links to preserving biodiversity at the genetic level (EPA 2002). If a population is isolated but a subset of a widespread (common) species, then it may not be recognised as threatened, but may have unique genetic characteristics. Conservation significance is applied to allow for the preservation of genetic richness at a population level, and not just at a species level. Species on the edge of their range, or that are sensitive to impacts such as habitat fragmentation, may also be classed as CS3, as may colonies of waterbirds. The Western Australian Department Environmental Protection, now DEC (2000), used this sort of interpretation to identify significant bird species in the Perth metropolitan area as part of the Perth Bushplan.

Invertebrate species considered to be short range endemics (SREs) also fall within the CS3 category, as they have no legislative or published recognition and their significance is based on interpretation of distribution information. Harvey (2002) notes that the majority of species that have been classified as short-range endemics have common life history characteristics such as poor powers of dispersal or confinement to discontinuous habitats. groups, therefore, have particularly high instances of short-range endemic species: Gastropoda (snails and slugs), Oligochaeta (earthworms), Onychophora (velvet worms), Araneae (mygalomorph spiders), Pseudoscorpionida (pseudoscorpions), Schizomida (schizomids), Diplopoda (millipedes), Phreatoicidea (phreatoicidean crustaceans), and Decapoda (freshwater crayfish). The poor understanding of the taxonomy of many of the short-range endemic species hinders their conservation (Harvey 2002).

Introduced species

In addition to these conservation levels, species that have been introduced (INT) are indicated throughout the report. Introduced species may be important to the native fauna assemblage through effects by predation and/or competition.

Ecological processes upon which the fauna depend

These are the processes that affect and maintain fauna populations in an area and as such are very complex; for example, populations are maintained through the dynamic of mortality, survival and recruitment being more or less in balance, and these are affected by a myriad of factors. The dynamics

of fauna populations in a project may be affected by processes such as fire regime, landscape patterns (such as fragmentation and/or linkage), the presence of feral species and hydrology. Impacts may be significant if processes are altered such that fauna populations are adversely affected, resulting in declines and even localised loss of species. Threatening processes as outlined below are effectively the ecological processes that can be altered to result in impacts upon fauna.

Appendix 2. Explanation of threatening processes

Potential impacts of proposed developments upon fauna values can be related to threatening processes. This is recognised in the literature and under the EPBC Act, in which threatening processes are listed (see Appendix 4). Processes that may impact fauna values are discussed below. Rather than being independent of one another, processes are complex and often interrelated. They are the mechanisms by which fauna can be affected by development. Impacts may be significant if large numbers of species or large proportions of populations are affected.

Loss of habitat affecting population survival

Clearing for a development can lead to habitat loss for a species with a consequent decline in population size. This may be significant if the smaller population has reduced viability. Conservation significant species or species that already occur at low densities may be particularly sensitive to habitat loss affecting population survival.

Loss of habitat leading to population fragmentation

Loss of habitat can affect population movements by limiting movement of individuals throughout the landscape as a result of fragmentation. Obstructions associated with the development, such as roads, pipes and drainage channels, may also affect movement of small, terrestrial species. Fragmented populations may not be sustainable and may be sensitive to effects such as reduced gene flow.

Degradation of habitat due to weed invasion leading to population decline

Weed invasion can occur as a result of development and if this alters habitat quality, can lead to effects similar to habitat loss.

Increased mortality

Increased mortality can occur during project operations; for example from roadkill, animals striking infrastructure and entrapment in trenches. Roadkill as a cause of population decline has been documented for the Eastern Barred Bandicoot, *Peremeles gunni* ((Dufty 1989), Eastern Quoll, *Dasyurus viverrinus* and Tasmanian Devil *Sarcophilus harrisii* ((Jones 2000). Increased mortality due to roadkill is often more prevalent in habitats that have been fragmented (Scheick & Jones 1999; Clevenger & Waltho 2000; Jackson & Griffin 2000).

Increased mortality of common species during development is unavoidable and may not be significant for a population. However, the cumulative impacts of increased mortality of conservation significant species or species that already occur at low densities may have a significant impact on the population.

Species interactions, including predation and competition

Changes in species interactions often occur with development. Introduced species, including the feral Cat, Fox and Rabbit may have adverse impacts upon native species and development can alter their abundance. In particular, some mammal species are very sensitive to introduced predators and the decline of many mammals in Australia has been linked to predation by the Fox, and to a lesser extent the feral Cat (Burbidge & McKenzie 1989). Introduced grazing species, such as the Rabbit, Goat, Camel and domestic livestock, can also degrade habitats and deplete vegetation that may be a food source for other species.

Changes in the abundance of some native species at the expense of others, due to the provision of fresh watering points, can also be a concern. (Harrington 2002) found the presence of artificial fresh waterpoints in the semi-arid mallee rangelands to influence the abundance and distribution of certain bird species. Common, water-dependent birds were found to outcompete some less common, water-independent species. Over-abundant native herbivores, such as kangaroos, can also adversely affect less abundant native species through competition and displacement.

Hydroecology

Interruptions of hydroecological processes can have major effects because they underpin primary production in ecosystems and there are specific, generally rare habitats that are hydrology-dependent. Fauna may be impacted by potential changes to groundwater level and chemistry and altered flow regime. These changes may alter vegetation across large areas and may lead to habitat degradation or loss. Impacts upon fauna can be widespread and major.

Changes to flow regime across the landscape may alter vegetation and may lead to habitat degradation or loss, affecting fauna. For example, Mulga has a shallow root system and relies on surface sheet flow during flood events. If surface sheet flow is impeded, Mulga can die (Kofoed 1998), which may impact on a range of fauna associated with this vegetation type.

Fire

The role of fire in the Australian environment and its importance to vertebrate fauna has been widely acknowledged (e.g. (Gill et al. 1981; Fox 1982; Letnic et al. 2004)). Fire is a natural feature of the environment but frequent, extensive fires may adversely impact some fauna, particularly mammals and short-range endemic species. Changes in fire regime, whether to more frequent or less frequent fires, may be significant to some fauna. Impacts of severe fire may be devastating to species already occurring at low densities or to species requiring long unburnt habitats to survive. Fire management may be considered the responsibility of managers of large tracts of land.

Dust, light, noise and vibration

Impacts of dust, light, noise and vibration upon fauna are difficult to predict. Some studies have demonstrated the impact of artificial night lighting on fauna, with lighting affecting fauna behaviour more than noise (Rich & Longcore 2006). Effects can include impacts on predator-prey interactions, changes to mating and nesting behaviour, and increased competition and predation within and between invertebrates, frogs, birds and mammals.

The death of very large numbers of insects has been observed around some remote mine sites and attracts other fauna, notably native and introduced predators (M.Bamford pers. obs). The abundance of some insects can decline due to mortality around lights, although this has previously been recorded in fragmented landscapes where populations are already under stress (Rich & Longcore 2006). Artificial night lighting may also lead to disorientation of migratory birds. Aquatic habitats and open habitats such as grasslands and dunes may be vulnerable to light spill.

Appendix 3. Categories used in the assessment of conservation status IUCN categories (based on review by Mace and Stuart 1994) as used for the *Environment Protection and Biodiversity Conservation Act* and the Western Australian *Wildlife Conservation Act*.

Extinct	Taxa not definitely located in the wild during the past 50 years.
Extinct in the Wild	Taxa known to survive only in captivity.
Critically Endangered	Taxa facing an extremely high risk of extinction in the wild in the immediate future.
Endangered	Taxa facing a very high risk of extinction in the wild in the near future.
Vulnerable	Taxa facing a high risk of extinction in the wild in the medium-term future.
Near Threatened	Taxa that risk becoming Vulnerable in the wild.
Conservation Dependent	Taxa whose survival depends upon ongoing conservation measures. Without these measures, a conservation dependent taxon would be classed as Vulnerable or more severely threatened.
Data Deficient (Insufficiently Known)	Taxa suspected of being Rare, Vulnerable or Endangered, but whose true status cannot be determined without more information.
Least Concern.	Taxa that are not Threatened.

Schedules used in the WA Wildlife Conservation Act

Schedule 1	Rare and Likely to become Extinct.
Schedule 2	Extinct.
Schedule 3	Migratory species listed under international treaties.
Schedule 4	Other Specially Protected Fauna

WA Department of Conservation and Land Management Priority species (species not listed under the Conservation Act, but for which there is some concern).

Priority 1	Taxa with few, poorly known populations on threatened lands.
Priority 2	Taxa with few, poorly known populations on conservation lands; or taxa with several, poorly known populations not on conservation lands.
Priority 3	Taxa with several, poorly known populations, some on conservation lands.
Priority 4.	Taxa in need of monitoring. Taxa which are considered to have been adequately surveyed, or for which sufficient knowledge is available, and which are considered not currently threatened or in need of special protection, but could be if present circumstances change.
Priority 5	Taxa in need of monitoring. Taxa which are not considered threatened but are subject to a specific conservation program, the cessation of which would result in the species becoming threatened within five years (IUCN Conservation Dependent).

Appendix 4. Ecological and threatening processes identified under legislation and in the literature.

Ecological processes are processes that maintain ecosystems and biodiversity. They are important for the assessment of impacts of development proposals, because ecological processes make ecosystems sensitive to change. The issue of ecological processes, impacts and conservation of biodiversity has an extensive literature. Following are examples of the sorts of ecological processes that need to be considered.

Ecological processes relevant to the conservation of biodiversity in Australia (Soule *et al.* 2004):

- Critical species interactions (highly interactive species);
- Long distance biological movement;
- Disturbance at local and regional scales;
- Global climate change;
- Hydroecology;
- Coastal zone fluxes;
- Spatially-dependent evolutionary processes (range expansion and gene flow); and
- Geographic and temporal variation of plant productivity across Australia.

Threatening processes (EPBC Act)

Under the EPBC Act (1999), a key threatening process is an ecological interaction that threatens or may threaten the survival, abundance or evolutionary development of a threatened species or ecological community. There are currently 17 key threatening processes listed by the federal Department of the Environment, Water, Heritage and the Arts

- Competition and land degradation by feral/unmanaged Goats (*Capra hircus*);
- Competition and land degradation by feral Rabbits (*Oryctolagus cuniculus*);
- Dieback caused by the root-rot fungus (*Phytophthora cinnamomi*);
- Incidental catch (bycatch) of Sea Turtles during coastal otter-trawling operations within Australian waters north of 28 degrees South;
- Incidental catch (or bycatch) of seabirds during oceanic longline fishing operations;
- Infection of amphibians with chytrid fungus resulting in chytridiomycosis;
- Injury and fatality to vertebrate marine life caused by ingestion of, or entanglement in, harmful marine debris;
- Land clearance:
- Loss of biodiversity and ecosystem integrity following invasion by the Yellow Crazy Ant (*Anoplolepis gracilipes*) on Christmas Island, Indian Ocean:
- Loss of climatic habitat caused by anthropogenic emissions of greenhouse gases;
- Predation by exotic rats on Australian offshore islands of less than 1000 km2 (100,000 ha);

- Predation by feral Cats (*Felis catus*);
- Predation by the European Red Fox (*Vulpes vulpes*);
- Predation, Habitat Degradation, Competition and Disease Transmission by Feral Pigs (*Sus scrofa*);
- Psittacine Circoviral (beak and feather) Disease affecting endangered psittacine species;
- The biological effects, including lethal toxic ingestion, caused by Cane Toads (Bufo *marinus*); and
- The reduction in the biodiversity of Australian native fauna and flora due to the red imported fire ant, *Solenopsis invicta*.

General processes that threaten biodiversity across Australia (The National Land and Water Resources Audit):

- Vegetation clearing;
- Increasing fragmentation, loss of remnants and lack of recruitment;
- Firewood collection;
- Grazing pressure;
- Feral animals;
- Exotic weeds;
- Changed fire regimes;
- Pathogens;
- Changed hydrology—dryland salinity and salt water intrusion;
- Changed hydrology—other such as altered flow regimes affecting riparian vegetation; and
- Pollution.

In addition to the above processes, the DSEWPaC has produced Significant Impact Guidelines that provide criteria for the assessment of the significance of impacts. These criteria provide a framework for the assessment of significant impacts. The criteria are listed below.

Will the proposed action lead to a long-term decrease in the size of a population.

Will the proposed action reduce the area of occupancy of the species.

Will the proposed action fragment an existing population.

Will the proposed action adversely affect habitat critical to the survival of a species.

Will the proposed action disrupt the breeding cycle of a population.

Will the proposed action modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline.

Will the proposed action result in introducing invasive species that are harmful to a critically endangered or endangered species becoming established in the endangered or critically endangered species' habitat.

Will the proposed action introduce disease that may cause the species to decline.

Will the proposed action interfere with the recovery of the species.

Appendix 5. Species lists derived from database searches and field investigations.

Status (CS1, CS2 and CS3) as per Appendix 1; INT refers to introduced or naturalised species.

Frogs

FROG SPECIES			Recorded
HYLIDAE ("tree" frogs)			
Giant Frog	Giant Frog Cyclorana australis		
Sheep Frog	Cyclorana maini		X
Little Red Tree Frog Litoria rubella			
LIMNODYNASTIDAE ('burrowing' frogs)			
Northern Burrowing Frog Neobatrachus aquilonius			
Desert Spadefoot Notaden nichollsi			X
Centralian Burrowing Frog Opisthodon spenceri			
MYOBATRACHIDAE (ground frogs)			
Glandular Toadlet Uperoleia glandulosa		CS3	
Northwest Toadlet Uperoleia russelli			

Reptiles

REPTILE SPECIES			Recorded
AGAMIDAE (dragons)			
	Amphibolurus longirostris		х
Ring-tailed Dragon	Ctenophorus caudicinctus		
Crested Dragon	Ctenophorus isolepis		
Central Netted Dragon	Ctenophorus nuchalis		
Western Netted Dragon	Ctenophorus reticulatus		
Blue-lined Dragon	Diporiphora winneckei		
Western Bearded Dragon	Pogona minor		х
DIPLODACTYLIDAE (stone §	geckoes and allies)		
Fat-tailed Gecko	Diplodactylus conspicillatus		
	Lucasium stenodactylum		
Beaked Gecko	Rhynchoedura ornata		
	Strophurus ciliaris		
	Strophurus elderi		
	Strophurus jeanae		
CARPHODACTYLIDAE (knob-tail geckoes)			
Smooth Knob-tailed Gecko Nephrurus levis			
GEKKONIDAE (dtellas and a	allies)		
Pilbara Dtella	Gehyra pilbara		
	Gehyra punctata		
	Gehyra purpurascens		
Varied Dtella	Gehyra variegata		
Asian House Gecko	Hemidactylus frenatus	INT.	
Bynoe's Gecko	Heteronotia binoei		
PYGOPODIDAE (legless-lizar	rds)		
	Delma haroldi		

Delma pax Delma tincta Burton's Legless-Lizard Burton's Legless-Lizard Delma tincta Burton's Legless-Lizard Delma tincta Pygopus nigriceps SCINCIDAE (skinks) Carlia munda Cryptoblepharus buchananii Fence Skink Cryptoblepharus plagiocephalus Ctenotus duricola Ctenotus grandis Ctenotus prandis Ctenotus helenae Leopard Ctenotus Ctenotus pantherinus Ctenotus pantherinus Ctenotus pantherinus Ctenotus serventyi Narrow-banded Sandswimmer Eremiascincus fasciolatus Lerista bipes Lerista clara Menetia greyii Morethia ruficauda Notoscincus ornatus Central Blue-tongue Tiliqua multifasciata VARANIDAE (goannas) Spiny-tailed Monitor Varanus acanthurus Short-tailed Pygmy Monitor Varanus brevicauda Pygmy Desert Monitor Varanus gouldii TYPHLOPIDAE (blind-snakes) Ramphotyphlops ammodytes Flower-pot Blind-Snake Ramphotyphlops pilbarensis	REPTILE SPECIES			Recorded
Burton's Legless-Lizard Pygopus nigriceps SCINCIDAE (skinks) Carlia munda Cryptoblepharus buchananii Fence Skink Cryptoblepharus plagiocephalus Ctenotus duricola Ctenotus grandis Ctenotus hanloni Ctenotus hanloni Ctenotus pantherinus Leopard Ctenotus Ctenotus piankai Ctenotus serventyi Narrow-banded Sandswimmer Eremiascincus fasciolatus Lerista bipes Lerista clara Menetia greyii Morethia ruficauda Notoscincus ornatus Central Blue-tongue Tiliqua multifasciata VARANIDAE (goannas) Spiny-tailed Monitor Varanus acanthurus Short-tailed Pygmy Monitor Varanus pouldii TYPHLOPIDAE (blind-snakes) Ramphotyphlops ammodytes Flower-pot Blind-Snake Ramphotyphlops grypus		Delma pax		
SCINCIDAE (skinks) Carlia munda Cryptoblepharus buchananii Fence Skink Cryptoblepharus plagiocephalus Ctenotus duricola Ctenotus grandis Ctenotus hanloni Ctenotus helenae Leopard Ctenotus Ctenotus pantherinus Ctenotus piankai Ctenotus piankai Ctenotus piankai Ctenotus serventyi Narrow-banded Sandswimmer Eremiascincus fasciolatus Lerista bipes Lerista clara Menetia greyii Morethia ruficauda Notoscincus ornatus Central Blue-tongue Tiliqua multifasciata VARANIDAE (goannas) Spiny-tailed Monitor Varanus acanthurus Short-tailed Pygmy Monitor Varanus pouldii TYPHLOPIDAE (blind-snakes) Ramphotyphlops ammodytes Flower-pot Blind-Snake Ramphotyphlops grypus		Delma tincta		
SCINCIDAE (skinks) Carlia munda Cryptoblepharus buchananii Fence Skink Cryptoblepharus plagiocephalus Ctenotus duricola Ctenotus grandis Ctenotus hanloni Ctenotus helenae Leopard Ctenotus Ctenotus pantherinus Ctenotus piankai Ctenotus piankai Ctenotus serventyi Narrow-banded Sandswimmer Eremiascincus fasciolatus Lerista bipes Lerista clara Menetia greyii Morethia ruficauda Notoscincus ornatus Central Blue-tongue Tiliqua multifasciata VARANIDAE (goannas) Spiny-tailed Monitor Varanus acanthurus Short-tailed Pygmy Monitor Varanus brevicauda Pygmy Desert Monitor Varanus gouldii TYPHLOPIDAE (blind-snakes) Ramphotyphlops ammodytes Flower-pot Blind-Snake Ramphotyphlops grypus	Burton's Legless-Lizard	Lialis burtonis		
Carlia munda Cryptoblepharus buchananii Fence Skink Cryptoblepharus plagiocephalus Ctenotus duricola Ctenotus grandis Ctenotus hanloni Ctenotus helenae Leopard Ctenotus Ctenotus pantherinus Ctenotus piankai Ctenotus piankai Ctenotus serventyi Narrow-banded Sandswimmer Eremiascincus fasciolatus Lerista bipes Lerista clara Menetia greyii Morethia ruficauda Notoscincus ornatus Central Blue-tongue Tiliqua multifasciata VARANIDAE (goannas) Spiny-tailed Monitor Varanus acanthurus Short-tailed Pygmy Monitor Varanus previcauda Pygmy Desert Monitor Varanus gouldii TYPHLOPIDAE (blind-snakes) Ramphotyphlops ammodytes Flower-pot Blind-Snake Ramphotyphlops grypus		Pygopus nigriceps		
Cryptoblepharus buchananii Fence Skink Cryptoblepharus plagiocephalus Ctenotus duricola Ctenotus grandis Ctenotus hanloni Ctenotus helenae Leopard Ctenotus Ctenotus pantherinus Ctenotus piankai Ctenotus piankai Ctenotus serventyi Narrow-banded Sandswimmer Eremiascincus fasciolatus Lerista bipes Lerista clara Menetia greyii Morethia ruficauda Notoscincus ornatus Central Blue-tongue Tiliqua multifasciata VARANIDAE (goannas) Spiny-tailed Monitor Varanus acanthurus Short-tailed Pygmy Monitor Varanus brevicauda Pygmy Desert Monitor Varanus gouldii TYPHLOPIDAE (blind-snakes) Ramphotyphlops ammodytes Flower-pot Blind-Snake Ramphotyphlops grypus	CINCIDAE (skinks)			
Fence Skink Ctenotus duricola Ctenotus grandis Ctenotus hanloni Ctenotus helenae Leopard Ctenotus Ctenotus pantherinus Ctenotus piankai Ctenotus serventyi Narrow-banded Sandswimmer Eremiascincus fasciolatus Lerista bipes Lerista clara Menetia greyii Morethia ruficauda Notoscincus ornatus Central Blue-tongue Tiliqua multifasciata VARANIDAE (goannas) Spiny-tailed Monitor Varanus acanthurus Short-tailed Pygmy Monitor Varanus brevicauda Pygmy Desert Monitor Varanus gouldii TYPHLOPIDAE (blind-snakes) Ramphotyphlops ammodytes Flower-pot Blind-Snake Ramphotyphlops grypus		Carlia munda		
Ctenotus duricola Ctenotus grandis Ctenotus hanloni Ctenotus helenae Leopard Ctenotus Ctenotus pantherinus Ctenotus piankai Ctenotus piankai Ctenotus serventyi Narrow-banded Sandswimmer Eremiascincus fasciolatus Lerista bipes Lerista clara Menetia greyii Morethia ruficauda Notoscincus ornatus Central Blue-tongue Tiliqua multifasciata VARANIDAE (goannas) Spiny-tailed Monitor Varanus acanthurus Short-tailed Pygmy Monitor Varanus brevicauda Pygmy Desert Monitor Varanus gouldii TYPHLOPIDAE (blind-snakes) Ramphotyphlops ammodytes Flower-pot Blind-Snake Ramphotyphlops grypus INT.		Cryptoblepharus buchananii		
Ctenotus prandis Ctenotus hanloni Ctenotus helenae Leopard Ctenotus Ctenotus pantherinus Ctenotus piankai Ctenotus serventyi Narrow-banded Sandswimmer Eremiascincus fasciolatus Lerista bipes Lerista clara Menetia greyii Morethia ruficauda Notoscincus ornatus Central Blue-tongue Tiliqua multifasciata VARANIDAE (goannas) Spiny-tailed Monitor Varanus acanthurus Short-tailed Pygmy Monitor Varanus eremius Gould's Monitor Varanus gouldii TYPHLOPIDAE (blind-snakes) Ramphotyphlops ammodytes Flower-pot Blind-Snake Ramphotyphlops grypus Lerista bipes Menetia greyii Morethia ruficauda Varentia greyii Morethia ruficauda Varentia greyii Morethia ruficauda Varentia greyii Morethia ruficauda Varanus eremius Varanus gouldii TYPHLOPIDAE (blind-snakes)	ence Skink Cry	ptoblepharus plagiocephalus		
Ctenotus hanloni Ctenotus helenae Leopard Ctenotus Ctenotus pantherinus Ctenotus piankai Ctenotus serventyi Narrow-banded Sandswimmer Eremiascincus fasciolatus Lerista bipes Lerista clara Menetia greyii Morethia ruficauda Notoscincus ornatus Central Blue-tongue Tiliqua multifasciata VARANIDAE (goannas) Spiny-tailed Monitor Varanus acanthurus Short-tailed Pygmy Monitor Varanus eremius Gould's Monitor Varanus gouldii TYPHLOPIDAE (blind-snakes) Flower-pot Blind-Snake Ramphotyphlops armodytes Flower-pot Blind-Snake Ramphotyphlops grypus		Ctenotus duricola		
Ctenotus helenae Leopard Ctenotus Ctenotus pantherinus Ctenotus piankai Ctenotus serventyi Narrow-banded Sandswimmer Eremiascincus fasciolatus Lerista bipes Lerista clara Menetia greyii Morethia ruficauda Notoscincus ornatus Central Blue-tongue Tiliqua multifasciata VARANIDAE (goannas) Spiny-tailed Monitor Varanus acanthurus Short-tailed Pygmy Monitor Varanus eremius Gould's Monitor Varanus gouldii TYPHLOPIDAE (blind-snakes) Ramphotyphlops ammodytes Flower-pot Blind-Snake Ramphotyphlops grypus		Ctenotus grandis		
Leopard Ctenotus Pantherinus Ctenotus piankai Ctenotus serventyi Narrow-banded Sandswimmer Eremiascincus fasciolatus Lerista bipes Lerista clara Menetia greyii Morethia ruficauda Notoscincus ornatus Central Blue-tongue Tiliqua multifasciata VARANIDAE (goannas) Spiny-tailed Monitor Varanus acanthurus Short-tailed Pygmy Monitor Varanus brevicauda Pygmy Desert Monitor Varanus eremius Gould's Monitor Varanus gouldii TYPHLOPIDAE (blind-snakes) Ramphotyphlops ammodytes Flower-pot Blind-Snake Ramphotyphlops grypus		Ctenotus hanloni		
Ctenotus piankai Ctenotus serventyi Narrow-banded Sandswimmer Eremiascincus fasciolatus Lerista bipes Lerista clara Menetia greyii Morethia ruficauda Notoscincus ornatus Central Blue-tongue Tiliqua multifasciata VARANIDAE (goannas) Spiny-tailed Monitor Varanus acanthurus Short-tailed Pygmy Monitor Varanus brevicauda Pygmy Desert Monitor Varanus eremius Gould's Monitor Varanus gouldii TYPHLOPIDAE (blind-snakes) Ramphotyphlops ammodytes Flower-pot Blind-Snake Ramphotyphlops grypus		Ctenotus helenae		
Ctenotus serventyi Narrow-banded Sandswimmer Eremiascincus fasciolatus Lerista bipes Lerista clara Menetia greyii Morethia ruficauda Notoscincus ornatus Central Blue-tongue Tiliqua multifasciata VARANIDAE (goannas) Spiny-tailed Monitor Varanus acanthurus Short-tailed Pygmy Monitor Varanus brevicauda Pygmy Desert Monitor Varanus eremius Gould's Monitor Varanus gouldii TYPHLOPIDAE (blind-snakes) Ramphotyphlops ammodytes Flower-pot Blind-Snake Ramphotyphlops grypus	eopard Ctenotus	Ctenotus pantherinus		
Narrow-banded Sandswimmer Eremiascincus fasciolatus Lerista bipes Lerista clara Menetia greyii Morethia ruficauda Notoscincus ornatus Central Blue-tongue Tiliqua multifasciata VARANIDAE (goannas) Spiny-tailed Monitor Varanus acanthurus Short-tailed Pygmy Monitor Varanus brevicauda Pygmy Desert Monitor Varanus eremius Gould's Monitor Varanus gouldii TYPHLOPIDAE (blind-snakes) Ramphotyphlops ammodytes Flower-pot Blind-Snake Ramphotyphlops grypus		Ctenotus piankai		
Lerista bipes Lerista clara Menetia greyii Morethia ruficauda Notoscincus ornatus Central Blue-tongue Tiliqua multifasciata VARANIDAE (goannas) Spiny-tailed Monitor Varanus acanthurus Short-tailed Pygmy Monitor Varanus brevicauda Pygmy Desert Monitor Varanus eremius Gould's Monitor Varanus gouldii TYPHLOPIDAE (blind-snakes) Ramphotyphlops ammodytes Flower-pot Blind-Snake Ramphotyphlops grypus		Ctenotus serventyi		
Lerista clara Menetia greyii Morethia ruficauda Notoscincus ornatus Central Blue-tongue Tiliqua multifasciata VARANIDAE (goannas) Spiny-tailed Monitor Varanus acanthurus Short-tailed Pygmy Monitor Varanus brevicauda Pygmy Desert Monitor Varanus eremius Gould's Monitor Varanus gouldii TYPHLOPIDAE (blind-snakes) Ramphotyphlops ammodytes Flower-pot Blind-Snake Ramphotyphlops grypus	larrow-banded Sandswimme	er Eremiascincus fasciolatus		
Menetia greyii Morethia ruficauda Notoscincus ornatus Central Blue-tongue Tiliqua multifasciata VARANIDAE (goannas) Spiny-tailed Monitor Varanus acanthurus Short-tailed Pygmy Monitor Varanus brevicauda Pygmy Desert Monitor Varanus eremius Gould's Monitor Varanus gouldii TYPHLOPIDAE (blind-snakes) Ramphotyphlops ammodytes Flower-pot Blind-Snake Ramphotyphlops grypus		Lerista bipes		
Morethia ruficauda Notoscincus ornatus Central Blue-tongue Tiliqua multifasciata VARANIDAE (goannas) Spiny-tailed Monitor Varanus acanthurus Short-tailed Pygmy Monitor Varanus brevicauda Pygmy Desert Monitor Varanus eremius Gould's Monitor Varanus gouldii TYPHLOPIDAE (blind-snakes) Ramphotyphlops ammodytes Flower-pot Blind-Snake Ramphotyphlops grypus		Lerista clara		
Central Blue-tongue Tiliqua multifasciata VARANIDAE (goannas) Spiny-tailed Monitor Varanus acanthurus Short-tailed Pygmy Monitor Varanus brevicauda Pygmy Desert Monitor Varanus eremius Gould's Monitor Varanus gouldii TYPHLOPIDAE (blind-snakes) Ramphotyphlops ammodytes Flower-pot Blind-Snake Ramphotyphlops grypus		Menetia greyii		
Central Blue-tongue Tiliqua multifasciata VARANIDAE (goannas) Spiny-tailed Monitor Varanus acanthurus Short-tailed Pygmy Monitor Varanus brevicauda Pygmy Desert Monitor Varanus eremius Gould's Monitor Varanus gouldii TYPHLOPIDAE (blind-snakes) Ramphotyphlops ammodytes Flower-pot Blind-Snake Ramphotyphlops grypus		Morethia ruficauda		
VARANIDAE (goannas) Spiny-tailed Monitor Varanus acanthurus Short-tailed Pygmy Monitor Varanus brevicauda Pygmy Desert Monitor Varanus eremius Gould's Monitor Varanus gouldii TYPHLOPIDAE (blind-snakes) Ramphotyphlops ammodytes Flower-pot Blind-Snake Ramphotyphlops braminus Beaked Blind-Snake Ramphotyphlops grypus		Notoscincus ornatus		
Spiny-tailed Monitor Varanus acanthurus Short-tailed Pygmy Monitor Varanus brevicauda Pygmy Desert Monitor Varanus eremius Gould's Monitor Varanus gouldii TYPHLOPIDAE (blind-snakes) Ramphotyphlops ammodytes Flower-pot Blind-Snake Ramphotyphlops grypus Beaked Blind-Snake Ramphotyphlops grypus	Central Blue-tongue	Tiliqua multifasciata		
Short-tailed Pygmy Monitor Varanus brevicauda Pygmy Desert Monitor Varanus eremius Gould's Monitor Varanus gouldii TYPHLOPIDAE (blind-snakes) Ramphotyphlops ammodytes Flower-pot Blind-Snake Ramphotyphlops braminus INT. Beaked Blind-Snake Ramphotyphlops grypus	'ARANIDAE (goannas)			
Pygmy Desert Monitor Varanus eremius Gould's Monitor Varanus gouldii TYPHLOPIDAE (blind-snakes) Ramphotyphlops ammodytes Flower-pot Blind-Snake Ramphotyphlops braminus INT. Beaked Blind-Snake Ramphotyphlops grypus	piny-tailed Monitor	Varanus acanthurus		
Gould's Monitor Varanus gouldii TYPHLOPIDAE (blind-snakes) Ramphotyphlops ammodytes Flower-pot Blind-Snake Ramphotyphlops braminus INT. Beaked Blind-Snake Ramphotyphlops grypus	hort-tailed Pygmy Monitor	Varanus brevicauda		
TYPHLOPIDAE (blind-snakes) Ramphotyphlops ammodytes Flower-pot Blind-Snake Ramphotyphlops braminus INT. Beaked Blind-Snake Ramphotyphlops grypus	ygmy Desert Monitor	Varanus eremius		
Ramphotyphlops ammodytes Flower-pot Blind-Snake Ramphotyphlops braminus INT. Beaked Blind-Snake Ramphotyphlops grypus	ould's Monitor	Varanus gouldii		
Flower-pot Blind-Snake Ramphotyphlops braminus INT. Beaked Blind-Snake Ramphotyphlops grypus	YPHLOPIDAE (blind-snake	s)		
Beaked Blind-Snake Ramphotyphlops grypus		Ramphotyphlops ammodytes		
1 01 1 0 01	lower-pot Blind-Snake	Ramphotyphlops braminus	INT.	
	Beaked Blind-Snake	Ramphotyphlops grypus		
	ilbara Blind-Snake			
BOIDAE (pythons)	SOIDAE (pythons)			
Black-headed Python Aspidites melanocephalus		Aspidites melanocephalus		
Woma Aspidites ramsayi CS1	-		CS1	
ELAPIDAE (front-fanged snakes)	LAPIDAE (front-fanged sna	kes)		
Desert Death Adder Acanthophis pyrrhus		-		
Yellow-faced Whipsnake Demansia psammophis	ellow-faced Whipsnake			
Rufous Whipsnake Demansia rufescens	_	Demansia rufescens		
Moon Snake Furina ornata				
Mulga Snake Pseudechis australis	Tulga Snake	Pseudechis australis		
Ringed Brown Snake Pseudonaja modesta	Ringed Brown Snake	Pseudonaja modesta		
Gwardar Pseudonaja nuchalis				
Desert Banded Snake Simoselaps anomalus	Desert Banded Snake	-		
Rosen's Snake Suta fasciata	Rosen's Snake			
·	ittle Spotted Snake	Suta punctata		

Birds

SPECIES	Status	Recorded
CASUARIIDAE (emu)		
Emu Dromaius novaehollandiae		
COTURNIDAE (true quails)		
Brown Quail Coturnix ypsilophora		
COLUMBIDAE (doves and pigeons)		
Rock Dove Columba livia	INT.	
Crested Pigeon Ocyphaps lophotes		х
Spinifex Pigeon Geophaps plumifera		
Diamond Dove Geopelia cuneata		х
Peaceful Dove Geopelia striata		
Bar-shouldered Dove Geopelia humeralis		х
PODARGIDAE (frogmouths)		
Tawny Frogmouth Podargus strigoides		
CAPRIMULGIDAE (nightjars)		
Spotted Nightjar Eurostopodus argus		
AEGOTHELIDAE (owlet-nightjar)		
Australian Owlet-nightjar Aegotheles cristatus		
APODIDAE (swifts and swiftlets)		
Fork-tailed Swift Apus pacificus	CS1	
CICONIIDAE (storks)		
Black-necked Stork Ephippiorhynchus asiaticus		
ARDEIDAE (herons and egrets)		
White-necked Heron Ardea pacifica		
White-faced Heron Egretta novaehollandiae		
Little Egret Egretta garzetta		
Nankeen Night-Heron Nycticorax caledonicus		
THRESKIORNIDAE (ibis and spoonbills)		
Glossy Ibis Plegadis falcinellus		
Australian White Ibis Threskiornis molucca		
Straw-necked Ibis Threskiornis spinicollis		
Royal Spoonbill Platalea regia		
Yellow-billed Spoonbill Platalea flavipes		
ACCIPITRIDAE (hawks, eagles and kites)		
Eastern Osprey Pandion cristatus		
Black-shouldered Kite Elanus axillaris		х
Square-tailed Kite Lophoictinia isura		
White-bellied Sea-Eagle Haliaeetus leucogaster		
Whistling Kite Haliastur sphenurus		
Brahminy Kite Haliastur indus		
Black Kite Milvus migrans		
Brown Goshawk Accipiter fasciatus		
Collared Sparrowhawk Accipiter cirrocephalus		
Spotted Harrier Circus assimilis		
Swamp Harrier Circus approximans		
Wedge-tailed Eagle Aquila audax		
Little Eagle Hieraaetus morphnoides		
FALCONIDAE (falcons)		
Nankeen Kestrel Falco cenchroides		х
Brown Falcon Falco berigora		х

SPECIES		Status	Recorded
Australian Hobby Falco longipe	ennis		
Peregrine Falcon Falco pereg		CS1	
Grey Falcon Falco hypole		CS2	
RALLIDAE (rails and crakes)			
Buff-banded Rail Gallirallus philippe	ensis		
Black-tailed Native-hen Tribonyx ven			
OTIDIDAE (bustards)			
Australian Bustard Ardeotis aus	tralis	CS2	х
BURHINIDAE (stone-curlews)			
Bush Stone-curlew Burhinus grall	arius	CS2	
CHARADRIIDAE (plovers and dotterels)			
Black-fronted Dotterel Elseyornis mela	nops		X
Red-kneed Dotterel Erythrogonys cir	nctus		
TURNICIDAE (button-quail)			
Little Button-quail Turnix	velox		X
GLAREOLIDAE (pratincoles)			
Oriental Pratincole Glareola maldive	arum	CS1	x
Australian Pratincole Stiltia isa	bella		
LARIDAE (gulls and terns)			
Silver Gull Chroicocephalus novaehollar	ndiae		
CACATUIDAE (cockatoos and allies)			
Galah Eolophus roseicap	pillus		X
Little Corella Cacatua sangi	ıinea		X
Cockatiel Nymphicus holland	dicus		X
PSITTACIDAE (parrots)			
Australian Ringneck Barnardius zon	arius		
Budgerigar Melopsittacus undu	latus		X
CUCULIDAE (cuckoos)			
Pheasant Coucal Centropus phasiar	ninus		
Horsfield's Bronze-Cuckoo Chalcites ba	ısalis		x
Pallid Cuckoo Cacomantis pal	llidus		
STRIGIDAE (hawk-owls)			
Barking Owl Ninox conn	ivens		
Southern Boobook Ninox novaeseelar	ndiae		
TYTONIDAE (barn owls)			
Eastern Barn Owl Tyto java	anica		
HALCYONIDAE (kookaburras and allies)			
Blue-winged Kookaburra Dacelo le			
Red-backed Kingfisher Todiramphus pyrrhopy			X
Sacred Kingfisher Todiramphus sar	nctus		
MEROPIDAE (bee-eaters)			
Rainbow Bee-eater Merops orr	natus	CS1	X
PTILONORHYNCIDAE (bowerbirds)			
Western Bowerbird Ptilonorhynchus gut	tatus		
MALURIDAE (fairy-wrens)	,		
White-winged Fairy-wren Malurus leucop			X
Variegated Fairy-wren Malurus lam	ıberti		
PARDALOTIDAE (pardalotes)			
Red-browed Pardalote Pardalotus rubric			
Striated Pardalote Pardalotus str	ratus		
MELIPHAGIDAE (honeyeaters)			

SPECIES			Recorded
Singing Honeyeater	Lichenostomus virescens		X
Grey-headed Honeyeater	Lichenostomus keartlandi		
White-plumed Honeyeater	Lichenostomus penicillatus		
Yellow-throated Miner	Manorina flavigula		
Crimson Chat	Epthianura tricolor		X
Brown Honeyeater	Lichmera indistincta		
POMATOSTOMIDAE (Austr	alian babblers)		
Grey-crowned Babbler	Pomatostomus temporalis		
CAMPEPHAGIDAE (cuckoo-	-shrikes and trillers)		
Black-faced Cuckoo-shrike	Coracina novaehollandiae		X
White-winged Triller	Lalage sueurii		
PACHYCEPHALIDAE (whist	tlers and allies)		
Rufous Whistler	Pachycephala rufiventris		
Grey Shrike-thrush	Colluricincla harmonica		
Crested Bellbird	Oreoica gutturalis		
ARTAMIDAE (woodswallows			
White-breasted Woodswallo	•		
Masked Woodswallow	Artamus personatus		
Black-faced Woodswallow	Artamus cinereus		Х
Pied Butcherbird	Cracticus nigrogularis		
Australian Magpie	Cracticus tibicen		
RHIPIDURIDAE (fan-tails)			
Grey Fantail	Rhipidura albiscapa		
Willie Wagtail	Rhipidura leucophrys		
CORVIDAE (crows and rave			
Little Crow			
Torresian Crow	Corvus bennetti Corvus orru		X
MONARCHIDAE (flycatcher			
Magpie-lark	Grallina cyanoleuca		X
ALAUDIDAE (larks)	<u> </u>		
Horsfield's Bushlark	Mirafra javanica		
MEGALAURIDAE (songlark			
Rufous Songlark	Cincloramphus mathewsi		X
Brown Songlark	Cincloramphus cruralis		Х
Spinifexbird	Eremiornis carteri		X
HIRUNDINIDAE (swallows a			
White-backed Swallow	Cheramoeca leucosterna		
Barn Swallow	Hirundo rustica	CS1	
Welcome Swallow	Hirundo neoxena		
Fairy Martin	Petrochelidon ariel		
Tree Martin	Petrochelidon nigricans		X
NECTARINIDAE (flowerped	· · · · · · · · · · · · · · · · · · ·		
Mistletoebird	Dicaeum hirundinaceum		
ESTRILDIDAE (finches)	= 10000 co		
Zebra Finch	Taeniopygia guttata		х
Star Finch	Neochmia ruficauda	CS2	
Painted Finch	Emblema pictum	352	
Pictorella Mannikin	Heteromunia pectoralis	CS2	X
MOTACILLIDAE (pipits and	*	352	21
Australasian Pipit	Anthus novaeseelandiae		
Yellow Wagtail	Motacilla aff. flava		
TCHOW WAGIAN	тошени ан. јшта	<u> </u>	

MAMMALS

SPECIES			Recorded
TACHYGLOSSIDAE (echidna)			
Echidna			
DASYURIDAE (carnivorou			
Kultarr	Antechinomys laniger		
Ampurta (Brush-tailed Mu	llgara) Dasycercus blythi	CS2	
Crest-tailed Mulgara	Dasycercus cristicauda	CS1	
Little Red Kaluta	Dasykaluta rosamondae		
Pilbara Ningaui	Ningaui timealeyi		
Lesser Hairy-footed Dunna	art <i>Sminthopsis</i> youngsoni		
THYLACOMYIDAE (bilbie	s)		
Greater Bilby	Macrotis lagotis	CS1	
MACROPODIDAE (wallab	es and kangaroos)		
Euro	Macropus robustus		X
Red Kangaroo	Macropus rufus		
PTEROPIDAE (fruit-bats a	and flying-foxes)		
Little Red Flying-fox	Pteropus scapulatus		х
MEGADERMATIDAE (fals			
Ghost Bat	Macroderma gigas	CS2	
HIPPOSIDERIDAE (leaf-n	osed bats)		
Pilbara Orange Leaf-nosed	CS1		
EMBALLONURIDAE (shea			
Yellow-bellied Sheathtail Bat Saccolaimus flaviventris			Х
Common Sheathtail Bat	Taphozous georgianus		
VESPERTILIONIDAE (eve	ning bats)		
Gould's Wattled Bat	Chalinolobus gouldii		х
Arnhem Long-eared Bat	Nyctophilus arnhemensis		
Northern Long-eared Bat	Nyctophilus daedalus		
Lesser Long-eared Bat	Nyctophilus geoffroyi		
Little Broad-nosed Bat	Scotorepens greyii		Х
Inland Cave Bat	Vespadelus finlaysoni		
MOLOSSIDAE (freetail bat			
White-striped Freetail Bat	Tadarida australis		
Northern Freetail Bat	Chaerephon jobensis		х
Beccari's Freetail Bat	Mormopterus beccarii		
MURIDAE (rodents)	•		
House Mouse	Mus musculus	INT	
Northern Hopping-Mouse	Notomys alexis		
Delicate Mouse	Pseudomys delicatulus		
	domys hermannsburgensis		
Western Chestnut Mouse	Pseudomys nanus		
CANIDAE (dogs and foxes)			
	anis lupus dingo/familiaris	INT	Х
European Fox	Vulpes vulpes	INT	
FELIDAE (cats)			
Feral Cat	Felis catus	INT	
	o he introduced although in		· 1

^{*}Dingo/feral dog is considered to be introduced although in an ecological sense may best be considered native or at least naturalised.

Significant fauna species considered to be extinct in the project area.

Species			Comments
Dasyuridae (carnivorous marsupials)			
Northern Quoll Dasyurus hallacatus			
Western Quoll	Dasyurus geofroii	CS1	
Peramelidae (bandicoots and bilbies)			
Golden Bandicoot Isoodon auratus			
Pig-footed Bandicoot	CS1	Extinct	
Desert Bandicoot Perameles eremiana			Extinct
Phalangeridae (possums)			
Common Brush-tailed Possum Trichosurus vulpecula			
Potoroidae (potoroo's and allies)			
Woylie, Burrowing Bettong	Bettongia lesueur	CS1	
Boodie, Brush-tailed Bettong Bettongia penicillata			
Macropodidae (kangaroos and allies			
Spectacled Hare-Wallaby	Lagorchestes conspicillatus	CS1	
Rufous Hare-Wallaby Lagochestes hirsutus			

Appendix 6. Field data on fauna.

A) <u>Motion-sensitive camera results.</u>

BCE01.

• No images.

BCE03.

• 7th Feb 2012 Australian Magpie-lark observed drinking from small waterbody.

BCE04.

· No images.

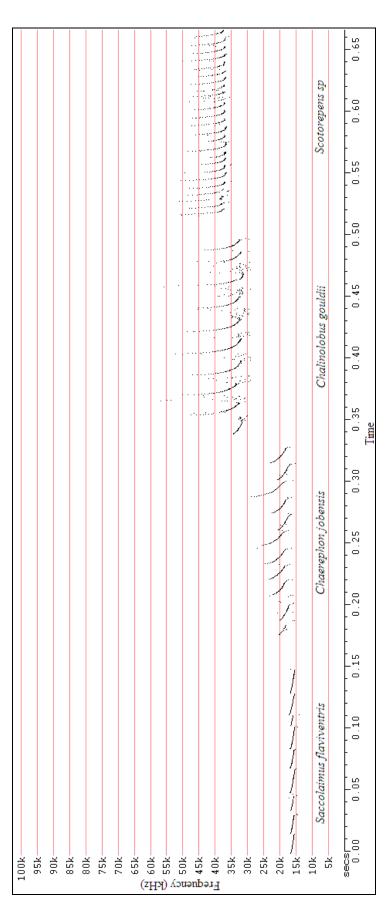
See Table 2 for details of motion-camera locations and recording periods.

B) Anabat results

Four microbat species were recorded, with details of the call characteristics provided in Table 10 and Figure 7.

Table 10. Call characteristics of microbat species recorded from the study area. Presented as an average (± standard deviation)

SPECIES	Number of pulses	Dur (ms)	F _{MAX} (kHz)	F _{MIN} (kHz)	F _{PEAK} (kHz)
Chaaranhan iahanais	10	10.64	22.07	18.03	18.86
Chaerephon jobensis	12	(±1.75)	(±2.88)	(±0.97)	(±0.72)
Sacralaimus flavivantais	9	13.75	17.21	15.85	16.09
Saccolaimus flaviventris		(±3.87)	(±1.36)	(±0.57)	(±0.48)
Chalinalahua mauldii	15	9.15	43.25	33.43	32.28
Chalinolobus gouldii	15	(±2.87)	(±6.56)	(±1.41)	(±0.55)
Costomoromoromii	24	4.82	51.64	37.08	37.65
Scotorepens greyii		(±1.30)	(±7.75)	(±1.70)	(±0.27)



South Hedland – Western Edge Precinct; Fauna Assessment

Samples of Anabat calls recorded from microbats within the study area. Calls presented with pulses at 16 expansion and time between calls compressed. Figure 7.

Appendix 7. Annotated species list for fauna assessment of the South Hedland – Western Edge Precinct.

Frogs

- 1. **Notaden nichollsi**. Two recorded along access tracks in Area A during evening vehicle traverses (6-7/2).
- 2. **Cyclorana sp.** One found along creek south-west of the study area (7/2).

Reptiles

- 1. *Amphibolurus longirostris*. Several recorded along creekline south-west of the study area (7-8/2).
- 2. **Pogona minor.** One observed basking part way up a small shrub in Area A (7/2)

Birds

- 1. **Crested Pigeon**. Small flocks (3-5 birds) seen regularly throughout the study areas.
- 2. **Diamond Dove**. Several seen throughout site, usually in association with small waterbodies/creeklines.
- 3. Bar-shouldered Dove. D
- 4. **Black-shouldered Kite.** One seen hunting over Area B and perching on powerlines (6/2).
- 5. **Nankeen Kestrel.** Regularly seen hunting over the study areas or perching on powerlines.
- 6. **Brown Falcon.** One seen hunting over Area A (8/2).
- 7. **Australian Bustard.** Remains of at least two birds recorded from powerline tracks on the southern boundary of Area A (6/2).
- 8. **Black-fronted Dotterel.** One seen along semi-permanent pools along creekline west of the study areas.
- 9. **Little Button-quail.** Several flushed during foot traverses of the study area.
- 10. **Oriental Pratincole.** Large flocks (200+ birds) seen flying over the study area in an easterly direction (7th pm 8th am/2).
- 11. **Galah.** Small flocks seen regularly across the study areas.
- 12. **Little Corella.** Small flocks heard and seen regularly, usually flying southwards during the morning and northwards during late afternoon.
- 13. **Cockatiel.** Several small flocks seen flying over the site (7/2)
- 14. **Budgerigar**. Several flocks (20-40? birds) heard and seen flying over the study areas (6-7/2).

