Holtze Subdivision: Land Suitability Assessment

Prepared for: Department of Lands, Planning and the Environment

Prepared by: EcOz Environmental Consultants

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Executive Summary

EcOz Environmental Consultants (EcOz) was contracted by the Department of Lands, Planning and the Environment (DLPE) to undertake a Land Suitability Assessment (LSA) for Sections 3281, 4229 and 4231 Hundred of Bagot (the project area). The main focus of this work was to survey the boundaries of land constrained by slopes and poor drainage and map the extent of unconstrained land within the parcels to determine suitability for the future proposed Holtze subdivision. Field investigations of soil and vegetation were undertaken to determine on-site constraint boundaries.

The project area is located between the Stuart Highway, Taylor Road and Wallaby Holtze Road, immediately east of Palmerston and approximately 20 km south of Darwin.

This report presents the results of desktop and field assessments of the project area, in accordance with the land suitability categories outlined by the NT Land Suitability Guidelines (DLPE 2013).

A desktop review was initially undertaken of existing relevant information pertaining to the site, including zoning, land units, slope, climate and potential presence of threatened flora and fauna. This informed a field assessment, which was undertaken on 2-3 October 2014 by two EcOz Environmental Scientists. The purpose of the field assessment was to determine the environmental constraints of land within the project area, survey the boundaries of land constrained by slopes and poor drainage and map the extent of unconstrained land.

Information obtained from the desktop and field assessments was used to map the project area based on three land suitability classes:

- Unconstrained land
- Marginally suitable land
- Constrained land

The most significant limiting factors in relation to the proposed subdivision are the erosion risk due to high slopes, and poorly drained land in the south-eastern section of the project area. Land with slopes of 0 - 1 