- 15. **Horsfield's Bronze-Cuckoo.** One heard calling from west of the study areas (7/2).
- 16. **Red-backed Kingfisher.** A single individual seen perching on powerlines to the west of the study area (8/2).
- 17. **Rainbow Bee-eater.** A large group of birds, possibly on their northwards migration, seen flying over the study areas (7/2).
- 18. **White-winged Fairy-wren.** Several small groups heard and/or seen throughout the study areas.
- 19. **Singing Honeyeater.** Heard and seen regularly throughout the study area.
- 20. Crimson Chat. Heard regularly throughout site but only seen occasionally.
- 21. **Black-faced Cuckoo-shrike.** A pair of birds seen crossing over Area A (6/2).
- 22. **Black-faced Woodswallow.** Common throughout study areas. Seen regularly perching on overhead powerlines.
- 23. **Torresian Crow.** Small flocks (3-7 birds) seen west of the study areas.
- 24. **Magpie-lark.** Common throughout study areas.
- 25. **Rufous Songlark.** Heard and seen throughout the study area and surrounds (6-8/2).
- 26. **Brown Songlark.** Heard and seen throughout the study area and surrounds (6-8/2).
- 27. **Spinifexbird.** One seen amongst Spinifex in Area A (8/2) and others heard throughout study areas.
- 28. **Tree Martin.** Occasionally seen over the study areas.
- 29. Zebra Finch. Large flocks seen throughout the study area.
- 30. **Pictorella Mannikin.** Small group of 3-4 birds seen amongst large flocks of Zebra Finches coming into drink at a small ephemeral pool in Area B

Mammals

- 1. **Euro**. Tracks seen throughout the study area and two individuals seen in grassland mosaic of Area A (7/2).
- 2. **Little Red Flying-fox**. Large flocks seen flying over the site in a southwesterly direction, perhaps towards Turner River (7/2).
- 3. **Yellow-bellied Sheathtail Bat** Saccolaimus flaviventris. Recorded over Area A.
- 4. **Gould's Wattled Bat** Chalinolobus gouldii. Recorded over Area A.
- 5. **Little Broad-nosed Bat** Scotorepens greyii. Recorded over Area A.
- 6. **Northern Freetail Bat** Chaerephon jobensis. Recorded over Area A.

7. **Dog/Dingo.** Tracks throughout; people walked dogs throughout the study

APPENDIX 5

Inspection of Animal Burrows at South Hedland



M.J. & A.R. Bamford CONSULTING ECOLOGISTS 23 Plover Way, Kingsley, WA, 6026

ph: 08 9309 3671 fx: 08 9409 2710 eml: bamford.consulting@iinet.net.au

ABN 84 926 103 081

Inspection of Animal Burrows at South Hedland

During field investigations at the South Hedland Western Edge Precinct in March 2012, RPS personnel located large animal burrows at: 665,845mE, 7,741,236mN; 665,816mE, 7,741,267mN; and 665,967mE, 7,740,915mN. The species of animal that had dug the burrows was uncertain, and could not be identified even from photographs provided to Bamford Consulting Ecologists (BCE). Therefore a site visit to examine these burrows was carried out on 20th April 2012 by Dr Mike Bamford and Mr Brenden Metcalf of BCE. This was considered important because the burrows had some resemblance to those of the Greater Bilby *Macrotis lagotis*, a species of high conservation significance known to persist in parts of the Pilbara. Both Dr Bamford and Mr Metcalf are familiar with the burrows of this and many other species in the Pilbara.

The three burrows were successfully re-located and additional similar burrows were also found. All were identified as foraging burrows of a large varanid lizard (goanna or monitor lizard), probably Gould's Goanna *Varanus gouldii*. Although the large piles of earth and the large entrance resembled the burrows of a Bilby, all burrows turned sharply down, all followed a small burrow of a spider or rodent, and all had at least an indication of a ridge on the lower surface, typically left because of the digging action employed by goannas. They were therefore not shelter burrows of a Bilby, which lack these features, and nor were they foraging burrows of a Bilby, which are smaller and a different shape. Some time was spent in the vicinity of the burrows and no Bilby tracks were found.

While the project area is within the known range of the Bilby, it can be concluded that there has been no Bilby activity in the area in the recent past.

Dr Mike Bamford Supervising Scientist



APPENDIX 3

Aboriginal Heritage Survey Report

PRELIMINARY ADVICE OF AN ABORIGINAL HERITAGE SURVEY OF THE SOUTH HEDLAND TOWN CENTRE DEVELOPMENT PROJECT, SOUTH HEDLAND, PILBARA REGION, WESTERN AUSTRALIA

May 2012

for *Marapikurrinya* Pty Ltd &
LandCorp

by Anthropos Australis Pty Ltd



INTRODUCTION

(Note: this document is to be read in conjunction with the attached Mapping)

LandCorp is proposing to develop land on the western boundary of the town of South Hedland in the Pilbara region of Western Australia (the Project Area, see Figure 1).

This Preliminary Advice details the results of an Aboriginal Heritage Survey (the Survey) that used a Site Avoidance methodology to examine the Survey Area, which lies within the *Kariyarra* native title claim (WC 99/003 – see Figure 1).

Marapikurrinya Pty Ltd (MPL) manages the conduct of Aboriginal heritage surveys on behalf of the *Kariyarra* native title claimants for South Hedland. MPL in turn engaged Anthropos Australis Pty Ltd to undertake the Survey.

The Survey Area (see Figure 1 and Table 1) consists of:

- Lot 3257 comprising an area of approximately 3.25 ha;
- Lot 3259 comprising an area of approximately 3.30 ha;
- Lot 308 comprising an area of approximately 85.3 ha;
- Stage 1C comprising an area of approximately 2.74 ha; and
- Lot 6109 comprising an area of approximately 0.97 ha.

The objective of the Survey was to:

• Examine the Survey Area in order to identify and record any Aboriginal ethnographic and archaeological sites pursuant to the *Aboriginal Heritage Act* 1972 (the Act), to Site Avoidance standard.

The Survey was conducted from Friday the 23rd of September 2011 to Saturday the 24th of September 2011 inclusive, by Catherine La Puma, Andrew Dowding and Tristan Adfield of Anthropos Australis Pty Ltd.

The Survey was conducted with the cooperation and involvement of the *Kariyarra* native title claimants nominated by MPL (the *Marapikurrinya* Consultants - see Plate 1).

This Preliminary Advice has been prepared in order to provide feedback to the Survey participants, MPL and LandCorp on the conduct and results of the Survey. A full Report on the Survey will be provided to MPL and LandCorp in due course.



Anthropos Australis Pty Ltd – May 2012

1

Table 1: Boundary Nodes of the Survey Area (GDA 94, Zone 50)

Point	Easting*	Northing*
Tome	(± 10m)	(± 10m)
1	665917	7742308
2	666387	7742294
3	666534	7742233
4	666540	7742190
5	666537	7741994
6	666437	7741996
7	666436	7741946
8	666537	7741944
9	666535	7741842
10	666567	7741836
11	666876	7741753
12	666919	7741714
13	666937	7741716
14	666945	7741547
15	666950	7741496
16	666958	7741445
17	666969	7741395
18	666984	7741346
19	666991	7741329
20	666986	7741315
21	666881	7741271
22	666547	7740718
23	666061	7741019
24	666010	7741062
25	665951	7741130
26	665926	7741216
27	665915	7742224



PERSONNEL

The following people and organizations participated in the Survey (the Survey Team):

ANTHROPOS AUSTRALIS PTY LTD

Catherine La Puma Andrew Dowding Tristan Adfield

MARAPIKURRINYA CONSULTANTS

Steven Stewart Snr Thomas Monaghan Frank Brown

Cliff Taylor Darryl Brown

Plate 1: The Marapikurrinya Survey Team at the Survey Area





SURVEY METHODS

The Survey involved the use of the following methods:

- 1. Archival research;
- 2. A formal ethnographic and archaeological Survey of the Survey Area; and
- 3. Consultation with the *Marapikurrinya* Consultants as representatives of MPL.

The archival research involved a Register search conducted at the Department of Indigenous Affairs (DIA) in order to access Aboriginal site files pertaining to previously recorded Aboriginal sites within the Survey Area and heritage survey reports detailing previous heritage surveys conducted in the region.

The results of the archival research were used to inform the Survey Team as to the nature and type of Aboriginal sites that could be expected to be encountered during the Survey and also to alert the Survey Team to the presence of those sites that have already been recorded in close proximity to the Survey Area itself.

The archival research showed that there are **no** previously recorded Aboriginal sites within the Survey Area (see Appendix 1).

PARTICIPATION OF THE MARAPIKURRINYA CONSULTANTS

The Survey Area is located within the *Kariyarra* native title claim area, which has been continuously used and occupied by the *Marapikurrinya* People until and including the present day. The *Marapikurrinya* People have a continued and enduring empathy and emotional and spiritual attachment to Country.

The *Marapikurrinya* Consultants that participated in the Survey were born and live in Port Hedland and the surrounding district and are very familiar with the Survey Area.

The *Marapikurrinya* Consultants that participated in the Survey were previously chosen by MPL. Diana Robinson and Kerry Robinson of MPL organised the *Marapikurrinya* Consultants that participated in the Survey.

SURVEY METHOD

At 9:36 am, on Friday the 23rd of September 2011, Catherine La Puma, Andrew Dowding, Tristan Adfield, Kerry Robinson, Steven Stewart Senior, Frank Brown, Darryl Brown, Cliff Stewart and Thomas Monaghan (the Survey Team) arrived at the Survey Area, after travelling in convoy from Port Hedland. Catherine La Puma and



4

Anthropos Australis Pty Ltd – May 2012

Andrew Dowding conducted a briefing on the Scope of Works and the Survey Methodology.

At 9:40 am, the Archaeological Survey Team assembled at the north eastern corner of the Survey Area, and commenced walking pedestrian transects of the Survey Area in an east/west direction, progressing southwards.

At 10:46 am, the Survey Team stopped for morning tea, utilising the facilities at Wangka Maya.

At 11:20 am, the Survey Team departed *Wangka Maya* for the Survey Area, arriving at 11:22 am. The Archaeological Survey Team resumed walking pedestrian transects of the Survey Area in an east/west direction, progressing southwards. The Ethnographic Survey Team discussed the ethnographic values of the Survey Area.

At 12:48 pm, the Survey Team stopped for lunch, once more utilising the facilities at *Wangka Maya*. At 1:42 pm, lunch was concluded and the Survey Team returned to the Survey Area, where the Archaeological Survey Team continued the pedestrian transects of the Survey Area.

At 2:55 pm, the Archaeological portion of the Survey was completed, and the Survey Team departed the Survey Area in order to return the *Marapikurrinya* Consultants to their respective homes in South Hedland and Port Hedland.

At 3:40 pm, Catherine La Puma, Andrew Dowding and Tristan Adfield arrived at their accommodation at Port Haven.

At 6:25 am, on Saturday the 24th of September, Catherine La Puma, Andrew Dowding and Tristan Adfield collected ice and supplies from their accommodation at Port Haven.

At 6:45 am, Catherine La Puma, Andrew Dowding and Tristan Adfield departed Port Haven for the Harbour Café in Port Hedland, arriving at 6:45 am, where they collected lunch and drinks for the day

At 7:09 am, Catherine La Puma, Andrew Dowding and Tristan Adfield departed the Harbour Café to collect the *Marapikurrinya* Consultants from their respective houses. They then continued on to the Survey Area.

At 7:40 am, Catherine La Puma, Andrew Dowding, Tristan Adfield, Steven Stewart Senior, Frank Brown, Darryl Brown, Cliff Stewart and Thomas Monaghan (the Survey Team) arrived at the Survey Area. The Survey Team proceeded to discuss the Survey Area and the Recommendations of the Survey. The Survey Team additionally took a Survey Team photograph.

At 8:15 am, the Survey Team concluded the Survey and departed the Survey Area in their respective vehicles, with the *Marapikurrinya* Consultants returning to their



5

houses, while Catherine La Puma, Andrew Dowding and Tristan Adfield departed for the MPL Office, in order to store their survey equipment.

At 8:30 am, Catherine La Puma and Tristan Adfield departed the MPL Office for their accommodation at Port Haven, while Andrew Dowding departed for Karratha. Catherine La Puma and Tristan Adfield arrived at Port Haven at 8:45 am.

At 5:30 pm, Catherine La Puma and Tristan Adfield departed their accommodation for Port Hedland Airport, where they took the 6:30 pm flight to Perth.

ETHNOGRAPHIC AND ARCHAEOLOGICAL SURVEY METHOD

The Aboriginal ethnographic component of the Survey was undertaken by driving to specific vantage points and places of interest within and adjacent to the Survey Area, at the direction of the *Marapikurrinya* Consultants. At each of these points, the extent of the Survey Area and associated ethnographic values were discussed by the Ethnographic Survey Team.

The Aboriginal archaeological component of the Survey was undertaken using pedestrian transects which provided 100% coverage of the Survey Area, with the Archaeological Survey Team members spaced 20 m apart at the commencement of each Transect (see Plate 2).

Catherine La Puma, Andrew Dowding and Tristan Adfield undertook regular briefings and debriefings with the *Marapikurrinya* Consultants during the course of the Survey (see Plate 3).

Catherine La Puma, Andrew Dowding and Tristan Adfield recorded details of the Survey in field notebooks and on recording sheets.

A pictorial record of the conduct of the Survey was also recorded on digital camera. GPS readings using the GDA 94 Datum that uses the MGA Grid Zone 50K were taken at selected points within the Survey Area in order to verify pre-existing coordinates and to record new co-ordinates.

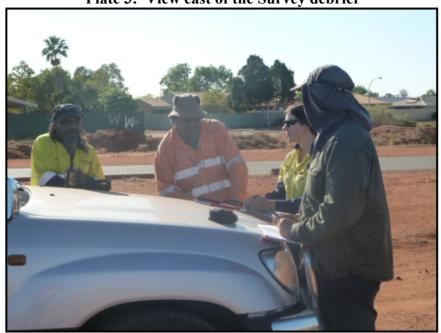


6

Plate 2: View east of the Survey Team walking transects in the Survey Area



Plate 3: View east of the Survey debrief





 $Anthropos\ Australis\ Pty\ Ltd-May\ 2012$

RESULTS

LOCATION

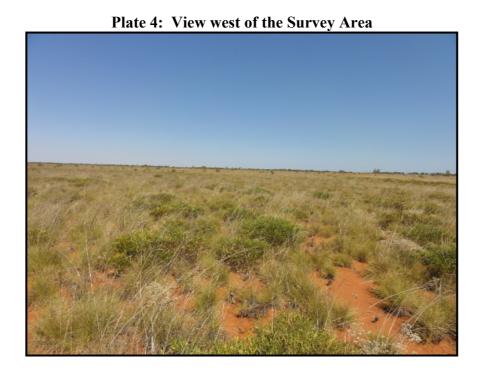
The Survey Area encompasses Lot 3257, Lot 3259, Lot 308, Stage 1C and Lot 6109, which are adjacent to Collier Drive, on the western boundary of the town of South Hedland in the Pilbara region of Western Australia (see Figure 1).

ENVIRONMENT

The topography of the Survey Area consists of flat low-lying pindan sands, forming part of the surrounding floodplains. The ground surface consists predominantly of pindan sand.

The vegetation within the Survey Area is comprised of low Spinifex (*Triodia* spp.), Buffel Grass (*Cenchrus ciliaris*), Butterfly Bush (*Petalostylis* spp.) and occasional *Acacia* and *hakea* scrub.

Ground surface visibility at the time of the Survey ranged from 10% to 80% depending on the vegetation coverage. The average ground surface visibility was, therefore, estimated to be around 50% (see Plate 4)





8

ETHNOGRAPHIC SURVEY RESULTS

The *Marapikurrinya* Consultants that participated in the Survey have had the opportunity to view the Survey Area. The recommendations regarding the Survey Area are detailed below.

The *Marapikurrinya* Consultants identified **no** Aboriginal ethnographic sites within the Survey Area.

The *Marapikurrinya* Consultants advised that, given the potential for sub-surface Aboriginal cultural material, including skeletal, to be disturbed, two MPL nominated *Marapikurrinya* Heritage Monitors must be engaged during initial ground disturbing activity associated with the proposed works.

The *Marapikurrinya* Consultants advised that, if any sub-surface Aboriginal cultural material, including skeletal, is found during ground disturbing activity, then works must stop and the *Marapikurrinya* People consulted.

ARCHAEOLOGICAL SURVEY RESULTS

During the course of the Survey, **no** Aboriginal archaeological sites or isolated artefacts were located within the Survey Area. The Survey Area was disturbed by vehicular and recent human activity.



RECOMMENDATIONS

The *Marapikurrinya* Consultants that participated in the Survey have had the opportunity to view the Survey Area. The recommendations regarding the Survey Area are detailed below. *Marapikurrinya* Pty Ltd also approved the recommendations set out in this document.

It is **recommended** that LandCorp ensure that its employees and contractors, as appropriate, are advised that:

1. There are **no** Aboriginal archaeological or ethnographic sites within the Survey Area.

It is **recommended** that, given the potential for Aboriginal cultural material to be disturbed, two *Marapikurrinya* Pty Ltd nominated *Marapikurrinya* Heritage Monitors be engaged by LandCorp through *Marapikurrinya* Pty Ltd during initial ground disturbing activity associated with the proposed works.

It is **recommended** that, if any Aboriginal cultural material, including skeletal, is found during ground disturbing activity, then works stop and the *Marapikurrinya* People are consulted.

It is **recommended** that LandCorp implements the following Stop Work Procedure should any sub-surface skeletal material and other cultural material be uncovered during the proposed ground disturbing activity:

- 1. Should any sub-surface skeletal material (or any other cultural material) be uncovered during excavation work associated with the proposed construction, contractors are to cease **all work immediately** and the area cordoned off;
- 2. Contractors are to formally notify the South Hedland Detectives (in the case of skeletal material), *Marapikurrinya* Pty Ltd and the Department of Indigenous Affairs;
- 3. LandCorp appoints a Bio-Archaeologist via Anthropos Australis to document and record the skeletal material (or any other cultural material); and
- 4. Further mitigation strategies and consultation with *Marapikurrinya* Pty Ltd and Anthropos Australis Pty Ltd will need to be instigated by LandCorp in response to this Stop Work Procedure.

It is **recommended** that where possible, LandCorp provide employment opportunities for the *Marapikurrinya* People.



10

Finally, it is **recommended** that LandCorp keep *Marapikurrinya* Pty Ltd informed of the proposed development, through regular meetings.



Anthropos Australis Pty Ltd – May 2012

E 665917 N 7742308 E 666387 N 7742294 E 665915 N 7742224 E-666540 N 7742190 E 666537 N 7741994 E 666537 N 7741944 E 666876 N 7741753 115.3 ha E 666881 N 7741271 E 665926 N 7741216 E 665951 N 7741130 E 666547 N 7740718 CONSULTATION HERITAGE AREA LANDCORP McMULLENNOLAN

Figure 1: Location of the Survey Area



12

APPENDIX 1 DIA REGISTER SEARCH EXTRACT



Anthropos Australis Pty Ltd – May 2012



Aboriginal Sites Database

Search Criteria

0 sites in a search polygon. The polygon is formed by these points (in order):

		ı																										
Zone 50	Easting	665917	666387	666534	666540	666537	666437	666436	666537	666535	666567	928999	666919	666937	666945	096999	666958	696999	666984	666991	986999	666881	666547	666061	666010	665951	665926	665915
MGA Zc	Northing	7742308	7742294	7742233	7742190	7741994	7741996	7741946	7741944	7741842	7741836	7741753	7741714	7741716	7741547	7741496	7741445	7741395	7741346	7741329	7741315	7741271	7740718	7741019	7741062	7741130	7741216	7742224

© Government of Western Australia

Aboriginal Sites Database

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

Copyright in the information contained herein is and shall remain the property of the State of Western Australia. All rights reserved. This includes, but is not limited to, information from the Register of Aboriginal Sites established and maintained under the Aboriginal Heritage Act 1972 (AHA).

Legend

)				
Resi	Restriction	Access	SS	Coordinate Accuracy
z	N No restriction	C	Closed	Accuracy is shown as a code in brackets following the site coordinates.
Σ	Male access only) C	Onen	[Reliable] The spatial information recorded in the site file is deemed to be reliable, due to mether
ш	Female access	>	Vulnerable	[Unreliable] The spatial information recorded in the site file is deemed to be unreliable due to err
				data capture arra/or duality or spatial information reported.

thods of capture.

Status

ACMC Decision Made	R - Registered Site	I - Insufficient information S - Stored Data
		†
IA - Information Assessed	Information Awaiting ACMC	Decision Assessment Only
R - Lodged	Information lodged,	awaiting assessment

*Explanation of Assessment

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

Final assessment and decisions 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.

Sites Shown on Maps

Site boundaries may not appear on maps at low zoom levels



Aboriginal Sites Database

List of Registered Aboriginal Sites with Map

No results

Aboriginal Sites Database





Selected Heritage Sites

- Registered Sites

Town

- Map Area
- Search Area

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

Cadastre, Local Government Authority, Native Title boundary data copyright © Western Australian Land Information Authority trading as Landgate (2011).

Geothermal Application, Geothermal Title, Mining Tenement, Petroleum Application, Petroleum Title boundary data copyright © the State of Western Australia (DMP) (2011.9).

For further important information on using this information please see the Department of Indigenous Affairs' Terms of Use statement at http://www.dia.wa.gov.au/Terms-Of-Use/



Aboriginal Sites Database

List of Other Heritage Places with Map

No results

Aboriginal Sites Database



Legend

Selected Heritage Sites



Other Heritage Places



Map Area

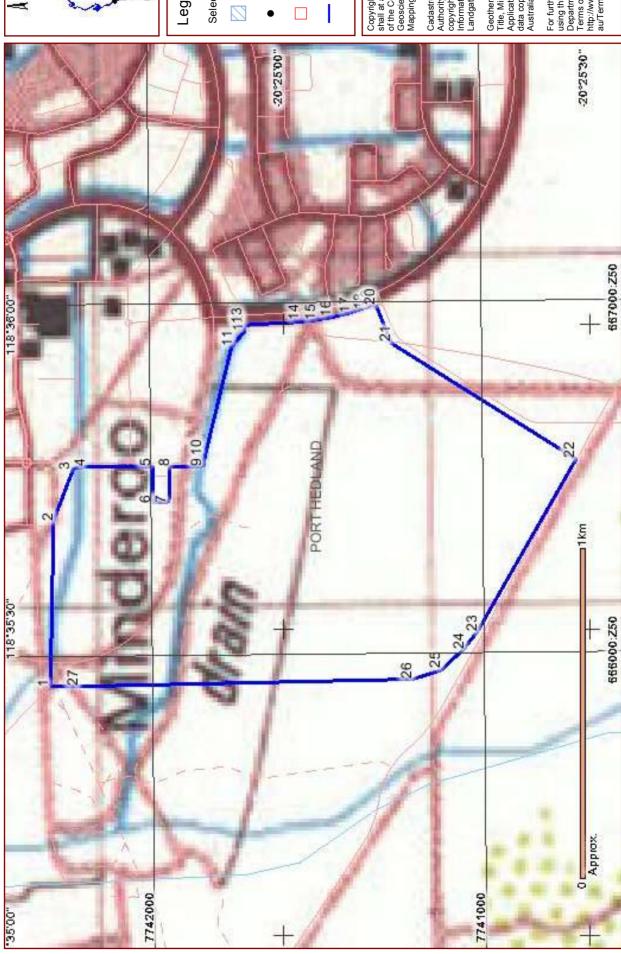
Search Area

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

Cadastre, Local Government Authority, Native Title boundary data copyright © Western Australian Land Information Authority trading as Landgate (2011).

Geothermal Application, Geothermal Title, Mining Tenement, Petroleum Application, Petroleum Title boundary data copyright © the State of Western Australia (DMP) (2011.9).

For further important information on using this information please see the Department of Indigenous Affairs' Terms of Use statement at http://www.dia.wa.gov.au/Terms-Of-Use/



Aboriginal Sites Database

Map Showing Registered Aboriginal Sites and Other Heritage Places

Aboriginal Sites Database



Legend

Negistered Sites

Other Heritage Places

Town

Map Area

Search Area

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

Cadastre, Local Government Authority, Native Title boundary data copyright © Western Australian Land Information Authority trading as Landgate (2011).

Geothermal Application, Geothermal Title, Mining Tenement, Petroleum Application, Petroleum Title boundary data copyright © the State of Western Australia (DMP) (2011.9).

For further important information on using this information please see the Department of Indigenous Affairs' Terms of Use statement at http://www.dia.wa.gov.au/Terms-Of-Use/





APPENDIX 4

Transport Assessment Report



SOUTH HEDLAND WESTERN EDGE LAND DEVELOPMENT

TRANSPORT ASSESSMENT

SOUTH HEDLAND WESTERN EDGE LAND DEVELOPMENT

TRANSPORT ASSESSMENT

Report Prepared For:

LANDCORP

Report Prepared By:

PORTER CONSULTING ENGINEERS

PO Box 1036

CANNING BRIDGE WA 6153 Phone: (08) 9315 9955 Fax: (08) 9315 9959

Fax: (08) 9315 9959 Email: office@portereng.com.au

Job No: 12-05-061 Date: 11/09/2012 Our Ref: R29.12

Rev: B

Checked:

CONTENTS

1.0	INTROD	UCTION		1
2.0	SCOPE	OF REPORT		1
3.0	TRANSI	PORT MODEL	LING	2
4.0	EXISTIN	IG SITE		2
	4.1	Development	Location	2
	4.2		nd	
	4.3			
	4.4	North Circula	r Road	6
	4.5	Forrest Circle)	6
	4.6	Yarrie Road		7
5.0	PROPO	SED ROAD N	ETWORK	7
	5.1	Previous Stud	dies	7
	5.2	Network Ope	ration	8
	5.3	Trip Generati	on	9
	5.4	Road Hierarc	hy	10
	5.5		S	
	5.6	Regional Net	work and Staging	15
6.0	ASSESS	SMENT OF TR	RAFFIC IMPACTS	16
	6.1	Traffic Distrib	ution	16
	6.2		sections	
			Circular Road Extension	
			on Road	
			Drive	
	6.3		l Network	
			t Distributor	
			oourhood Connectors	
			Access Streets	
			ections	
	6.4	•	gement	
	6.5		and Cyclists	
	66	Public Transp	oort	28

7.0	SUMMARY	29
APPE	NDICES	
	ndix 1 – Developme ndix 2 – Street Netw	•



1.0 INTRODUCTION

Porter Consulting Engineers has been engaged by LandCorp to provide transport assessment of proposed residential subdivision in the South Hedland Western Edge.

This report assesses undeveloped land for residential housing that is expected to also include Education Centres, Aged Persons Dwellings and Active Recreation areas.

The purpose of this report is to examine transport aspects, in particular the land-use/transport integration with respect to accessibility, circulation and safety for all transport modes.

<u>The South Hedland Town Centre Consolidated Traffic Report</u> by Porter Consulting Engineers provides details of current and anticipated future development of the Town. The Western Edge proposed subdivision will add development traffic to South Hedland. <u>The South Hedland Town Centre Consolidated Traffic Report</u> should therefore be read in conjunction with this report.

Assessment is made of the strategic transport aspects of land use/transport integration for the South Hedland Western Edge plus the future developable land to the east, including:

- Traffic volumes and street hierarchy
- Street cross-sections
- Traffic management
- Public transport
- Pedestrians and cyclists

This report has been prepared in accordance with the intentions of the Western Australian Planning Commission (WAPC) draft <u>Guidelines for Developments</u>, Volume 2 – Structure Plans, August 2006.

2.0 SCOPE OF REPORT

The scope of this report is primarily to address the following matters:

- Proposed development traffic generation and road network operation.
- Assess traffic impacts on the surrounding environment.
- Assess impact on the road network traffic safety and efficiency.



3.0 TRANSPORT MODELLING

Traffic modelling prepared for the South Hedland Western Edge subdivision concept includes at the request of LandCorp, the potential subdivision land to the south-east of South Hedland. As a result trip generation figures presented in the traffic model are not limited to the South Hedland Western Edge trip generation but include all of the assessed future developable area.

The main traffic carrying roads within the Western Edge subdivision and those outside of the Western Edge subdivision are presented with predicted traffic flows at full development. As a result, traffic generation from outside areas not part of the LandCorp development area have been included to identify the ultimate traffic carrying demands on the roads within the LandCorp Western Edge subdivision.

4.0 EXISTING SITE AND ACCESS

4.1 Development Location

The proposed South Hedland Western Edge Subdivision Area (the Site) is located in the suburb of South Hedland within the Local Government Authority of the Town of Port Hedland.

The Town of Port Hedland Town Planning Scheme No.5 has the Site coloured rural with a notation describing it as 'Development Plan Area South Hedland West'.

The Site is located on land generally bounded to the north and east by the roads of Forrest Circle and Collier Drive. The western boundary is generally along South Creek. The location of the Site within South Hedland is shown in the following diagram.





Figure 1. Location

Our Ref: R29.12, 12-5-61



Main Roads Western Australia provides details of the Functional Road Hierarchy Classification for the Rural and Metropolitan road network. Details of the roads surrounding the development site according to the Main Roads WA Rural Road Hierarchy are listed in the following table.

Table 1. Surrounding Roads

Road	Classification	Geometry		
Hamilton Road	Rural Local Distributor	Undivided two-way carriageway		
Collier Drive	Rural Local Distributor	Undivided two-way carriageway		
Forrest Circle	Rural Local Distributor	Median-divided two-way carriageway		
North Circular Rd	Rural Local Distributor	Undivided two-way carriageway		
Yarrie Road	Rural Local Distributor	Undivided two-way carriageway		

The density of development, extent of area and characteristics of development in South Hedland are more closely aligned with Metropolitan rather than rural development. Accordingly, the road network presented in this report for the proposed development and South Hedland Town Centre is on the basis of a Metropolitan Road Hierarchy.

Table 2. Road Volumes

Road Category	Street	Desirable Maximum Volume ADT (veh/day)
District Distributor	North Circular Road	15,000 - 35,000
	Hamilton Road (north)	
	Forrest Circle	
Neighbourhood Connector A	Hamilton Road (south)	7,000 - 15,000
Neighbourhood Connector B	Collier Drive	3,000 - 7,000
(Local Distributor)	Yarrie Road	
Access Road	Various	1,000 - 3,000

4.2 Hamilton Road

Hamilton Road north of Forrest Circle is intended to perform the function of carrying traffic and freight between districts. To achieve that function, traffic flow must receive as little constraint and interruption as possible. No special provision is generally made for small numbers of vehicles entering and exiting. However, where large volumes must do so, then dependant on the volume, appropriate treatment at the connecting road is provided.

South of Forrest Circle the road character reflects the South Hedland Town Centre (SHTC). The existing section of Hamilton Road immediately to the north of the development concept plan area is within the SHTC and is an undivided two-way single carriageway classified as a District Distributor under the Town of Port Hedland Road Hierarchy speed zoned at 50km/h.



The most recent traffic count on Hamilton Road near the development area was taken on the section of Hamilton Road south of Throssell Road in 2011 where a combined two-way traffic volume of 1,655 veh/day AWT was recorded.

Main Roads WA interactive web site provides summary crash data. In the 5 years from 2007 to 2011 the following table shows the number of crashes recorded at the adjacent intersections.

Table 3. Crash Data, Hamilton Road

Intersection	No. of Crashes over 5 Years
Hamilton Road / Forrest Circle	1
Hamilton Road / Throssell Road	0
Hamilton Road / McLarty Boulevard	0
Hamilton Road / Colebatch Way	0

4.3 Collier Drive

Abutting the development site Collier Drive currently comprises an undivided single two way carriageway with no direct property access. It is classified as a Local Distributor under the Town of Port Hedland Road Hierarchy speed zoned at 70km/h north of Yarrie Road and 60km/h south of Wambiri Street.

Main Roads WA interactive web site provides summary crash data. In the 5 years from 2007 to 2011 the following table shows the number of crashes recorded at the adjacent intersections.

Table 4. Crash Data, Collier Drive

Intersection	No. of Crashes over 5 Years
Collier Drive / Forrest Circle	3
Collier Drive / Wambiri Street	1
Collier Drive / Yarrie Road	0
Collier Drive / Steamer Avenue	0
Collier Drive / Masters Way	0

Included in recent roadworks (2012) for the South Hedland Town Centre was disconnection of Forrest Circle with Collier Drive which previously formed a right-angle bend. As the intersection no longer exists the opportunity for crashes at this intersection is eliminated.

The most recent traffic count on Collier Drive near the development area was taken on the section north of Steamer Avenue in 2009 where a combined two-way traffic volume of 745veh/day AWT was recorded. As Collier Drive has now been disconnected from Forrest Circle the 2009 recorded traffic flow of 745veh/day will have reduced. A new count is not currently available.



The subdivision layout proposes to disconnect and realign the northern section of Collier Drive to create a north-south Local Distributor Road connecting to an east-west District Distributor road linking with North Circular Road.

4.4 North Circular Road

North Circular Road is an undivided single carriageway two-way semi-rural road speed zoned at 80km/h. It is classified as a District Distributor under the Town of Port Hedland Road Hierarchy. The most recent recorded traffic counts for North Circular Road were undertaken in 2011 and recorded 3,510veh/day west of Parker Street and 705veh/day south of Murdoch Drive. Main Roads WA interactive web site provides summary crash data. In the 5 years from 2007 to 2011 the following table shows the number of crashes recorded at the adjacent intersections.

Table 5. Crash Data North Circular Road

Intersection	No. of Crashes over 5 Years
North Circular Road / Hamilton Road	5
North Circular Road / Parker Street	3
North Circular Road / Stanley Street	1
North Circular Road / Cottier Drive	3
North Circular Road / Murdoch Drive	2
North Circular Road / Butt Weld Rd	1

North Circular Road is intended to perform the function of carrying traffic and freight around the perimeter of South Hedland providing transport connection between districts. In the future there is a proposal for North Circular Road to be extended to the south and west when these areas are subdivided and developed with residential housing, to provide a continuous circulation route surrounding the developed area of South Hedland.

4.5 Forrest Circle

Forrest Circle is a single carriageway two-way road with both median-divided and undivided sections speed zoned at 60km/h. It is classified as a District Distributor under the Town of Port Hedland Road Hierarchy. The most recent recorded traffic counts were undertaken in 2011 and recorded 4,720veh/day east of Hamilton Road and 2,985 veh/day south of Murdoch Drive.



Main Roads WA interactive web site provides summary crash data. In the 5 years from 2007 to 2011 the following table shows the number of crashes recorded at the adjacent intersections.

Table 6. Crash Data Forrest Circle

Intersection	No. of Crashes over 5 Years
Forrest Circle / Hamilton Road	1
Forrest Circle / Tonkin Street	2
Forrest Circle / Cottier Drive	1
Forrest Circle / Throssell Road	4
Forrest Circle / Hunt Street	6
Forrest Circle / Murdoch Drive	4
Forrest Circle / Collier Drive	3

Forrest Circle was disconnected in 2012 from Collier Drive and re-routed to connect with Daylesford Close. The subdivision layout proposes to provide a new east-west link road connecting to Daylesford Close via Wambiri Street at the eastern end to an extension of North Circular Road at the western end. This will provide a local east-west connection between the existing residential area and the proposed new residential area.

4.6 Yarrie Road

Yarrie road is a single carriageway two-way undivided rural road speed zoned at 50km/h. It is classified as a Local Distributor under the Town of Port Hedland Road Hierarchy. The are no recorded traffic volumes for this road and only one crash listed as at mid-block in the 5 years from 2007 to 2011.

5.0 PROPOSED ROAD NETWORK

This section of the report details the investigations required to estimate the traffic generated by the development.

5.1 Previous Studies

In 2011 Porter Consulting Engineers prepared a Draft Traffic Report for the Town of Port Hedland and a separate South Hedland Town Centre Traffic Report for LandCorp which included forecast modelling of traffic flows. The forecast traffic flows for the year 2030 are shown in the following diagram. This proposed residential development of the South Hedland Western Edge results in new traffic flows. Accordingly, new modelling has been undertaken and is discussed in Section 5 of this report.



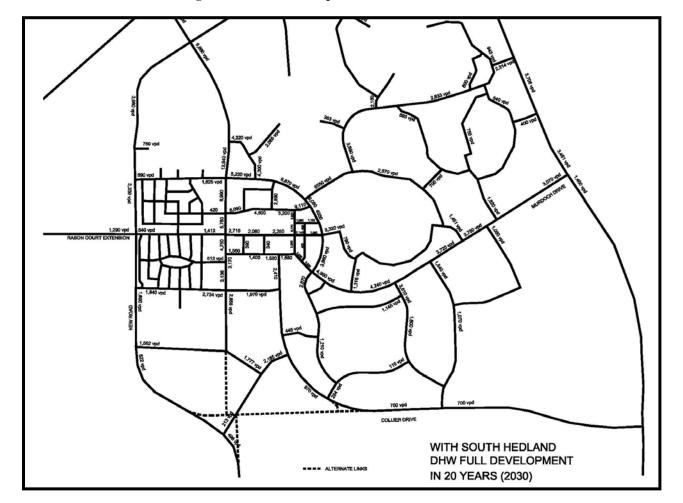


Figure 2. Previous Anticipated 2030 Traffic Flows

5.2 Network Operation

The proposed Preliminary Concept Plan for subdivision of the total land area requires construction of an internal road network servicing the created lots. External access to the internal road network requires connection with the bounding and linking roads of North Circular Road, Collier Drive and Hamilton Road. There will also be interconnection with the abutting residential area to the east via the local road network at Hamilton Road, McLarty Boulevard, Colebatch Way, Wambiri Street, Steamer Avenue and Collier Drive.



The Preliminary Concept Plan has five main zone types consisting of:

- Residential R20, R30, R40 and R50/60
- Key Worker Village
- Primary School
- District Open Space
- Multi-use corridors (main drainage, etc)

5.3 Trip Generation

There are a number of resource documents used to determine the traffic generated by particular development land use types. The two most relevant in Australia are:

- <u>Land Use Traffic Generating Guidelines</u>, Director General of Transport, South Australia, 1986.
- Guide to Traffic Generating Developments, Roads and Traffic Authority, NSW, 2002.
- Trip Generation, Institute of Transportation Engineers, 7th Edition, 2003.

These are the industry recognised documents used by Traffic Engineers and Planners Australia wide.

The total potential residential development yield is estimated at 760 Lots plus 100 dwellings in the Key Worker Village. Trip generation rates typically vary by use and density. For the purpose of this assessment the average rates selected are presented in Table 7.

The current and proposed uses comprise the uses and trip generation described in the following table. The trip generation described is the potential occurring under full utilisation for each use.

Land Use	No./Area	Tr	ip Rate	No. of Trips		
Land Use	No./Alea	Peak Hour	Peak Hour Daily Peak		Daily	
Residential R20	1,305 lots	.8	8	1,044	10,440	
Residential R30	632 lots	.8	8	505.6	5,056	
Residential R40	261 lots	.8	8	208.8	2,088	
Residential R50/60	81 lots	.6	6	48.6	486	
Key Worker Village	100 dwellings	.6	6	60	600	
			Total	1,867	18,670	

Table 7. Traffic Generation – Preliminary Concept Plan

The above evaluation has been conservative so that a robust analysis is presented in comparing the current and proposed land use. That is, traffic movements generated by this site are fairly presented and should not exceed anticipated use described by the trip generation guideline documents.



5.4 Road Hierarchy

The classification of roads in Western Australia is provided under the Main Roads Act 1930. Under the Act, the Governor (following recommendation by the Commissioner for Main Roads) has the power to proclaim roads or part of roads into the following classifications:

- Highways
- Main Roads
- Secondary Roads

Concurrence of local government authorities concerned is required before the Commissioner can recommend a proclamation to the Governor. Declared 'Highways' and 'Main Roads' form the State Road Network of which Main Roads WA is the owner, manager and financier. Secondary Roads, whilst still provided for under Section 26 of the Act are no longer used. A review of the Secondary Road Network in 1995 saw all Secondary Roads either upgraded to Main Roads or decommissioned completely. Roads that are not declared as either Highway, Main Roads or Secondary Roads under the Act are unclassified roads. Most unclassified roads are commonly referred to as Local Roads and are the responsibility of Local Government Authorities. Other unclassified roads depending on their location can be under the jurisdiction of other Government Authorities. There are also a number of private roads owned, for example, by mining companies. Some of these roads are accessible to the public.

Main Roads WA, in cooperation with Local Government, developed a Road Hierarchy to further designate the type and function required of each road in the network. In general, road networks are designated with regard to two main documents:

- Main Roads WA Metropolitan Functional Road Hierarchy
- WA Planning Commission Liveable Neighbourhoods



Table 7 Functional Road Hierarchy Designations and Main Characteristics

Туре	Function	Responsible Authority	Development Access	Speed Km/h	Volume Veh/day
Primary Distributor	Arterial routes that are highly connective with service roads where possible, limited intersections and often signal controlled.	Main Roads WA	None or restricted	60-110 depending on operating characteristics	Over 35,000
District Distributor Integrator A	An arterial route that has frequent connections to local streets, development frontage along its length. Typically have services roads with on-street parking and direct vehicle access where there are no service roads.	Local Government	Limited. May have some commercial access.	60-80	15,000 to 35,000
District Distributor Integrator B	An arterial route that has frequent connections to local streets, development frontage along its length, typically has one lane in each direction with on-street parking.	Local Government	Residential and commercial access	60-70	7,000 to 15,000
Neighbourhood Connectors/ Industrial Road	Provide the sub-arterial network servicing and linking neighbourhoods. Spread local traffic loads, act as bus route, have frequent connections to local streets and may typically be traffic calmed to facilitate pedestrians and cycling.	Local Government	Access is permitted except at controlled intersections.	50	3,000 to 7,000
Access Streets	Streets providing predominantly residential access where the local environment is dominant, traffic speeds are low and pedestrian and cycle movements are allocated.	Local Government	Access is permitted	40-50	Less than 3,000



In this assessment the functional road hierarchy has been assessed in line with the above table of main characteristics via a process which includes the following:

- **Surrounding areas** this includes an assessment of surrounding land use to establish higher order road links to key uses such as the Port Hedland and South Hedland Town Centres. Differentiation of roads which have a traffic carrying function to commercial destinations and lower order roads to medium and lower density residential.
- **Abutting land use** the use of land abutting each road establishes trip generation contributing to the traffic volumes on the road. Land uses such as Town Centres and Main Streets generate traffic onto the through traffic component and therefore should be assigned a higher order of road classification.
- **Road connections** the road hierarchy should be such that lower order roads connect to the next higher order roads and that their traffic feeds on to them.
- Catchments the road hierarchy needs to be assessed against the catchment of the higher order roads. The role of lower order roads is to collect traffic and provide connections onto higher order roads and then to District roads. It is important that the catchment onto these roads is not overly substantial and that each of these roads is able to perform its intended function in the current and anticipated future context. If the catchment onto any road link is too great and the intended maximum volume is exceeded, then congestion may result and the road system could lose its ability to operate efficiently and safely.
- Orderly hierarchy the road hierarchy should be such that lower order roads perform a traffic access function and that higher order roads perform a traffic carrying function. Higher order roads are therefore generally longer creating spines through an area and have priority over connecting lower order roads.

In Appendix 2 is indicated the hierarchy of roads for the development area network recommended to provide suitable street environments consistent with the function of the proposed residential development and the South Hedland Town Centre.

5.5 Speed Zones

Main Roads Western Australia has the responsibility to set and post speed zones on public roads in Western Australia. It provides Technical Guidelines on Speed Zoning on their web site.

A Speed Zone is defined on a carriageway by a speed limit sign at the beginning and at the end by means of either an END speed limit sign, another speed limit sign, or a T-junction where that carriageway ends. The Main Roads desirable minimum lengths between speed zone changes are given in the following table. Main Roads table differs from the Australian Standard AS1742.4-2008, Table 2.2.



Table 8. Main Roads Minimum Length of Speed Zones

Speed Limit (km/h)	Minimum Length of Speed Zone (km)		
30	0.3		
40	0.4		
40 (School Zone)	0.2		
50	0.5		
60	0.6		
60 (School Zone)	0.3		
70	0.7		
80	0.8		
90	0.9		
100	2.0		
110	4.0		
Buffer Zones	0.3 (minimum)		
Durier Zolles	0.5 (preferred)		

The most important consideration in assessment of speed zones is a determination of the crash rate of the road. Crash history can be viewed in two ways:

- 1. the risk faced by individuals, which is measured by the casualty rate per 100 million vehicle kilometres; and
- 2. the collective risk, which is measured by the casualty rate per kilometre of road.

Collective risk represents the total risk along a length of road as opposed to the risk faced by the individual driver. Using collective risk as a basis for setting speed limits may create anomalies. Focusing on individual risk can provide a more consistent relationship between speed limits to the characteristics of the road and to the road environment, giving a hierarchy of limits that provides a more apparent association to most road users.

Non-geometric enforcement is usually negligible on low volume roads and this limits the extent to which lower speed limits can reduce individual risk. Consequently reducing the speed limit on low volume roads often requires geometric changes (e.g. Local Area Traffic Management Devices) to be made to the carriageway and/or the road environment in order for a reduced speed limit to be effective.

The matching of road function with road design must be correct to minimise the collision risk. Higher speeds are only achievable where the road design meets the safety standards appropriate to the function and the speed limit reflects the road as it is, not as it should be.



Other major factors considered in the speed zoning assessment are.

Pedestrians and cyclists

- the presence and type of pedestrian and cyclist facilities provided to separate them from motorised vehicles;
- volume and composition of unseparated traffic (including heavy vehicles, cyclists and pedestrians);
- traffic patterns or special activities that impact on the unconstrained traffic flow and speed (including schools and school crossings, bus stops and frequency, pedestrians and cyclists).

Geometry

- geometric features including alignment and gradient;
- cross-section and separation of opposing traffic flow;
- number and width of traffic lanes;
- presence and width of sealed or unsealed shoulders;
- offset from roadside features.
- pavement surface.

Abutting Development and Activity

- restriction of access to one or both sides of road;
- differences in development along length of road and between opposite sides of road;
- number, distance between and types of intersections;
- number, distance between and types of driveways;
- type of roadside development activity (e.g. residential, office, shopping and industrial).

A traditional consideration in assessing or reviewing speed limits is the 85th percentile speed. This has been discontinued by many road authorities as a key factor as it is not supported by the Safe System approach to road safety. Accordingly, it is not used in this assessment.

The road network has been assessed and recommendations presented for speed zones with the intent of providing a road network of streets in accordance with the function, operation and safety of the road hierarchy.

In Appendix 2 is indicated the recommended speed zones for the future road network to provide suitable street environments consistent with the function of the proposed residential development area and the South Hedland Town Centre.



5.6 Regional Network and Staging

The timing for construction of a western extension of North Circular Road is unknown as it is not yet on the Town of Port Hedland construction programme. This is mainly due to a limited need for this road until such time as increased development occurs around the western edge of South Hedland.

The potential staging of development for new residential land subdivision and development of the South Hedland Town Centre land are unknowns. The staging of development for these areas cannot be predicted with any certainty.

The staging of the road network is therefore proposed in the following manner. However, a review should be undertaken within 2 to 5 years to identify if the progress of development has changed to the extent that priorities need to be re-assessed.

Stage 1

Assuming initial development of land subdivision will occur to the south of Throssell Road and west of Hamilton Road and Collier Drive.

- Extend Hamilton Road south past the Hospital to connect with the development land.
- Extend McLarty Boulevard and Colebatch Way west to connect with the development land.
- Modify the intersection of Collier Drive with Wambiri Street to connect with the new subdivision road in a 4-way intersection controlled by a roundabout.

Stage 2

Assuming the next stage of land subdivision development will comprise a greater area of the Western Edge extending south to encompass the Primary School/District Open Space and area north of Road A. This area of development will increase trip generation to the point where construction of Road A in the subdivision is required and the Local Authority will need to construct the western extension of North Circular Road to connect with Road A. If the western extension of North Circular Road is not constructed then Hamilton Road will by default carry the burden of north-south commuting traffic. Traffic generated by this area of subdivision will result in Hamilton Road experiencing severely congested operating conditions.



Stage 3

Assuming the next stages of land subdivision are areas south of the Powerline reserve.

- Connect Yarrie Road with Hamilton Road at a dual-lane roundabout on Road A
- Extend Collier Drive east to connect with North Circular Road

6.0 ASSESSMENT OF TRAFFIC IMPACTS

The Site abuts the South Hedland Town Centre and surrounding residential development. It is not anticipated that any significant change in current residential amenity will occur as the proposed uses are consistent with adjacent areas and in accordance with existing developed areas.

6.1 Traffic Distribution

A possible proposed future extension of North Circular Road to the west of Hamilton Road is outside of the proposed Western Edge land development area. Although the extension ultimately ties in with the proposed new Western Edge road network. As to when the future extension of North Circular Road west of Hamilton Road may be constructed by the Town of Port Hedland is unknown. The Town has not supplied an indication of expected timeframe for its construction. Future land development in the surrounding district in conjunction with staging of new roads will result in some changes to travel patterns as and when new roads in the network are constructed and in particular, as major roads are constructed. Therefore, the work trip destinations and attraction by population density for the purpose of this evaluation are distributed at full development.

In determining the estimated peak hour entry and exit traffic flows the following assumptions have been made based on directional distributions from the Institute of Traffic Engineers.

- AM Residential Peak Hour trips will be split 75% exiting and 25% entering.
- PM Residential Peak Hour trips will be split 35% exiting and 65% entering.

In the absence of other information, the following are assumptions made in developing the estimated daily traffic generation presented in Appendix 2.

- 1. Land use is based on the estimated maximum permitted that could be developed. This may exceed the actual available or permitted arising from factors not currently known.
- 2. The Department of Planning and the Local Government Authority may impose restriction on locations and areas of developable land, road network and recreation space which may differ from the Preliminary Concept Plan used for this assessment.
- 3. Service Authorities may impose restriction on the availability and location of services and infrastructure. It has been assumed there are no restrictions.



6.2 External Roads

6.2.1 North Circular Road

The estimated daily traffic flows presented in Appendix 2 assume full future development. The predicted maximum 18,930 veh/day volume for Road A is within the 1,000 veh/hour mid-block maximum capacity for a median-divided two-way single lane road.

Road A connects outside the development area with a future extension of North Circular Road west of Hamilton Road. Construction of North Circular Road west of Hamilton Road to west of Collier Drive is required for subdivision of residential development land south-west of South Hedland to provide for traffic generated by the new residential developments. If this section of North Circular Drive is not constructed then Hamilton Road will be required to carry the traffic load which can be expected to result in congested traffic conditions within the South Hedland Town Centre.

It is recommended that following commencement of development of the proposed residential subdivision development south-west of South Hedland, the Local Authority construct North Circular Road west of Hamilton Road to Forrest Circle as soon as possible.

At full development of all assessed land subdivision areas the existing North Circular Road and its western extension will be carrying sufficient traffic to require that sections to the north of South Hedland (west of Wallwork Road) are dual-carriageway.

6.2.2 Hamilton Road

The Town of Port Hedland intends to construct, in the short term, a second carriageway from Hedditch Street to south of North Circular Road to complete the median-divided dual-carriageway of Hamilton Road from Forrest Circle to North Circular Road. This will provide for major traffic movements and ingress and egress to abutting property in the short and long term on this section of Hamilton road. Hamilton Road north of North Circular Road to Great Northern Highway is serviced by a single carriageway which is expected to be sufficient in the long term.

Hamilton Road from Forrest Circle to Forrest Circle provides a north-south link to entering traffic which then distributes onto the east-west connecting roads. This road will remain a significant traffic carrier and distributor in the short, medium and long terms. Analysis of this route for short and medium term development proposed by LandCorp and potential medium and long term subdivision development to the south and west, suggests that Hamilton Road should be median-divided with limited frontage access to abutting development to maximise traffic movement and minimise intersections congestion. However, in keeping with the Town Centre, a low speed environment is recommended to be maintained which may include onstreet parking.



Roundabouts are currently constructed at the intersections with Throssell Road and Colebatch Way. It is recommended that a roundabout also be constructed at the intersection with McLarty Boulevard. This would be in keeping with a proposal for the extension of McLarty Boulevard to the west to connect with the residential development.

6.2.3 Collier Drive

Forrest Circle has been proposed to be extended to the west of Scadden Road to connect with Hamilton Road and Collier Drive, to form a continuous route surrounding the South Hedland Town Centre. More recent investigation of potential development of land within the South Hedland Town Centre and creation of residential development to the south-west suggests that a more permeable road network can be created with the western extension of North Circular Road. Forrest Circle would extend west of Scadden Road to connect with North Circular Road on the north of South Hedland and to the south a new east-west road would be created from Collier Drive west to North Circular Road. This has the additional benefit of allowing for the Hospital site to be extended further south to permit future expansion. Future construction of an east-west link road immediately south of the Hospital connecting with North Circular Road permits a high level of accessibility.

6.3 Internal Road Network

The proposed Preliminary Concept Plan road network is intended to accommodate all internal traffic movements between lots and connection with major roads in the existing network.

This report seeks to illustrate a road system which provides an acceptable balance between the diverse uses of semi-rural type living in a remote Town, where personal private transport in a large robust motor vehicle comprises the majority of means of travel for residents. The report seeks to balance the conflict in function between the road network as a traffic route for vehicles and pedestrians and as a place for a range of residential dwelling densities and community activities. The report also acknowledges conventional town centre and community guidelines, such as the West Australian Planning Commission Liveable Neighbourhoods, but seeks to adapt those to reflect the local environment e.g. rural stormwater runoff drainage and community activities in South Hedland.



Figure 4. Main Road Network Development Area Interconnection

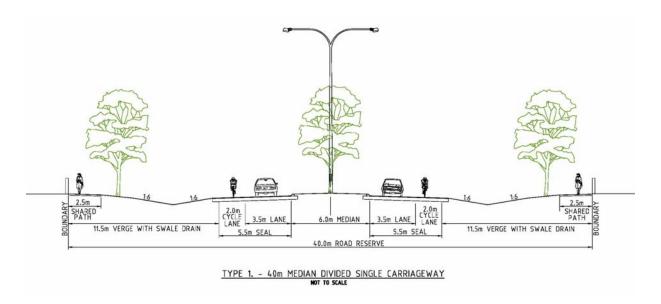
6.3.1 District Distributor

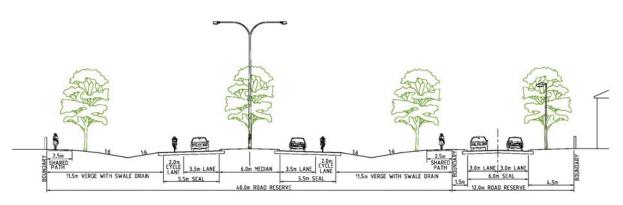
Road A

The proposal for the extension of North Circular Road (Road A) where it abuts the Development is for a street cross section, as shown in the following diagrams, to accommodate predicted traffic flows, intersections and stormwater runoff.

Road Reservation Width	40 metres
Speed Limit	80km/h
Intersection controls	Median/islands at 3-way
	Roundabout at 4-way







TYPE 2. - 40m+12m MEDIAN DIVIDED SINGLE CARRIAGEWAY AND ABUTTING ACCESS STREET

In the proposed Development Plan, sections of the extension of North Circular Drive abut internal Access Streets. A separate street cross section is included to present this combination (Type 2) shown above.

6.3.2 Neighbourhood Connectors

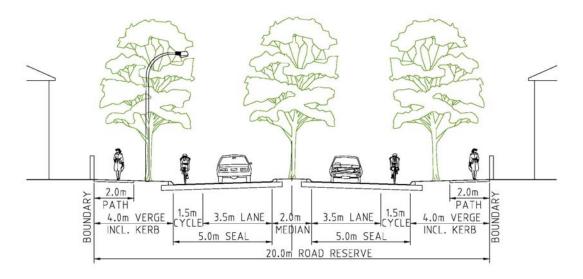
Roads B, C, D, F and G

Neighbourhood Connector streets mostly have residential frontage providing the road link between neighbourhoods. Liveable Neighbourhoods suggests networks may have two types of Neighbourhood Connector. Those carrying traffic volumes between 3,000 to 7,000 veh/day and those carrying less than 3,000 veh/day. Where a Neighbourhood Connector Road carries 3,000 to 7,000 veh/day then a Type 3 street cross-section would apply and where the Connector serves a lesser traffic carrying function (less than 3,000 veh/day) then Type 4 street cross-section is applicable. Those streets can provide for on-street parking without significant impact on their lower volume traffic carrying function.

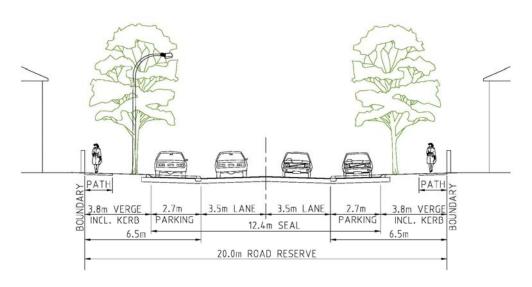


Road Reservation Width	20 metres
Speed Limit	50km/h
Intersection controls	Median/islands at 3-way major connections.
	Roundabout at 4-way.

Road C (Hamilton Road extension) will be a Type 3 as will Road D and F. Roads B and G will be Type 4.



TYPE 3. - 20.0m WITH MEDIAN AND CYCLING
NOT TO SCALE



TYPE 4. - 20m AND 7.0m WITH PARKING NOT TO SCALE

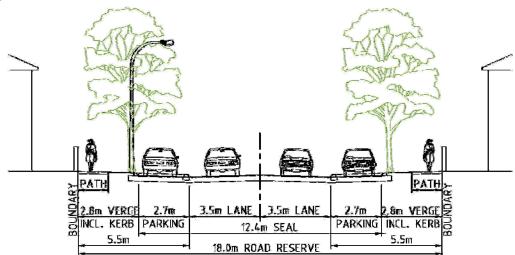


6.3.3 Local Access Streets

The following cross-sections are recommended depending on application.

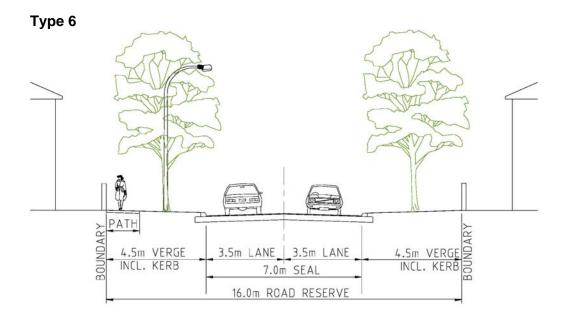
Road Reservation Width	Varies from 15 to 18 metres
Speed Limit	50km/h
Intersection controls	Give Way/Stop control at connections.
	Roundabout at major 4-way connections.

Type 5



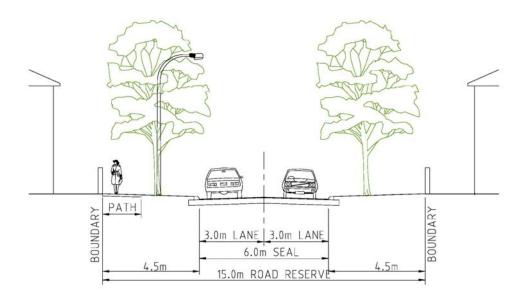
TYPE 5. - 18m AND 7.0m WITH PARKING NOT TO SCALE





 $\frac{\text{TYPE 6.} - 16\text{m AND } 7.0\text{m}}{\text{NOT TO SCALE}}$

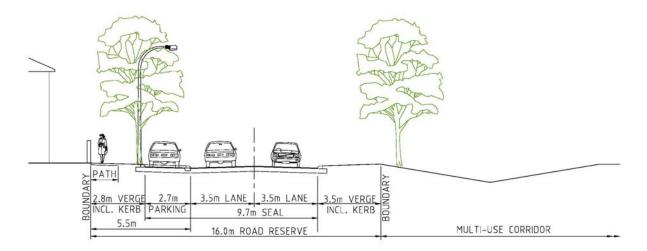
Type 7



TYPE 7. - 15m AND 6.0m NOT TO SCALE

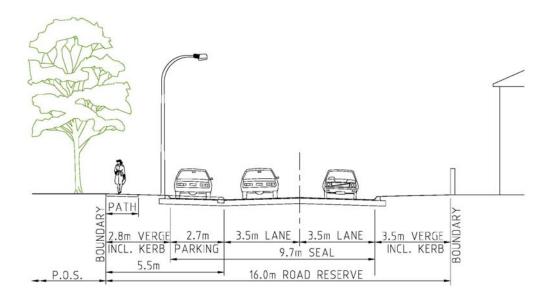


Type 8



TYPE 8. - 16m AND 7.0m WITH PARKING OPPOSITE DRAIN NOT TO SCALE

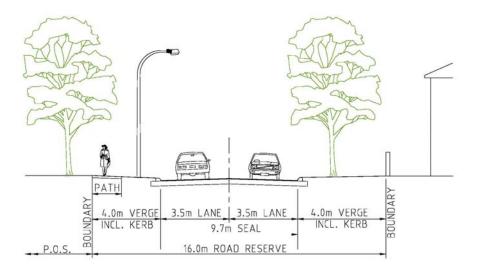
Type 9



TYPE 9. - 16m AND 7.0m WITH PARKING ON POS SIDE NOT TO SCALE



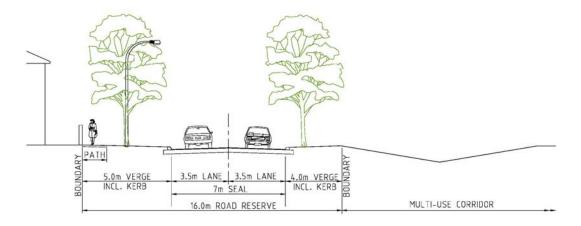
Type 10



TYPE 10. - 15m AND 7.0m

NOT TO SCALE

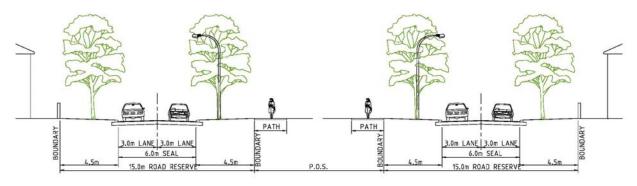
Type 11



TYPE 11. - 16m AND 7.0m WITH DRAIN RESERVE



Type 12



TYPE 12. - 15m AND 6.0m WITH P.O.S. BETWEEN

6.3.4 Intersections

The purpose of preparing a Road Network for a Development Plan is to provide a designed solution achieving a layout of streets which spreads local traffic loads and leads to higher order streets which in turn lead to major District Distributor roads. Included in the street network design are the locations, types and operation of intersections which are intended to manage traffic flow and provide for the safe movement of vehicles, pedestrians and cyclists.

Street network design guides, including Liveable Neighbourhoods, promote a highly interconnected street network with frequent junctions. Intersections are designed for vehicle and pedestrian safety taking into account traffic volume, types of vehicle, likely traffic speed, turning movements, topography and any potential need for an intersection to act as a speed reducing device in one or more directions. The spacing between intersections will typically be provided at not less than 20m for Access streets and not less than 40m for Neighbourhood Connectors.

6.4 Traffic Management

Management of traffic flows on roads and at intersections within the proposed road network is a necessary requirement to maintain safe operation of the road network by minimising risk. Traffic management measures at locations which will benefit from supplementary street and intersection control measures are presented in Appendix 2.

T-junctions must be provided with adequate sight distance and where that is available the intersection requires only normal Give Way control. Where sight distance is restricted then Stop Sign control may be more appropriate.



High traffic speeds exceeding the designated 50km/h Default Urban Speed Limit should not occur within the road network under the proposed cross-sections and where there are relatively short road lengths between controlled intersections.

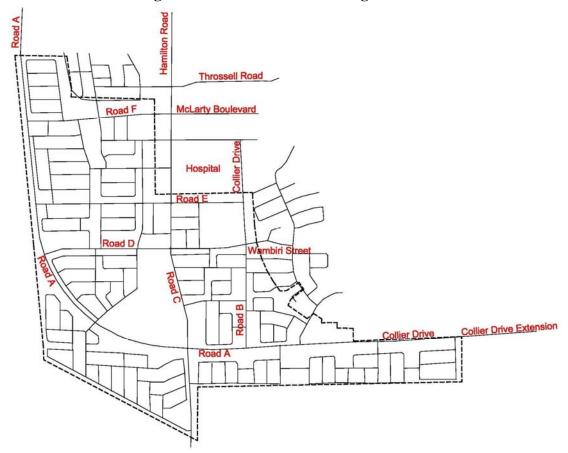


Figure 5. Network Traffic Management

6.5 Pedestrians and Cyclists

Planning guidelines recommend provision of a footpath along every street with a developed frontage. Footpaths should be a minimum of 1.5m on residential access streets and 2.0m in the vicinity of schools, commercial centres and other activity centres.

Other than for the Neighbourhood Connectors the Access streets in the network have low daily traffic volumes suitable for on-road cycling. Informal on-street parking will, however, create some interference for on-road cycling but typically this will occur on very low traffic volume roads where the opportunity for conflict should be low.

In Appendix 2 is indicated where pedestrian footpaths and cycle paths are recommended. Regional paths and shared paths are also shown, indicating connection with the Town of Port Hedland's existing and proposed path network.

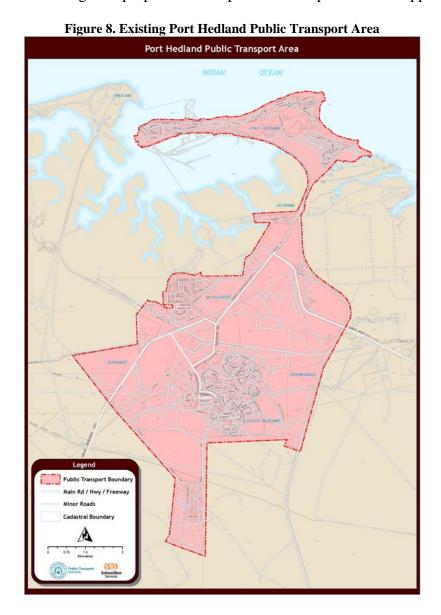


6.6 Public Transport

The Public Transport Authority's current public transport bus service contractor for Port Hedland is Hedland Bus Lines who provide public transport on behalf of the Public Transport Authority for:

- South Hedland Town Bus Service
- School Pick-up and Drop-off

With proposed development of the South Hedland Town Centre and the Western Edge residential land subdivision including new roads and major activity centres, these areas can be better serviced by Public Transport. A recommended extension of the current public transport bus route through the proposed development area is presented in Appendix 2.





7.0 SUMMARY

Estimated traffic generation and arrangements for operation of the proposed Development Concept Plan road network have been assessed. It is considered that the proposed development area road network will operate in a satisfactory manner and should not have undue impact on the abutting road environment.

Traffic generation by the proposed development area is anticipated to be in accordance with permitted land use as described by current practice trip generation rate guidelines.

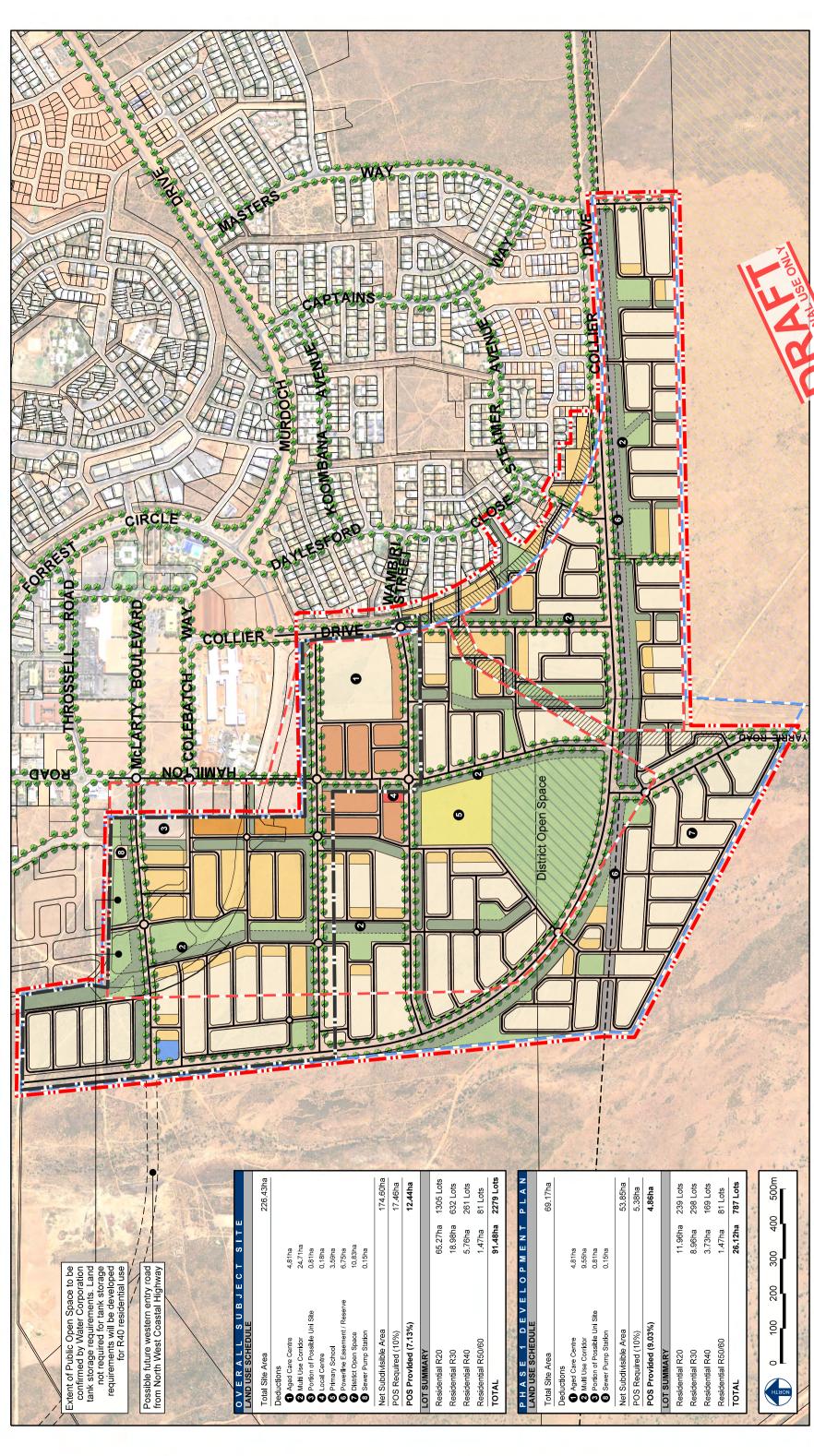
For the proposed land subdivision development:

- At full development of all subdivisible land under this assessment there is impact on the road network that will require the major transport roads to be upgraded by the Local Authority.
- For the Western Edge Land Development, roads to be modified under the land development are Collier Drive and Hamilton Road. Construction of Road A will provide for a future connection with the extension of North Circular Road by the Local Authority.
- The Western Edge Land Development internal street network layout and operation will be sufficient to provide for the proposed residential dwellings, school, public open space and ancillary development and land uses.
- Provision of a high quality pedestrian and bicycle network inter-connected with the
 existing and proposed South Hedland network will be sufficient to meet the needs of
 the proposed land development area.

APPENDIX 1 Development Area Concept

PROPOSED DEVELOPMENT PLAN
Western Edge, SOUTH HEDLAND

RPS Australia East Pty Ltd
ABN 44140292762
PO Box 465 SUBIACO WA 6904
38 Station Street SUBIACO WA 6008
T +61 8 9211 1111 W rpsgroup.com.au



LEGEND

- Subject Site

Extent of Heritage

Proposed "Phase 1" Development Plan Boundary Urban Development Zone Boundary (Sept / Oct 2011)

Public Open Space Multi Use Corridor Local Centre

> Residential R20 Residential R30

Existing 66kva Powerline

Powerline Easement / Reserve Primary School Site Mixed Use

> Residential R50/60 Residential R40

District Open Space

Proposed Collier Drive Closure Proposed Yarrie Road Closure

Long Term Future Urban Growth (as per Growth Plan)

Base data supplied by Landgate. Aerial Photography dated Nov 2009. Accuracy +/- 4m. Projectlon PHG94.

S.D. PLANNER L.W.: DRAWN

2957_17-2-001e.dgn : PLAN No 19 June 2012 : DATE

e : REVISION

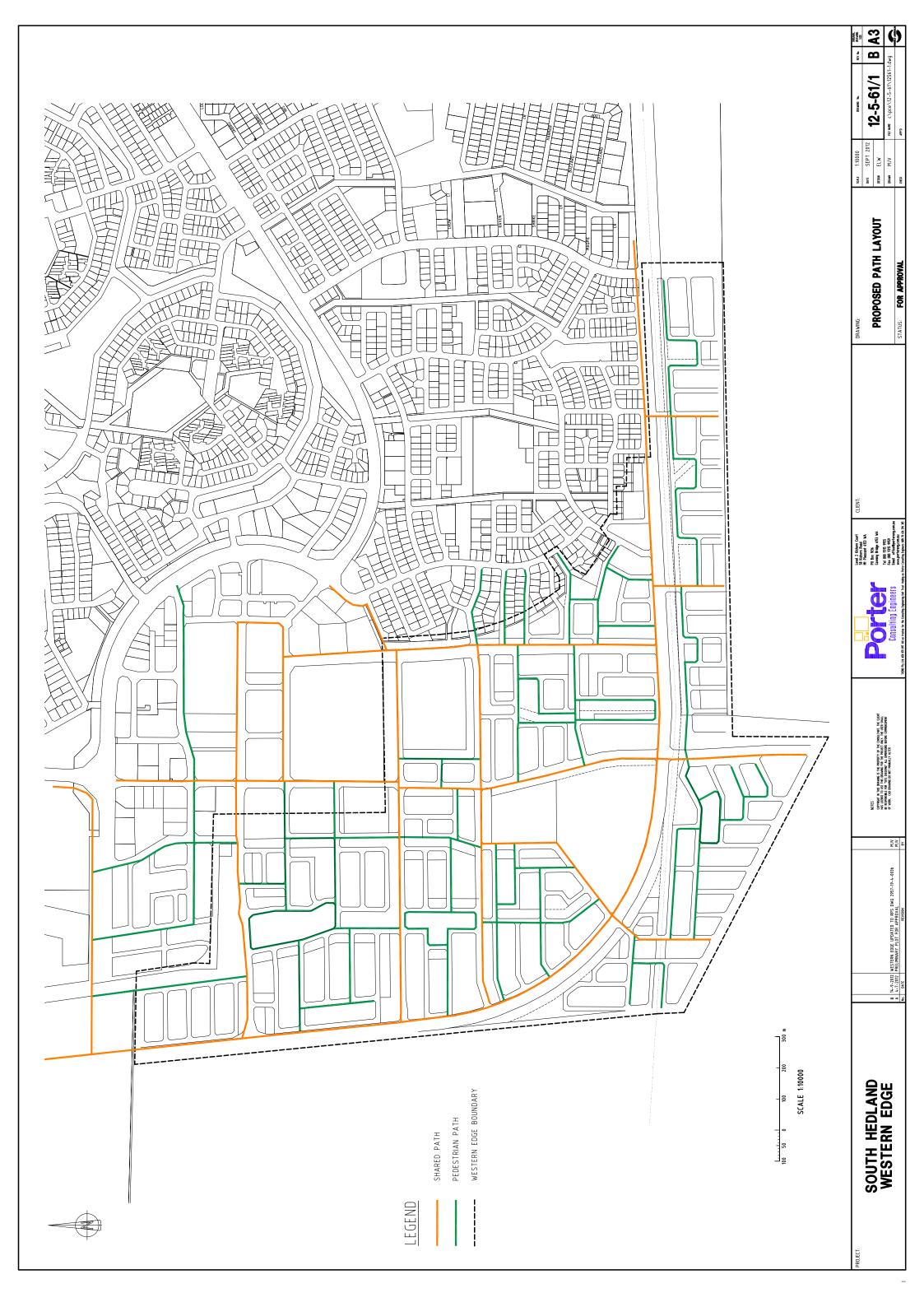
RPS Environment and Planning Pty Ltd ACN 108 680 977 ABN 45 108 680 977

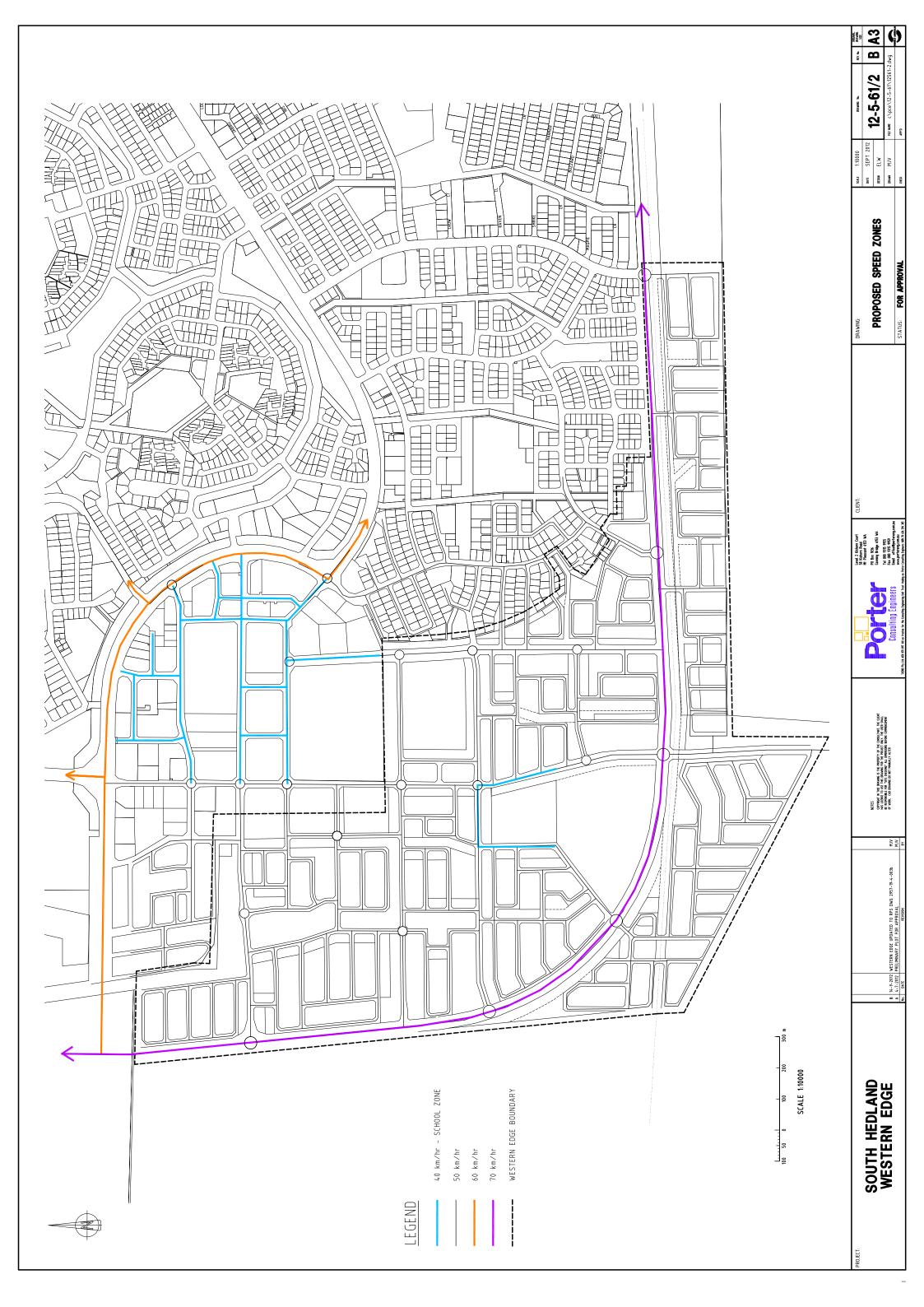
PRELIMINARY CONCEPT PLAN Western Edge, SOUTH HEDLAND

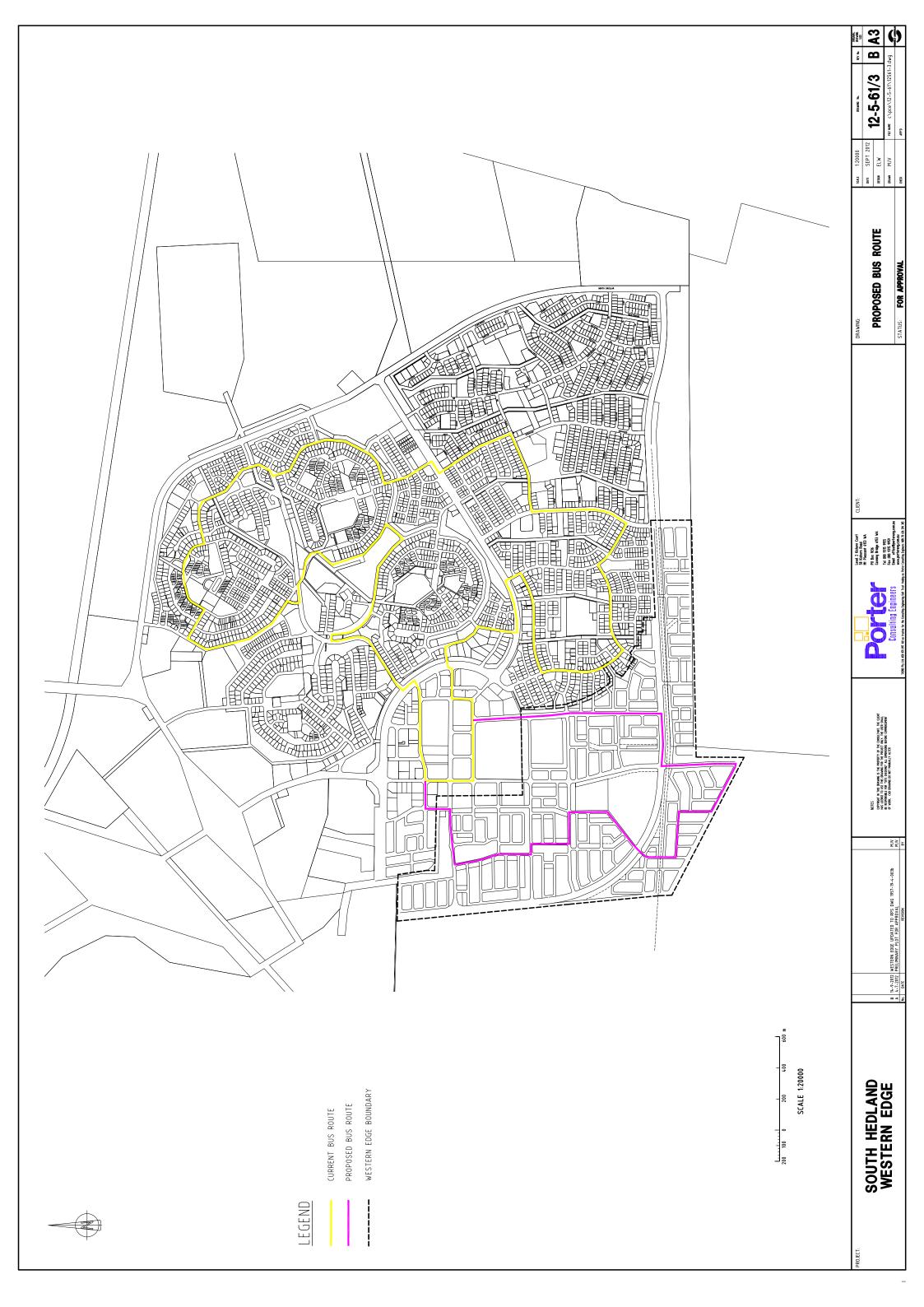
PO Box 465 Subiaco WA 6904 38 Station Street Subiaco WA 6008

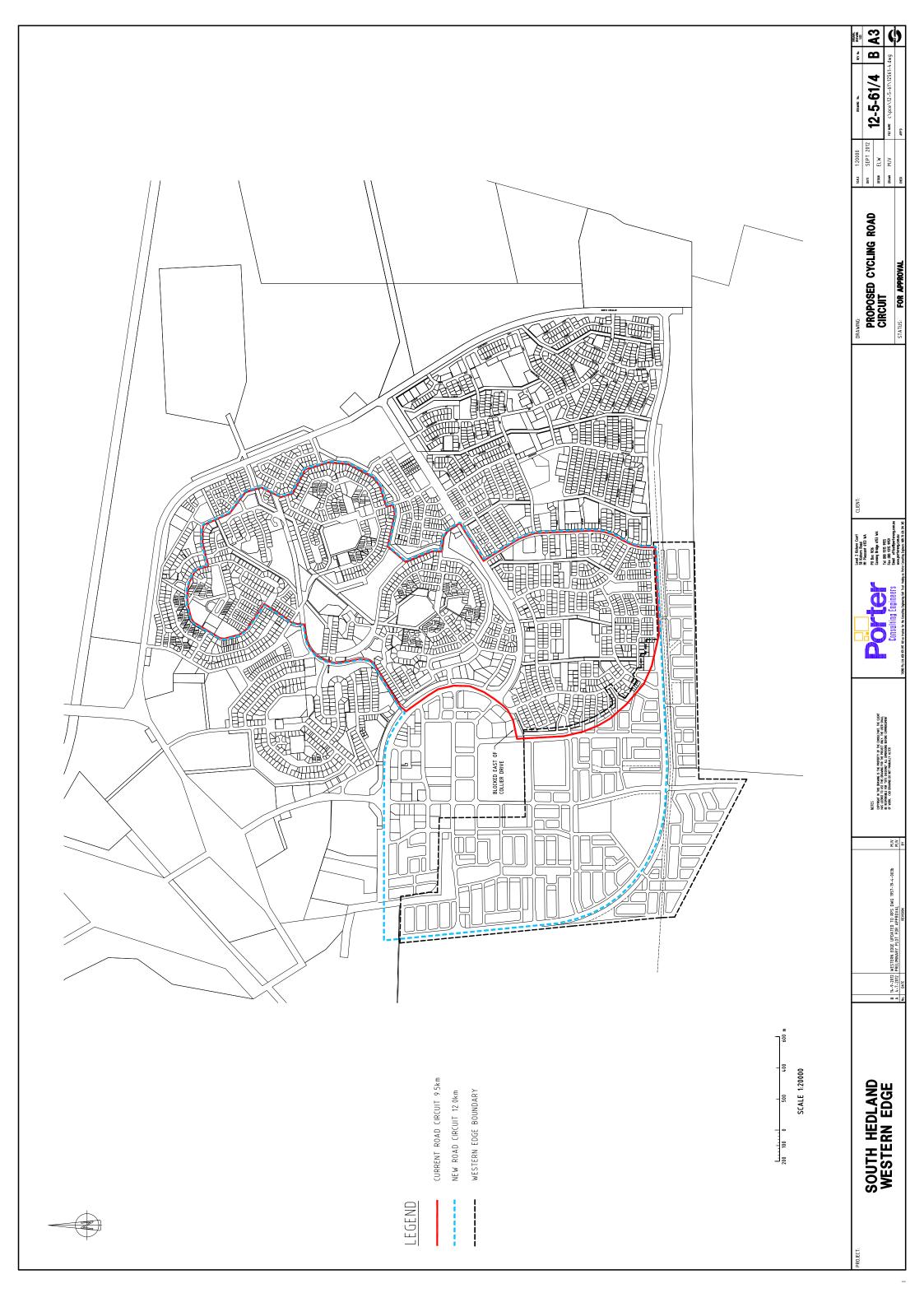
T +61 8 9211 1111 F +61 8 9211 1122

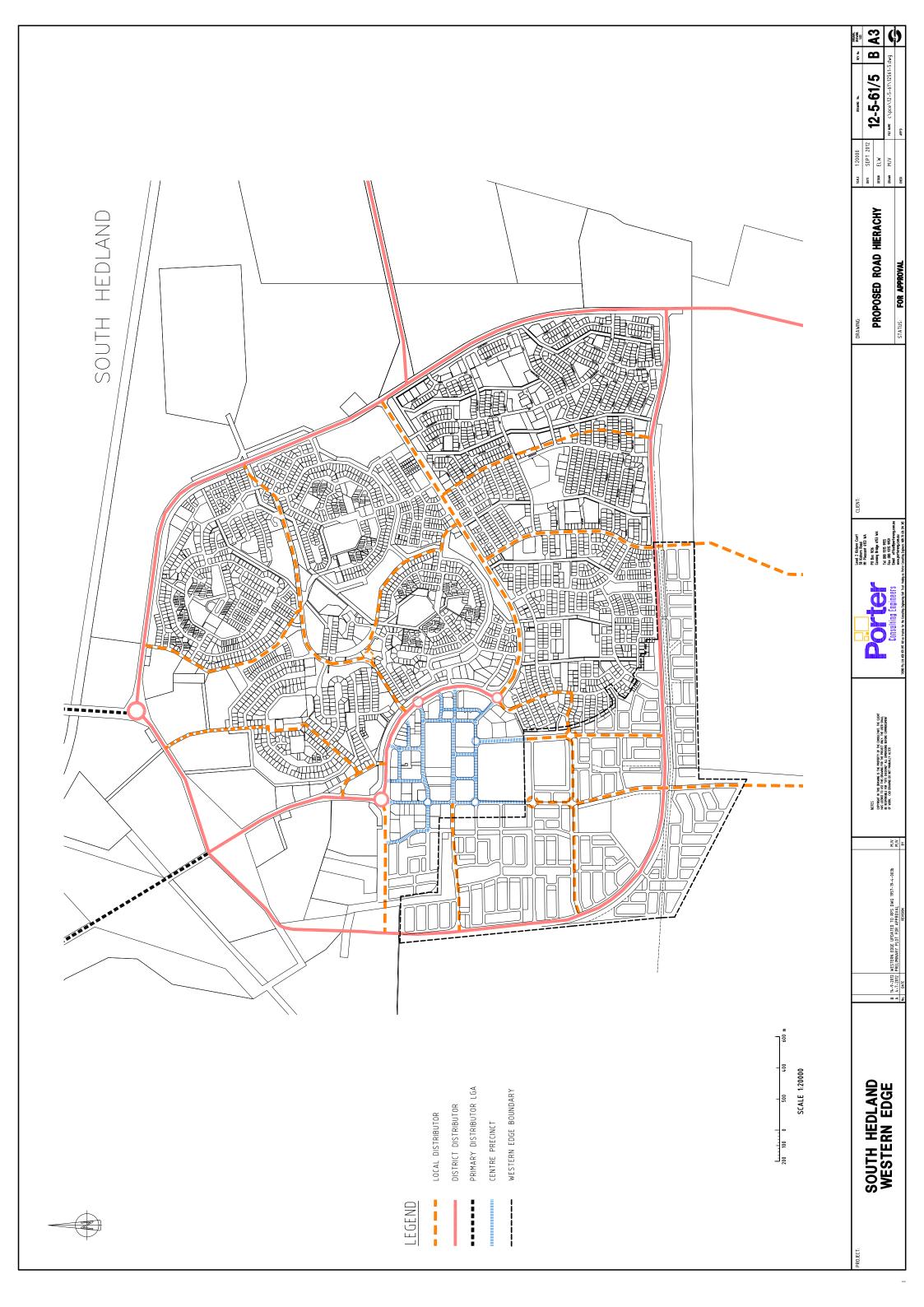
APPENDIX 2 Street Network Maps

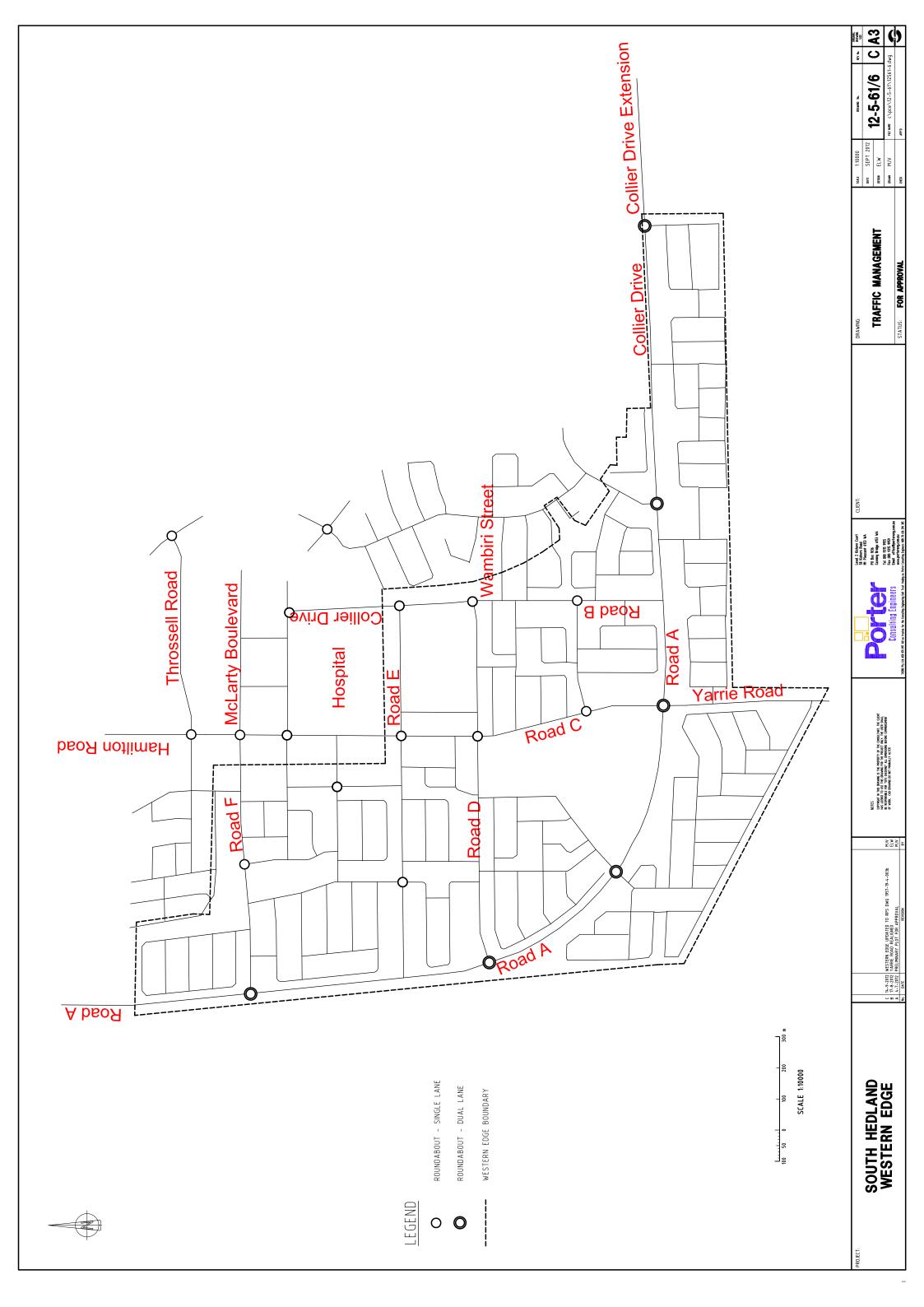


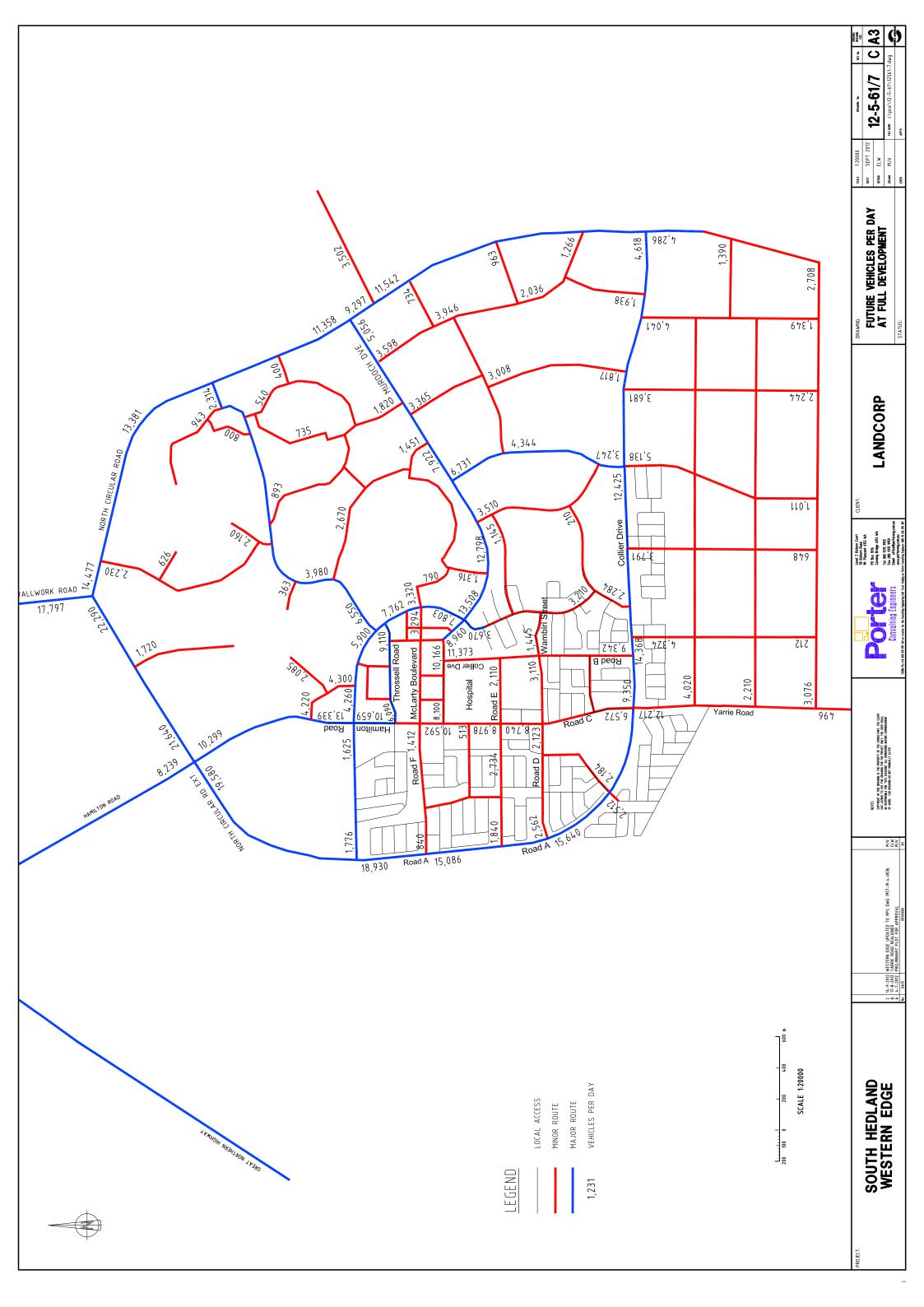














APPENDIX 5

Landscape Concept Plan

■ SOUTH HEDLAND, WESTERN EDGE | DRAFT DEVELOPMENT PLAN

Landscape Strategy REV D



SEPTEMBER 2012



Level 1A 3-5 Josephson Street, Fremantle WA 6160 †+61 (08) 9430 7060 f+61 (08) 9430 7060 w udla.com.au Prepared for: Prepared by:

Locked Bag 5, Perth Business Centre, PERTH 6849

Landcorp Pty Ltd

P: (08) 9482 7499

F: (08) 9481 0861

UDLA

Level 1A 3-5 Josephson Street,

Fremantle

9190

P: (08) 9336 7577

F: (08) 9430 7060

W: www.udla.com.au

Information Input by:

RPS

290 Churchill Avenue, SUBIACO WA 6008

PO Box 465, SUBIACO WA 6904

T:(08) 9382 4744

F: (08) 9382 1177

E: admin02@rpsgroup.com.au

W: www.rpsgroup.com.au

DISCLAIMER:

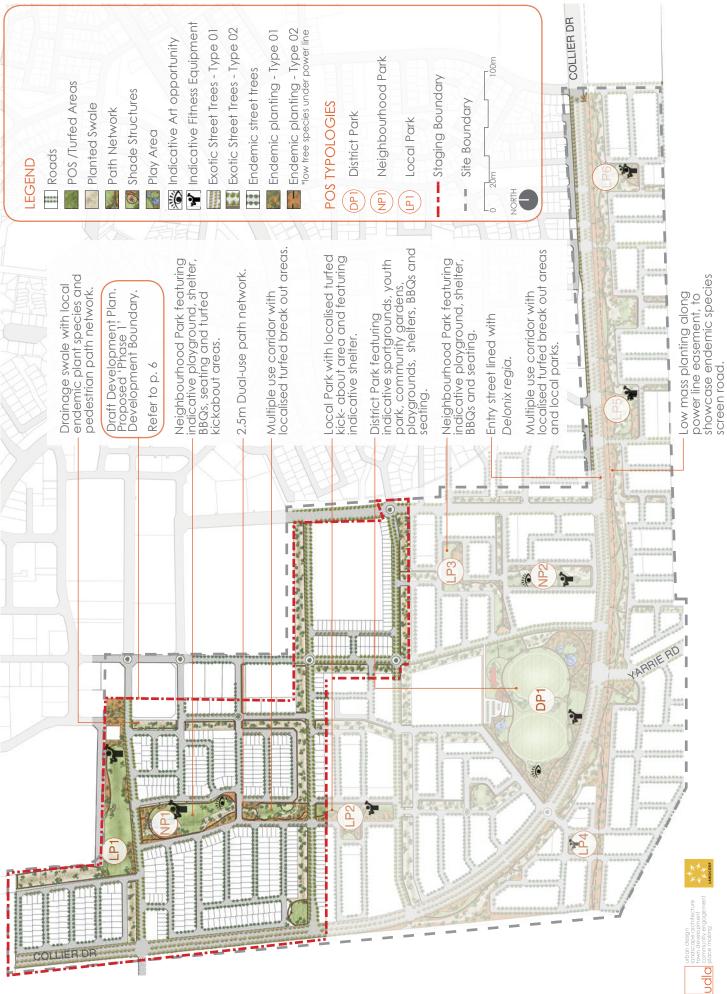
This document has been prepared for Landcorp Pty Ltd by UDLA.

UDLA reserves the right, at any time with or without notice, to amend, modify or retract any part or all of this document including any opinions, conclusions, or recommendations contained therein.



CONTENTS

01	INTRODUCTION	2
00	SITE CONTEXT Climate Landform and Geology Soils Water and Drainage Fauna Vegetation	9 9 9 1 1 2 5
03	URBAN WATER MANAGEMENT & MULTI USE CORRIDORS Urban Water Management Multi Use Corridors 'Inline' and 'Offline' Parkland	20 1 1 1 2 2 3 3 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4
40	PARKLAND TYPOLOGIES, CIRCULATION & LINKAGES Neighborhood Parklands Local Parklands Break- out Parkland	22 28 31 31
05	STREETSCAPE TYPOLOGIES District Distributor Neighbourhood Connector Access Roads Streetscapes and Shade	33 34 38 38
90	WATERWISE LANDSCAPES, IRRIGATION AND PLANTING PALETTE Tree Species Selection Criteria	43
0	WEED AND PEST MANAGEMENT Weed Control and Management Pest Management	4 4 4 7 5 5
08	CLIMATE RESPONSIVE DESIGN	46
60	Sustainability	46
10	DESIGNING SAFE PLACES	47
Ξ	OPEN SPACE ART AND INTERPRETATION STRATEGY	48
12	BUILDING LOCAL INDUSTRY CAPACITY	48
7		70



01 INTRODUCTION

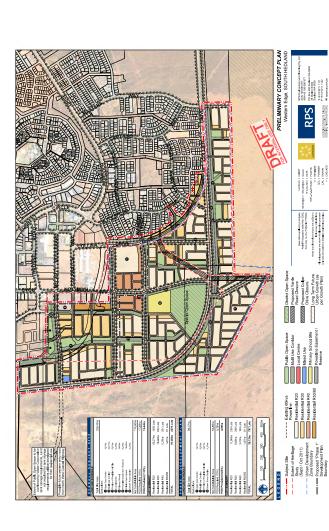
Coastal and overland flooding have been the major constraints for town expansion within the present day extractive industry town of Port Hedland situated in the heart of the booming Pilbara region. South Hedland was designed in the 1970s to mitigate housing shortages associated with the mining boom and was sited approximately 10km south of Port Hedland to alleviate flooding issues. The Western Edge Development, also sited on higher ground away from coastal inundation, is expanding south due to physical and development constraints elsewhere.

This report focuses on the provision of open space providing amenity that responds to the local Hedland context: biophysical, social and cultural.

The South Hedland township was planned in the early 1970's under the Radburn design model. This town planning model included emphasis on open space and pedestrian linkages reducing the prospect of crossing too many vehicular roads, especially between different communities. The plan enclosed neighborhood cells via an internal road network surrounded by an open space and pedestrian/bike linkage network. Originally pedestrian/bike linkages to the broader planned network were also provided via narrow cul- de- sac heads. Time has shown that these open space and internal pedestrian linkages have failed within the South Hedland/ Radburn model due mostly to the Pilbara's harsh and climate, poor open space amenity and inappropriate behaviour issue alongside private residents where the tight neighbourhood links were provided. This malfunction of public space has since grown a culture of tall fences to ward off private intrusion issues, self perpetuating surveillance issues by limiting the opportunity for friendly neighborhood passive surveillance.

Furthermore, much of the external cell open space required an extensive and often steep sided impenetrable drainage system further discouraging pedestrian scale activation and healthy social movement patterns. Therefore most movement within this town structure reverted back to onerous vehicle trips that traverse the cell structure to eventually penetrate through to the next neighbourhood cell or major connector road.

Open space areas within South Hedland are presently unsustainable requiring ongoing large amounts of materials, maintenance and resources to provide sufficient amenity. Large costs attributed to open space has meant most open space is in disrepair, weed and rubbish burdens decreasing community value and respect and increasing anti-social behaviour.



Plan | Preliminary Concept Plan

NOT TO SCALE

<source: RPS>





Plan | Draft Development Plan

NOT TO SCALE

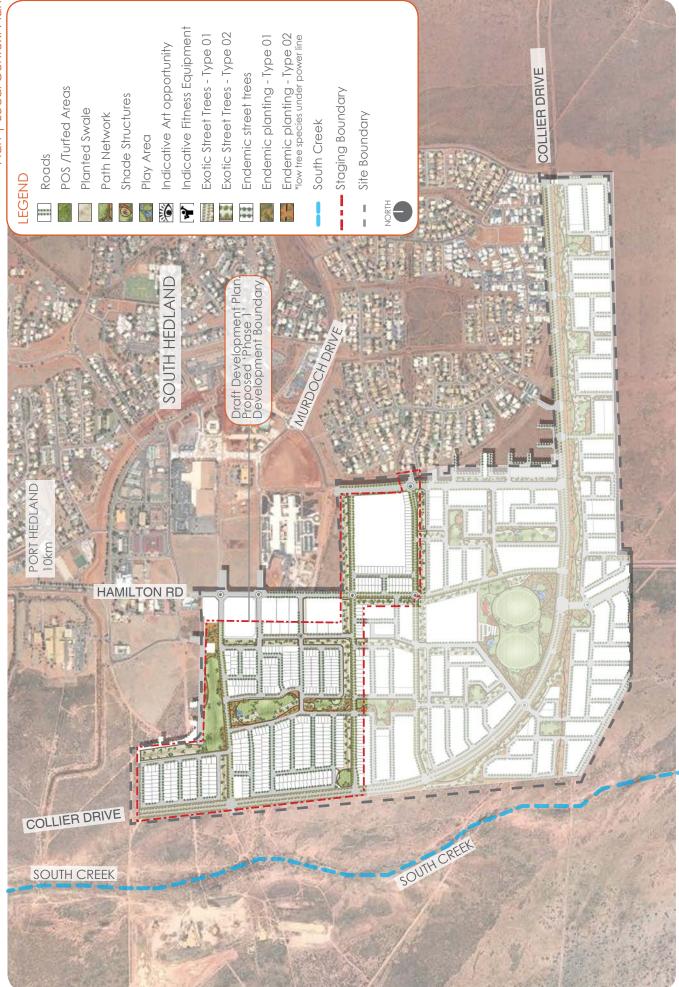
<source: RPS>

The South Hedland Western Edge development seeks to learn from the negative aspects of the existing township and endeavour to provide a linked network of usable, manageable and sustainable spaces providing the amenity needs for a growing population. Open space that effectively combines multi- functional uses such as active/passive parklands, dual- use pedestrian/bike linkages together with the conveyance of urban water drainage and pedestrian scaled streetscapes shall provide South Hedland with contemporary public open space that acknowledges and responds to the Pilbara context.

The Western Edge | Draft Development Plan Landscape Strategy will address the following:

- Multi- use corridors & urban water management- what is best practice and addressing a new form of open space multi functional amenity;
- Parkland typologies
- Streetscape typologies
- Responding to water wise landscapes Irrigation strategy and planting palette;
- Weed & Pest Management
- Design for place and climate providing safe places and responding to climatic conditions;
- Open Space Art & Interpretation Strategy Recognising cultural and social diversity and heritage through local art and interpretation opportunities.

The above mentioned open space design aspects can be used to develop positive places that are functional, meaningful and comfortable providing a sense of well being and with unique qualities, providing a 'sense of place'.







02 SITE CONTEXT

South Hedland is located within the Pilbara region, North West of Western Australia approximately 1,647 kilometres from Perth via Great Northern Highway. In order to build the community with a strong emphasis on connection to country, the open space planning must enhance and protect the local site ecology, as well as create opportunities and outcomes uniquely sensitive to local culture and site. Understanding the local environment provides the future development with a sustainable way forward that provides a landscape reflective of the local sense of place, considering the strong biophysical and cultural issues that are closely interlinked in the Pilbara landscape.

CLIMATE

The West Pilbara is affected by cyclonic wind patterns from December-March. Summer temperatures average 32°C to 36°C with the cooler season June to August average temperatures ranging from 26°C to 29°C. Extremes can range from 0°C (at night) to 45°C plus.

Summer wind patterns consist of mild to strong easterly winds in the morning, changing to a strong westerly breeze in the afternoon. The Breezes over the hot often humid 'wet' season period are considered not to be cool breezes. Air movement can advantage cooling within shaded and protected areas.

In the 'dry' season cooler to cold winds can be experienced from the east as they carry dry breezes from the inland desert country.

Semi-tropical to arid climate with major rainfall events during cyclonic activity in summer or 'wet' season months.

LANDFORM AND GEOLOGY

The Western Edge Developments' topography is typical of the Pilbara landscape: flat and highly weathered with low rangelands occurring in the interior. This landscape has remained largely unchanged for 100 million years.

The coastline of the greater Hedland region consists of flat sandy lowlands, with broad areas of bare coastal mudflats, intertidal mudflats and tidal



calcilutite, which outcrops discontinuously near the coast. These dune, beach unconsolidated sedimentary soils described as sandy calcarenite, oolite and ridge, beach and offshore bar deposits are predominantly marine, with the creeks, and a significantly aftered open harbour at Port Hedland. The Port exception of the barrier dune system which is of Aeolian origin. DoA 2004. Hedland area is located on the Holocene, Bossut Formation, a body of

The following geological maps exist for Greater Hedland region:

- Port Hedland Bedout Island, Western Australia, 1:250,000 Geological Series, Geological
- Survey of WA, Department of National Development and Energy,
- Boodarrie Geological Survey of Western Australia, 1:50,000 Urban Geology Series, Department of Lands and Surveys, 1983;
- Geology Series, Department of Lands and Surveys, 1983 (GSWA 1983); Port Hedland Geological Survey of Western Australia, 1:50,000 Urban
- Geological Series, Department of Minerals and Energy, 2001; Wallaringa Geological Survey of Western Australia, 1:100,000
- Yule Geological Survey of Western Australia, 1:100,000 Geological Series, Department of
- Minerals and Energy, 2001; and
- Port Hedland Bedout Island, Geological Survey of Western Australia, 1:250,000 Geological Series, Department of Industry and Resources,

SOILS

has a collapsible structure however can be extremely hard to work when dry. clayish loam. Pindan is the basis of most soils in the North West with the area around South Hedland gaining added texture from gravel. Hedland Pindan The inland local soil type is predominantly made up of Pindan, a fine red

aquatic ecosystems can occur. Deposition of Pindan also impacts drainage disturbed and exposed, silting of tributaries and smothering of downstream Experience in the North West has uncovered that fine clay particles within Pindan are believed to smother aquatic ecosystems. If Pindan soils are infrastructure by blocking pipes when dry and crusted.

stabilise Pindan soils, preventing surface erosion and overland sediment flows Endemic ground-covering species such as Spinifex and Kangaroo grasses during cyclonic rain events.

WATER AND DRAINAGE

Overland water flow is a major consideration in the design and development is situated on generally flat land with a slight overland drainage grade of the Western Edge Development. The Western Edge Development channelling water west towards South Creek.

arge sandy depressions to infiltrate or evaporate over time, or eventually into the ocean via tree-lined ephemeral creeks (such as South Creek) that lead Due to the hydrophobic nature of Pindan, overland drainage is broad and sheet-flows are common. Slow moving sheet flows are either directed to nto Mangal flats and sheltered bays.

that the nutrient stripping capacity of this environment is minimal during larger quality in the North West relies on overland sheet flows being filtered through improvement techniques such as low- flow bio-filtration is ineffective. Water perennial grasses that contain sediments or contaminates. It is understood While rain events occur infrequently, events often produce large volumes of water over short periods of time. As a result traditional water quality events.



Pindan Deposition



Wetland | Pre event



Wetland | Post event





FAUNA

The fauna habitat type within the Western Edge Development is a Grassland Mosaic as detailed within RPS's accompanying Western Edge Environmental Assessment Report (2012).

In summary, ten vertebrate fauna species have been identified (two mammals and eight birds) as occurring within the Grassland Mosaic habitat. As this habitat type surrounds the subject land, all ten species potentially occur within the Western Edge Development, providing the presence of suitable vegetation for habitat. The ten species are as follows:

Mammals

- Australia and a population is known to occur in the Hedland Region. In arid environments Ghost Bats are mainly found near rocky outcrops and roost in small colonies in caves, mines and rock clefts.
- Rhinonicteris aurantia: (Pilbara form) Pilbara Leaf-nosed Bat is restricted in distribution to the Pilbara. The Pilbara Leaf-nosed Bat is known to roost in the mines of the Eastern Pilbara, in the Hamersley Range and in the sandstone formations south of the Hamersley Range.

Birds

- Falco peregrines: Peregrine Falcons are widespread across most habitats in Australia and generally prefer coastal and inland cliffs or open woodlands near water.
- Ardeotis australis: Australian Bustards are tall birds that live on open grassy plains and low shrubby areas in northern Australia.
- Falco hypoleucos: The Grey Falcon is infrequently seen over much of and and semi-arid Australia and favours timbered lowland plains

that are crossed by tree-lined watercourses. The Grey Falcon is also known to frequent grassland and woodland habitats.

- Heteromunia pectoralis: Pictorella Mannikin is usually found near water in acacia shrublands that have a grassy understorey and in the Triodia hummock grasslands of northern Australia.
- Apus pacificus: The Fork-tailed Swift are known to occur from Eyre
 Bird observatory to Denmark. They are widespread in coastal and
 sub coastal areas between Augusta and Carnarvon, including
 near and offshore islands. The Fork-tailed Swift prefers habitat
 in coastal areas including cliffs and beaches and occasionally in
 treeless grassland and sand plains.
- Glareola maldivarum: The Oriental Pratincole prefers open plains, flood plains or short grasslands, offen occurring near terrestrial wetlands. It also occurs on the coast, inhabiting beaches, mudflats and islands.
- Hirundo rustica: The Barn Swallows non- breeding range occurs
 along the north coast of Australia. Preferred habitat includes
 open country with low vegetation, such as pasture, meadows and
 farmland preferably with nearby water.
- Merops ornatus: The Rainbow Bee-eater is most often found in open forests, woodlands and shrublands, and cleared areas, usually near water. It can be found on farmland with remnant vegetation and in orchards and vineyards. It will use disturbed sites such as quarries, cuttings and mines to build its nesting tunnels.

References

Bamford (2012) South Hedland – Western Edge Precinct, Fauna Assessment. Kingsley: Western Australia (unpublished).



VEGETATION

Port Hedland is situated within the Interim Biogeographical Regionalisation of Australia region of Pilbara 4, and more specifically, within the coastal subregion of Roebourne.

A detailed description of vegetation within the subject site can be found in RPS's accompanying Western Edge Environmental Assessment Report 2012.

The Roebourne subregion is described as:

Quaternary alluvial plains with a grass savannah of mixed bunch and hummock grasses, and dwarf Shrub Steppe of Acacia translucens or A. pyrifolia and A. inaequilatera. Resistant linear ranges of basalts occur across the coastal plains. These uplands are dominated by *Triodia* hummock grasslands. Ephemeral drainage lines support *Eucalyptus* woodlands. Samphire, Sporobolus grasslands and mangal occur on the marine alluvial flats and river deltas.

Table 1: Vegetation Types Recorded in the Subject Land (Source RPS Environmental Assessment Western Edge 2012)

Vegetation Type











Vegetation Description

Low to Low Open Shrubland of Acacia stellaticeps, Bonamia spp., Ptilotus astrolasius and Hybanthus aurantiacus over Closed to Open Tussock Grassland of Triodia epactia, Eriachne obtusa, Aristida holathera var. holathera, Chrysopogon fallax and Paraneurachne muelleri.

Shrubland of Acacia stellaticeps Hi over Low Open Shrubland of To Acacia stellaticeps, Bonamia he spp. with Tussock Grassland of to Open Tussock Grassland of Triodia lanigera, Aristida spp. and Scattered Herbs of Cassytha spcapillaris.

High Open Shrubland to Scattered Tall Shrubs of Dolichandrone heterophylla and or Low Shrubland to Low Scattered Shrubs of Acacia stellaticeps, Ptilotus astrolasius and Bonamia spp. with Tussock to Open Tussock Grassland of Triodia schinzii over Scattered Herbs of Mollugo

Closed to Open Tussock Grassland

spp., Ptilotus astrolasius and Hybanthus aurantiacus over holathera, Chrysopogon fallax

and Paraneurachne muelleri.

obtusa, Aristida holathera var.

of Triodia epactia, Eriachne

Low to Low Open Shrubland of

Acacia stellaticeps, Bonamia

molluginis and Cyperus blakeanus; mosaic Tussock to Open Tussock Aristida holathera var. holathera over Scattered Herbs/Sedges of cardiophylla, Ptilotus astrolasius, Grassland dominated by either or Eriachne obtusa with Triodia Hybanthus aurantiacus over a Acacia tumida var. pilbarensis Bonamia alatisemina, Mollugo Triodia epactia, Triodia schinzii lanigera, Chrysopogon fallax, incanus, Bonamia rosea and Low to Low Open Shrubland on moister soils in lower lying with Scattered Tall Shrubs of Acacia colei var. colei and of Acacia stellaticeps, Sida Corchorus incanus subsp. depressions.

References

- RPS Environmental Assessment Report for the Western Edge 2012
- BHP (2011). Section 5: Existing Terrestrial Environment. Accessed 12 January 2012 http://www.bhpbiliton.com/home/aboutus/regulatory/Documents/per/section5ExistingTerrestrialEnvironment.pdf
- Department of Conservation and Land Management (2002). A Biodiversity Audit of Western Australia's 53 Biogeographic Subregions in 2002, Perth,
- Van Vreeswyk, A.M.E., Payne, A.L., Leighton, K.A. and Hennig, P. (2004). An inventory and condition survey of the Pilbara region, Western Australia. Department of Agriculture, Western Australia Technical Bulletin No. 92.

URBAN WATER MANAGEMENT AND MULTI- USE CORRIDORS 03

URBAN WATER MANAGEMENT

Intermittent yet often heavy seasonal rain events dictate the importance of a roads, streetscape and open space play an integral part in the overall urban water management strategy for the Western Edge Development with overall well-considered and efficient urban water drainage strategy. Holistically the that urban water management is successfully incorporated effectively into A key objective and one that sets this development apart will be ensuring the public open space network as useable public open space amenity. development design keeping the above objective in mind.

roads with flush kerbs. The swale system or drainage path is part of a multi- use In broad terms, run-off from hardstand and lots is directed down sealed roads corridor network that includes linear dual- use pedestrian and bike linkages, and kerbs. The road pavement water is then frequently channelled into the extensive bands of endemic vegetation and passive and active break-out broader natural swale system via drainage shoots or one-way cross flow

minimise large vegetation within these swales proposes trees and large shrubs planted with endemic perennial grasses. It is important that vegetation cover The flat topography grades slightly west towards the South Creek catchment. minimise the opportunity for swale roughness by vegetation. Opportunities to water within this treatment train, flat grades also heighten flooding issues and urban drainage. Although best practice is to slow, infiltrate and treat urban Due to the flat grade there is limited opportunity to easily outfall or remove are planted on minimum 1:6 batters with the main base area only being is used to bind the local Pindan soil and improve water quality.

Drainage flow is to be managed through the use of a three tiered topographic profile as follows;

Tier one

to limit areas impacted by residual or standing water. Only endemic or Low flow areas at the base of the swales are designed to manage the impact of 1:1 to 1:5 year rain events. The low flow areas are desigend recreational grasses to be used in this zone;

Tier two

The intermediate tier provides opportunity for slightly graded vegetation or open lawn and are designed to take flow events from 1:10 to 1:100. The planting of trees and shrubs within this areas is to be kept to a minimum to ensure flow velocity is maintained while still providing effective shade and visual aesthetic; and,

that substantial infrastructure such as playground, dual use paths, fitness stations, hardstand areas and constructed shelters are kept away from The 'offline' tier is designed above the 100 year flood level to ensure possible flooding damage. This area is suggested to be substantially vegetated with large shaded trees and shrubs where appropriate.



Lot Drainage Retention



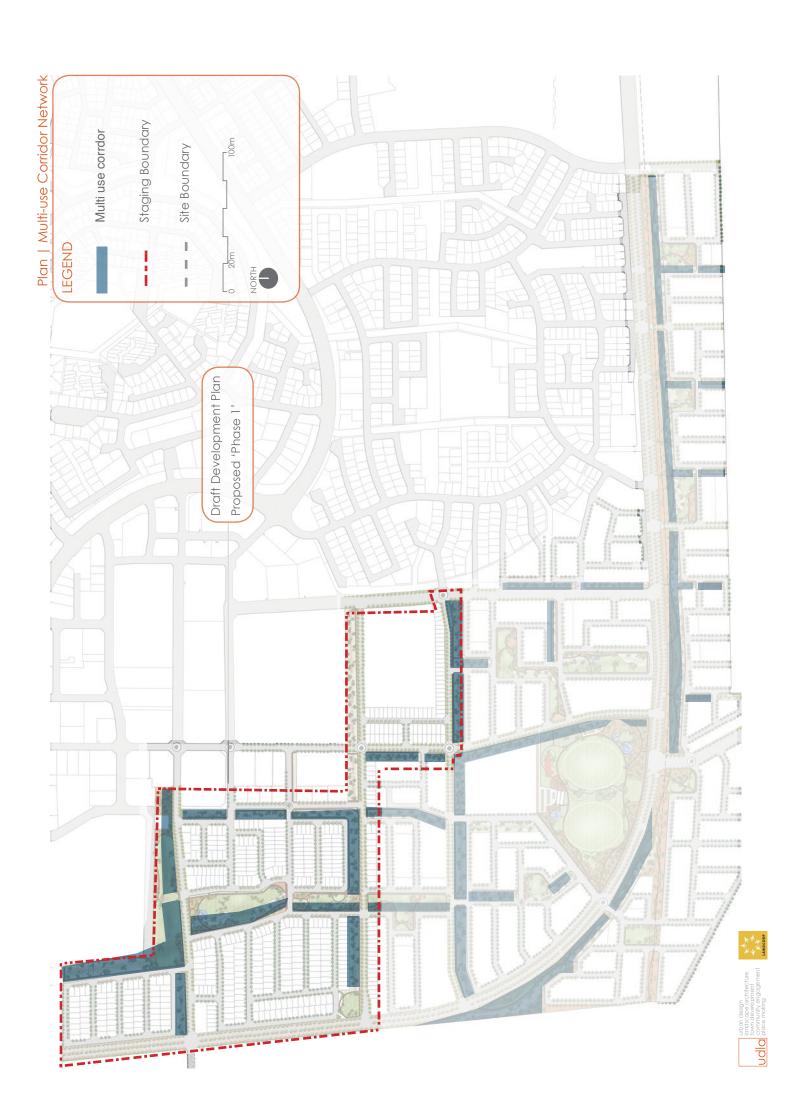
Multi-use Corridor 1



Drainage control 'V' cut weir



Drainage control 'V' cut weir



MULTI- USE CORRIDORS

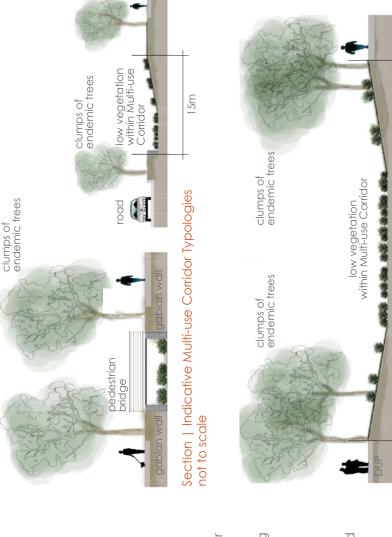
Multi-use corridors consist of a combination of linear dual-use pedestrian/ cycle linkages, extensive bands of amenity providing endemic vegetation simple vegetative buffer amenity through to recreation and connection corridors merge with the adjacent urban fabric-ranging from providing and passive/active break- out parklands. It is important that multi- use options for residence, free from roads and cars.

Specific multi- use corridor functions include;

- The provision of ecological links throughout the development area and the town centre;
- The provision of urban amenity links that create an opportunity for greater development density adjacent to multi- use corridor amenity;
- development area, linking adjacent neighbourhood cells and the existing The provision of car free pedestrian and cycle networks throughout the town centre;
- Access to drainage space (that is infrequently operational) for recreational use and variation in topography;
- The provision of easily accessed break- out parkland with active/passive recreation spaces and part of the linear path network;
- Opportunities for cultural, environmental and educational interaction and interpretation including community art and development projects; and,
 - Provide North West Australia best practice urban water and flood management.

Section | Indicative Multi- use Corridor Typologies

not to scale





clumps of endemic

Multi use corridor Grass treatment



Endemic Vegetation Multi use corridor Treatment

road

1:5 year rain

planted drainage

1:10 - 1:100swale

LEGEND Inline POS Offline POS Site Boundary Site Boundary

'INLINE' AND 'OFFLINE' PARKLAND

Parkland that has a drainage function is referred to as 'inline parklands' whilst open space that is placed outside of the multi- use corridors and therefore has no drainage function is referred to as 'offline parklands'. 'Inline parkland' treatment is composed of lawn that crosses the drainage tiers (1:1 to 1:100 events). This makes functional use of space that is otherwise unused for the majority of the year. The drainage function of inline parks is only required during storm events that occur 1-5 times a year with water runoff conveyed within the hour.

The form of a multi- use corridor provides for variation in topography in an otherwise flat landscape. The incorporation of gentle gradients allows recreation areas to be extended into the drainage zones enabling the facilitation of a wider range of activities. The linear forms (recommended minimum width of multi- use corridor is 30m) of the vegetated and active corridors allow for greater provision of passive surveillance within the open space network. These recreation spaces also being part of a pedestrian and bike network promote consistent activation of these spaces endeavouring to minimise possible anti-social behaviour.

Hard stand areas with shared seating and built shade structures will provide linking and destination spaces with the ability for these areas to be able to be used for community events and gatherings. Materials and furniture will be robust to minimise the impact of vandalism yet designed to a high quality finish, taking into consideration the impact of climate on elements such as public open space furniture.



Plan | Inline and Offline POS

Inline park



Offline park



Offline park



Neighbourhood Park | Section B Typical example of Inline parkland scale 1:1000

open turfed mulfi-use corridor for active recreation and provides access



Local Park | Section C Typical example of Offline parkland scale 1:1000

PARKLAND TYPOLOGIES, CIRCULATION AND LINKAGES 04

LEGEND



Total Area 83,286 m2

42,928 m2

Total Area

117,005 m2

Total Area



Neighbourhood Park



Local Park



District Park



The Parkland typologies within this development include; from smallest to largest: 6 x Local Parks (average 5,000m2) plus associated lawn break out areas;

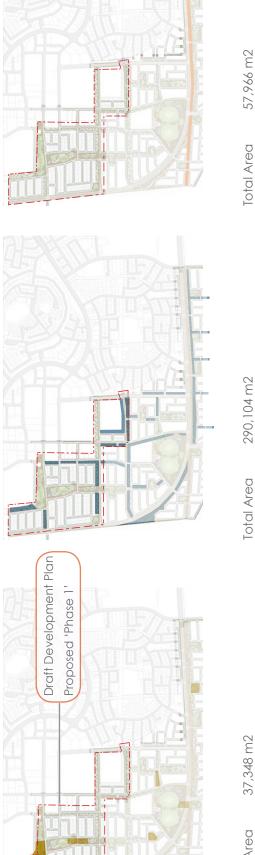
parkland shall include 'inline' and 'offline' drainage functions, however with a

primary function of providing useable community open space amenity.

network and therefore limiting isolated pocket parks. The active/passive

The majority of parkland typologies are to be linked via the multi- use corridor

- 2 x Neighbourhood Parks (average 10,000m2) 1 x District Park (approx 11Ha)

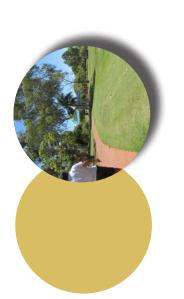




37,348 m2 Total Area

Total Area

Total Area



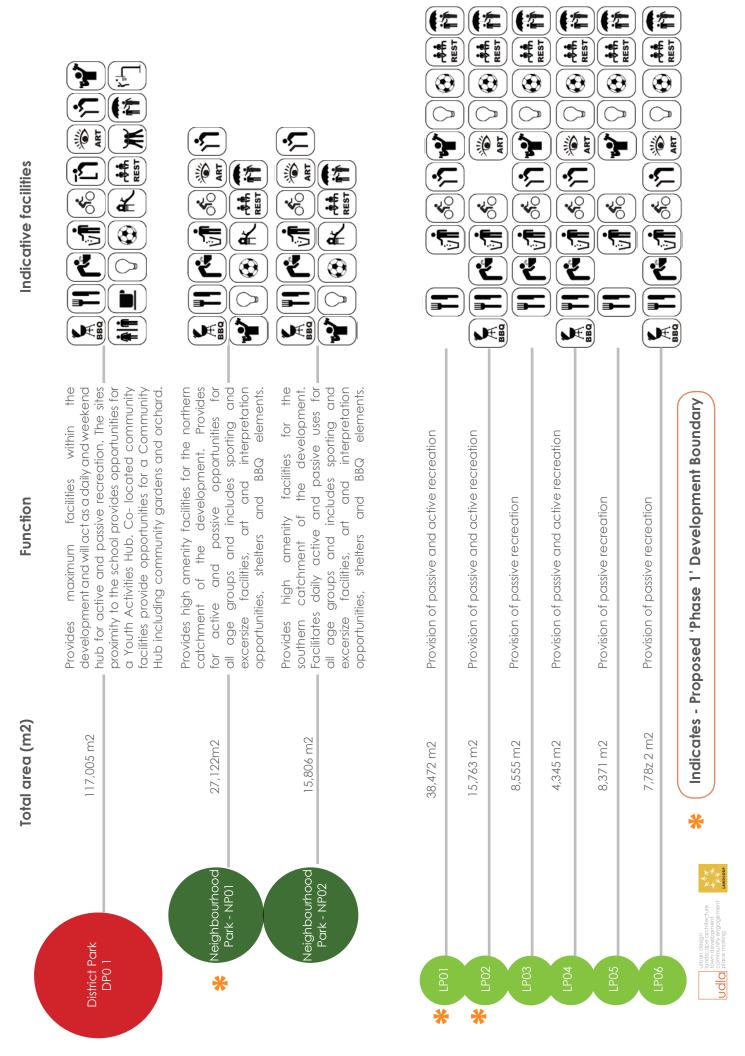
Breakout POS

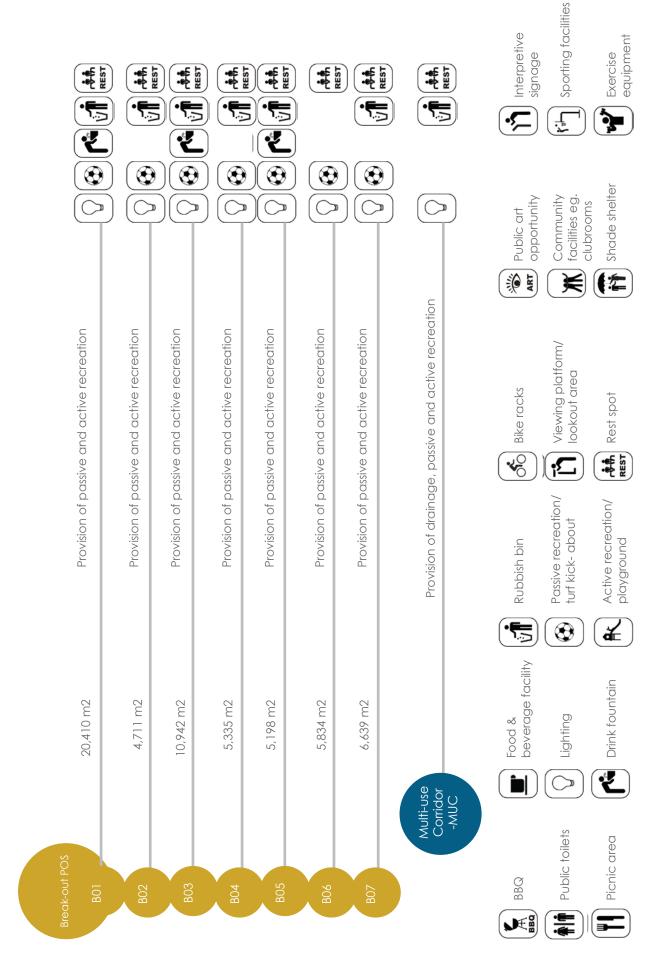


Multi-use Corridor



Powerline easement





COLLIER DR



Pedestrian orientated development













CORTH

Location plan | Neighbourhood Park

NEIGHBOURHOOD PARKLANDS

core. It is proposed that these parks will endeavour to be part of the multi- use update) requires neighbourhood parks to be approximately 5000 m2 or larger The WAPC urban planning document Liveable Neighbourhoods (WAPC, 2009 located between or towards the edge of neighbourhoods rather than at the maximum 400m or 5 minutes walk from most dwellings. They should also be This park hierarchy collective is to serve about 600-800 dwellings and be a with the proposed 2 x neighbourhood parks being average of 10,000m2. corridor network and have street services to most of their perimeters.

a high level of useable space and shall feature the following open space Neighbourhood parks within the Western Edge Development are to offer amenity:

half-court basketball, tennis courts, kick-about areas, exercise equipment, age appropriate play equipment and inline skateable elements. There Formal recreation areas that cater for all ages and abilities including will also be an emphasis on natural play elements within parklands;



Neighborhood POS | SECTION A Scale 1:1000



Pedestrian road crossing



Shade Structures



Playscape opportunities integrated with the landscape



Opportunities for local artwork / sculpture installation



Open turf kick-about areas







Opportunities for fitness equipment equipment



Dual use path







- Seating, picnic and BBQ facilities would be positioned under shade structures;
- Grassed open space areas for active and passive recreation. Some of these areas shall include interesting topographical variation that form part of the larger drainage network and provide easy access for pedestrians to adjacent neighbourhoods across the linear open space;
 - A strong, legible dual- use pathway that provides a linear link to the immediate community and beyond via the connected multiple use corridor network;
 - Areas of retained mature existing vegetation (providing immediate landscape structure, habitat, shade and visual amenity);

- Hard-stand areas which use local concrete and aggregates, with further rest areas consisting of local gravels and/or compacted Pindan;
 - Opportunities for lawn inigation hydro-zoning according to active and passive uses; and,
- Interpretation, art and excersise opportunities as developed with the local community and Traditional Owners as part of an open space art strategy.

The two neighbourhood parks within the development are located within the central north-south multi- use corridor.





Shaded play space



shaded paths





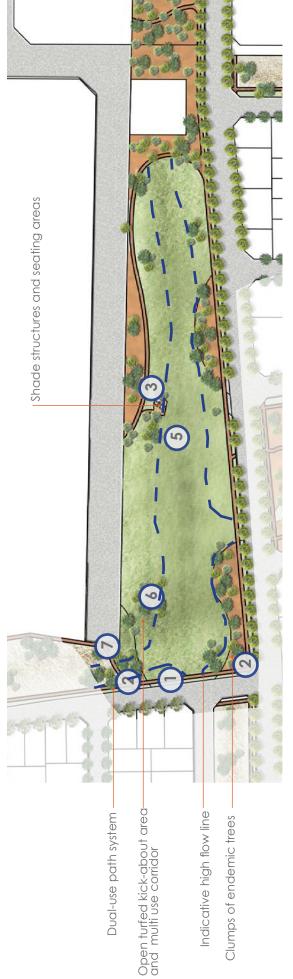




Grassed kick- about areas



play structures



Plan | Local Park LP 01

NORTH 0 15m 30m 45m 60m 75m



LOCAL PARKLAND

Six local parklands have been proposed within the Western Edge development area. These parklands are to have an approximate area of 6000m2 and are to immediately service residential lots within 5 minute walking time from most dwellings. Each local park shall include low key, formal and informal play spaces in order to service active and passive functions.

BREAK- OUT PARKLAND

Four simple lawns break out parklands are proposed adjacent to the Local Parks and within the multi- use corridors. These spaces provide little to no formal functions but allow access across the swale and provide for a contrasting landscape treatment compared to local vegetation areas.

- Recreation pathway with opportunities for artworks and/or fitness equipment to be sited.

Shade structures and seating areas

Indicative high

flow line

Open turfed kick-about area and Multi-use corridor

Clumps of endemic trees

Plan | Local Park LP 02 and Stage 1





Shade shelter



Shade Structures

Pedestrian road crossing

Robust paving treatment on street edge



Opportunities for local artwork / sculpture installation







Opportunities for fitness equipment equipment

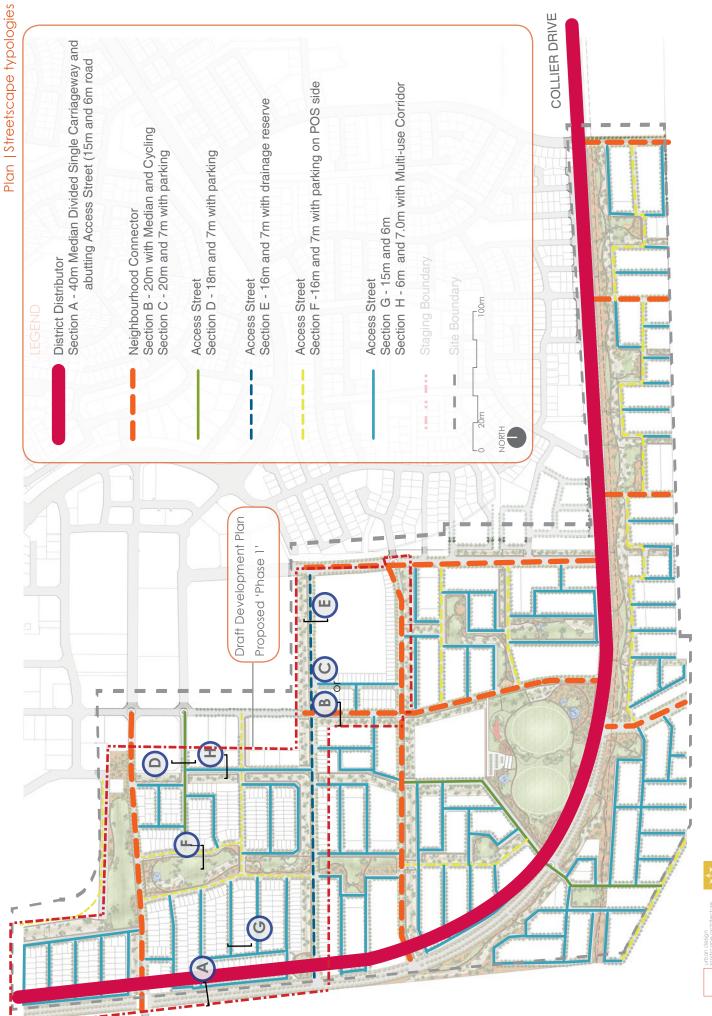




Open turf kick-about areas



Dual use path





STREETSCAPE TYPOLOGIES

Development. Some variations in confiburation exist based on parking There are three main streetscape typologies within the Western Edge requirements and road reserve widths. These are:

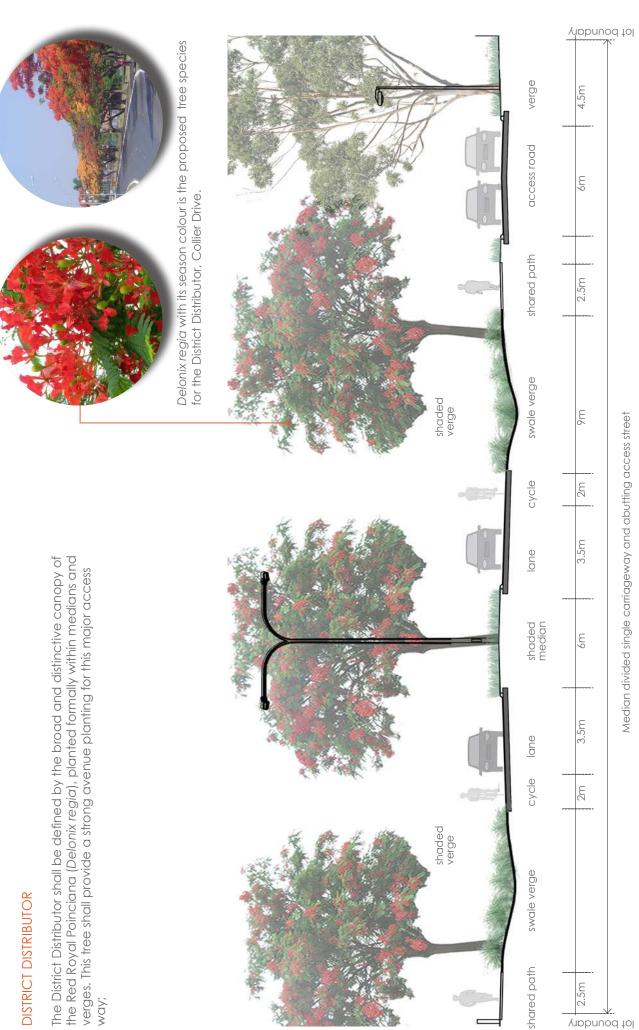
- District Distributor
- Neighbourhood Connector
- Access Street (three variations)

In general it is proposed that street trees shall be used to provide:

- legibility and identity within the development;
 - inform street scale;
- shade amenity; and,
 - visual amenity.

Townscape legibility of streetscapes shall be determined by the species, size, form and planting style of trees used.

the Red Royal Poinciana (*Delonix regia*), planted formally within medians and verges. This tree shall provide a strong avenue planting for this major access The District Distributor shall be defined by the broad and distinctive canopy of WQY;



District Distributor | Section A Scale 1:200





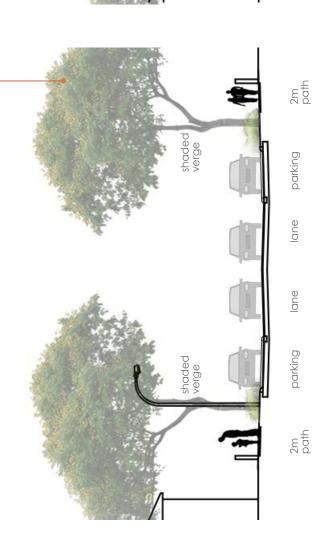
NEIGHBOURHOOD CONNECTOR

dense canopy of the Yellow Flame Tree (Peltophorum ptercarpum), planted similar street tree functions and will aid in providing continuity in streetscape formally within verges. This tree species has been used in South Hedland for The Neighbourhood Connector shall be defined by the upright form and language throughout the broader South Hedland context.





Peltophorum pterocarpum is a suggested tree species for the Neighbourhood Connector streets.



	\L	op	und	k. od	tol
<u>-</u>		3.8m			
		2.7m			ng
		3.5m			20m Road Reserve and parking
		3.5m			Road Resen
		2.7m			20m

3.8m

lot boundary

Neighbourhood Connector | Section B

Scale 1:200

Neighbourhood Connector - Section C Scale 1:200

20m with median and cycling

Nabanuod tol

4m

4m

lot boundary

2m path

cycle

lane

shaded median

lane

cycle

2m path

shaded verge

SOUTH HEDLAND WESTERN EDGE 36 DRAFT DEVELOPMENT PLAN | Landscape Strategy REV D

ACCESS ROADS

Access Roads will be defined by the Tuckeroo Tree (*Cupaniopsus anacardioides*), a compact shade tree better suited to the finer grain of the inner residential streets. This tree has been widely used throughout the South Hedland Town Centre to great effect.

Access streets that front multi- use comidors will be defined by the local Coolibah White Gum (Eucalyptus victrix) to provide continuity between the endemic bushland planting and the adjacent streetscape.





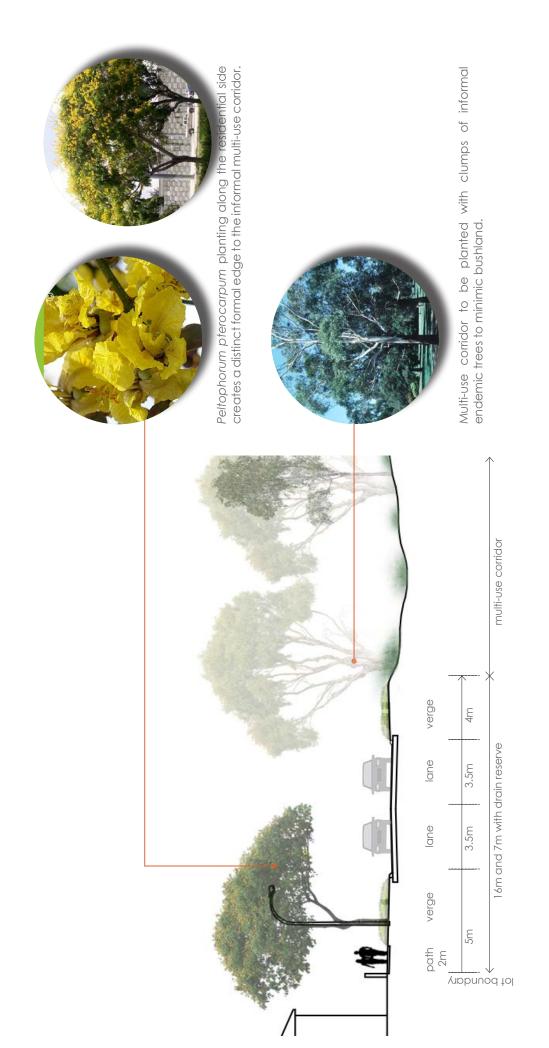
Cupaniopsus anacardioides provides dense shade and breaks up the built form.



/	(uppun	od tol
path 2m	2.8m	
parking	2.7m	
lane	3.5m	th parking
lane	3.5m	8m and 7m with parking
parking	2.7m	18n
path 2m	2.8m	
/	nuqau	iod tol

Local Access Road - Section D Scale 1:200



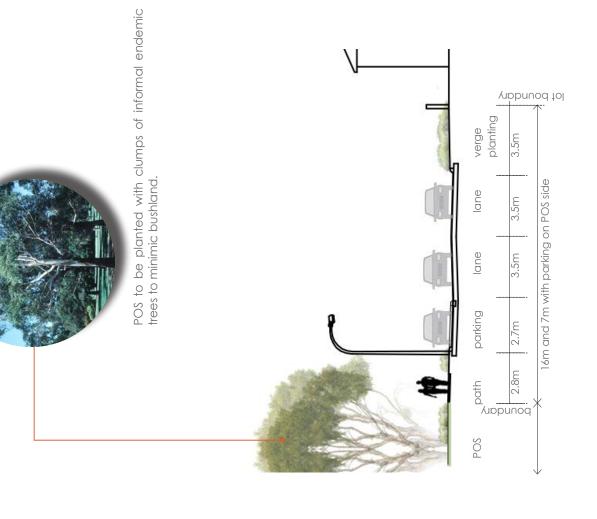


Local Access Road - Section E Scale 1:200

STREETS CAPES AND SHADE

The provision of shade along pedestrian corridors and paths is essential in fulfilling the principles that underpin the Western Edge Development Landscape Plan. Shade trees along road verges adjacent to footpaths provide reprieve from the heat and create an intimate sense of scale to the otherwise sparsely vegetated landscape.

Street tree planting along major neighbourhood roads will be used to define the road hierarchy and provide variation in scale to development.



Local Access Road - Section F Scale 1:200



Cupaniopsus anacardioides provides shade and breaks up the built form.



lot boundary

15m Road Reserve

lot boundary

planting verge

lane

lane

planting path verge 2m plantin



06 WATERWISE LANDSCAPES, IRRIGATION AND PLANTING PALETTE

A focus on water conservation is inherent within the design and management of all streetscapes and public open spaces within the Western Edge Draft Development Plan. Limiting lawn to areas required for recreation and maximising use of local planting shall also aid in reducing water consumption.

It is proposed that the development area shall be serviced by non-potable reclaimed water from the nearby South Hedland sewerage plant (west of South Creek). Establishment of a reliable water source for irrigation is projected for mid 2014 by the Water Corporation.

Earlier irrigation requirements require irrigation systems to be compatible with non-potable water, however will require scheme water until non-potable water is available. Initial irrigation planing shall also include a provision for use of purple pipe and an allotment for an irrigation storage and treatment facility within the development.

It is imperative that landscape treatments are designed to minimise water consumption and ensure that what is used is done so efficiently.

Design strategies to uphold integrity of planting areas and to minimise consumption would include:

- Extensive use of endemic species within the development.
- Ensuring that revegetation areas are planted or seeded at the optimum time of year to ensure survival with minimal irrigation.
- Lawn species is selected specifically based on low water consumption and tolerance of local climatic conditions.
 - Irrigation delivery system is designed based efficient use of water, extensive use of drippers for shrub and tree planting.
- Regular assessments of the irrigation systems are undertaken to ensure the effectiveness and efficiency of the system are maintained.
- Irrigation systems are designed in accordance with Town of Port Hedland specifications.
 - Alternate endemic and innovative water sourcing solutions be investigated and assessed.

EXOTIC SHADE TREES

Delonix regia Ficus microcarpa var. hillii Mimusops elegans Peltophorum ptercarpum

Royal PoincianaWeeping FigBullet Wood

- Bullet Wood

- Golden Flame

ENDEMIC TREES

Acacia aneura
Acacia tumida
Corymbia aspera
Corymbia dichromophloia
Corymbia flavescens
Brachychiton gregorii
Corymbia terminalis
Eucalyptus victrix
Melaleuca dealbata
Melaleuca leucadendra
Terminalia canescens

- Mulga

- Pilbara Pindan Wattle - Rough-leaved ghost gum

- Bloodwood
- Telopea
- Desert Kurrajong
- Desert Bloodwood
- Western coolibahSilver leafed Paperbark
- Cajeput Tree





Corymbia terminalis - Desert Bloodwood





SOUTH HEDLAND WESTERN EDGE DRAFT DEVELOPMENT PLAN | Landscape Strategy REV D

SMALL SHRUBS

Acacia wickhamii Acacia hilliana Acacia adoxa

- Wickham's Wattle

- Hilltop Wattle

- Gregory's Wattle

- Silver Saltbush

- Wild Jack Bean

- Coastal Caper

Acacia adoxa var. subglabra Pedley

Atriplex bunburyana Acacia gregorii

Canavalia rosea Capparis spinosa Corchorus walcottii Diplopeltis stuartii

- Desert Pepperflower

- Barrier Salt Bush

- Batchelor Buttons

- Woolly Corchorus

Gomphrena canescens Enchylaena tomentosa

pomoea pes- caprae subsp. Brasiliensis pomea muellerii

Indigofera boviperda Maireana georgei

Myoporum parvifolium Pimelea ammocharis

Ptilotus appendiculatus Polymeria ambigua

- Morning Glory - Spoon Tipped Mulla Mulla

- Creeping Boobialla

- Satiny Bluebush

GRASSES

Cyperus vaginatus Spinifex longifolius riodia intermedia riodia epactia

ecticornia auriculata eucrium racemosum Solanum lasiophyllum Ptilotus calostachyus Scaevola browniana Ptilotus rotundifolius Swainsona formosa scaevola parvifolia Ptilotus exaltatus Senna notabilis ribolus hirsutus Ptilotus axillaris

Cymbophogon ambiguus Triodia pungens riodia schinzii

Ptilotus arthrolasius

- Weeping Mulla Mulla

- Mat Mulla Mulla

- Royal Mulla Mulla

- Pink mulla mulla

- Sturt's Desert Pea

- Flannel Bush

- Camel Wed

- Grey Germander

- Scentgrass

- Beach Spinifex - Stiffleaf Sedge

- Lobed Spinifex

- Soft spinifex



Ptilotus exaltatus - Pink Mulla Mulla

Acacia hilliana - Wickham's Wattle

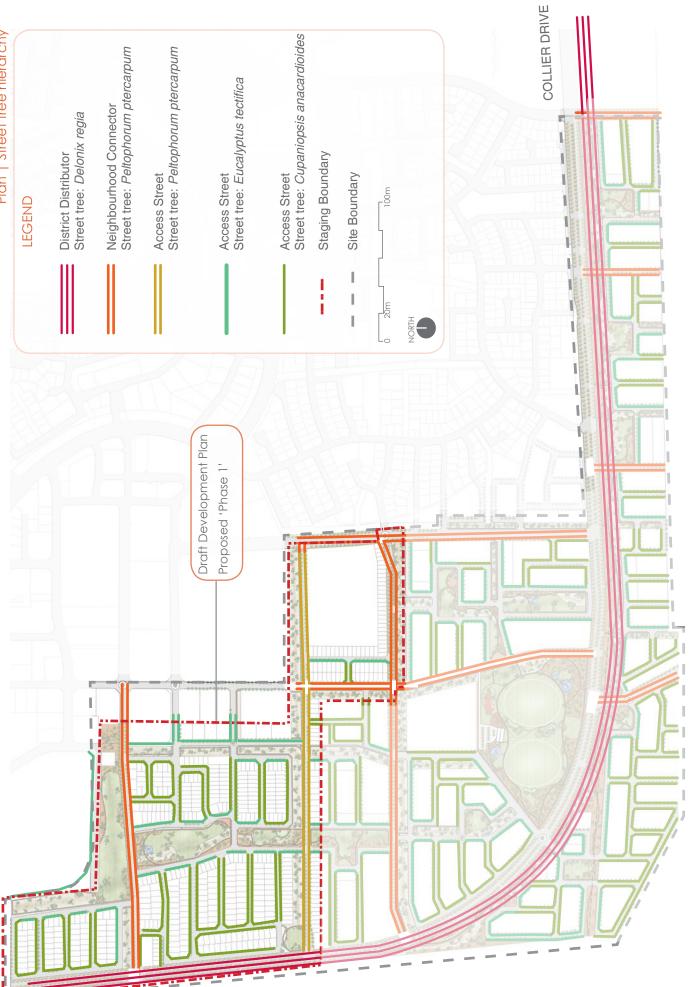


Swainsona formosa - Sturt's Desert Pea





Triodia schinzii





.

SOUTH HEDLAND WESTERN EDGE DRAFT DEVELOPMENT PLAN | Landscape Strategy REV D

TREE SPECIES SELECTION CRITERIA

Tree species have been selected based on their hardiness, growth rate and provision of shade. Very few local trees meet this 'streetscape amenity' criteria and have been substituted with non-endemic species. Endemic species will be used as part of the broader landscape pallette in swales, open spaces and as feature trees where appropriate.



Delonix regia

Form deciduous tree Height 10m Bark smooth pale Flower red, February



Peltophorum ptercarpum

Form deciduous tree Height 10m Bark smooth pale Flower yellow, February



Eucalyptus tectifica

Form deciduous tree Height 10m Bark smooth pale Flower red, February



Cupaniopsis anacardioides

Form deciduous tree Height 10m Bark smooth pale Flower red, February





7 WEED AND PEST MANAGEMENT

WEED MANAGEMENT

Introduced weed species have been identified across the site area and reflect the extent of disturbance throughout South Hedland as a result of land clearing, vehicle access and rubbish dumping.

To reduce the spread of weed species, the following management and control actions should be adopted:

- Minimising clearing where possible (during the construction period);
- Where possible, using existing tracks and roads, preventing uncontrolled access to the site and minimising the number of new tracks required;
 - Ensuring cleared vegetation and topsoil (if contaminated with weed seed) is removed and disposed of at Shire, approved dumpsites;
- Supplementation of endemic vegetation (e.g. gradually replacing Buffell Grasses);
- Ensuring all vehicles and machinery are cleaned of plant material and soil before and after entering the site (in particular when working along the perimeter of the site or in areas noted to have an invasive weed presence);
 - Imported soils and materials should be certified weed free; and;
- All litter and waste materials should be contained and removed off-site regularly.

General vegetation mitigation for the area would include the following:

- Manual removal of weeds;
- Weed spraying using the industry's best practice and appropriate regimes including use of non-residual herbicides, limit herbicide overspray, herbicide only applied by a by qualified technician and use of an appropriate herbicide near waterways; and
 - Representation of invasive grasses/low shrubs before seeding

South Hedland Western Edge Precinct Weed List - RPS	t Weed List - RPS
Family	Name
Amaranthaceae	Aerva javanica
Cucurbitaceae	Citrullus colocynthis
Fabaceae	Stylosanthes hamata
Podcede	Cenchrus ciliaris
Poaceae	Cynodon dactylon

PEST MANAGEMENT

The most common pest in South Hedland that affects trees and furniture is the ocal termite. General mitigation for this pest includes:

- Use materials resistant to termites
- Minimise use of wood mulch adjacent to timber structures
- Regular inspection of timber structures and wood mulch areas to detect termite infestation
- Spraying of areas/structures if required





Termite damage

8 CLIMATE RESPONSIVE DESIGN

Shade, shelter and cyclone resistance are the key factors in producing climate responsive design for the Western Edge Draft Development Plan. Climate responsive design can be achieved and tackled at various scales within the development-from large scale development design addressing heat load, shade and drainage to detail design elements that provide shade and amenity whilst tolerating cyclone strength conditions.

The above factors of shade, shelter, drainage and cyclone resistance have been addressed as follows

- 'Open Plan' landscape designs which allow for breezeways through public open space.
 - Shaded, dual-use walkways to increase shade, reduce dust and encourage community interaction.
- Incorporating multi-use corridors with POS allows for seasonal water flow to be directed around formal recreation areas, play equipment and other facilities
- A mix of broad canopied trees and shade structures used to provide relief from sun
 - Greenery of trees and shrub planting provides variation and relief from harsh visual environment.
- Cyclones all shade structures need to be cyclone rated according to AS 1170.2 Structural design actions Part 2: Wind actions.
 - Drainage systems are designed to allow for large flood events.

09 SUSTAINABILITY

UDLA's landscape masterplan concept creates a sustainable landscape by creating a welcoming pedestrian oriented laneway and pathways lined with shady trees and low planting. It encourages a walkable residential development and reduces the need for vehicular traffic.

The plan uses robust and high quality materials to suit the local environmental conditions without the need for a high level of maintenance or resources, where appropriate local materials will also be used. A palette of light coloured paving and pathways have also been chosen to the reduce heat island effect within the development.

The local planting has been carefully selected to provide passive recreational opportunities to enhance habitats for local native fauna and to conserve

Water will be further conserved by using mulch, efficient irrigation, watering only when necessary and by grouping plants with similar water needs together.

The integration of LED-powered landscape lighting has been chosen to reduce energy consumption. Also, solar lighting were appropriate should be considered.



Drainage control



Shaded paths provide comfortable connectivity



light coloured materials minimise stored heat



Durable materials and hardy planting

DESIGNING SAFE PLACES

In order to create safe, useable and habitable spaces, design must address Design) is a design model that attempts to influence offender decisions that social behaviour issues. CPTED (Crime Prevention through Environmental precede criminal acts. Key CPTED principles include:

- Natural Surveillance; See and be seen. Well placed lighting and retaining view lines through POS from edges and residences creates safer spaces. _-
- Natural Access Control; Using lighting, walkways, signage and landscape manipulation to direct flow of pedestrian movement through proper routes and entrance/exit points. \vec{c}
- Clear delineation between public and private spaces whilst avoiding the Territorial reinforcement, Allows for a sense of stewardship over areas. use of high fences and walls between the two. e,
- Maintenance maintaining the site and repairing any damage/ vandalism quickly helps to reduce further vandalism. 4.

some alteration to become culturally and climatically specific to the South These principles can be seen as painting with a broad brush and require Hedland context.

vandalism and anti-social behaviour. Crime is also less frequent when passive Vandalism is a significant problem in South Hedland. Use of CPTED principles as well as culturally specific interventions can help prevent and ameliorate higher amenity and greater functional and useable space will in turn deter surveillance and usage of spaces is high. Therefore, making spaces with vandals away from public open spaces.



Open spaces allow passive surveillance from adjacent properties



Lighting providing safe spaces



- View corridors through vegetation ie above shrubs and below trees
- Lighting should spill past paths, not create shadow spots and glare which limit visibility
- Clear paths with visible destinations Avoid meandering paths which lead 'nowhere'
- Involve the community in development and particularly specific elements such as art works to give a sense of ownership
 - Use sturdy materials to avoid damage through accidental breakage or vandalism
- Co-locate pedestrians, cyclists and vehicles where possible



Lighting providing safe spaces



Solar and LED lighting

1 OPEN SPACE ART & INTERPRETATION STRATEGY

The cultural and social diversity of South Hedland can be effectively represented through local art and interpretation opportunities. The master plan has been designed to facilitate opportunities for the placement of artwork and interpretive elements.

These elements further enhance the residential development by emphasising 'sense of place', create places to meet or provide 'wayfinding' devices.

The artworks may be sited to form an 'art and exercise trail' throughout the development. This trail will further act as 'wayfinding' device as well as integrate exercise equipment within nodes throughout the Public Open Space system.

For these artworks to be successful, they should be approached collaboratively between artist, landscape architect and community.



Artwork in infrastructure



Artwork in infrastructure



Striking feature artwork



Community developed artwork

12 BUILDING LOCAL INDUSTRY CAPACITY

The longevity of the developments' implementation timeline (10-15 years) offers an exciting opportunity to build local community and industry capacity through the construction and maintenance of built landscapes.

This capacity building objective can be achieved through early support and ongoing engagement with the local construction and landscape industries, including cultural and artist opportunities.

The establishment of local industry and capacity will have local impact and will also act as a catalyst within the region. Local industries and capital will have the ability to support both local and regional projects. This will have a play on effect as locally sourced materials, plants and staff will help local economies and ecologies.

Landscape Architects are well placed to develop industry and community capacity as they tend to be with the project from planning to well after construction and ongoing maintenance periods.

In their place making role, Landscape Architects tend to develop strong local relationships and link key outcomes with local opportunities. The opportunity to support existing local industry or incubate new industries through finding local 'industry champions' is rewarding, leaves behind a positive legacy and will be a key indicator for the success of the development process.

Capacity building opportunities within the Western Edge Development include:

- 1. Developing construction/landscape material resource industries such as:
 - Building materials
 - Nursery stock
- Landscape materials
 - Irrigation suppliers
- Paving, concrete and aggregate suppliers
- Fence suppliers
- 2. Developing broader industries include:
 - Land Management
- Cultural Management
- Public Artists



- The introduction of local contractors can grow following the introduction of local suppliers and include:
- Nurseries
- Structural Landscapers;
- Maintenance Landscapers
- Concrete Contractors

 - Pavers
- Fencing

shall be actively seeking local business outcomes by developing key industry 'champions' with special attention to local indigenous empowerment and UDLA's philosophy through place making is to develop local capacity and employment.



Community involvement in public artwork creates ownership in space



Local 'Champion' Contractor | Wanna Work, Port Hedland



Community involvement in public artwork creates ownership in space



Local 'Champion' Contractor | Tim'Williams, Northern Landscapes,

13 CONCLUSION

andscape amenity for the Western Edge Draft Development Plan can be acknowledging the unique Pilbara 'lifestyle' including Traditional Owners achieved through understanding the unique ecological conditions and he Landscape Strategy demonstrates that sustainable and site specific cultural relationship to the site and associated lands. The open space opportunities that are unique to this development include understanding of:

- Multi- use corridors;
- Linear pathways ;
- Linking break- out open space that include Local and Neighbourhood park typologies;
- Open space that often include a gently sloping inline drainage function for a very limited time of the year;
 - Open spaces that adopt CPTED Principles;
- Recreation spaces that are well lit in the evenings;
- Traditional Owner culture through interpretation and public artwork Open space that acknowledges the local 'lifestyle', history and opportunities, and;
- A city building process that encourages local capacity skill building within the construction and maintenance of the development.

infrastructure and space amenity in isolation, but rather attempts to considers all the layers of the "landscape" to provide design responses that provide an attractive place to live, but also encourages building local stainability The Landscape Development Strategy doesn't look at the green outcomes.

supporting a thriving hub with local community industry, pride and ownership. Draft Development Plan is an opportunity to build on a strong Pilbara City, a sense of pride within this potential lengthy project. The Western Edge The opportunity to build the capacity of the local community creates



APPENDIX 6

Local Water Management Strategy

LandCorp

South Hedland Western Edge Local Water Management Strategy (LWMS)



October 2012





DISCLAIMER

This document is published in accordance with and subject to an agreement between JDA Consultant Hydrologists ("JDA") and the client for whom it has been prepared ("Client"), and is restricted to those issues that have been raised by the Client in its engagement of JDA. It has been prepared using the skill and care ordinarily exercised by Consultant Hydrologists in the preparation of such documents.

Any person or organisation that relies on or uses the document for purposes or reasons other than those agreed by JDA and the Client without first obtaining a prior written consent of JDA, does so entirely at their own risk and JDA denies all liability in tort, contract or otherwise for any loss, damage or injury of any kind whatsoever (whether in negligence or otherwise) that may be suffered as a consequence of relying on this document for any purpose other than that agreed with the Client.

QUALITY ASSURANCE

JDA provides quality assurance through all aspects of the company operation and is endorsed to AS/NZS ISO 9001:2000 Quality Assurance Accreditation, with third party certification to Bureau Veritas Quality International.



Document Version No.	Issue Date
J4943d - Draft	1 August 2012
J4943e	2 October 2012

	Name	Signature	Date
Author	Alex Rogers	Jakes -	2 October 2012
Checked by	Wendy Green	WErega	2 October 2012
Approved by	Alex Rogers	ARO	2 October 2012

J4943e



CONTENTS

1.	INT	RODUCTION	1
	1.1	BACKGROUND	1
	1.2	Previous Studies	2
		1.2.1 Town Planning Flood Study for South Hedland (Wyche, 1975)	2
		1.2.2 South Hedland Town Centre Drainage Design (PWD, 1976)	2
		1.2.3 South Hedland Flood Study (GHD, 2011)	2
		1.2.4 South Hedland Town Centre – East Precinct: LWMS (JDA, 2011)	2
		1.2.5 Port Hedland Coastal Vulnerability Study (Cardno, 2011)	3
		1.2.6 State Planning Policy 2.9 - Water Resources 1.2.7 Stormwater Management Manual for WA	2
	1.3	KEY DESIGN PRINCIPLES AND OBJECTIVES	5
2.	PRE	E-DEVELOPMENT ENVIRONMENT	7
	2.1	LOCATION AND EXISTING LAND USE	7
	2.2	Topography	7
	2.3	CLIMATE	7
	2.4	GEOLOGY AND SOILS	8
	2.5	GEOTECHNICAL INVESTIGATION	8
	2.6	SURFACE WATER HYDROLOGY	8
		2.6.1 Surface Drainage	8
		2.6.2 Surface Water Quality	g
	2.7	GROUNDWATER HYDROLOGY	10
		2.7.1 Groundwater Levels	10
		2.7.2 Permeability	10
	0.0	2.7.3 Groundwater Quality	11
		WETLANDS	11
		ACID SULPHATE SOILS	11
	2.10	Water Resources	11
3.	PRO	OPOSED DEVELOPMENT	12
4.		CAL WATER MANAGEMENT STRATEGY	13
	4.1	WATER USE & SUSTAINABILITY INITIATIVES	13
		4.1.1 Water Sources	13
		4.1.2 Water Conservation 4.1.3 Non Potable Water Supply & Water Balance	13 14
	4.2	SURFACE WATER MANAGEMENT	
	4.2	4.2.1 Regional Flood Management	14 <i>1</i> 4
		4.2.2 Local Flood Management	15
		4.2.3 Conceptual Stormwater System Design	15
	4.3	GROUNDWATER MANAGEMENT	18
	4.4	EROSION & SEDIMENTATION MANAGEMENT	18
	4.5	WETLAND MANAGEMENT	19



	4.6	WATER QUALITY MANAGEMENT	19
	4.7	CONSTRUCTION MANAGEMENT	20
		4.7.1 Dewatering	20
		4.7.2 Acid Sulphate Soils	20
	4.8	WATER MANAGEMENT STRATEGY SUMMARY	20
5.	IMP	LEMENTATION	22
	5.1	ROLES AND RESPONSIBILITIES	22
	5.2	SUBDIVISION PROCESS	22
	5.3	STORMWATER SYSTEM OPERATION AND MAINTENANCE	23
	5.4	MONITORING PROGRAM	23
6.	REF	FERENCES	24

LIST OF TABLES

- 1. Integrated Planning And Urban Water Management Process
- 2. LWMS Key Principles And Objectives
- 3. Catchment Areas & Peak Flows
- 4. Peak Flows at Study Area Boundary
- 5. Monitoring Bore Data
- 6. BMP Water Quality Performance In Relation To Design Criteria
- 7. Summary Of Proposed Local Water Management Strategy
- 8. Implementation Responsibilities
- 9. Maintenance Schedule for Drainage Infrastructure



LIST OF FIGURES

- 1. Location Plan
- 2. Study Area and Land Use
- 3. GHD (2011) Catchment Mapping
- 4. Port Hedland CVS 100 Year ARI Flood Mapping
- 5. Port Hedland CVS Model Input & Connection Nodes (Cardno, 2011)
- 6. Topography Airborne Laser Scanning
- 7. Topography Feature Survey
- 8. Port Hedland Annual and Monthly Rainfall
- 9. Surface Geology
- 10. Geotechnical Investigation Pit Location
- 11. Existing Local Surface Drainage Infrastructure
- 12. Existing Catchment Mapping
- 13. Existing Catchment 100 year ARI Peak Flows and Depths
- 14. Groundwater Bores
- 15. Acid Sulphate Soil Mapping
- 16. Proposed Structure Plan
- 17. Proposed Development Plan
- 18. Impact of Fill on South Creek 100 Year ARI Flood Levels
- 19. Schematic of Regional and Local Flood Protection Levels
- 20. Proposed Stormwater Management System
- 21. Post Development Catchments
- 22. Drainage Swale Conceptual Cross Sections
- 23. Hydraulic Model Bathymetry
- 24. 100 Year ARI Event Plan & Model Results Northern Catchment
- 25. 100 Year ARI Event Plan & Model Results Southern Catchment
- 26. 5 Year ARI Event Plan & Model Results Northern Catchment
- 27. 5 Year ARI Event Plan & Model Results Southern Catchment
- 28. 1 Year ARI Event Plan & Model Results Northern Catchment
- 29. 1 Year ARI Event Plan & Model Results Southern Catchment
- 30. 100 Year ARI Longsections
- 31. Minimum Groundwater Clearance
- 32. 5 Year ARI Event Flow Velocities

APPENDICES

- A. Local Water Management Strategy Checklist for Developers
- B. JDA (2012) South Hedland Western Edge Flood Modelling
- C. DoW Floodplain Management Section Advice



1. INTRODUCTION

This Local Water Management Strategy (LWMS) has been prepared to support the Development Plan for the Western Edge precinct of South Hedland in the Town of Port Hedland, in accordance with Better Urban Water Management (WAPC, 2008b). The Study Area is presented in Figures 1 and 2.

1.1 Background

This document has been prepared to support a Development Plan by RPS for the South Hedland Western Edge within the Town of Port Hedland. The LWMS has been developed by JDA Consultant Hydrologists on behalf of LandCorp. The relationship of this document to the planning process is shown in Table 1. The compilation of this document has included a range of expertise and guidelines from leading authorities including the Department of Water (DoW), Water Corporation (WC) and Town of Port Hedland (ToPH) to assist in achieving the implementation of best practice in water management and sustainable development within the context of the Pilbara region.

To manage and protect Western Australia's water resources, DoW and the Department of Planning and Infrastructure (DPI) produced a key document *Better Urban Water Management (BUWM)* (WAPC, 2008b) to guide urban development in Western Australia.

Discussions with DoW, Perth on 1 June 2010 (and subsequent follow up emails) guide the approach required for the preparation of the South Hedland Town Centre LWMS. The guidance requirements are detailed in section 1.3.

In Port Hedland, surface runoff issues are erosion and sedimentation as well as management and protection for 100 year ARI events. Peak flow rates do not need to be detained to pre development peak flow, but the velocity of the post development flow should to be minimised to prevent erosion.

An LWMS Checklist has been included as Appendix A to assist ToPH and DoW in review of this document.

TABLE 1: INTEGRATED PLANNING AND URBAN WATER MANAGEMENT PROCESS

Planning Phase	Planning Document	Water Management Document and Status
District	Pt Hedland Land Use Master Plan (LUMP); also Pt Hedland Planning Study Ultimate Development Plan (UDP)	Flood studies detailed in section 1.2 - EXISTING.
Local – Town Planning	Western Edge, South Hedland Concept Plan RPS (2012)	South Hedland Western Edge, Local Water Management Strategy (LWMS) - THIS DOCUMENT.
Subdivision	Subdivision Application	Urban Water Management Plan (required for individual stages of development) - FUTURE PREPARATION

J4943e 2 October 2012



1.2 Previous Studies

This LWMS considers the following key documents:

1.2.1 Town Planning Flood Study for South Hedland (Wyche, 1975)

The flood study by Wyche (1975) for South and South West Creeks provided flood level estimates for each channel for the 10, 20, 50 and 100 year ARI events, upstream of Great Northern Highway to town planning purposes in South Hedland.

Scenarios were investigated to provide flood protection for the town site and additional land availability between the two creek systems. A design line along the eastern bank of South Creek was calculated, to provide a limit of development westwards from the town site.

1.2.2 South Hedland Town Centre Drainage Design (PWD, 1976)

The study examined drainage from the Town Centre and surrounding areas. Two drainage channels, one to north of the Town Centre and the other to the south were proposed to discharge stormwater runoff. The drainage channels were designed for the 5 year ARI flood event, consistent with the PWD Manual of Standards (Urban Drainage) (PWD, 1980).

The study included the undeveloped land to the south of the Town Centre as well as the existing residential and commercial areas to the north east, east and south east. Trapezoidal drains called Sub B and Sub B8 were designed by PWD to both the north and south of the Town Centre to convey the 5 yr average recurrence interval (ARI) runoff from the external and internal Town Centre catchments. These are the existing drainage features to the north and south of the Town Centre.

1.2.3 South Hedland Flood Study (GHD, 2011)

The Town of Port Hedland appointed GHD to assess the drainage system of South Hedland and identify opportunities and constraints to allow for planning for upgrading and maintenance of the system. GHD developed a one dimensional (1D) flood model of the drainage system using Infoworks CS to simulate catchment hydrology and hydraulic analysis. The model was then used to assess impacts of upgrades and improvements.

The hydraulic model was developed based on survey of the existing drainage system and site inspection. Culverts were included and photographed. Catchment boundaries were estimated based on available contour data, cadastre, drainage features and site inspection (Figure 3). It is noted that this study was completed prior to the aerial survey (LiDAR) of Port and South Hedland being completed.

The hydraulic modelling provided an assessment of the existing drainage infrastructure and mapping allowed identification of problem areas. The hydraulic model was then used to assess the impact of proposed changes.

1.2.4 South Hedland Town Centre – East Precinct: LWMS (JDA, 2011)

The Local Water Management Strategy was prepared for the East Precinct of the South Hedland Town Centre immediately adjacent to the Study Area on the north eastern boundary. The revitalisation of the Town Centre resulted in modification of the existing drainage system, removing temporary storage basins, reducing existing basin storage and enlarging the perimeter drain around the Town Centre.



Modelling of the Town Centre using the 2D hydraulic model MIKEFLOOD confirmed the 5 year ARI flood conveyance capacity of the perimeter drains. Modelling of the pre and post development environment for the 100 year ARI event found that the proposed works resulted in reduced flood levels, particularly for the residential areas to the north east of the Town Centre.

Drainage for the current Study Area incorporates part of the Town Centre East Precinct drainage, consistent with the East Precinct LWMS drainage concepts.

1.2.5 Port Hedland Coastal Vulnerability Study (Cardno, 2011)

The Port Hedland Coastal Vulnerability Study (CVS) was commissioned by LandCorp and investigated storm surge and catchment runoff for the Port and South Hedland area. The study modelled the 2, 10, 100, 200 and 500 year ARI events, as well as simulating conditions for the current climate and the 2060 and 2110 projected climate scenarios. The CVS provides flood mapping across the Port and South Hedland region, including the current Study Area. An example of the flood mapping results is included in Figure 4 for the 100 year ARI event.

The hydraulic modelling of catchment runoff was undertaken using the SOBEK 1D2D modelling system from Deltares. A grid size of 40 m by 40 m was used across the model area, with nested 10 m by 10 m grids for South Hedland and Wedgefield. Flow is input to the model using lateral inflow points using time varying inflow points, with inflow hydrographs estimated from hydrologic modelling.

In the areas adjacent to the current Study Area, flow for South Creek is input at nodes G2 and G6 (Figure 5). Flow is also input for the drains within the existing residential areas to the north and east of Western Edge. Flow from the upstream catchment to the Forrest Circle drain is input at the southern extent of the drain in Koombana (node G6a_1). Flow for the eastern drainage system is input at the upstream extent of each drainage line (Figure 5 – nodes C5a_1, C5a_2, C5a_3 and C5a_4). Peak flows are provided for each node (although the four C5a node peak flows are combined). It is noted that these input flows occur at the upstream extent of the defined drain, and not necessarily at the upstream extent of the urban areas. It is also noted the CVS is a regional study and local scale features may not have been included based on the scale of modelling.

1.2.6 State Planning Policy 2.9 - Water Resources

The LWMS has been developed in accordance with regional and local principles and objectives of Integrated Urban Water Management (IUWM), outlined in State Planning Policy 2.9.

The Western Australian Planning Commission (2006) defines IUWM (also known as total water cycle management) as promoting

"management of the urban water cycle as a single system in which all urban water flows are recognised as a potential resource and where the interconnectedness of water supply, stormwater, wastewater, flooding, water quality, waterways, estuaries and coastal waters is recognised".

IUWM promotes water conservation measures, reuse and recycling of water and best practice in stormwater management (Western Australian Planning Commission 2006).

To provide a process to implement State Planning Policy 2.9, Planning Bulletin 92: Urban Water Management (WAPC, 2008a) and Better Urban Water Management (WAPC, 2008b) outlined the required water planning for each stage of the land use planning system in WA. Better Urban Water Management



(BUWM) focussed on objectives required for the Swan Coastal Plain, rather than the Pilbara region. However it still provides guidance for integration of water management with the planning process as outlined in Table 1.

1.2.7 Stormwater Management Manual for WA

The Stormwater Management Manual for Western Australia was first published by the Waters and Rivers Commission in 1998 to define and describe in practical terms Best Management Practices (BMP's) to reduce pollutant and nutrient inputs to stormwater drainage systems as well as guidelines for the incorporation of water sensitive urban design principles. A major review of the Stormwater Management Manual was undertaken by the DoW, with additional input by other State and Local Government Authorities and sectors of the urban development industry. This revised version of the Stormwater Management Manual was officially launched in 2007, though some chapters were published in 2004.

DoW's current position on Urban Stormwater Management in Western Australia is outlined in Chapter 2: Understanding the Context of the Stormwater Management Manual for Western Australia (DoW, 2007), which details the management objectives, principles, and a stormwater delivery approach for WA. Principle objectives for managing urban water in WA are:

- Water Quality: To maintain or improve the surface and groundwater quality within development areas relative to pre-development conditions.
- Water Quantity: To maintain the total water cycle balance within development areas relative to the pre-development conditions.
- Water Conservation: To maximise the reuse of stormwater.
- Ecosystem Health: To retain natural drainage systems and protect ecosystem health.
- Economic Viability: To implement stormwater systems that are economically viable in the long term.
- Public Health: To minimise the public risk, including risk of injury or loss of life to the community.
- Protection of Property: To protect the built environment from flooding and waterlogging.
- Social Values: To ensure that social aesthetic and cultural values are recognised and maintained when managing stormwater.
- Development: To ensure the delivery of best practice stormwater management through planning and development of high quality developed areas in accordance with sustainability and precautionary principles.

DoW released the Decision Process for Stormwater Management in WA in August 2009 to provide a decision framework for the planning and design of stormwater management systems and assist in meeting the objectives specified above.



1.3 Key Design Principles and Objectives

A meeting was held at DoW, Perth on 1 June 2010 to discuss the approach required for the South Hedland Town Centre, as the Department has not published any guidelines to assist with the preparation of LWMS specifically for sites in the Pilbara Region of Western Australia.

The minutes of the meeting are summarised below:

- Towns in the Pilbara have been developed using open drains rather than piped drainage and this
 is appropriate due to the high rainfall intensities and runoff rates compared with the South West of
 WA.
- Need to ensure that existing creeks and drains are retained as far as possible working with the
 existing drainage system, rather than against it.
- Flood risk is the main issue from surface water, however groundwater levels also need to be checked.
- Management of erosion and sedimentation is important.
- Other water quality issues such as nutrient concentrations are of lower priority in the Pilbara.
- DoW accepts there will not be 2 years of pre development groundwater monitoring data. DoW
 will expect some monitoring bores to be installed to show the elevation of the water table relative
 to ground level to indicate whether imported fill will be required.
- DoW may require ongoing post development surface water and groundwater quantity and quality monitoring to protect and/or improve ecosystem health.
- The LWMS checklist contained in BUWM (WAPC, 2008b) should still be used.

Summary of the key principles and objectives applicable to this LWMS for the Study Area in the Pilbara region is based on agreement with DoW.



TABLE 2: LWMS KEY PRINCIPLES AND OBJECTIVES

Key WSUD Guiding Principles

- Facilitate implementation of sustainable best practice in water management in the Pilbara region
- Provide integration with planning processes and clarity for agencies involved with implementation
- To minimise public risk, including risk of injury or loss of life
- Protection of infrastructure from flooding and waterlogging
- Encourage environmentally responsible development

Category	Principles	Design Objectives
Water Supply and Conservation	 Consider all potential water sources in water supply planning. Integration of water and land use planning Sustainable and equitable use of all water sources having consideration of the needs of all users, including community, industry and environment Maximise the reuse of stormwater 	Minimise the use of potable water where drinking water quality is not essential, particularly ex-building use. Apply waterwise landscaping measures to swales in road reserve to reduce/avoid irrigation.
Surface Water Flows and velocity	 Protect development from flooding and waterlogging Implement economically viable stormwater systems Retain natural drainage systems and protect and/or improve ecosystem health – For the Pilbara, reduce the stormwater velocity to prevent export of sediments. Ensure that stormwater management recognises and maintains social, aesthetic, and cultural values Where there are identified impacts on significant ecosystems, maintain or restore desirable environmental flows and/or hydrological cycles consistent with DoW's requirements. 	 Use swales through the development to disperse flow throughout the development with the aim to minimise velocity. Swales sized to minimum 10yr ARI, with larger events flowing along road reserve. For South Creek flood management, finished floor levels are a minimum of 0.5 m above the 100 year ARI flood level in South Creek for a 100 m wide corridor adjacent to South Creek. For local flood management, lot levels have minimum 100 yr ARI protection, with 0.3 m freeboard above kerb height.
Groundwater Levels	Protect development from waterlogging	Protect development from waterlogging
Water Quality	Where development is associated with an ecosystem dependent upon a particular hydrologic regime, minimise discharge or pollutants to shallow groundwater and receiving waterway and maintain water quality in specified environment	No sensitive ecosystems in vicinity. The receiving environment is South Creek which discharges to the intratidal zone prior to discharging to the ocean. (Note nutrients are not a problem in the Pilbara).



2. PRE-DEVELOPMENT ENVIRONMENT

The environmental conditions of the pre development Study Area provide an important context for planning future water management strategies. This section describes the pre development details.

2.1 Location and Existing Land Use

The South Hedland Western Edge Study Area is located to the south west of the South Hedland Town Centre within the Town of Port Hedland (Figure 1). The Study Area is located on the eastern bank of South Creek, between the South Creek channel and the existing South Hedland Town Centre and residential areas (Koombana).

The land use of the site (Figure 2) is existing vacant land covered by native vegetation, primarily spinifex grasses. A powerline easement crosses the southern section of the Study Area in an east-west alignment.

2.2 Topography

Two sets of topographic data are available for the Study Area.

As part of the Port Hedland Coastal Vulnerability Study (Cardno, 2011), LiDAR (Light Detection and Ranging) (also known as Airborne Laser Scanning - ALS) was used to estimate topographic levels across the Port / South Hedland area. This has an accuracy of \pm 0.1 m. The LiDAR survey results are shown in Figure 6.

A feature survey of the Study Area conducted by MAPS is presented in Figure 7.

The topography of the Study Area is relatively flat, with elevations of 15 m AHD along the southern boundary of the Study Area grading to elevations of 11 to 12 m AHD along the western boundary adjacent to South Creek. The land generally falls in a north west direction towards South Creek.

2.3 Climate

South Hedland's climate can be described as being arid sub tropical with warm, dry winters and hot humid summers.

The long term average rainfall for Port Hedland Airport (station no. 004032) is 313 mm (1943 – 2011). Annual and monthly rainfall data in Figure 8 shows many years without significant rainfall occurring, (BoM, 2012). Most of the rain comes in summer months January to March from approximately 15 to 20 scattered thunderstorms and the occasional tropical cyclone (BoM, 2012). A secondary small peak in the monthly rainfall occurs in May as a result of rainfall caused by tropical cloud bands which intermittently affect the area mostly in May and June (BOM, 2012).

The coast from Port Hedland to Exmouth Gulf is the most cyclone prone area in Australia, with 49 cyclones since 1910 recorded, averaging one every two years (BoM, 2012). The cyclone season runs from December to April peaking in February.



The average annual pan evaporation for Port Hedland is approximately 3590 mm, with monthly averages shown on Figure 8 (Luke et al, 1988).

2.4 Geology and Soils

The soil within the Study Area can be described as a red sandy loam (GSWA, 1983), generally referred to as Pindan Sand (Figure 9). The soil has a small clay component, and sands are generally fine to medium grained, sub-angular to sub-rounded quartz. This can become hard when dry, and waterlogged during heavy rainfall. Onsite inspection indicated that these soils extended to a depth of at least 4 m.

2.5 Geotechnical Investigation

A geotechnical investigation was completed for the Study Area (Coffey, 2011) during October 2011. A total of 48 test pits were completed to depths between 1.1 m and 3.5 m (80% completed to at least 3 m). Figure 10 shows the locations of the test pits, and details natural surface and depth of excavation at each site.

The investigation described the soils as being clayey sand at the surface (topsoil to 0.2 m depth) and clayey sand below that to the maximum depth of investigation. The soil was described as being dense to very dense, fine to coarse grained with low to medium plasticity fines, generally red brown in colour. Particle size distribution indicated that 15 to 40% of the soil matter was silt or clay. It was concluded that the soils were Pindan Sands (in agreement with regional soil mapping – see Section 2.4).

Groundwater was not encountered in any of the test pits to depths of up to 3.5 m. Test pit base elevations were between 8.9 and 12.1 m AHD.

Coffey (2011) also concluded that soakwells were not considered effective for disposal of stormwater runoff due to the high percentage of fines in the sand and the high rainfall intensities during the wet season.

2.6 Surface Water Hydrology

2.6.1 Surface Drainage

As can be seen from the aerial photography (Figure 2), most of the Study Area is undeveloped. In the majority of this area there is little evidence of defined runoff routes, with runoff likely to occur by overland flow.

In the northern section of the Study Area there is an existing drainage line (Figure 11) which drains the western section of Koombana adjacent to Collier Dr and part of the Town Centre adjacent to the Hospital. Within the existing residential areas bordered by Collier Dr, Murdoch Dr and Masters Way, there are several drainage paths which discharge flow to the north. There is also a drainage line east of Masters Way between Murdoch Dr and Osprey Dr.

Catchment mapping for the areas discharging through the Study Area are shown in Figure 12. This mapping does not include the full South Creek catchment, which discharges through the western section of the Study Area. The mapping indicates several large catchments draining through the eastern section of the Study Area east of Yarrie Rd. The easternmost catchment (catchment F) discharges across Collier Dr and flows down to the downstream drainage system north of Osprey Dr.



Flow from the three eastern catchments (D, E and F) was estimated using several methods. Using the available LiDAR survey information, a two dimensional (2D) hydraulic model was set up using MIKEFLOOD, with catchment runoff generated using the "rain-on-grid" approach. A 5 m grid was used, with a Mannings n of 0.05 adopted for the predominantly spinifex vegetation. A proportional loss of 20% was adopted based on catchment soil types and characteristics. This is effectively equivalent to an initial loss of 25 mm and continuing loss of 5 mm/hr, which is slightly less than the initial loss of 40 mm and continuing loss of 5 mm/hr suggested for the Pilbara by Australian Rainfall and Runoff (IEAust, 2000). Peak flows were confirmed using XP-Storm using the Laurenson Method for routing and assuming the same loss model as above. Peak flows for the 100 year ARI event are shown in Table 3 below.

Figure 13 shows peak flows and flood depths for the 100 year ARI event for the eastern section of Western Edge. Table 4 tabulates the peak flows for the 1, 5 and 100 year ARI event at the southern boundary of the Study Area. It can be seen that a total peak flow of 26.5 m³/s enters the southern boundary of the Study Area east of Yarrie Rd. Most of this then discharges north west through the western section of the Study Area and on to South Creek. Part of the flow from the central section breaches Collier Dr near Pilbara Way and flows northward into the existing drainage system. In the far eastern catchment, there are two breaches of Collier Dr. There is a main breach just east of Masters Way, which is the primary flow route for the catchment, which discharges north towards Osprey Dr and has a peak flow of 26 m³/s for the 100 year ARI event at Collier Dr. The second breach occurs near Kimberley Ave. The flood modelling indicates than the flow entering the eastern section of the Study Area partially re-joins the main flow, before flowing north west to Collier Dr and discharging across the road into the existing residential area.

TABLE 3: CATCHMENT AREAS & PEAK FLOWS

Catchment	Area (ha)	1 Year ARI Peak Flow (m³/s)	5 Year ARI Peak Flow (m³/s)	100 Year ARI Peak Flow (m³/s)
D	288	2.0	5.9	17.7
Е	46	0.9	2.5	7.8
F	388	2.8	8.1	26.1

TABLE 4: PEAK FLOWS AT STUDY AREA BOUNDARY

Catchment	1 Year ARI Peak Flow (m³/s)	5 Year ARI Peak Flow (m³/s)	100 Year ARI Peak Flow (m³/s)
D (boundary)	1.7	5.0	15.4
E (boundary)	0.8	2.2	6.6
F (boundary)	0.5	1.5	4.5

2.6.2 Surface Water Quality

There is no surface water quality data available for this region.



2.7 Groundwater Hydrology

2.7.1 Groundwater Levels

There are no long term groundwater monitoring bores within the South Hedland / Port Hedland Area. All mapped bores from the Department of Water WIN database are shown in Figure 14. Few bores are located close to the Study Area. Most bores are owned by mining companies, or are used for livestock watering. Therefore there is no data record to indicate seasonal variability.

Five groundwater monitoring bores have been installed within the Study Area (Figure 14) in March 2012. These bores were installed by hand auger to a depth where refusal was encountered. Bore depth varied between 1.7 m and 3.4 m (Table 5). Bore GW1 (located just north of the Hospital) was also included.

No water was encountered in the monitoring bores. Bores were fitted with data loggers to monitor if groundwater rose into the bore casing following installation, with data downloaded in May 2012. The data loggers showed no water in any of the bores between late March and early May 2012. This is generally consistent with the test pit data from the geotechnical investigation (Section 2.5).

TABLE 5: MONITORING BORE DATA

Bore Name	Easting (mE)	Northing (mN)	Top of Casing Elevation (mAHD)	Natural Surface (mAHD)	Total Depth (m)	Water Level (April 2012) (mAHD)
GW1	666730	7742106	11.73	11.70	3.9	< 7.8
GW2	666024	7741902	12.18	12.20	3.4	< 8.8
GW3	666752	7741652	13.12	13.15	2.6	< 10.5
GW4	667615	7740788	14.56	14.58	1.7	< 12.9
GW5	666588	7740837	13.84	13.85	2.4	< 11.4
GW6	666024	7741059	13.40	13.45	3.0	< 10.4

2.7.2 Permeability

The geotechnical investigation (Coffey, 2011) did not include infiltration / permeability testing as part of the study. However the report concluded that infiltration measures such as soakwells would not be appropriate due to the high percentage of fines in the soil, indicating that vertical soil permeability (hydraulic conductivity) would be expected to be low (as would be expected for a clayey sand).

Nearby infiltration testing at Wedgefield Industrial Estate approximately 2 km north of the Study Area was performed in Pindan Sands, similar to those found in the Study Area. Testing of the soils at 0.5 m below surface was conducted by GHD (2009) as part of the Geotechnical Investigation. Permeability measurements of 3 to 4 m/day were recorded, but permeability for design purposes was estimated at 1 m/day "based on correlation of the material classification with published data" (GHD, 2009).

Based on anecdotal evidence, a permeability of 1 m/d may be considered high, as ponding on the soil surface occurs as rainfall commences.

It has been assumed that the soil has little to no capacity for infiltration and on site infiltration has not been considered.



2.7.3 Groundwater Quality

Little data is available for groundwater quality. Nearby groundwater bores to the north of the South Hedland Town Centre (one a garden irrigation bore and the other for livestock) indicated salinity greater than 4,000 mg/L.

2.8 Wetlands

No Environmental Protection Policy (EPP) or Conservation Category wetlands are located within or near the Study Area. No sensitive receiving environments are downstream of the Study Area.

2.9 Acid Sulphate Soils

According to mapping published by the Department of Environment and Conservation (2008), the Study Area is mapped as having low risk of having Acid Sulphate Soils (ASS) occurring less than 3 m from surface (DoEC, 2008). Regional Acid Sulphate Soil mapping is shown in Figure 15.

2.10 Water Resources

Opportunities for water extraction from the superficial formation are limited and groundwater is of poor quality due to salinity.

The DeGray River wellfield and Yule River wellfields supply water to the Port Hedland region, operated by the Water Corporation, and protected by a Water Source Protection Plan (WRC, 2000). The development area is greater than 75 km from the DeGray River Wellfield and 50 km from the Yule River Wellfield.

Treated wastewater from the Hedland Waste Water Treatment Plant is available for irrigation of Public Open Space, and is used for irrigation in other areas of South Hedland. The WWTP is located on the western side of South Creek adjacent to the South Hedland Town Centre.



3. PROPOSED DEVELOPMENT

The proposed Concept Plan (RPS, 2012) for the Study Area is shown in Figure 16. The plan covers an area of 226 ha and encompasses part of the western section of the South Hedland Town Centre and a large area of undeveloped land to the south and west of the Town Centre and existing residential development.

The Plan proposes a major expansion to the South Hedland townsite, with over 2,300 lots proposed.

The Concept Plan shows that land use in the proposed development will consist of:

- A mix of residential products ranging from higher density R50/60 to larger R20 lots;
- An Aged Care Centre, located adjacent to the Hospital;
- · A primary school;
- A large District Open Space area located in the southern section of the Study Area.

Key elements of the structure plan relating to water management include:

- Proposed drainage swales located throughout the Study Area for the discharge of stormwater runoff;
- Provision of a major drainage swale adjacent to the Powerline Reserve (through southern section of Study Area) to provide flood protection to existing residential development;
- Upgrade of the Forrest Circle south drain downstream of Collier Dr to increase capacity and improve drainage for the Hospital site and adjacent areas.

A Development Plan has been developed for the first section of the Concept Plan area and is shown in Figure 17. Although there have been some minor amendments to road layouts and roundabouts added, there has been no change in drainage swale layout or function.



4. LOCAL WATER MANAGEMENT STRATEGY

The proposed Local Water Management Strategy for the Study Area is outlined in this chapter. It includes discussions regarding water use and conservation, and details key elements of groundwater, surface water and water quality management with respect to demonstrated best management practice in water sensitive design.

Issues related to implementation are discussed in Chapter 5.

4.1 Water Use & Sustainability Initiatives

The supply and sustainable use of water within the proposed development are key components of the management strategy.

4.1.1 Water Sources

Potable water supply to the Study Area is proposed from the scheme water serviced via an extension of the Water Corporation's existing infrastructure for the South Hedland townsite.

The use of groundwater as a non-potable water supply source, particularly for POS irrigation purposes, is considered unlikely due to poor yields and high salinity from the Pindan Sand aquifer. POS areas will be landscaped appropriately for the climatic conditions and areas requiring irrigation will be minimised. It is proposed that any irrigation of POS areas within the Study Area be sourced using treated wastewater from the South Hedland Waste Water Treatment Plant.

A development scale water reuse scheme is not planned for the Study Area.

4.1.2 Water Conservation

Development of the Study Area will lead to an increased demand for water. Water conservation measures will be promoted to reduce scheme water consumption within the development and will be consistent with Water Corporation's "Waterwise" land development criteria which could include:

- Promotion of use of waterwise practices including water efficient fixtures and fittings (taps, toilets and appliances, waterwise landscaping).
- Use of native vegetation requiring no/less irrigation in proposed drainage swales.
- Recharge of the groundwater to improve salinity concentration by on site infiltration of fresh stormwater in drainage swales. While infiltration is expected to be low due to low permeability of the soil strata, there may be some periods when inundation to some degree may exist for several days.
 Minor infiltration of low salinity water will provide some dilution of the existing groundwater salinity.
- Rainwater tanks as one method of collecting roof stormwater for possible reuse at a domestic scale.
 However given the low rainfall pattern of the region, viability will need to be assessed prior to implementation.
- Buildings to be built consistent with current Building Codes of Australia (DCBC, 2012) water efficiency standards and the State Government 6 Star Plus Scheme.

Specific measures to achieve water conservation and will be detailed in the UWMP.



4.1.3 Non Potable Water Supply & Water Balance

A water balance at the LWMS stage is generally requested to support the identification of excess water generated by the development for potential use as a non potable water supply scheme.

Based on geotechnical investigations (Section 2.5) opportunities for infiltration (pre and post development) and storage of stormwater for reuse in the Study Area are limited. Furthermore, recharge and abstraction from the superficial aquifer for non potable use is considered unlikely due to the presence of high fines content within the soil.

Whilst development generally leads to an increase in the post development peak flow and volume of surface water discharge to the receiving environment, the limited infiltration and high runoff rates are similar for both pre and post development condition. Consequently, change in landuse to post development generates limited excess water from a water balance perspective.

4.2 Surface Water Management

Management of the surface water in the study area following development involves mitigating the impacts from flooding and designing a suitable stormwater system.

4.2.1 Regional Flood Management

The Study Area is immediately adjacent to South Creek, a significant watercourse in the region. The Port Hedland CVS (Cardno, 2011) provides the most recent assessment of flooding and flow rates within South Creek. These levels and rates were used to set minimum fill levels within the proposed development.

As the proposed development is within the floodplain of South Creek, and subject to flooding, importing fill to the site has the potential to raise flood levels and impact negatively upon other landowners and users.

To assess the impact of fill on South Creek flood levels, a Mike21 2D hydraulic model was created for the existing natural surface elevation. A second model was then developed with natural surface raised to above flood levels. These models were developed based on flow data and levels from Cardno (2011) and simulate flow from the South Creek catchment. Details of the flood modelling have been included in Appendix B.

Figure 18 shows the results of the flood modelling, and details the impact of fill on South Creek flood levels for the 100 year ARI event. It can be seen that immediately adjacent to the south western boundary of the Study Area there is an increase of 320 mm, which is the greatest increase in flood level. This quickly decreases to less than 150 mm approximately 200 m away. Beyond this, impact of fill on flood levels reduces to almost negligible (< 25 mm) 400 m south of the fill. The impact of on flood levels in South Creek to the west of the Study Area is generally less than 75 mm, dissipating quickly downstream.

The Growth Plan for South Hedland indicates that the area south of the Study Area and west of Yarrie Rd (including South Creek) is shown as "Natural Landscape/Conservation. Therefore the area impacted by fill is not planned for future development and so although a small area has a flood rise of greater than 150mm, this will not impact on other users or future development (which will occur east of Yarrie Rd).

This approach is considered by the Floodplain Management Section at Department of Water to not detrimentally impact on the existing flooding regime of South Creek (see Appendix C).



To provide adequate flood protection for the proposed development, minimum floor levels are set at 0.5 m above the 100 year ARI flood level (including impact of fill). A 100 m wide zone immediately adjacent to South Creek has finished floor levels at 0.5 m above the 100 year ARI flood level, with a peak earthworked ground level set to the same. North and east within this zone, finished floor levels are determined by the local 100 year flood levels (rather than South Creek levels). This is shown in Figure 19. This approach has been adopted following discussions with Department of Water Floodplain Management Section (S. Rodgers, DoW, pers. comm., 10/5/12).

4.2.2 Local Flood Management

Local stormwater management is proposed to be undertaken consistent with water sensitive design practices and meet key objectives and criteria as detailed in Table 1.

The stormwater drainage system will be designed using a major/minor approach. The minor drainage system is defined as a swale and road drainage system designed to carry runoff generated by low frequency ARI storms, less than 5 year ARI. The major drainage system is defined as the arrangement of roads and drainage reserves to provide safe passage of stormwater runoff from extreme events which exceeds the capacity of the minor system.

The stormwater drainage system will be designed using the arrangement of roads, drainage swales and open space areas planned to provide safe passage of stormwater runoff from extreme events to South Creek. Stormwater runoff generated by the lots and impervious areas of the road reserve will be collected in the swale system and discharged to South Creek.

The drainage swales will provide some attenuation of peak surface water flows, and some water quality treatment for the proposed development prior to discharge from the Study Area. Due to the large rainfall intensity and volumes experienced in the North West Region of WA, conveyance of stormwater is via overland flow paths and open drainage systems, rather than underground pipe systems.

Opportunities for infiltration are limited due to the low permeability of the soil strata. Infiltration options such as soakwells and bottomless manholes are not appropriate in this hydrogeological setting and are not proposed here.

Given the nature of the existing environment and the limited infiltration capacity, it has been assumed that the existing runoff coefficient is 80%. A similar value has been used for the post development environment, though with a reduced roughness coefficient for the impermeable surfaces.

All stormwater swales areas are proposed to be ephemeral and no open water body lakes are proposed, consistent with the DoW's current policy.

4.2.3 Conceptual Stormwater System Design

The proposed water management system is shown in Figure 20. Stormwater runoff from lots and road reserves are discharged to the swales via the road system. The swales then convey flow downstream to South Creek. Post development catchments are shown in Figure 21.

4.2.3.1 Road Design

Roads will convey stormwater runoff generated by impervious areas from both the lots and the road reserve via the road gutter system into drainage swales.



Stormwater runoff within the roads will be contained within the depth of the kerb for rainfall events up to the critical 5yr ARI. For rainfall events greater, stormwater runoff may exceed the depth of the kerb and utilise part of the road reserve as the overland flow path prior to discharge into a main drainage swale. For roads located adjacent to drainage swales or South Creek, they may contain a one way crossfall which directs stormwater runoff towards the drainage system over a flush kerb.

Locations where flow from roads discharge into a drainage swale will be sufficiently protected by rock armour or engineering structures such as drop structures to assist in minimising or preventing scouring and erosion.

4.2.3.2 Swale Design

A swale drainage system will convey stormwater runoff from the Study Area and the external catchments to the south. A series of swales will convey flow to two outlets to South Creek. A third cutoff drainage swale along the southern boundary of the Study Area will intercept from the southern catchments and discharge flow westward to South Creek, with its own discharge point. The northern swale system links into the existing Forrest Circle North Drain, to the west of the Town Centre, using an existing drainage reserve. This was done to provide a lower discharge level for the proposed catchment, reducing fill requirements. The Forrest Circle North Drain channel has been increased in size to convey both the existing and proposed catchments. The swale outlets will be appropriately designed during detail design with sufficient protection such as rock armouring, drop structures or concrete spillways to prevent or minimise scouring and erosion

The swales have been designed to be multiple use corridors, incorporating drainage and POS functions. Proposed cross sections showing conceptual layouts are shown in Figure 22 for a number of sections, with more details provided in the South Hedland Western Edge Landscape Report (UDLA, 2012). The majority of swales have been designed to have 1 in 6 side slopes. Other areas encompass active POS areas which will provide flood storage in the 100 year ARI event.

Swale design is based on modelling of the runoff from the internal catchment. To minimise fill, a minimum longitudinal grade of 1 in 1000 was used for the swale inverts. Swale depths were determined based on required fill levels, flow rates and drain cross sectional areas. The drainage swales will have varying base widths being smaller upstream (~2m) to wider downstream (~8m) as the contributing flow areas increase. The base width may also vary due to landscaping treatments and erosion control measures to be detailed during detailed.

At proposed road crossings, culverts have been included to discharge flow. The road crossing culverts provide a constraint on flow, resulting in attenuation of flow and reduction in flow velocities within the swales. The swales have been designed to convey the 5 year ARI event as a minimum. For larger events such as the 100 year ARI event, roads adjacent to the swales will also convey flow to shallow depth.

4.2.3.3 Post Development Stormwater System Modelling

Conceptual stormwater modelling was performed for the Study Area using a combination of the 1D XP-STORM hydraulic model and the 2D MIKEFLOOD hydraulic model. These were used to determine post development flood storage requirements and assess whether sufficient area has been provided within the POS in the Western Edge Concept Plan for drainage purposes. The 1D XP-STORM model was used to provide an assessment of the drainage swales and required culvert sizing and capacity. The 2D



hydraulic model was then used to model runoff from the catchments and assess the swale and road conveyance system, along with South Creek flood impact.

The design storms modelled by XP-STORM for pre-development were calculated internally by the model with reference to the methodology in Australian Rainfall & Runoff (AR&R) (Institution of Engineers, Australia 2000). The rainfall temporal pattern was assumed to be spatially uniform across the catchment. Storm durations modelled ranged from 10 minutes to 72 hours for the 1 year, 5 year and 100 year ARI storm events.

The loss model adopted for the post development modelling assumed a proportional loss of 10% from both the Lot and Road Reserve areas for the 1 year, 5 year and 100 year ARI rainfall events.

The MIKEFLOOD model was developed using the available LiDAR survey information for South Hedland. Model post development topography (bathymetry) is shown in Figure 23. The model area was developed to assess impact on flood levels of development on the existing residential areas (Koombana) and Town Centre, as well as detailing flood levels within the Study Area, and flood levels in South Creek.

External southern catchment inflows were based on the MIKEFLOOD catchment model described in Section 2.7. Inflows for South Creek were based on data from Cardno (2011). The northern boundaries within the existing drainage system were assumed to be at bank full level.

A Mannings n of 0.05 was used for the drainage swales to simulate spinifex planting. This value was also used for the undeveloped areas to the south and west of the Study Area. A value of 0.04 was used for the existing developed areas. A Mannings n value of 0.02 was used for the road reserve areas within the Study Area and a value of 0.045 was used for lots.

Figure 21 shows that runoff from the Study Area has been divided into a northern and a southern catchment.

The hydraulic modelling indicated that the 3 hour storm duration was critical for each of the three ARI simulations.

The 100 year ARI flood mapping from the MIKEFLOOD model is shown in Figures 24 and 25 for the Northern and Southern Catchments respectively. These provide visual description of flood depth, with flood levels, flows and velocities detailed for locations within the Study Area.

It can be seen that flow is contained within the swale and road system, with some inundation of POS areas. The cutoff drain along the southern boundary of the Study Area collects flow from the southern external catchments and discharges this flow to South Creek. Peak flow in this cutoff drain is $34 \text{ m}^3/\text{s}$, with $13.5 \text{ m}^3/\text{s}$ coming from east of Yarrie Rd. Flows from the existing residential areas and Town Centre are incorporated into the drainage system.

The 5 year ARI mapping is shown in Figures 26 and 27 for the Northern and Southern Catchments respectively. Flood levels are generally 0.4 to 0.6 m lower than the 100 year ARI results. While flow rates are lower than the 100 year flows, flow velocities are slightly higher due to a steeper hydraulic grade with lower downstream backwater level.

The 1 year ARI mapping is shown in Figures 28 and 29 for the Northern and Southern Catchments respectively. Flood levels are approximately 0.3 m lower than the 5 year ARI results, with flow velocities less than 1 m/s within the swale channels.



Longsection data for the 100 year ARI storm event is shown in Figure 30. This details three longsections for the major drainage routes through the Study Area and shows flood levels and flows. It can be seen that the drainage swales can sufficiently accommodate stormwater runoff for up to the critical 100 year ARI event without flow over crossings.

4.3 Groundwater Management

A groundwater management strategy is required to ensure the required separation between building floor levels for development and groundwater level is achieved.

As discussed in Sections 2.5 and 2.7, the watertable is at least 3 m below the existing natural surface. Bores installed at the end of the wet season, when the highest groundwater levels would be expected, and monitored for 6 weeks using data loggers, showed no recording of groundwater indicating that groundwater was at least 2.4 to 3.4 m below natural surface.

In addition, it is proposed to import up to 2 m of fill across the Study Area (approximately 0.6 m on average). Figure 31 shows the base level of the geotechnical test pits along with proposed fill levels.

Consequently, as there is at least 2m of clearance to groundwater from the natural surface level, groundwater management such as subsoil drainage is currently not required.

The geotechnical report (Coffey, 2011) suggests that soakwells would not be effective for disposal of stormwater runoff due to the high percentage of fines in the soil, limiting its infiltration capacity.

Note that fill required to satisfy flood levels and geotechnical requirements are considered to be the critical factor in determining fill requirements rather than groundwater levels.

However, while this LWMS establishes criteria and the general approach for setting development levels, finished lot levels and fill requirements are a detailed design issue and will addressed during preparation of Urban Water Management Plans (UWMP's).

4.4 Erosion & Sedimentation Management

The erosion potential in channels and overland flow paths can be estimated based on the velocity of flow during storm events. Flow velocity can therefore be used to identify areas where stabilization of channels will be required.

The geotechnical investigation of the Study Area (Coffey, 2011) found that the soils are classed as clayey sands with between 15 to 40% fine material (silt and clay). French (1985) indicates that for these soil types, erosion will start to commence at velocities greater than 0.8 to 1.1 m/s.

Figure 32 shows maximum flow velocities for the 5 year ARI event. It can be seen that across the majority of the Study Area, flow velocities are less than 1 m/s within the swale channels, with much of the flow travelling at less than 0.5 m/s.

Flow velocity in excess of 1 m/s occurs in the channel at the downstream extent of the Northern Catchment. In this stretch of channel (~250 m) flows of up to 1.5 m/s can be seen, with flows greater than 1.5 m/s immediately adjacent to the proposed culvert location.

As well as these areas, there are several other areas which have higher flow velocities, primarily around culvert structures, as would be expected. These are areas where bank and channel stabilisation works, such as concrete wing walls and rock / concrete bedding, would be incorporated to minimise erosion and scour.



The drainage channel at the northern outlet may require treatment to prevent erosion of the channel during storm events. Some protection of the southern outlet may also be required as flow velocities are approaching scour velocities.

Erosion control measures suggested by AgWA (2001) include:

- Drop structures;
- Sediment traps;
- Vegetation stabilisation;
- · Mulching;
- Geomat[®] type products;
- Geocell[®] type products;
- Rip-Rap type drain lining;
- Reno Mattresses:
- Revetment mattresses; and
- Rock Gabions.

These may be used to protect drain batter slopes against steep flow into the channel and from flows in the channel.

4.5 Wetland Management

As previously discussed in Section 2.7, there are no EPP or Conservation Category Wetlands located within or downstream of the Study Area. No specific strategy for protection of wetlands is therefore required for this development.

4.6 Water Quality Management

With respect to water quality management the LWMS proposes the use of the following structural and non-structural controls as being the appropriate treatment for minor events in the Pilbara region. Note that the use of vegetated swales with appropriate longitudinal grades has been used to minimise flow velocities to minimise sediment transport.

Structural Controls

Use of vegetated swales to control silt and sedimentation Infiltration of frequent events where possible within vegetated swales Creation of ephemeral detention areas

Non Structural Controls

Planning practices (wide road reserves to accommodate dedicated drainage swales)
Construction practices (construction management, use of appropriate native plantings)
Maintenance practices (of the swale systems)

Other water quality parameters such as oils, grease and hydrocarbons are considered to be treated by structural controls as specified by the Town of Port Hedland.



Table 6 details a summary from DoW's Stormwater Management Manual for Western Australia (2007) of expected pollutant removal efficiencies for vegetated swales and detention/retention systems in relation to the water quality design criteria. These values have been presented as an estimate as pollutant removal efficiencies for the spinifex species proposed for vegetation of the swales are unknown.

TABLE 6: BMP WATER QUALITY PERFORMANCE IN RELATION TO DESIGN CRITERIA

Parameter	Structural Controls Nutrient Output Reduction ¹ Vegetated Detention/ Swales Retention Measures	
Total Suspended Solids	60-80%	65-99%
Total Phosphorus	30-50%	40-80%
Total Nitrogen	25-40%	50-70%
Gross Pollutants	-	>90%

^{1.} Typical Performance Efficiencies via DoW (2007)

4.7 Construction Management

The presence of groundwater and acid sulphate soils may require management during construction of the proposed development.

4.7.1 Dewatering

Dewatering may be required for some elements of subdivision construction (particularly sewer). Given the depth of construction, dewatering will only be in the superficial aquifer. As the volume of dewatering is generally minor and of a temporary nature, the overall impact on the aquifer will be minimal, although some drawdown will occur at the dewatering site.

As discussed in Section 2.7, groundwater was not encountered within 4 m of the surface and therefore dewatering is unlikely to be required for the development. If required, JDA understand that prior to the commencement of any dewatering, the construction contractor will apply for and obtain from DoW a "Licence to Take Water". All dewatering will be carried out in accordance with the conditions of a licence.

Where possible, construction will be timed to minimise impacts on groundwater and any dewatering requirements.

4.7.2 Acid Sulphate Soils

As previously discussed in Section 2.9, there is low risk of ASS being present within the Study Area.

4.8 Water Management Strategy Summary

Table 7 provides an overall summary of key elements of the proposed water management strategy for the Study Area, with an assessment of the strategy in relation to DoW (2007) principle objectives for stormwater management in Western Australia (Section 1.2.4).



TABLE 7: SUMMARY OF PROPOSED LOCAL WATER MANAGEMENT STRATEGY

Principle	Key LWMS Elements
Water Quantity To maintain the total water cycle balance within development areas relative to the pre-development conditions.	Maintain flow paths for existing catchments Maintain or reduce 100 year ARI peak flood levels from the Study Area
Water Quality To maintain or improve the surface and groundwater quality within development areas relative to pre-development conditions.	 Maintain 1 in 1 year ARI event post development discharge volume relative to pre-development conditions Application of source controls – including street sweeping, native plantings. Application of structural controls – vegetated swales for erosion control.
Water Conservation To maximise the reuse of stormwater	Encourage implementation of water efficiency and demand management measures in and ex-building. Use of native plantings in swale and drainage areas to minimise irrigation
Ecosystem Health To retain natural drainage systems and protect ecosystem health	Retained South Creek. Management of post development flows to minimise sediment transport.
Economic Viability To implement stormwater systems that are economically viable in the long term	Use of proven structural WSUD technology for the Pilbara. Use of source control techniques to minimise cost of nutrient management
Public Health To minimise the public risk, including risk of injury or loss of life to the community	Design in accordance with relevant design standards, best management practices, council regulations and government agency requirements.
Protection of Property To protect the built environment from flooding and waterlogging	Identification of 100 year ARI flood levels for Study Area, with finished floor levels at least 0.3 m above local stormwater levels and 0.5 m above South Creek flood levels within 100 m of South Creek. Protection of downstream areas by minimising impact on flood levels with DoW criteria for storm events up to 100 year ARI.
Social Values To ensure that social aesthetic and cultural values are recognised and maintained when managing stormwater	Use of swales within public areas for stormwater conveyance Integration of drainage and POS functions
Development To ensure the delivery of best practice stormwater management through planning and development of high quality developed areas in accordance with sustainability and precautionary principles.	Urban water management in accordance with Better Urban Water Management (WAPC, 2008b) Development of the LWMS in accordance with government agency guidelines and best management practice recommendations



5. IMPLEMENTATION

Implementation of the Local Water Management Strategy involves defining the roles and responsibilities of the developer and local authority, outlining further documentation required to support the development and defining operation, monitoring and maintenance of the stormwater system.

5.1 Roles and Responsibilities

Table 8 details the roles and responsibilities to undertake the implementation plan.

The operation and maintenance of the stormwater management system with the Study Area will be the responsibility of the developer initially. Responsibility for all areas will ultimately be reverted to the local authority following hand over to the Town of Port Hedland. Preparation of the UWMP will be the responsibility of the developer.

TABLE 8: IMPLEMENTATION RESPONSIBILITIES

	IMPLEMENTATION	RESPONS	SIBILITY
LWMS Action Section		Developer	Town of Port Hedland
5.2	Preparation of an Urban Water Management Plan as required to support subdivision conditions	~	
5.3	Construction of stormwater system	✓	
5.3	Stormwater system operation and maintenance Initially Following hand over	√	~

5.2 Subdivision Process

A UWMP for the stages of the Study Area may be required by the Department of Water. If so, then a UWMP will be submitted by the Developer to the Department of Water and the Town of Port Hedland as required under relevant conditions of subdivision. Preparation of the UWMP will take into consideration *Urban Water Management Plans: Guidelines for preparing plans and complying with subdivision conditions* (DoW 2008). The UWMP will address:

- Detailed stormwater management design including the size, location and design of swales, integrating major and minor flood management capability, landscape plants for the swales as related to stormwater function, details of local geotechnical investigations and impact on stormwater design;
- Detail measures to reduce velocity of stormwater to prevent erosion and sediment transportation;
- Management of groundwater levels, and if any proposed dewatering is necessary;
- Agreed/approved measures to achieve water conservation and efficiencies of use including sources
 of water for non-potable uses and detailed designs, controls, management and operation of any
 proposed system;
- Management of sub-divisional works (management of soil/sediment including dust).



5.3 Stormwater System Operation and Maintenance

Operation and maintenance of the drainage system will be the responsibility of the Town of Port Hedland. The surface drainage system will require routine maintenance to ensure its efficient operation. It is considered the following operating and maintenance practices will be implemented periodically:

- removal of debris to prevent blockage of culverts;
- cleaning of sediment build up and litter layer on the bottom of swales;

A summary of the proposed maintenance schedule is presented in Table 9 below.

TABLE 9: MAINTENANCE SCHEDULE FOR DRAINAGE INFRASTRUCTURE

Item	Maintenance Interval	
	Biannually	As required
Swales		
Inspect for erosion + sediment accumulation	✓	
Assess health of vegetation. Remove dead plants. Slashing of swales.	✓	
Removal of sediment and leaf litter layer build up and debris blocking culverts.		✓

5.4 Monitoring Program

The stormwater management system outlined in this LWMS focuses on implementation of current known best management practice without the requirement of a post development monitoring program.



6. REFERENCES

Agriculture Western Australia (2001) Erosion and Sediment Control Manual for the Darling Range, Perth, Western Australia.

Cardno (2011) Port Hedland Coastal Vulnerability Study. Report to LandCorp, August 2011.

Coffey Geotechnics (2011) South Hedland Town Centre Development – Areas A & B: Geotechnical Investigation Report. Report to LandCorp, December 2011.

Department of Environment and Conservation (2008) Acid Sulphate Soil Mapping.

Department of Water (2007) Stormwater Management Manual for Western Australia, August 2007.

Department of Water (2008) Interim: Developing a Local Water Management Strategy.

Department of Water (2008) Urban Water Management Plans: Guidelines for preparing plans and complying with subdivision conditions.

Geological Survey of Western Australia (1983) 1:50,000 geological map, Port Hedland Map Sheet

GHD (2009) Wedgefield Industrial Area Report on Geotechnical Investigation. November 2009.

GHD (2011) South Hedland Flood Study. Report to Town of Port Hedland, February 2011.

Global Environmental Modelling Systems (2000) Greater Port Hedland Storm-surge Study. Final Report to WA Ministry for Planning and Port Hedland Town Council, October 2000.

Institution of Engineers Australia (2000). Australian Rainfall and Runoff – A Guide to Flood Estimation.

JDA Consultant Hydrologists (2009) Wedgefiled Industrial Estate, Port Hedland – Flood Levels. Report to Landcorp, October 2009 (Ref J4485a)

JDA Consultant Hydrologists (2011) South Hedland Town Centre Revitalisation: East Precinct – Local Water Management Strategy. Prepared for LandCorp, August 2011.

Luke, G.L., Burke, K.L. & O'Brien, T.M. (1988). Evaporation Data for Western Australia – Technical Report 65. Perth: W.A. Department of Agriculture, Division of Resource Management.

Public Works Department (1976) South Hedland Town Centre Drainage Design.

Public Works Department (1980) Manual of Standards: Part DU – Urban Drainage, January 1980.

RPS (2012) Western Edge, South Hedland Concept Plan. Prepared for LandCorp, June 2012.

UDLA (2012) South Hedland Western Edge

Water and Rivers Commission (2000) DeGray River Water Reserve Water Source Protection Plan; Port Hedland Regional Water Supply. Water Resource Protection Series, Report WRP 24.



Western Australian Planning Commission (2003) WAPC Planning Bulletin 64, Acid Sulphate Soils, November 2003.

Western Australian Planning Commission (2006) Water Resources State Planning Policy 2.9.

Western Australian Planning Commission (2007) Liveable Neighbourhoods, A Western Australian Government Sustainable Cities Initiatives.

Western Australian Planning Commission (2008a) Planning Bulletin 92 Urban Water Management.

Western Australian Planning Commission (2008b) Better Urban Water Management, October 2008

Wyche, P.J. (1975) Town Planning Flood Study for South Hedland. Main Roads Department Western Australia Technical Report No. 4. July 1975.

FIGURES

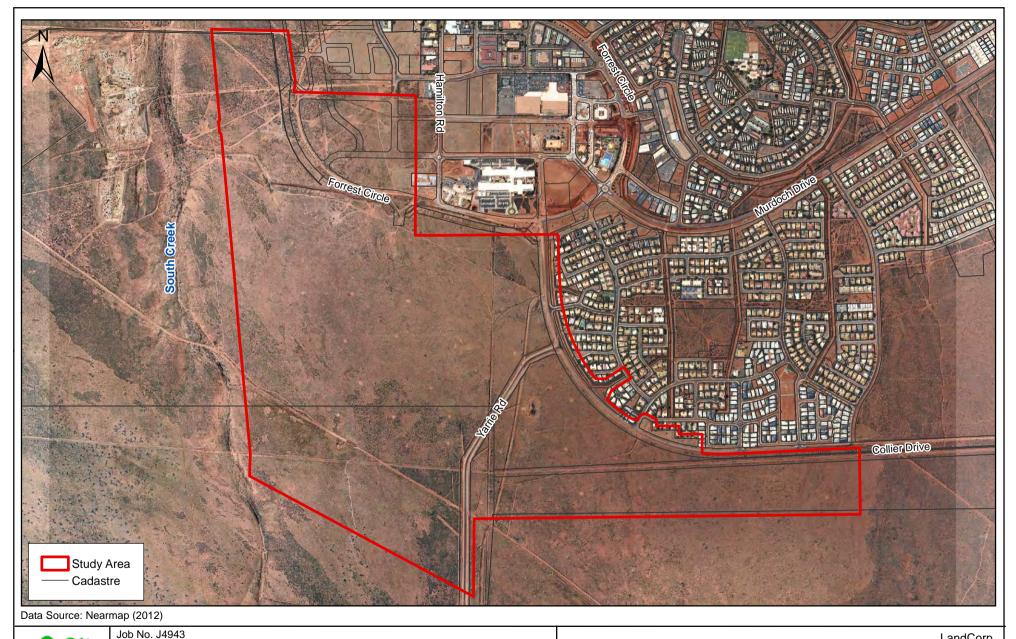


JDA

Job No. J4943

South Hedland Western Edge: LWMS

Figure 1: Location Plan



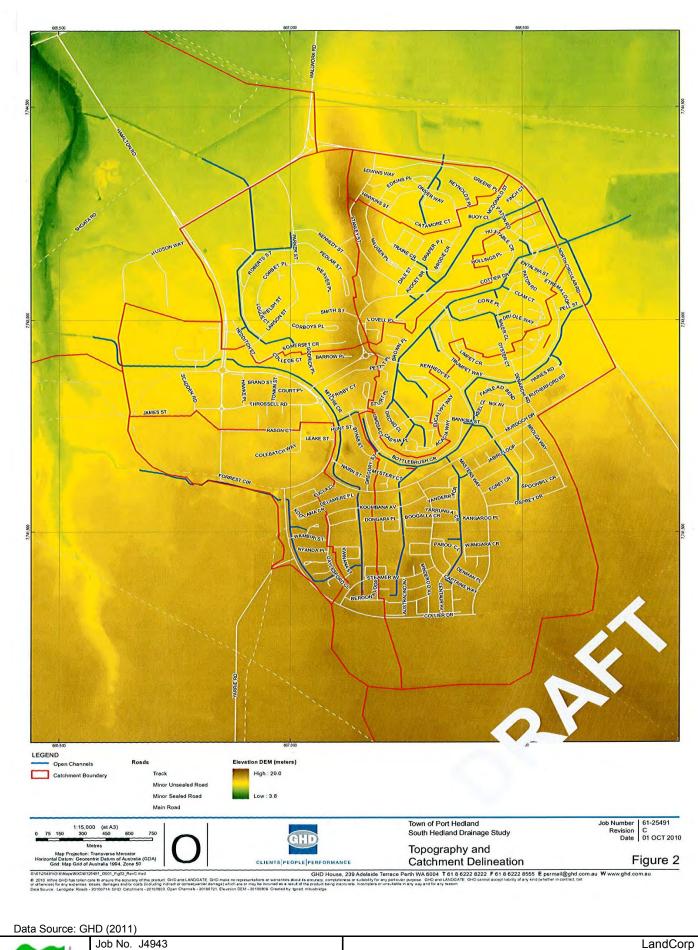


Scale: 1:15,000

0 200 400 600 800

Meters
© COPYRIGHT JIM DAVIES & ASSOCIATES PTY. LTD. 2012

LandCorp South Hedland Western Edge : LWMS Figure 2: Study Area and Landuse



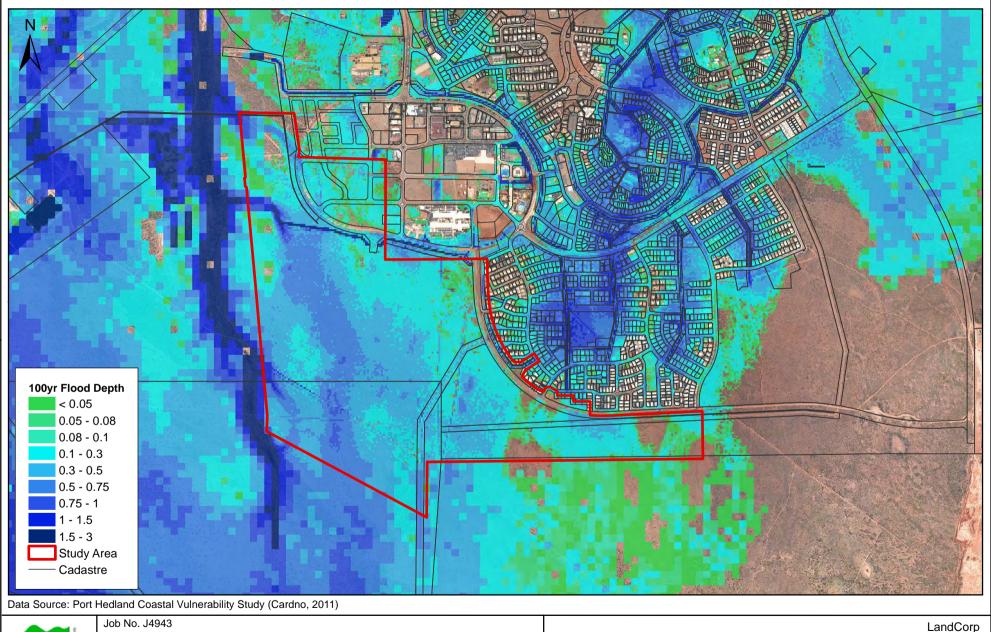
JDA

Job No. J4943

South Hedland Western Edge: LWMS

Figure 3: GHD (2011) South Hedland Flood Study **Catchment Mapping**

© COPYRIGHT JIM DAVIES & ASSOCIATES PTY. LTD. 2012



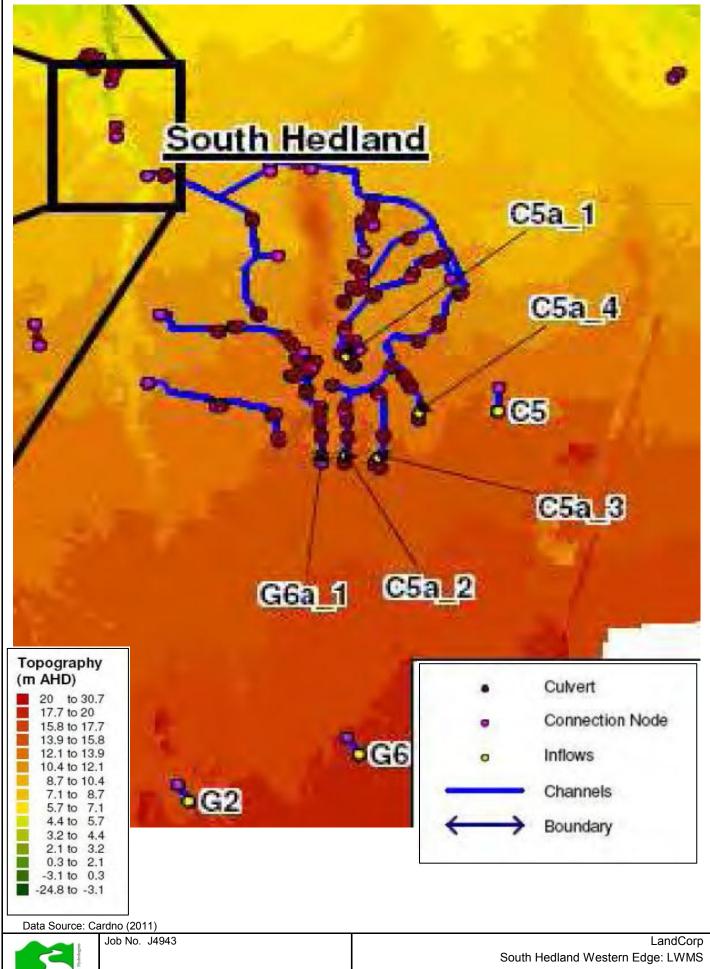
JDA

Scale: 1:21,000

0 200 400 600 800

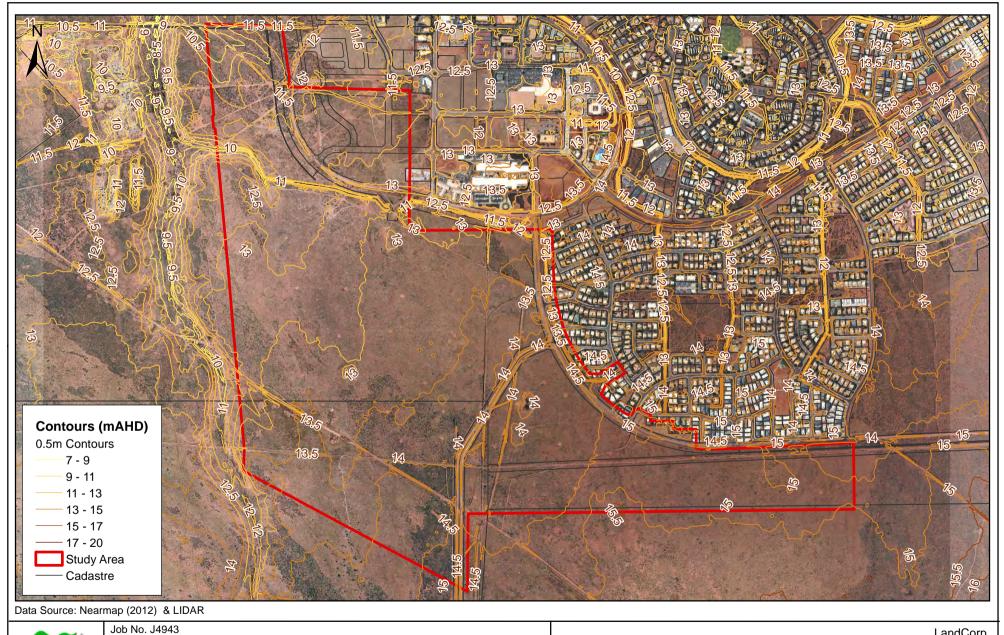
COPYRIGHT JIM DAVIES & ASSOCIATES PTY. LTD. 2012

South Hedland Western Edge : LWMS Figure 4: Port Hedland CVS 100 Year ARI Flood Mapping



JDA

© COPYRIGHT JIM DAVIES & ASSOCIATES PTY. LTD. 2012



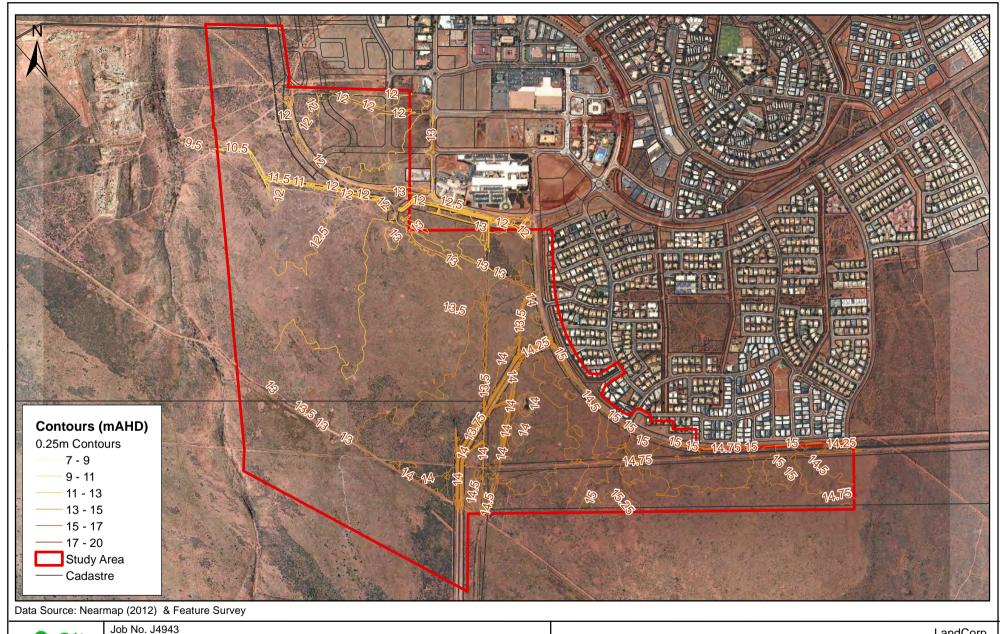


Scale: 1:15,000

0 200 400 600 800

© COPYRIGHT JIM DAVIES & ASSOCIATES PTY. LTD. 2012

LandCorp South Hedland Western Edge : LWMS Figure 6: Topography - Airborne Laser Scanning





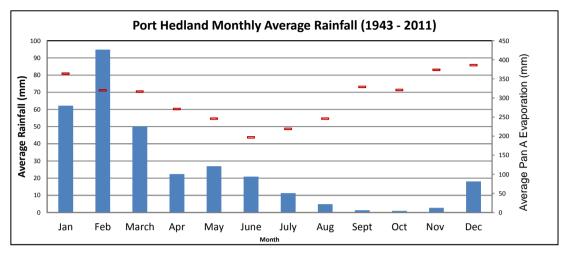
Scale: 1:15,000

0 200 400 600 800

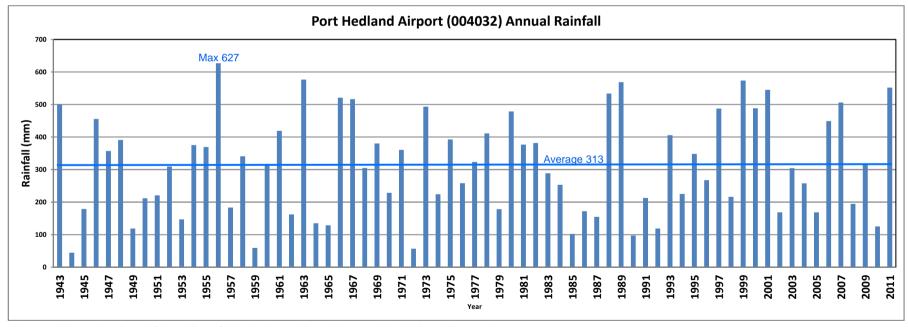
Meters
© COPYRIGHT JIM DAVIES & ASSOCIATES PTY. LTD. 2012

LandCorp South Hedland Western Edge : LWMS Figure 7: Topography - Feature Survey









Data Source: Bureau of Meterology (2012) Climate Data Online. Luke et al (2003) Average Monthly Pan A Evaporation.



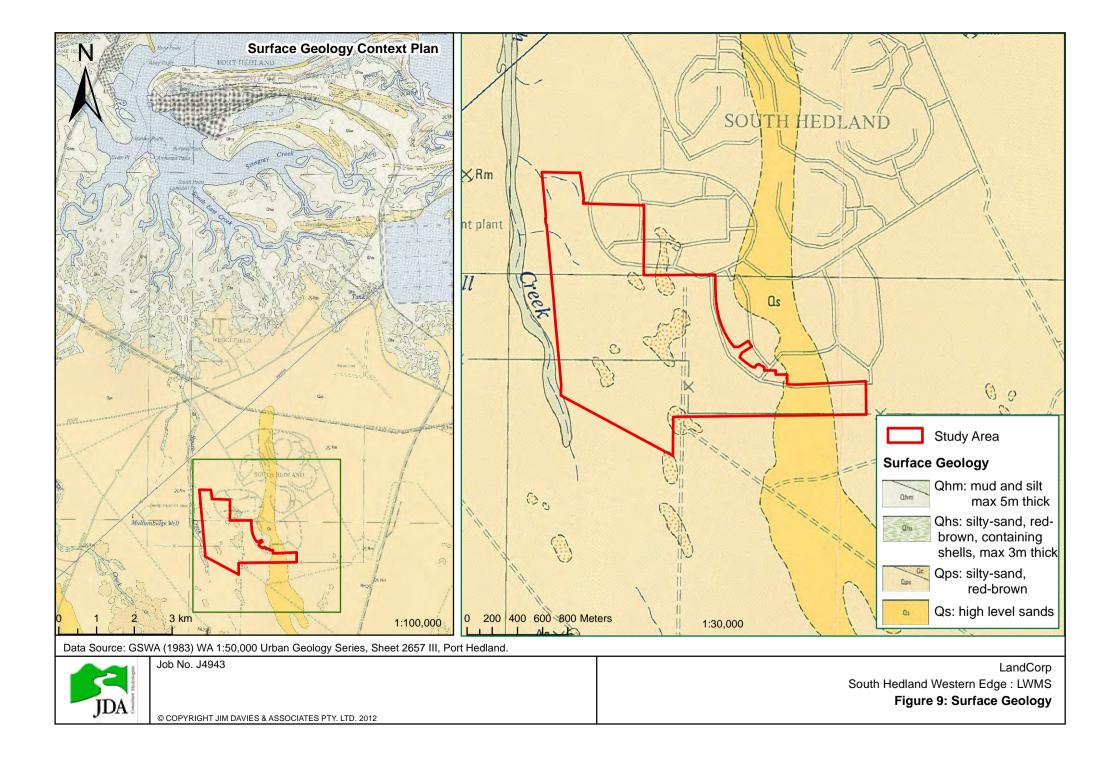
Job No. J4943 Scale:1:73,222

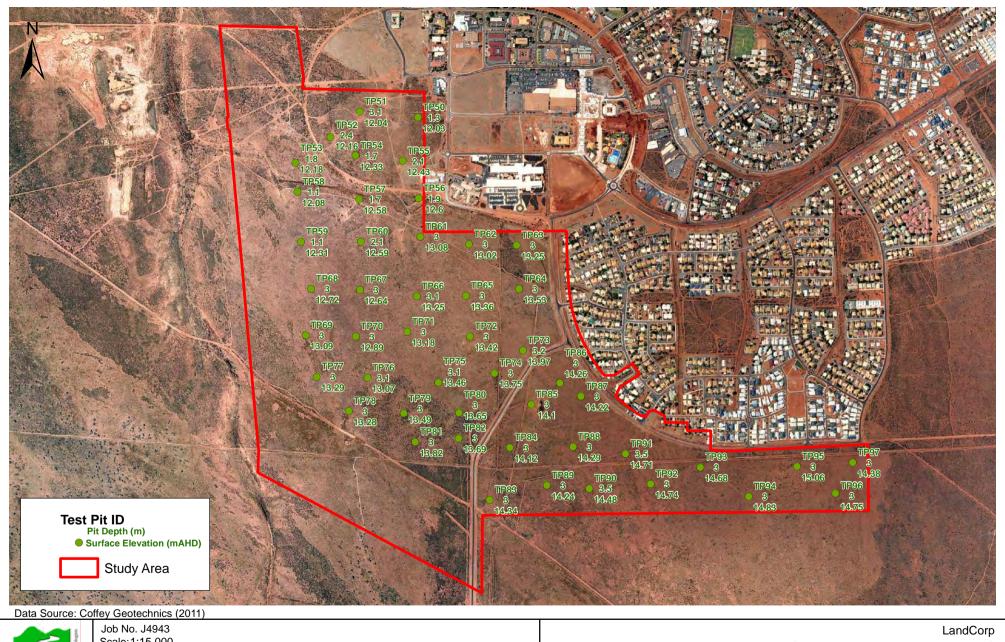
0 500 1,000 1,500 2,000 Meters

© COPYRIGHT JIM DAVIES & ASSOCIATES PTY. LTD. 2012

LandCorp

South Hedland Western Edge : LWMS Figure 8: Port Hedland Annual & Monthly Rainfall



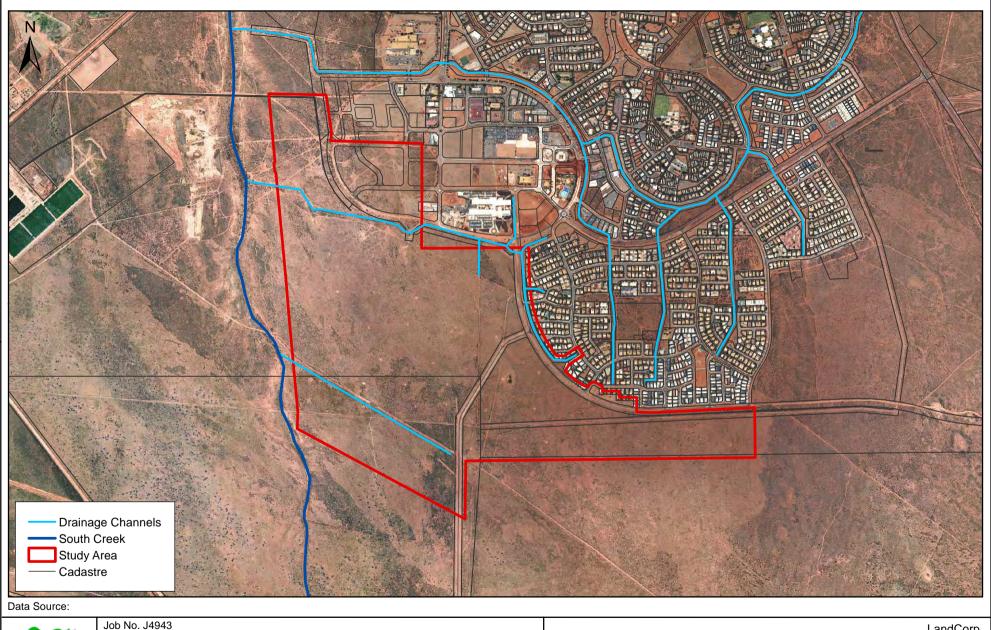


JDA

Scale: 1:15,000 500 1,000 Meters © COPYRIGHT JIM DAVIES & ASSOCIATES PTY. LTD. 2012

South Hedland Western Edge: LWMS

Figure 10: Geotechnical Investigation Pit Location



JDA complete Profession

Scale: 1:20,000

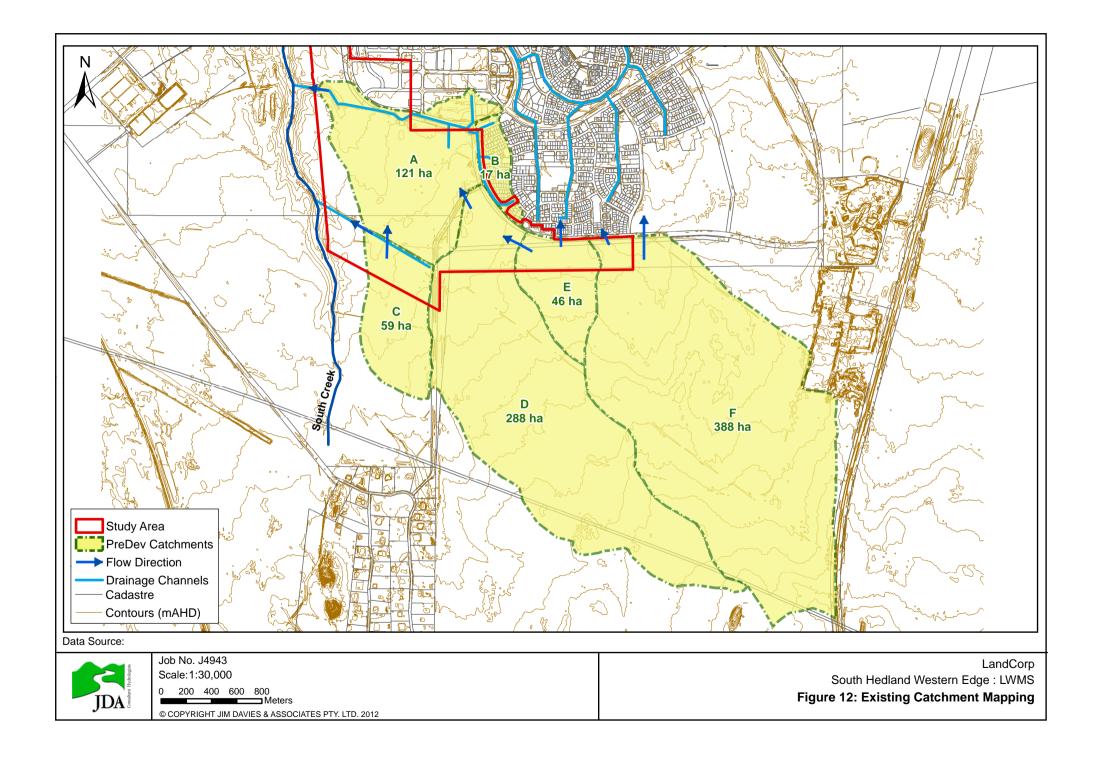
0 200 400 600 800

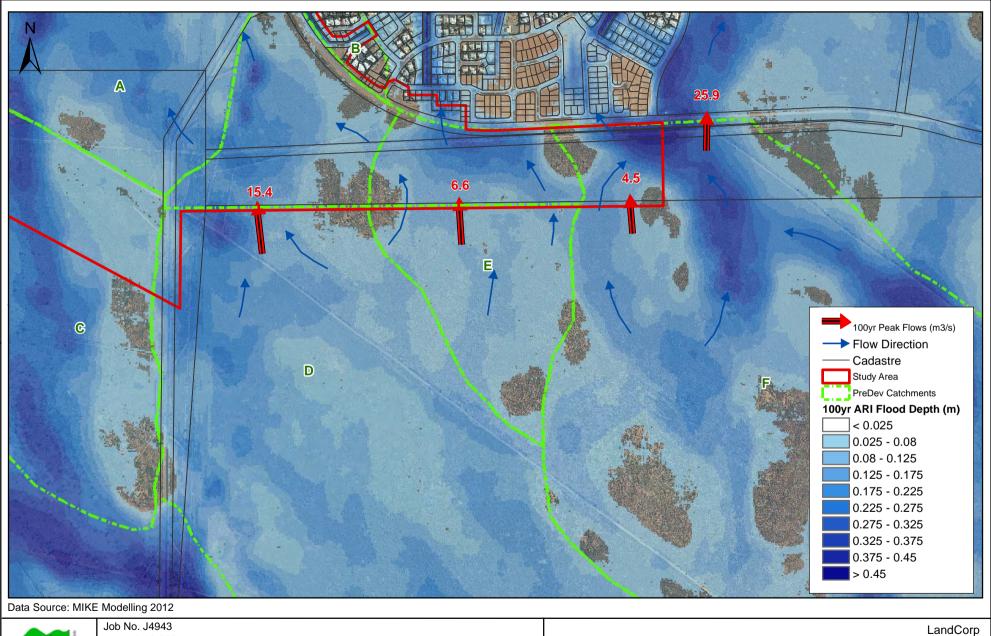
Meters

© COPYRIGHT JIM DAVIES & ASSOCIATES PTY. LTD. 2012

LandCorp South Hedland Western Edge : LWMS

Figure 11: Existing Local Surface Drainage Infrrastructure



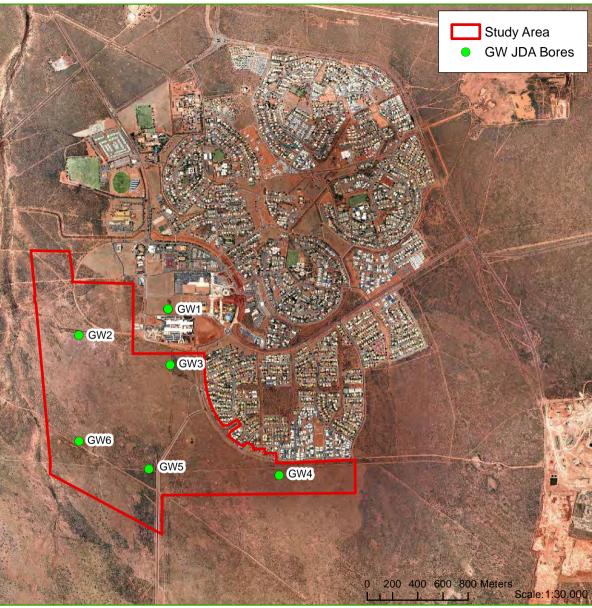


Scale: 1:12,000 800 Meters 200 600 © COPYRIGHT JIM DAVIES & ASSOCIATES PTY. LTD. 2012

South Hedland Western Edge: LWMS

Figure 13: Existing Catchment 100yr ARI Peak Flows & Depth



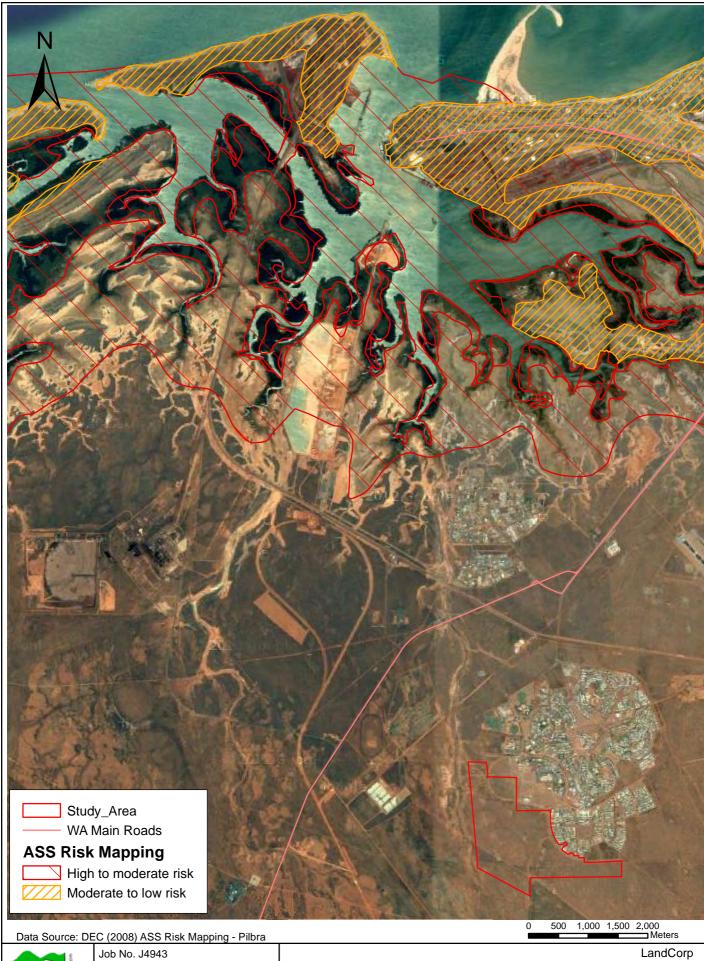


Data Source: DoW (2012) WIN Database



Job No. J4943

LandCorp South Hedland Western Edge : LWMS Figure 14: Groundwater Bores



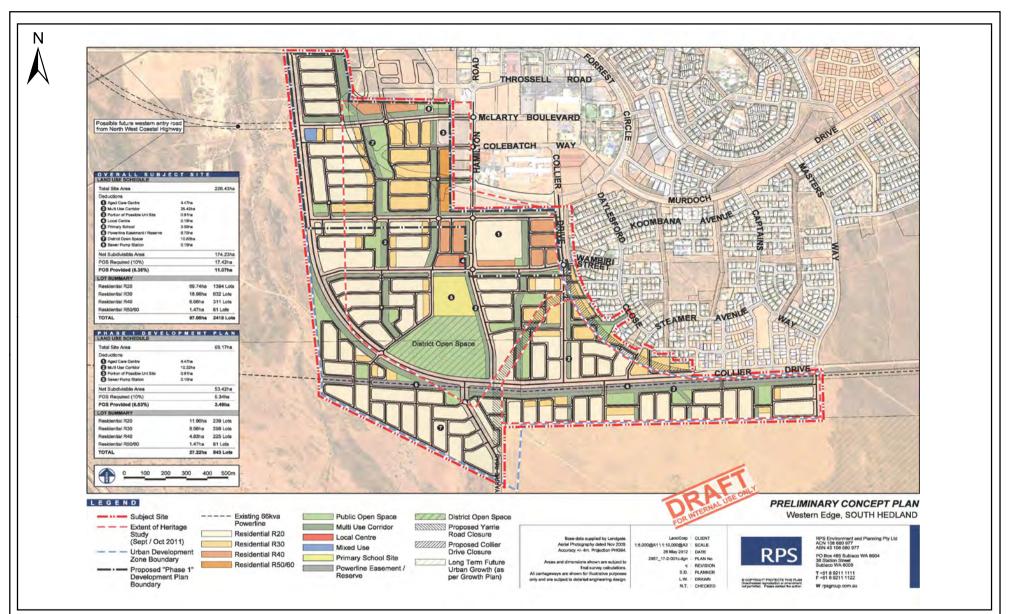
JDA O JUNE 1 Included to 1 Inc

Job No. J4943 Scale 1:63,360

© COPYRIGHT JIM DAVIES & ASSOCIATES PTY. LTD. 2010

LandCorp South Hedland Western Edge : LWMS

Figure 15: Acid Sulfate Soil Mapping

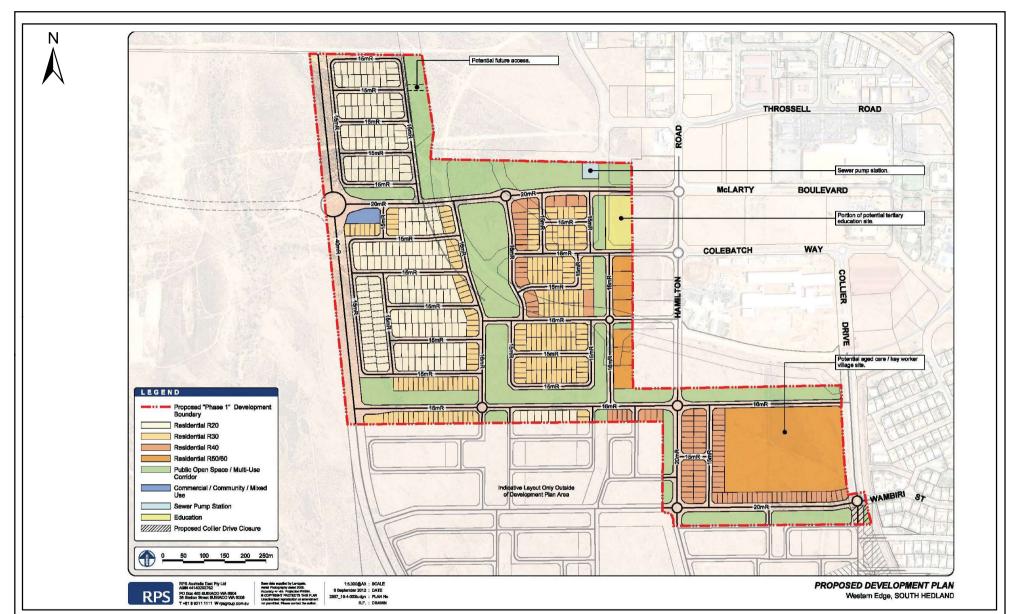


Data Source:



Job No. J4943
Scale: 1:37,469
0 200 400 600 800
Meters
© COPYRIGHT JIM DAVIES & ASSOCIATES PTY. LTD. 2012

LandCorp South Hedland Western Edge: LWMS Figure 16: Proposed Structure Plan



Data Source:

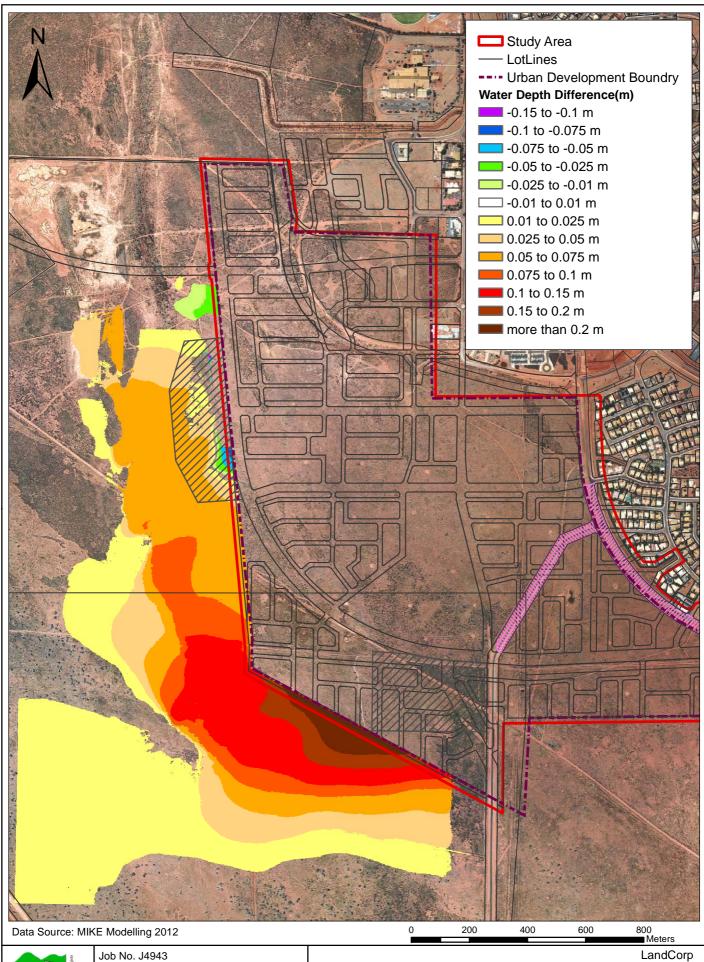


Job No. J4943

LandCorp South Hedland Western Edge : LWMS

Figure 17: Proposed Development Plan

© COPYRIGHT JIM DAVIES & ASSOCIATES PTY. LTD. 2012





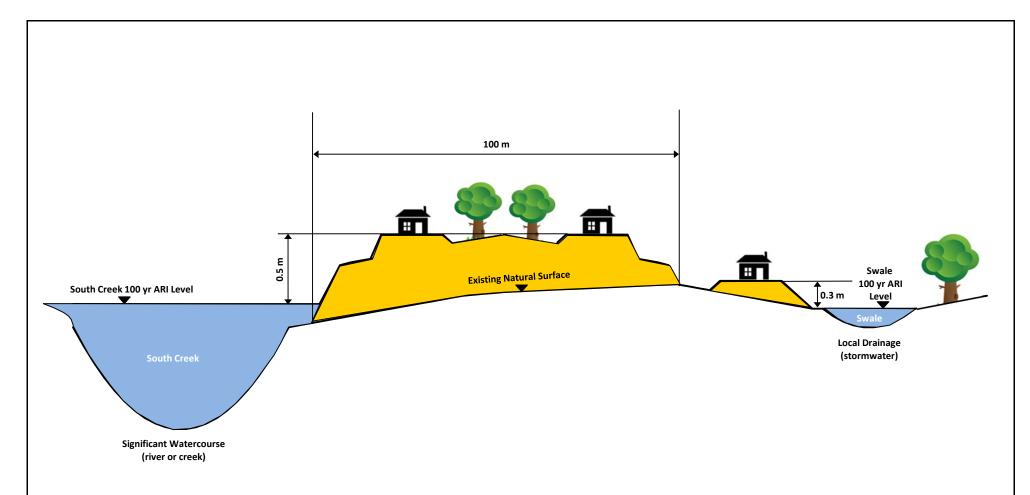
Scale 1:13,000

© COPYRIGHT JIM DAVIES & ASSOCIATES PTY. LTD. 2012

LandCorp

South Hedland Western Edge: LWMS

Figure 18: Impact of Fill on South Creek 100yr ARI



Floodplain and stormwater management provide:

- 0.5 m minimum freeboard between the 100 yr ARI flood level in South Creek and minimum buildings floor level;
- 100 m wide zone of protection for South Creek flood levels, with ground/fill level minimum of 0.5 m above the 100 yr ARI flood level at some point within the zone;
- 0.3 m minimum freeboard between the 100 yr ARI flood level in the local drainage swales and minimum building floor level;

This approach was adopted following discussions with Department of Water Floodplain Management.



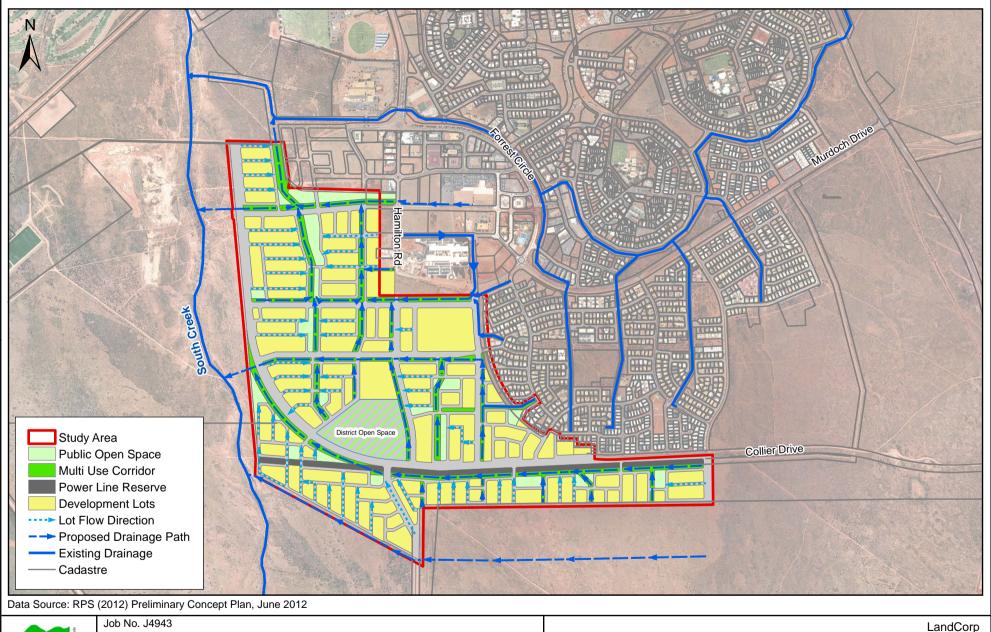
Job No. J4943

Scale: Diagrammatic

© COPYRIGHT JIM DAVIES & ASSOCIATES PTY. LTD. 2012

LandCorp South-Hedland Western Edge LWMS

Figure 19: Schematic of regional and local flood protection level



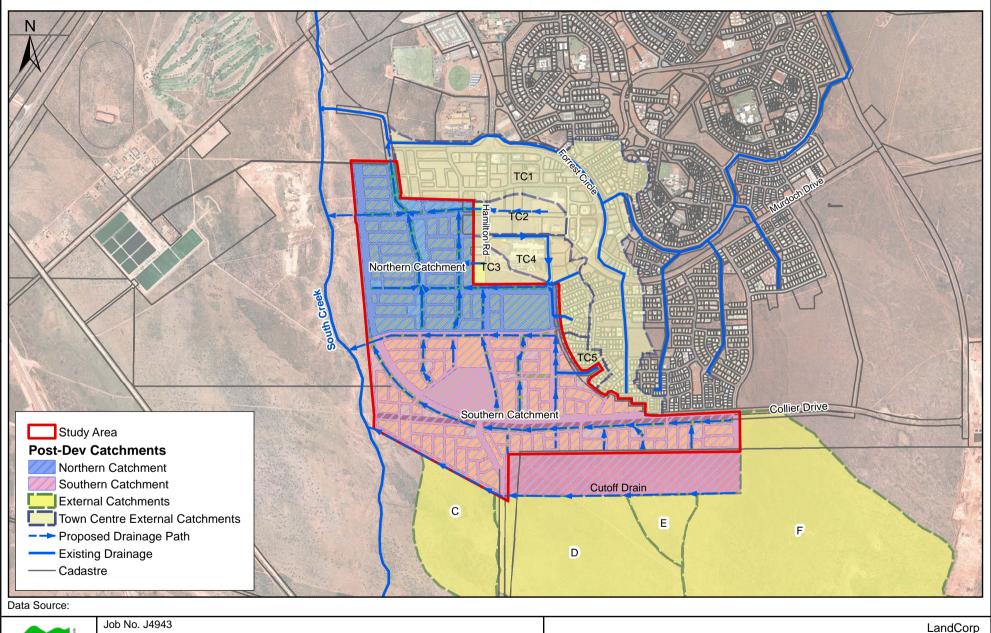
JDA Consultant Hydrologists

Scale:1:20,000

0 200 400 600 800

© COPYRIGHT JIM DAVIES & ASSOCIATES PTY. LTD. 2012

South Hedland Western Edge LWMS
Figure 20: Proposed Stormwater Managment System



JDA Crossillant Hydrologists

Scale:1:25,000

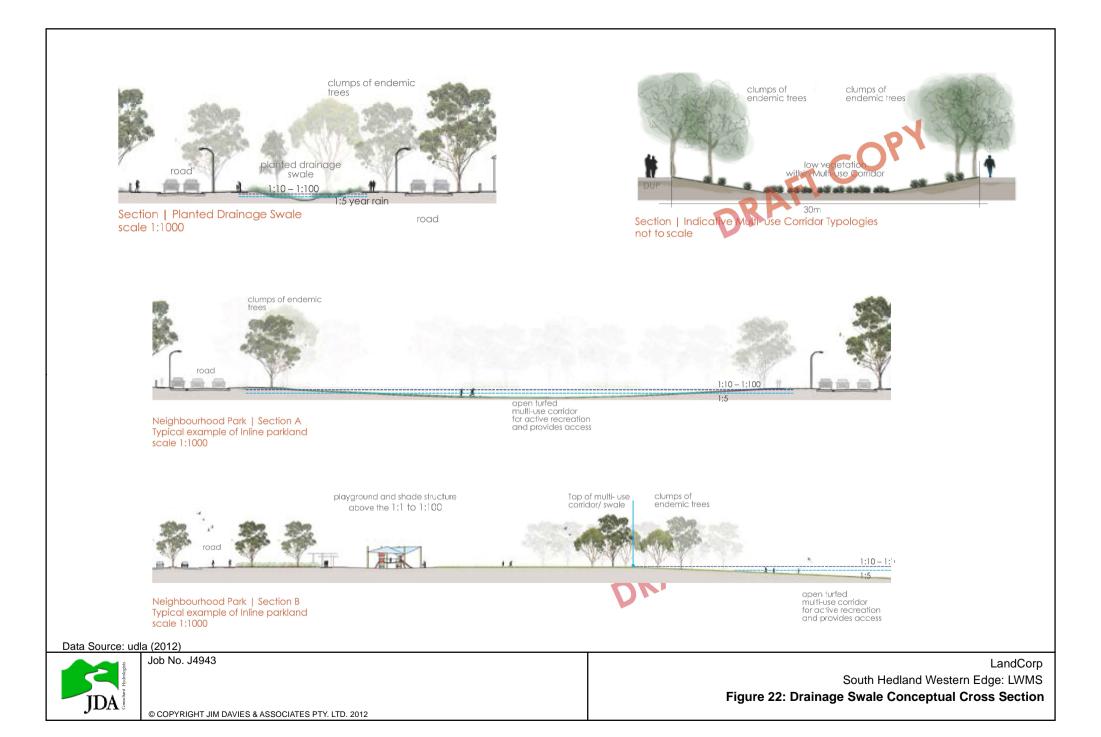
0 200 400 600 800

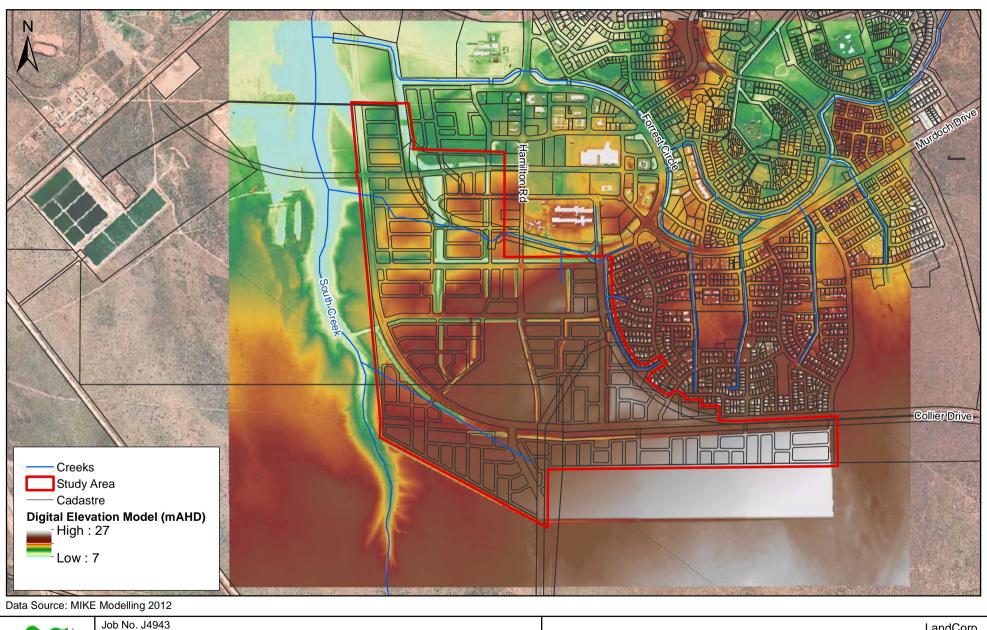
Meters

© COPYRIGHT JIM DAVIES & ASSOCIATES PTY. LTD. 2012

South Hedland Western Edge LWMS

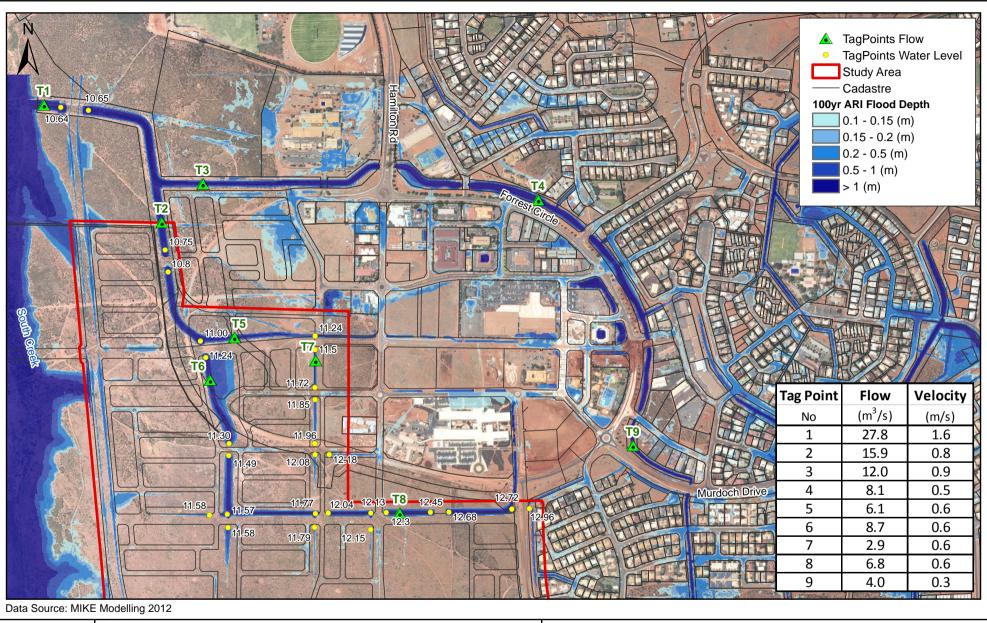
Figure 21: Post-Development Catchments





Scale:1:20,000 200 400 600 800 Meters © COPYRIGHT JIM DAVIES & ASSOCIATES PTY. LTD. 2012 LandCorp

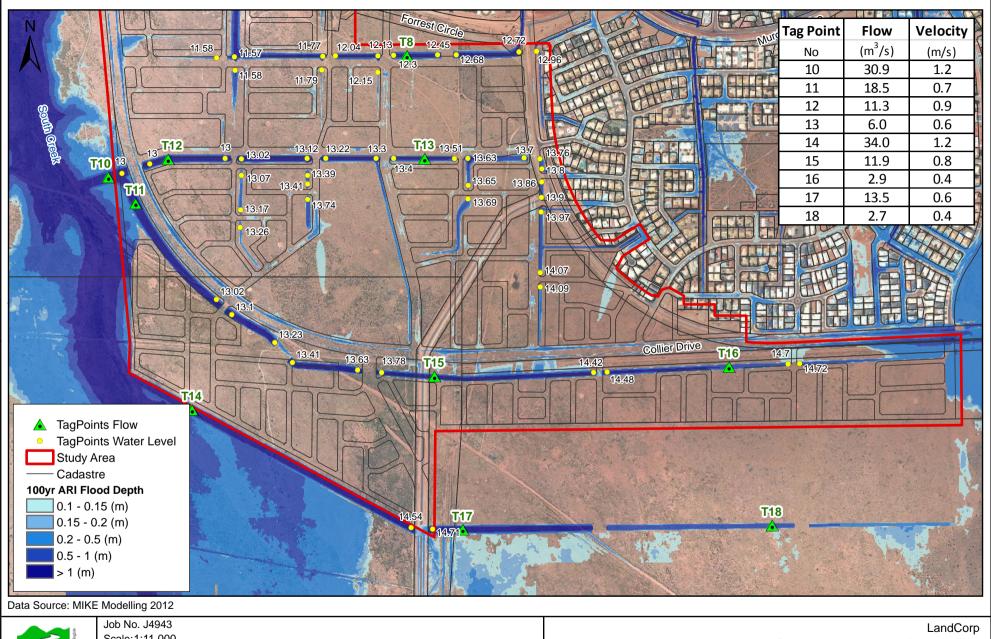
South Hedland Western Edge: LWMS Figure 23: Hydraulic Model Bathymetry (DEM)



Job No. J4943 Scale:1:11,000 800 Meters 400 600 © COPYRIGHT JIM DAVIES & ASSOCIATES PTY. LTD. 2012

LandCorp South Hedland Western Edge: LWMS

Figure 24: 100yr ARI Event Plan & Model Results - Northern Catchment



JDA
Consultant Hydrologists

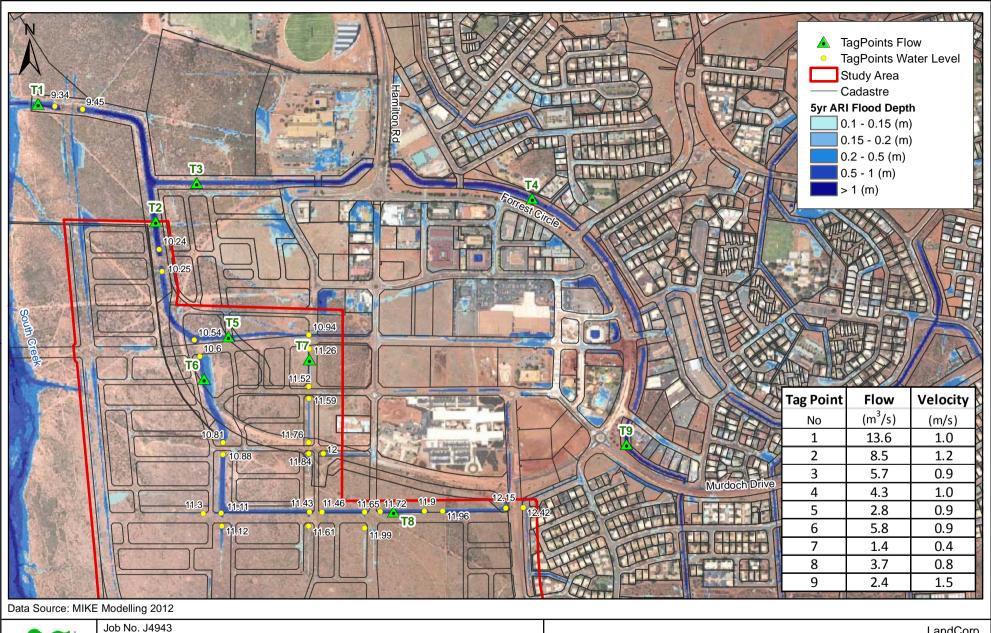
Job No. J4943

Scale:1:11,000

0 200 400 600 800

Meters
© COPYRIGHT JIM DAVIES & ASSOCIATES PTY. LTD. 2012

South Hedland Western Edge : LWMS Figure 25: 100yr ARI Event Plan & Model Results - Southern Catchment

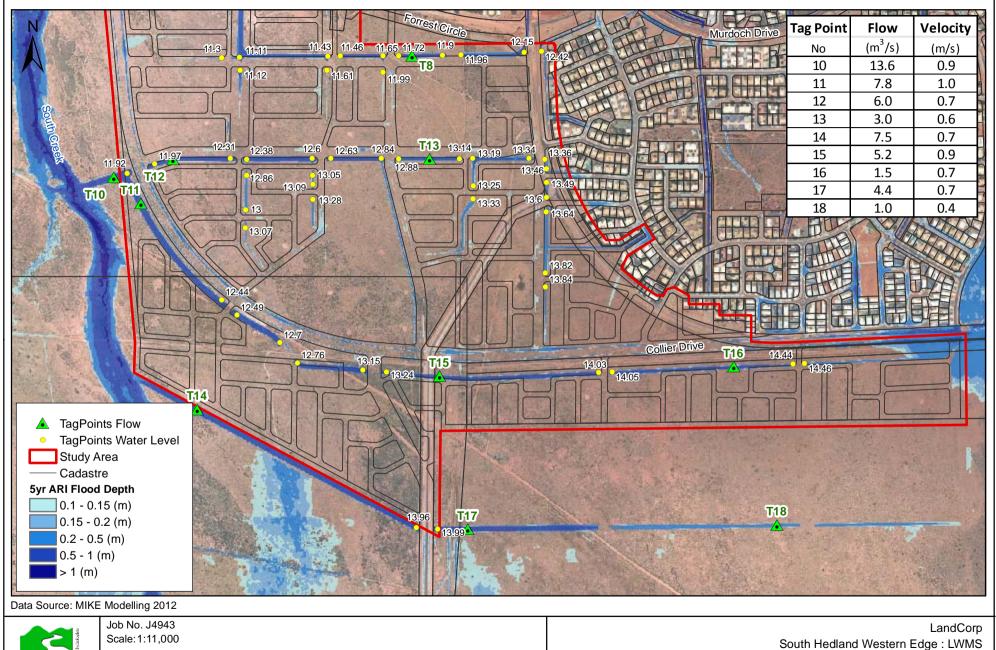


JDA

Scale: 1:11,000 800 Meters 400 600 © COPYRIGHT JIM DAVIES & ASSOCIATES PTY. LTD. 2012

LandCorp

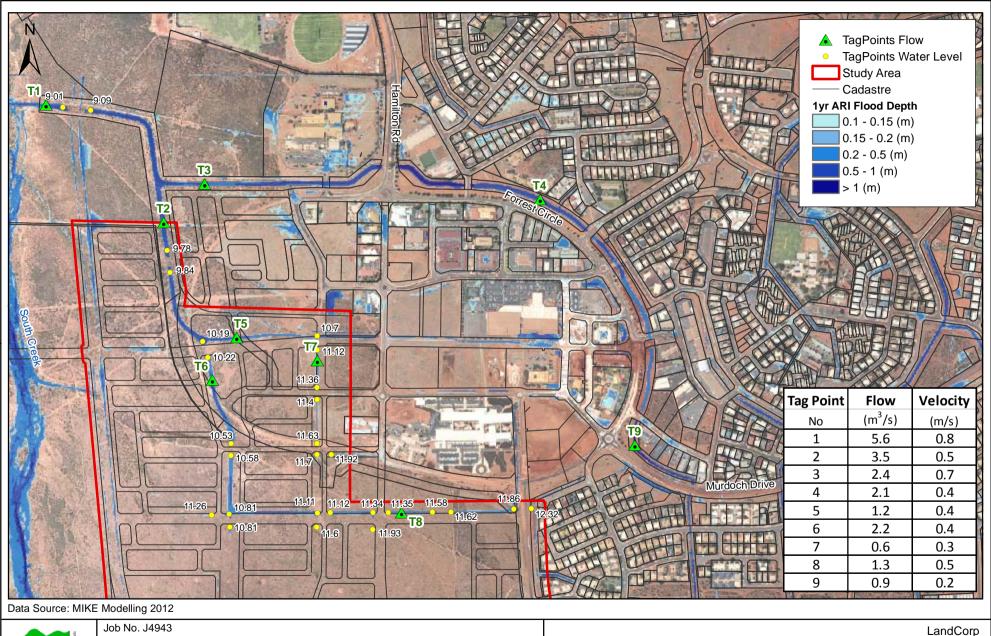
South Hedland Western Edge: LWMS Figure 26: 5yr ARI Event Plan & Model Results - Northern Catchment





Job No. J4943
Scale: 1:11,000
0 200 400 600 800
Meters
© COPYRIGHT JIM DAVIES & ASSOCIATES PTY. LTD. 2012

Figure 27: 5yr ARI Event Plan & Model Results - Southern Catchment



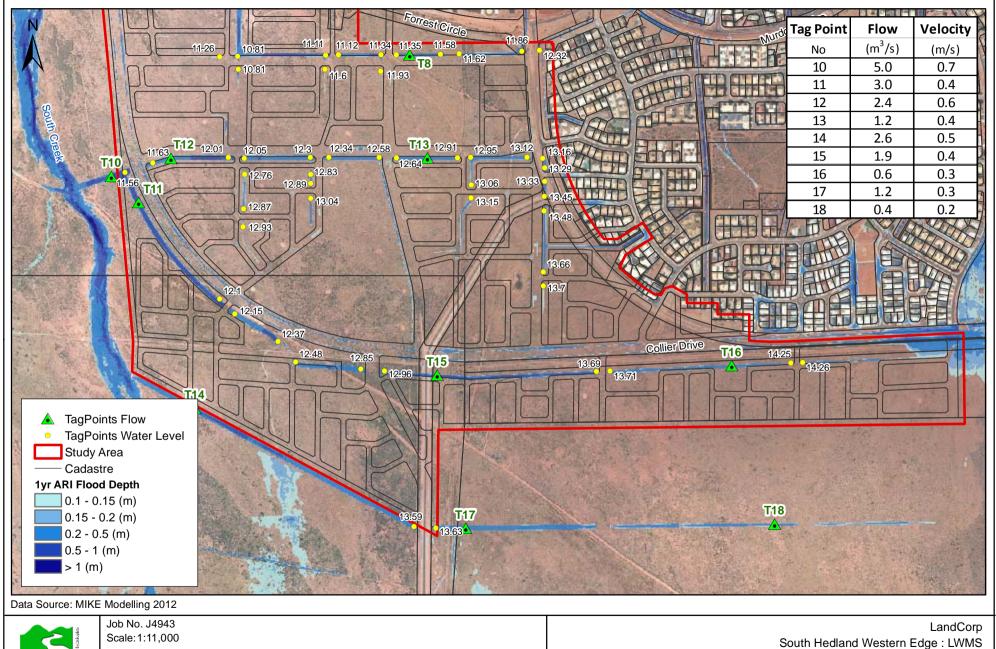
JDA COSMIRES Hydrocypies

O 200 400 600 800

© COPYRIGHT JIM DAVIES & ASSOCIATES PTY. LTD. 2012

South Hedland Western Edge : LWMS

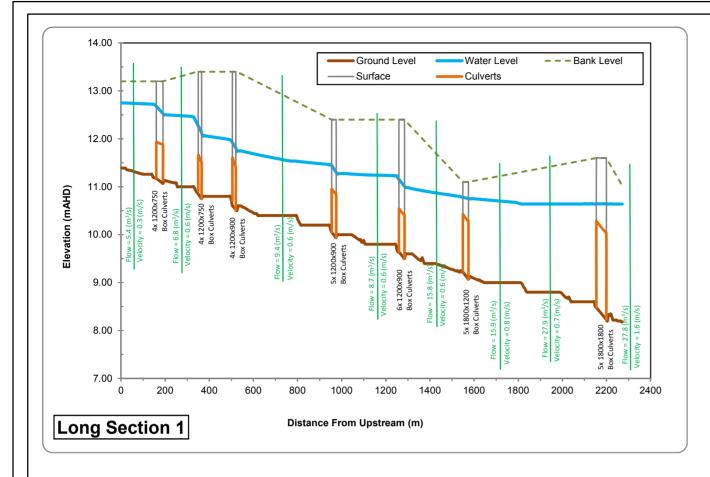
Figure 28: 1yr ARI Event Plan & Model Results - Northern Catchment

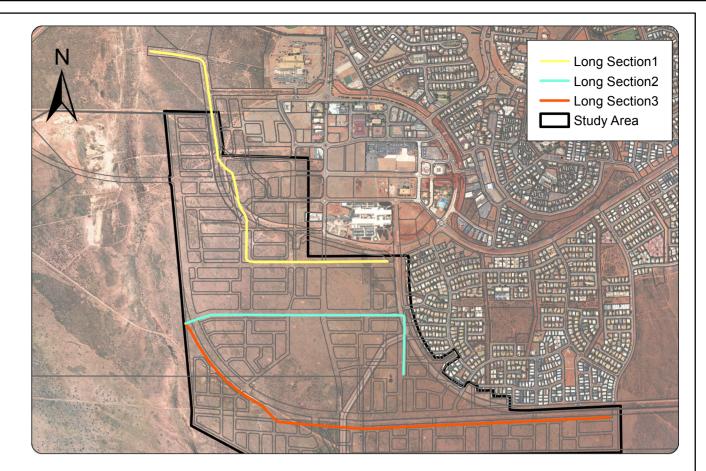


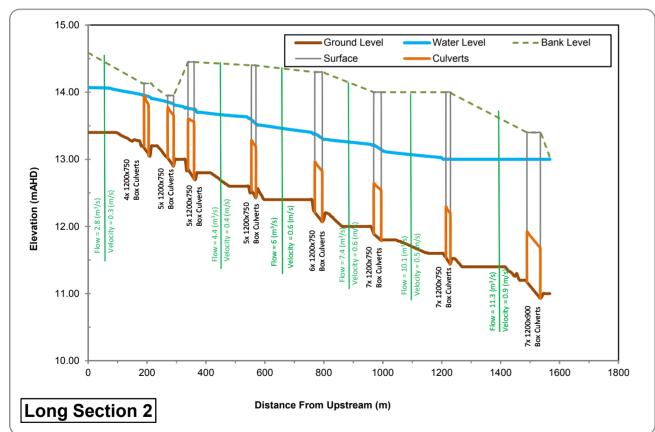
JDA Consulters Hydrokopies

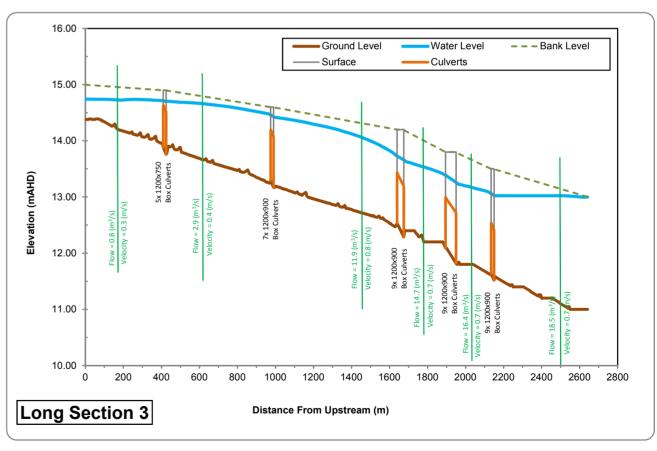
Job No. J4943
Scale: 1:11,000
0 200 400 600 800
Meters
© COPYRIGHT JIM DAVIES & ASSOCIATES PTY. LTD. 2012

Figure 29: 1yr ARI Event Plan & Model Results - Southern Catchment







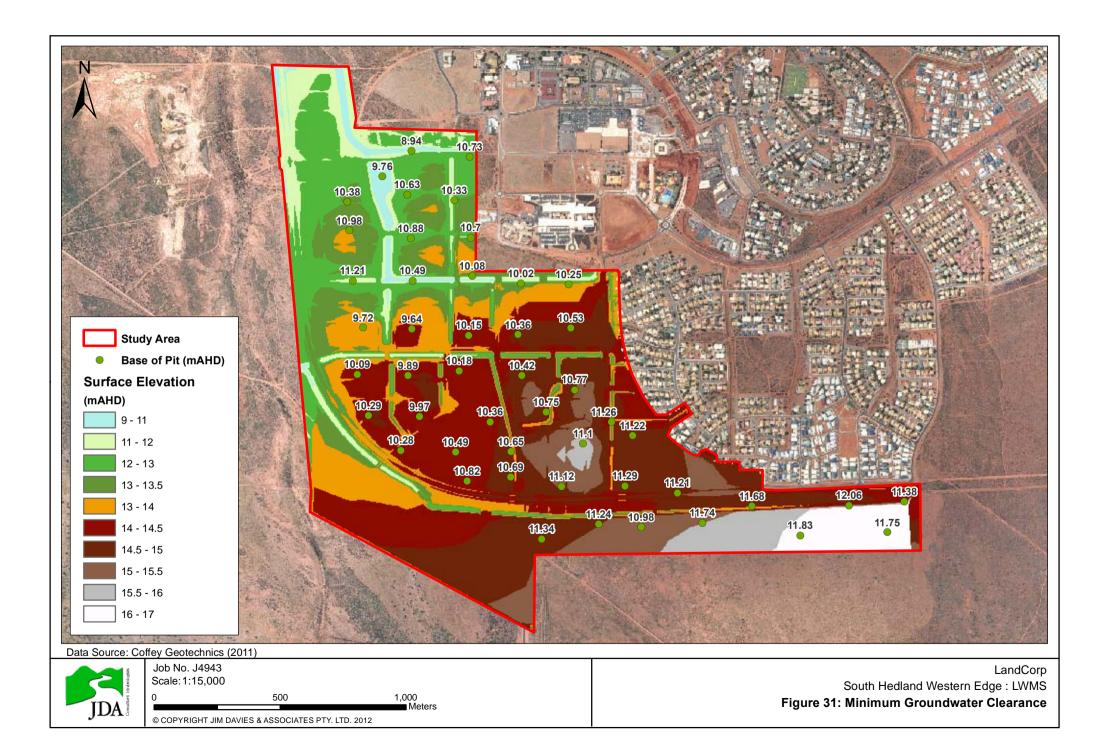


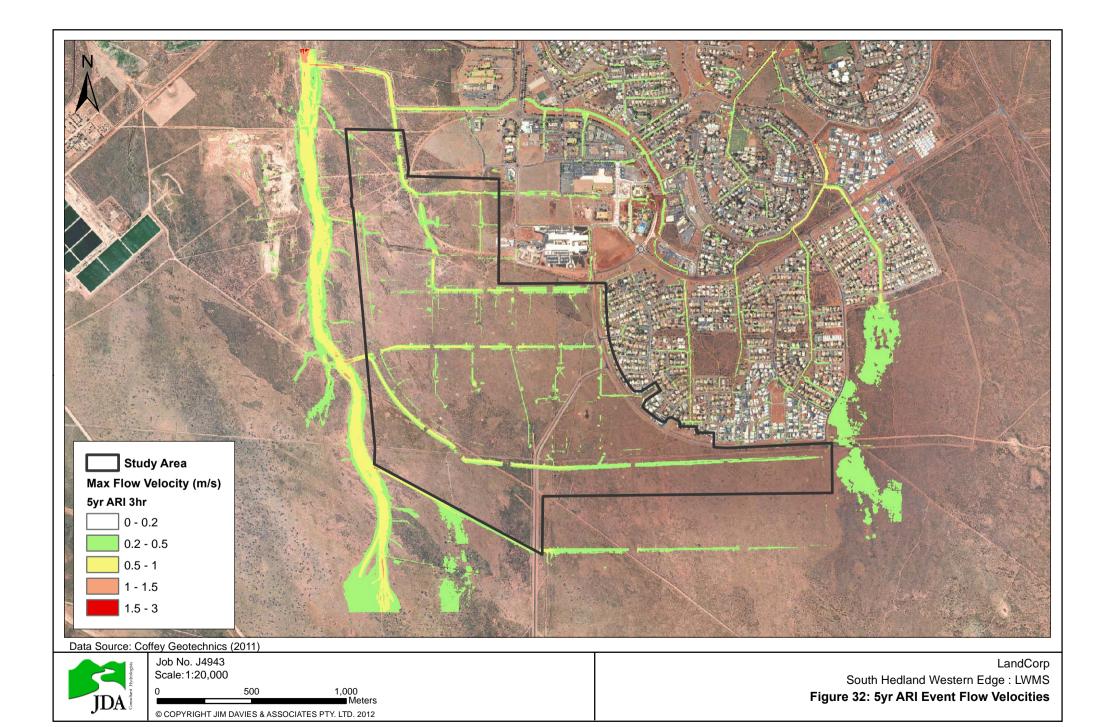
Data Source: MIKE Modelling 2012

Job No. J4943



LandCorp South Hedland Western Edge : LWMS Figure 30: 100 Year ARI Longsections





APPENDIX A

Local Water Management Strategy Checklist for Developers

LOCAL WATER MANAGEMENT STRATEGY: CHECKLIST (WAPC, 2008)

The following checklist provides a guide to items which should be addressed by developers in the preparation of Local Water Management Strategies for assessment by the local authority when an application for a structure plan is lodged.

- 1. Tick the status column for items for which information is provided
- 2. Enter N/A in the status column if the item is not appropriate and enter the reason in the comments column
- 3. Provide brief comments on any relevant issues

4. Provide brief descriptions of any proposed best management practices, e.g. multi-use corridors, community based-social marketing, water re-use proposals

Applicant: Landcorp Date: July 2012

Name of Structure Plan: South Hedland Western Edge

Contact: Alex Rogers, JDA Consultant Hydrologists
Address: Suite 1, 27 York St Subiaco WA 6008

Telephone: 9388 2436 Email: alex@jdahydro.com.au

Local Water Management Strategy Item	Required Deliverable	LWMS Reference	Deliverable Comment		Comment			
Executive Summary								
Summary of the development design strategy, outlining how the design objectives are proposed to be met	Table 1: Design elements and requirements for BMPs and critical control points	Section 4.8 Table 7						
Introduction								
Total water cycle management – principles & objectives Planning background Previous studies		Section 1.3 Section 1.1 Section 1.2						
Proposed Development								
Structure plan, zoning and land use. Key landscape features Previous land use	Site context plan Structure plan	Section 3, Figure 16 Section 3, Figure 16 Section 2.1						
Landscape - proposed POS areas, POS credits, water source, bore(s), lake details (if applicable), irrigation areas	Landscape Plan	Section 3, Section 4.1 Figures 14, 16, 17						

Local Water Management Strategy Item	Required Deliverable	LWMS Reference	Deliverable Comment		Comment		
Design Criteria							
Agreed design objectives and source of objective		Sections 1.2, 1.3					
Pre-development Environment							
Existing information and more detailed assessments (monitoring). How do the site characteristics affect the design?		Section 2					
Site Conditions - existing topography / contours, aerial photo underlay, major physical features	Site Condition Plan	Section 2.2, Figures 2, 6, 7					
Geotechnical - topography, soils including acid sulfate soils and infiltration capacity, test pit locations	Geotechnical Plan	Sections 2.5, 2.9, Figures 10, 15					
Environmental - areas of significant flora and fauna, wetlands and buffers, waterways and buffers, contaminated sites	Environmental Plan plus supporting datasets where appropriate	Section 2.8					
Surface Water – topography, 100 year floodways and flood fringe areas, water quality of flows entering and leaving (if applicable)	Surface Water Plan	Section 2.6, Figures 12, 13					
Groundwater – topography, pre development groundwater levels and water quality, test bore locations	Groundwater Plan plus details of groundwater monitoring and testing	Section 2.7, Figure 14					
Water Use Sustainability Initiatives							
Water efficiency measures – private and public open spaces including method of enforcement		Section 4.1					
Water supply (fit-for-purpose strategy), agreed actions and implementation. If non-potable supply, support with water balance		Section 4.1					
Wastewater management		Section 4.1					
Stormwater Management Strategy							
Flood protection - peak flow rates, volumes and top water levels at control points,100 year flow paths and 100 year detentions storage areas	100yr event Plan Long section of critical points	Section 4.2, Figures 18, 20, 21, 24, 25, 30 Appendix B					
Manage serviceability - storage and retention required for the critical 5 year ARI storm events Minor roads should be passable in the 5 year ARI event	5yr event Plan	Section 4.2, Figures 20, 26, 27, 32					

Local Water Management Strategy Item	Required Deliverable	LWWC D. f	Deliverable		Comment		
Stormwater Management Strategy (cont) Comment Comme							
Protect ecology – detention areas for the 1 yr 1 hr ARI event, areas for water quality treatment and types of (including indicative locations for) agreed structural and non-structural best management practices and treatment trains. Protection of waterways, wetlands (and their buffers), remnant vegetation and ecological linkages	1yr event plan Typical cross sections	Section 4.2, Figures 20, 22, 28, 29					
Groundwater Management Strategy							
Post development groundwater levels, fill requirements (including existing and likely final surface levels), outlet controls, and subsoils areas/exclusion zones	Groundwater/subsoil Plan	Section 4.3					
Actions to address acid sulfate soils or contamination		Section 4.7.2					
The Next Stage - Subdivision and Urban Water Management Plans							
Content and coverage of future urban water management plans to be completed at subdivision. Include areas where further investigations are required prior to detailed design.		Section 5.2					
Monitoring							
Recommended future monitoring plan including timing, frequency, locations and parameters, together with arrangements for ongoing actions		Section 5.4					
Implementation							
Developer commitments		Section 5.1					
Roles, responsibilities, funding for implementation		Section 5.1			_		
Review		Section 5.1					

Western Australian Planning Commission (2008), Better Urban Water Management, Perth, WA

APPENDIX B

JDA (2012) South Hedland Western Edge Flood Modelling

APPENDIX B

JDA (2012) South Hedland Western Edge Flood Modelling

Alex Rogers

From: Alex Rogers

Sent: Monday, 7 May 2012 1:50 PM

To: RODGERS Simon (Simon.RODGERS@water.wa.gov.au)

Cc: Stuart (Stuart@wallisproperty.com.au); 'Roland Staniforth'; Stuart Devenish

(Stuart.Devenish@rpsgroup.com.au)

Subject: South Hedland Western Edge Flood Modelling

Attachments: Figure 1 100yr Flood Depth-Scenario 1.pdf; Figure 2 100yr Water Level-

Scenario1.pdf; Figure3 Scenario1 Flood Rise Compared to Pre Development.pdf;

Figure4 100yr Flood Depth-Scenario2.pdf; Figure5 100yr Water Level-

Scenario2.pdf; Figure6 Scenario2 Flood Rise Compared to Pre Development.pdf;

GrowthPlan_DraftC.pdf; 2957_19-2-001a.pdf

Categories: Note

Hi Simon,

Following our meeting on Tuesday 1 May 2012, please find below a summary of the flooding modelling performed for South Hedland Western Edge, the estimated impact of filling the development area, and context of these results to the Port Hedland Growth Plan.

Model Description

A Mike21 2D hydraulic model was set up to model flow in South Creek and the adjacent floodplain region.

The 100 year ARI flow was used as input to the model at the upstream boundary – this was based on the results of the Cardno Port Hedland Coastal Vulnerability Study. The 100 year ARI flood level in South Creek adjacent to the TAFE was used as the downstream boundary condition. Results of the Cardno flood modelling were supplied by Department of Water in GIS format and flow and level hydrographs were supplied by Cardno in Excel format.

There is a secondary flow channel to the east of South Creek as it discharges through the Study Area. The Cardno modelling indicates that flow in this channel peaks at approximately 60 m³/s for the 100 year ARI. In South Creek adjacent to the Study Area, 100 year ARI peak flow is approximately 250 m³/s. These flows (as hydrographs) have been applied at the southern boundary.

A Mannings roughness of 0.05 has been used across the model area.

The model was run to simulate the existing pre development condition.

Two post development scenarios were considered:

- A draft Structure Plan has been developed for the Study Area for the area south of the Town Centre
 and west (and partly south) of Collier Drive (see attached). This sees the southern section of Collier
 Drive extended westward and then bending north to form a bypass road for the Town Centre. The
 first scenario assumes the Structure Plan area is filled above the 100 year ARI flood level (excluding
 the potential District Open Space locations).
- The draft Structure Plan does not fully use the Urban Development Zone. The second scenario assumes the full Urban Development Zone is filled above the 100 year ARI flood level.

Model Results

The attached model results for the two post development scenarios show the flood depth (Figures 1, 4), flood level (Figure 2, 5), and change in flood levels compared to the pre development scenario (Figures 3, 6).

It can be seen from Figures 3 and 6 that the greatest increase in flood levels occurs where the secondary flow channel intersects the proposed fill. In this location there is a peak rise of 240mm (Scenario 1) and 320mm (Scenario 2). Flood rise above 150mm to an area 150m south and 400m east-west for Scenario 1 and 200m south and 600m east-west for Scenario 2. Beyond these areas, impact of filling reduces to almost negligible 400-500m south of the fill. Impact on levels in South Creek is generally less than 75mm adjacent to the Study Area.

Context to Port Hedland Growth Plan

Attached is the Port Hedland Growth Plan (Draft C). It should be noted that this document has not be finalised and has not been formally adopted by the Town of Port Hedland at this stage. It can be seen that the Study Area has been allowed for in this Plan, although it shows a previous Structure Plan (see "Original Project Boundary" on the draft Structure Plan). South of this and west of Yarrie Rd, the area (including South Creek) is shown as "Natural Landscape/Conservation". Therefore the area impacted by fill is not planned for future development and so although a small area has a flood rise of greater than 150mm, this will not impact on other users or future development (which will occur east of Yarrie Rd).

We would therefore propose development according to Scenario 2, with full development to the Urban Development Zone Boundary and would seek Department of Water endorsement of this approach.

Your earliest response would be appreciated – in our meeting you mentioned a possible turnaround of within a week?

Regards,

Alex Rogers | Senior Engineering Hydrologist

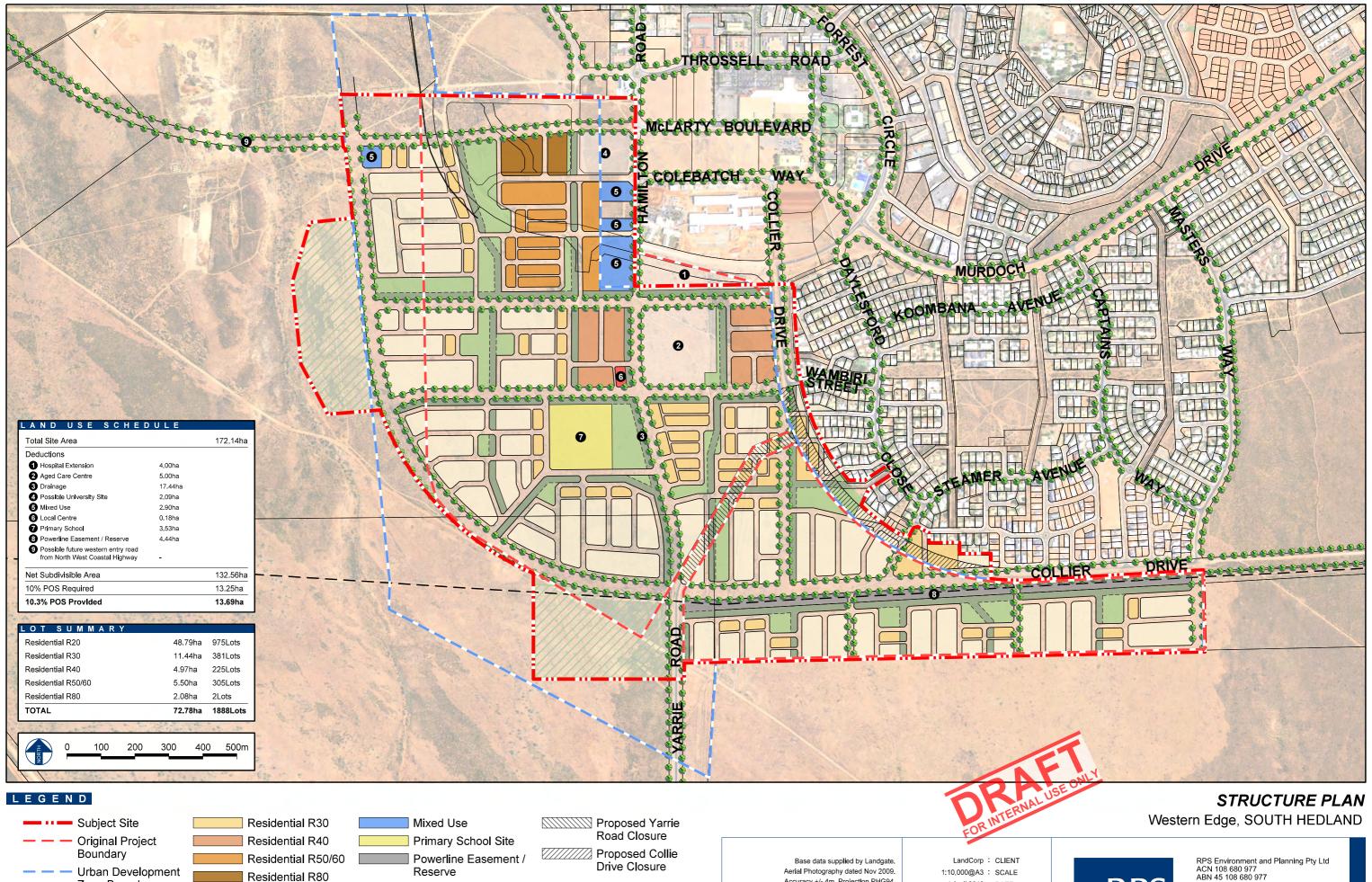


JDA CONSULTANT HYDROLOGISTS
Suite 1/27 York St, Subiaco WA 6008 | PO Box 117, Subiaco WA 6904 |
Reception: (08) 9388 2436 | Fax: (08) 9381 9279 | www.jdahydro.com.au

The company is not liable for any views/opinions contained in this message unless expressly identified as views/opinions held by the company. Any personal views/opinions expressed by the writer are those of the individual sender and may not necessarily represent views/opinions of the company. This email message and any attachments are confidential. If you are not the intended recipient, any use, interference with, disclosure, distributing or copying of this material is expressly prohibited. The recipient must check this email and any attachments for viruses. No liability is accepted for any loss or damage caused by viruses transmitted by this email. This email and any attachments may also be subject to copyright. No part of them may be reproduced, adapted or transmitted without the written permission of the copyright owner. If you have received this email in error, please immediately advise the sender by return email and delete the email and attachments from your system.



Please consider the environment before printing this e-mail



Boundary Residential R50/60 Urban Development Residential R80 Zone Boundary Public Open Space Existing 66kva Drainage Powerline Local Centre Residential R20

Powerline Easement / Reserve Alternative Locations for District Open Space (10ha)

(Subject to Further Review)

Drive Closure

Base data supplied by Landgate Aerial Photography dated Nov 2009. Accuracy +/- 4m. Projection PHG94.

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. 1:10,000@A3 : SCALE 4 April 2012 : DATE

> 2957_19-2-001a.dgn : PLAN No a: REVISION

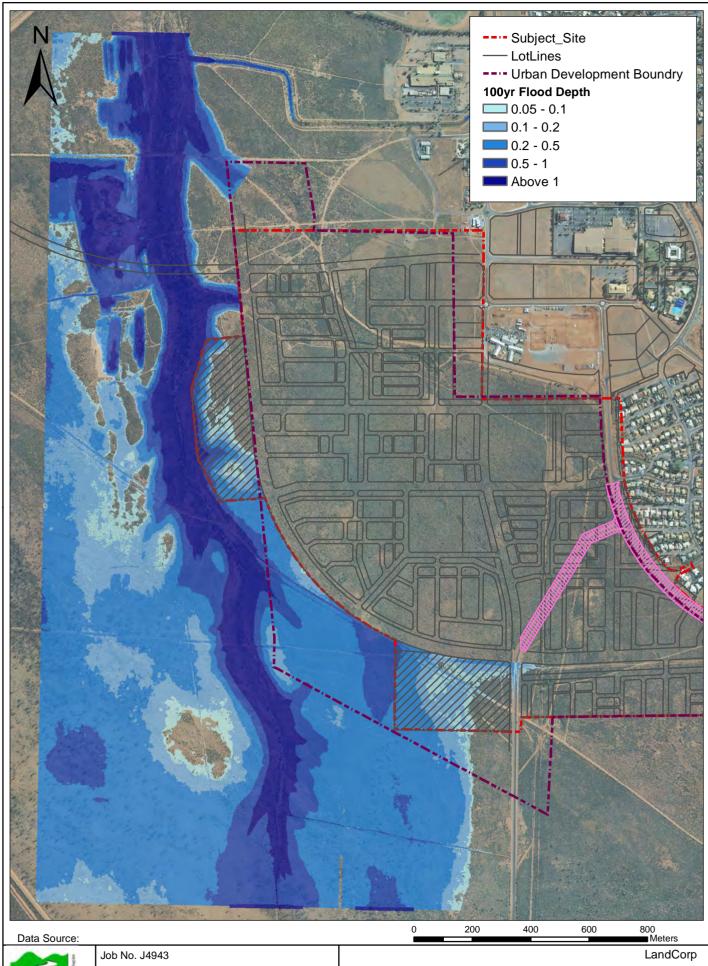
S.D.: PLANNER L.W/R.F.: DRAWN

- : CHECKED

PO Box 465 Subiaco WA 6904 38 Station Street Subiaco WA 6008

T+61 8 9211 1111

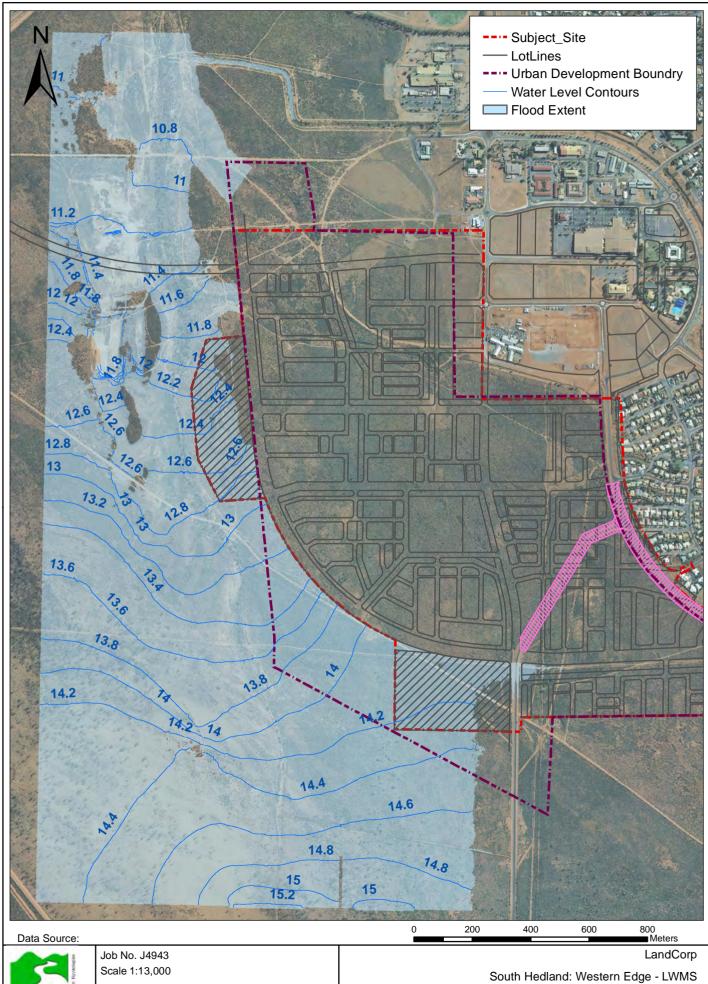
W rpsgroup.com.au



Scale 1:13,000

© COPYRIGHT JIM DAVIES & ASSOCIATES PTY. LTD. 2012

South Hedland: Western Edge - LWMS Figure 1:100yr Flood Depth - Scenario1

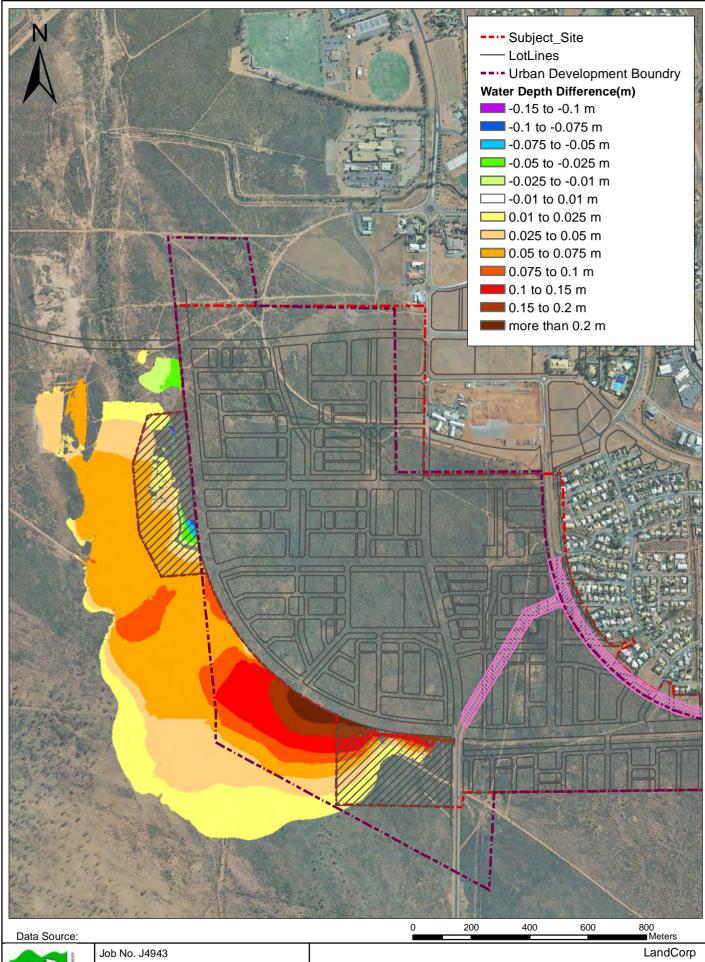


JDA

Scale 1:13,000

© COPYRIGHT JIM DAVIES & ASSOCIATES PTY. LTD. 2012

Figure 2:100yr Water Level - Scenario1

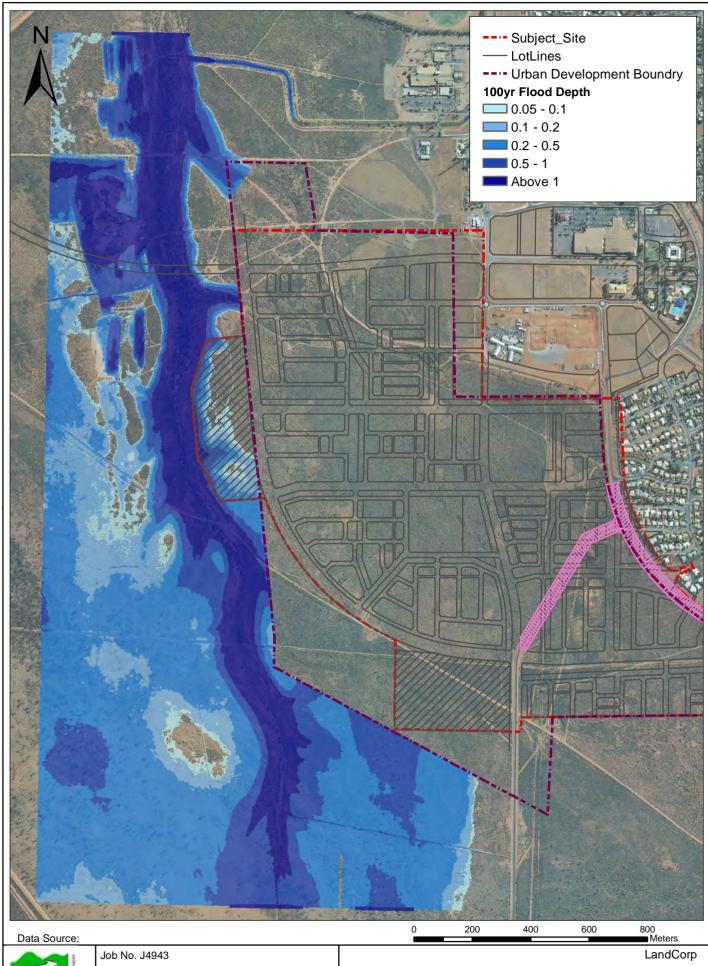




Scale 1:13,000

© COPYRIGHT JIM DAVIES & ASSOCIATES PTY. LTD. 2012

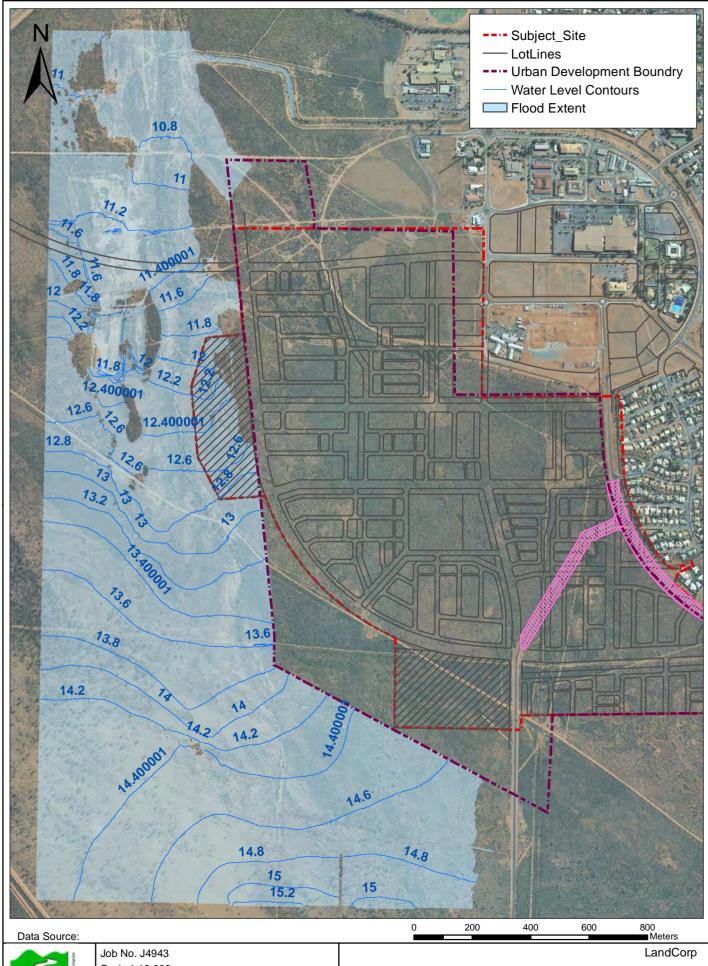
South Hedland: Western Edge - LWMS



Scale 1:13,000

© COPYRIGHT JIM DAVIES & ASSOCIATES PTY. LTD. 2012

South Hedland: Western Edge - LWMS Figure 4:100yr Flood Depth - Scenario2



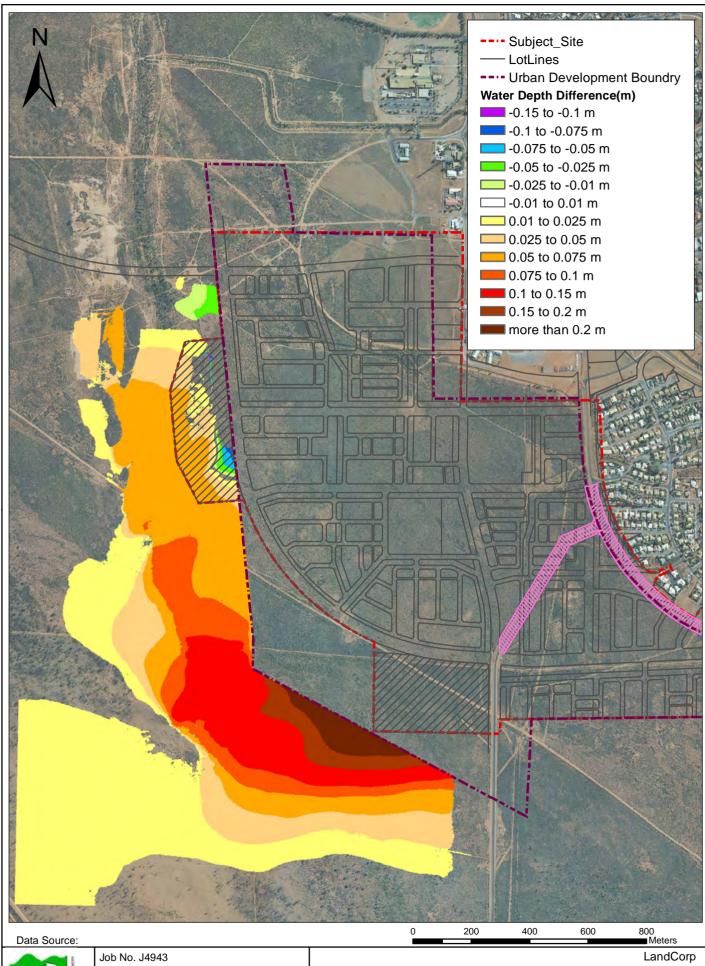
JDA

Scale 1:13,000

© COPYRIGHT JIM DAVIES & ASSOCIATES PTY. LTD. 2012

South Hedland: Western Edge - LWMS

Figure 5:100yr Water Level - Scenario2



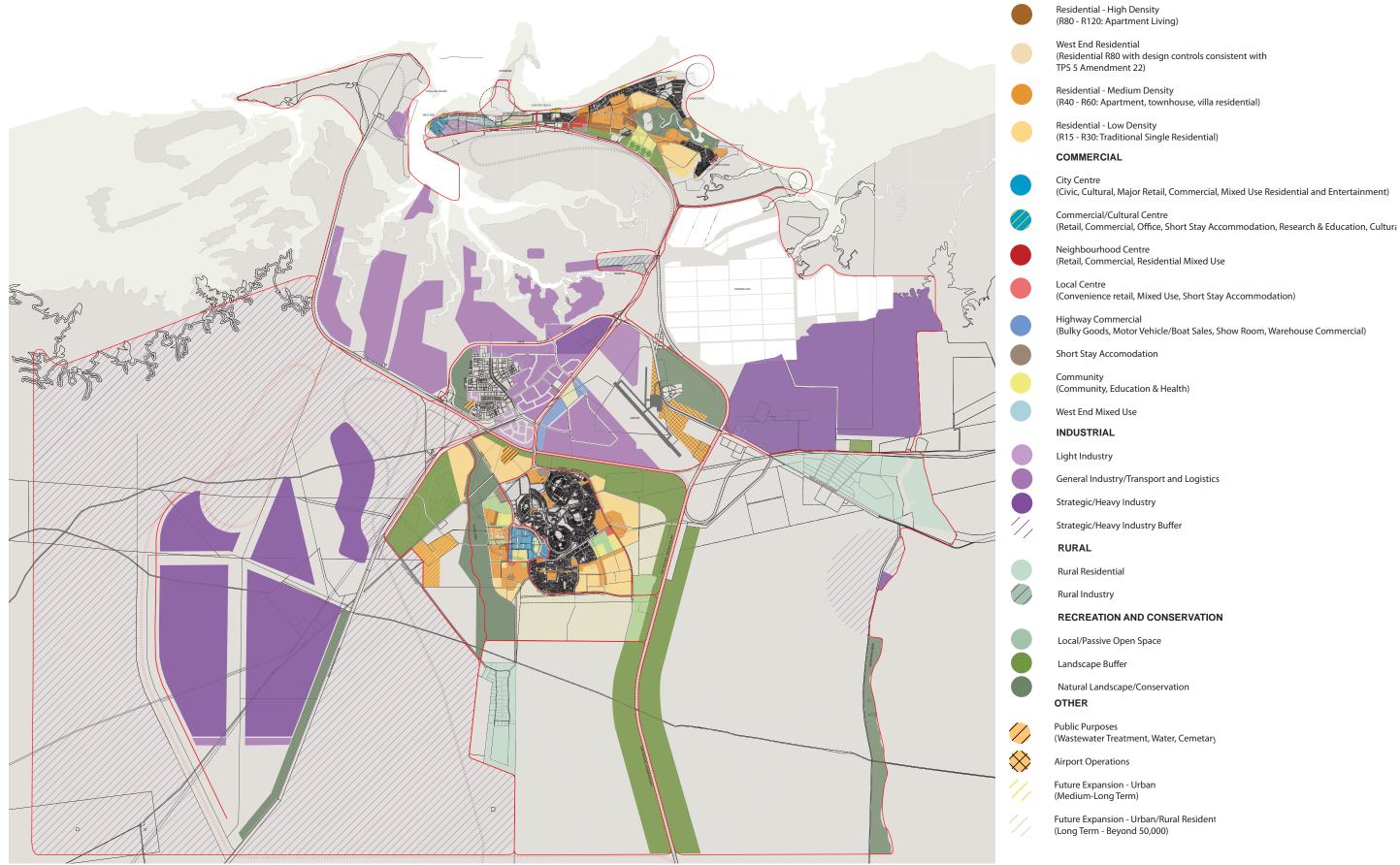


Job No. J4943 Scale 1:13,000

© COPYRIGHT JIM DAVIES & ASSOCIATES PTY. LTD. 2012

South Hedland: Western Edge - LWMS

CITY GROWTH STRATEGY



RESIDENTIAL

Figure 5.11: Growth Plan

APPENDIX C

Department of Water Floodplain Management Section Advice

APPENDIX C

Department of Water Floodplain Management Section Advice

Alex Rogers

From: RODGERS Simon <Simon.RODGERS@water.wa.gov.au>

Sent: Tuesday, 15 May 2012 4:48 PM

To: Alex Rogers

Cc: Stuart Devenish (Stuart.Devenish@rpsgroup.com.au); Stuart

(Stuart@wallisproperty.com.au); 'Roland Staniforth';

Gretel.Purser@rpsgroup.com.au; 'anthony.sheehan@epa.wa.gov.au';

'stephen.pavey@epa.wa.gov.au'

Subject: RE: South Hedland Western Edge Flood Modelling

Hi Alex

The Department of Water, in carrying out its role in floodplain management, provides advice and recommends guidelines for development on floodplains with the object of minimising flood risk and damage. Our Department uses the following guiding principles to ensure proposed development in floodprone areas is acceptable with regard to major flooding:

- Proposed development has adequate flood protection from a 100 year ARI flood.
- Proposed development does not detrimentally impact on the existing flooding regime of the general
 area.

Based on your hydraulic modeling results, the following comments are provided:

- The 2 development scenarios modelled (ie, scenario 1 and Scenario 2) are not considered to detrimentally impact on the existing flooding regime of South Creek.
- Your mapping and the growth plan indicates a proposed access route to Great Northern Highway crosses South Creek near the upstream boundary of your study area. If this access road is not expected to progress further than this conceptual planning stage then the current hydraulic modelling is adequate. However, if this access road is likely to be further investigated with a view to construct then the possible combined effect of this crossing and your development scenarios needs to be considered against our above guiding principles. This would require additional hydraulic modelling to be undertaken that includes the proposed crossing.
- Minimum habitable floor levels of 0.5 metre above the appropriate 100 year ARI flood level are recommended to ensure adequate flood protection

Please note that a failure to properly adhere to these recommendations will result in a greater exposure to risks of flood damage. It should be noted that this advice is related to major flooding only and other planning issues, such as drainage, environmental and ecological considerations, may also need to be addressed.

Regards

Simon Rodgers

Supervising Engineer, Floodplain Management Department of Water

168 St Georges Terrace, Perth | PO Box K822, WA 6842 Ph: 08 6364 6923 | Email: simon.rodgers@water.wa.gov.au

From: Alex Rogers [mailto:Alex@jdahydro.com.au]

Sent: Monday, 7 May 2012 1:50 PM

To: RODGERS Simon

Cc: Stuart (Stuart@wallisproperty.com.au); 'Roland Staniforth'; Stuart Devenish

(Stuart.Devenish@rpsgroup.com.au)

Subject: South Hedland Western Edge Flood Modelling

Hi Simon,

Following our meeting on Tuesday 1 May 2012, please find below a summary of the flooding modelling performed for South Hedland Western Edge, the estimated impact of filling the development area, and context of these results to the Port Hedland Growth Plan.

Model Description

A Mike21 2D hydraulic model was set up to model flow in South Creek and the adjacent floodplain region.

The 100 year ARI flow was used as input to the model at the upstream boundary – this was based on the results of the Cardno Port Hedland Coastal Vulnerability Study. The 100 year ARI flood level in South Creek adjacent to the TAFE was used as the downstream boundary condition. Results of the Cardno flood modelling were supplied by Department of Water in GIS format and flow and level hydrographs were supplied by Cardno in Excel format.

There is a secondary flow channel to the east of South Creek as it discharges through the Study Area. The Cardno modelling indicates that flow in this channel peaks at approximately 60 m³/s for the 100 year ARI. In South Creek adjacent to the Study Area, 100 year ARI peak flow is approximately 250 m³/s. These flows (as hydrographs) have been applied at the southern boundary.

A Mannings roughness of 0.05 has been used across the model area.

The model was run to simulate the existing pre development condition.

Two post development scenarios were considered:

- A draft Structure Plan has been developed for the Study Area for the area south of the Town Centre
 and west (and partly south) of Collier Drive (see attached). This sees the southern section of Collier
 Drive extended westward and then bending north to form a bypass road for the Town Centre. The
 first scenario assumes the Structure Plan area is filled above the 100 year ARI flood level (excluding
 the potential District Open Space locations).
- The draft Structure Plan does not fully use the Urban Development Zone. The second scenario assumes the full Urban Development Zone is filled above the 100 year ARI flood level.

Model Results

The attached model results for the two post development scenarios show the flood depth (Figures 1, 4), flood level (Figure 2, 5), and change in flood levels compared to the pre development scenario (Figures 3, 6).

It can be seen from Figures 3 and 6 that the greatest increase in flood levels occurs where the secondary flow channel intersects the proposed fill. In this location there is a peak rise of 240mm (Scenario 1) and 320mm (Scenario 2). Flood rise above 150mm to an area 150m south and 400m east-west for Scenario 1 and 200m south and 600m east-west for Scenario 2. Beyond these areas, impact of filling reduces to almost negligible 400-500m south of the fill. Impact on levels in South Creek is generally less than 75mm adjacent to the Study Area.

Context to Port Hedland Growth Plan

Attached is the Port Hedland Growth Plan (Draft C). It should be noted that this document has not be finalised and has not been formally adopted by the Town of Port Hedland at this stage. It can be seen that the Study Area has been allowed for in this Plan, although it shows a previous Structure Plan (see "Original Project Boundary" on the draft Structure Plan). South of this and west of Yarrie Rd, the area (including South Creek) is shown as "Natural Landscape/Conservation". Therefore the area impacted by fill is not planned for future

development and so although a small area has a flood rise of greater than 150mm, this will not impact on other users or future development (which will occur east of Yarrie Rd).

We would therefore propose development according to Scenario 2, with full development to the Urban Development Zone Boundary and would seek Department of Water endorsement of this approach.

Your earliest response would be appreciated – in our meeting you mentioned a possible turnaround of within a week?

Regards,

Alex Rogers | Senior Engineering Hydrologist



JDA CONSULTANT HYDROLOGISTS
Suite 1/27 York St, Subiaco WA 6008 | PO Box 117, Subiaco WA 6904 |
Reception: (08) 9388 2436 | Fax: (08) 9381 9279 | www.jdahydro.com.au

The company is not liable for any views/opinions contained in this message unless expressly identified as views/opinions held by the company. Any personal views/opinions expressed by the writer are those of the individual sender and may not necessarily represent views/opinions of the company. This email message and any attachments are confidential. If you are not the intended recipient, any use, interference with, disclosure, distributing or copying of this material is expressly prohibited. The recipient must check this email and any attachments for viruses. No liability is accepted for any loss or damage caused by viruses transmitted by this email. This email and any attachments may also be subject to copyright. No part of them may be reproduced, adapted or transmitted without the written permission of the copyright owner. If you have received this email in error, please immediately advise the sender by return email and delete the email and attachments from your system.



Please consider the environment before printing this e-mail

Disclaimer:

This e-mail is confidential to the addressee and is the view of the writer, not necessarily that of the Department of Water, which accepts no responsibility for the contents. If you are not the addressee, please notify the Department by return e-mail and delete the message from your system; you must not disclose or use the information contained in this email in any way. No warranty is made that this material is free from computer viruses.

Disclaimer:

This e-mail is confidential to the addressee and is the view of the writer, not necessarily that of the Department of Water, which accepts no responsibility for the contents. If you are not the addressee, please notify the Department by return e-mail and delete the message from your system; you must not disclose or use the information contained in this email in any way. No warranty is made that this material is free from computer viruses.

Suite 1, 27 York St, Subiaco WA 6008 PO Box 117, Subiaco WA 6904 Ph: +61 8 9388 2436 Fx: +61 8 9381 9279

www.jdahydro.com.au

info@jdahydro.com.au







APPENDIX 7

Engineering Servicing Report



SOUTH HEDLAND WESTERN EDGE PHASE 1 DEVELOPMENT AREA SERVICING & INFRASTRUCTURE REPORT REPORT 6020-HA2 AUGUST 2012



Level 2, 431 Roberts Road SUBIACO WA 6008 Tel: (08) 9422 5800 Fax: (08) 9422 5801 admin@cosweb.com.au www.cosweb.com.au

Table of Contents

1.0.	INTRODUCTION	3
2.0.	SITE CONDITIONS	3
3.0.	ACCESS & ROAD NETWORK	4
4.0.	STORMWATER DRAINAGE	4
5.0.	WATER SUPPLY	6
	WASTEWATER	
7.0.	POWER SUPPLY	7
8.0.	TELECOMMUNCATIONS	7
9.0	CONCLUSION	8

Appendices

Appendix A – Locality Plan: Draft Development Plan 1- 2957_19-4-003a

Appendix B – Water Corporation Planning

Wastewater Scheme Planning dated 21 June 2012

Water Scheme Planning dated 21 June 2012

1.0. INTRODUCTION

This Servicing & Infrastructure Report has been prepared by Cossill & Webley (CW) for LandCorp to accompany the development application for the area referred to as "Development Plan 1, Western Edge South Hedland" (Phase 1) as presented in Appendix A (RPS plan reference 2957_19-4-003a.dgn revision – dated 1 August 2012).

This report serves to provide initial advice on the presence of existing service infrastructure, development constraints and servicing requirements for the residential development of the land within Phase 1.

Cossill & Webley have some knowledge of the servicing requirements for the sites and has had preliminary discussions with some service Agencies and sub-consultants in regard to the servicing for the proposed residential development.

2.0. SITE CONDITIONS

The Site is generally covered in sparse vegetation comprising low scrub and grasses. CW has made some investigations into determining the extent of existing services within the area and understands there may be communications conduits and sewer pressure mains within the area.

The area of land directly to the east of the Phase 1 development area consists of the South Hedland Town Centre which is currently undergoing a transformation managed by Landcorp. This report assumes that the works associated with the redevelopment will be completed and thus no further upgrades of the services and Infrastructure will be required.

The Phase 1 Development plan area has a slight grade from south to north ranging in elevation from RL 14m AHD adjacent to the south-east boundary to RL 12m AHD at the northern boundary.

A geotechnical investigation was completed by Coffey Geosciences over the Site in October 2011 (refer "Geotechnical Investigation Report South Hedland Town Centre Development – Areas A & B GEOTPERT09075AH-AC Rev 2 dated 20 December 2011") which confirmed that the site is largely underlain by Clayey Sand (to several metres below surface) which is commonly referred to as Pindan Sand.

Coffey has confirmed that, subject to appropriate site treatment (clearing, removal of topsoil, foundation compaction and /or over excavation in select locations depending on the extent of fill), the Site is capable of supporting residential development and would achieve a Class M-D Site Classification in accordance with AS2870-1996 "Residential Slab and Footings".

Coffey has advised that "groundwater was not encountered during the investigations however it should be noted that groundwater levels are subject to fluctuation due to the influence of rainfall, temperature, local drainage and the seasons". This has been confirmed during previous geotechnical investigations of the nearby Hospital site completed in 2007.

An investigation into the regional flood mapping has been prepared by JDA Consultants and accompanies the rezoning application. This is discussed further in Section 4 of this report.

3.0. ACCESS & ROAD NETWORK

The majority of the eastern edge of Phase 1 is bordered by the existing roads of Hamilton Road or Collier Drive. As part of any planned residential development of the Site, the presence and hierarchy of these existing roads will need to be considered.

Porter Consulting have provided a preliminary hierarchy of road within the Phase 1 Development Area and they have prepared a separate Traffic Report (refer South Hedland Western Edge Land Development Transport Assessment, R29.12 Rev A). Collier Drive (will be disconnected near intersection of Wambiri Street and proposed to be re-aligned south of this location) and the extensions of McLarty Boulevard and Hamilton Road will ultimately become Neighbourhood Connectors. A District Distributor road will form a "western outer ring road" which will ultimately connect to the south and east via the realignment of the existing Collier Drive and to the north by connection to the North Circular Road. All other roads within Phase 1 have been deemed to be Access Streets or local roads.

Porter Consulting have provided various indicative cross-sections of these roads in their report providing guidance on typical widths, on street parking, footpath treatments and differences between roads adjacent to POS and houses.

4.0. STORMWATER DRAINAGE

Jim Davies & Associates (JDA) has prepared a report on the hydrological considerations for the Site entitled "South Hedland Western Edge – Hydrology". This includes reference to the Port Hedland Coastal Vulnerability Study prepared by Cardno in 2011.

The Department of Water and Town of Port Hedland have established a recommended approach to stormwater drainage design for the region as follows:

- Impact of post development works should result in less than 150mm increase in the 100 year ARI flood levels impacting on other landholders of undeveloped land;
- Existing development (such as the community 1.5km south of the Site) should not be impacted; and
- Habitable flood levels should be at least 0.5m above the 100 year ARI flood levels for a 100m zone immediately adjacent to South Creek. North and east of this zone the finished floor levels can be set at 0.3m above the local 100 year flood levels(rather than the South Creek levels).

Where possible, existing waterways and natural drainage lines through the Site will be retained or realigned with the aim of minimising changes to the pre-development hydrology. Given the existing topography and grades across the Site, it is anticipated that post-development, the Site will continue to grade and discharge into South Creek.

Flood protection of new lots and infrastructure will be a key criteria for the design of the Site. This issue will be addressed as part of the preparation of the Local Water Management Strategy that will accompany the Local Structure Plan.

The preliminary drainage modelling by JDA will be based on the network of open drains and culvert crossings shown on the current planning layout by RPS (2957_19-4-003a.dgn revision – dated 1 August 2012) for the Phase 1 area. It is understood that the drainage corridors within the development are to be treated as "Multi-use Corridors" (MUCs) which provide an opportunity for drainage and recreation activities. As such the preliminary sizing of the drains and reserve widths have allowed for roughness coefficient to reflect some vegetation that will be used within the MUC which may vary from grass to low shrubs and spinifex, the modelling precludes the use of large shrubs and trees within the drainage channels. The modelling incorporates receiving stormwater flow from both the development area and upstream catchment within the South Hedland town centre and future development south of Phase 1.

The prelim drainage modelling establishes the drains and culvert cross sections and provides the 100 year water level which CW has used to undertake the preliminary earthworks design.

Preliminary modelling by JDA and CW confirm that drainage design, whilst critical, will not provide an impediment to the rezoning of the Site.

5.0. WATER SUPPLY

As a result of the Pilbara Port City Growth Plan the Water Corporation are currently reviewing their water capacity constraints for the East Pilbara Water Supply Scheme. Verbal advice from Wayne Burns and Russell Nelson of the Water Corporation (4 January 2012) confirmed that the Water Corporation have no objections to the rezoning of Heritage Area A & B, of which Phase 1 forms a part, to support future residential development.

The East Pilbara Water Supply Scheme is under extreme pressure and is not able to immediately service the extent of the Site. The Corporation has identified the need and is planning for major infrastructure upgrades and new assets to facilitate servicing of the planned growth of Port and South Hedland.

Water supply to the town of Port Hedland (and South Hedland) is sourced from the Yule & De Grey borefields located tens of kilometres from the towns. It is understood that the Water Corporation has recently received an increase in its groundwater allocation from the Department of Water to provide for the planned expansion of the region. The ability of the Corporation to meet water supply demands will be subject to the density and timing of development. Pending planned development strategies the Water Corporation should be consulted to confirm that the proposed demand can be supplied from their planned source upgrades and to confirm the timing of any trunk mains that may be required.

There is existing water supply reticulation mains in the adjoining and nearby developments and the ability to extend these mains to service initial phases of development would be subject to further investigation.

6.0. WASTEWATER

As with the water supply scheme, the Water Corporation is currently reviewing their conceptual sewerage catchment planning in response to the Pilbara Port City Grown Plan. Current Water Corporation sewer catchment planning is presented in Appendix B. Verbal advice from Wayne Burns and Russell Nelson of the Water Corporation (4 January 2012) confirm that the Water Corporation have no objections to the rezoning of Heritage Area A & B, of which Phase 1 forms a part, to support future residential development.

The Phase 1 Development works is located within the current Water Corporation planning catchment boundary, and will gravitate to a proposed Type 180 pump station to be located at the northern extent of Phase 1. Recent discussions with the Water Corporation have indicated that current anticipated completion of the pump station will be early 2014. This pump station will discharge to the existing South Hedland Wastewater Treatment Plant west of the Site. The Water Corporation has recently completed a review of odour contours for the South Hedland Wastewater Treatment Plant and confirm that the odour buffer does not impact on the Phase 1 Development Area.

The Type 180 pump station will be fully funded by Water Corporation utilising their own design and procurement processes. The location of the Type 180 Pump Station has been determined, fixed and is noted on the plans. In addition to this Water Corporation has

requested that additional land be set aside to the west of the Type 180 site to incorporate storage tanks and a future Type 350 pump station. This area is shown as POS on the Phase 1 plan and the extent of land required is pending further planning and design by the Water Corporation.

The Phase 1 Development will require construction of prefunded sewer mains with a nominal size of DN600mm (subject to design). Further investigation is required with Water Corporation to determine the ultimate extents of prefunded infrastructure within the development area.

7.0. POWER SUPPLY

The existing development within the Town Centre and surrounds is serviced from the Murdoch Zone substation located in Murdoch Drive near Demarchi Road.

It is understood that the Murdoch Zone substation is supplied from the Alinta Gas 66KVA overhead transmission line that traverses the area south of the Phase 1 boundary and through the planned Department of Housing land south of Murdoch Drive near the Outer Ring Road in the south-east corner of the existing South Hedland Townsite.

It is understood that the Murdoch Zone substation is running near capacity at Summer Peak Loads and any significant new development may require an upgrade of this facility or a new facility. In order to understand any capacity constraints to service the Site, Horizon Power will need to complete a detailed HV System Study. It is understood that representations have been made by government Agencies (Pilbara Cities, LandCorp & Department of Housing) and their representatives to progress this investigation and study.

CW is aware of preliminary discussions held with Horizon Power to provide an overall plan for the servicing of South Hedland and understand this may include a new substation site in the Western or Northern area of South Hedland. It is anticipated that satisfactory and timely planning by Horizon Power will be critical to the servicing of the Phase 1 works.

8.0. TELECOMMUNCATIONS

The Federal Government has a stated objective to roll out fibre to the home for all residences within metropolitan areas. Part of this initiative includes the Government's decision to fund and deploy fibre to all greenfield developments within the National Broadband Network (NBN) footprint, with developers responsible for funding the associated pit and pipe only.

The Site currently sits beyond NBN Co's fibre footprint, but NBN Co officers Peter Gerring and Alex Zimmermann have confirmed that it is likely that the inclusion of these areas can be treated as an extension to LandCorp's South Hedland Town Centre redevelopment and would hence be included in the NBN roll-out.

The current design practice for road reserves, pavement and verge provisions will make adequate allowance for services including broadband in accordance with the agreed Utilities

Service Providers handbook. There will be some local land requirements for equipment sites, similar to current provisions which will be accommodated at detailed subdivision stage.

9.0. CONCLUSION

We do not consider there are any engineering constraints to the Western Edge Phase 1 development area in South Hedland, and the land is capable of supporting urban development. Fundamental to the progression of development will be the advancing of key infrastructure to service the site.

Further investigations and detailed design will be required for the next level of planning approvals to confirm the servicing strategies for the site.

APPENDIX A

Locality Plan

Draft Development Plan 1 2957_19-4-003a

PROPOSED DEVELOPMENT PLAN
Western Edge, SOUTH HEDLAND

RPS Australia East Pty Ltd
ABN 44140292762
PO Box 465 SUBIACO WA 6904
38 Station Street SUBIACO WA 6008
T +61 8 9211 1111 W rpsgroup.com.au

APPENDIX B

Water Corporation Planning

Wastewater Scheme Planning dated 21 June 2012

Water Scheme Planning dated 21 June 2012

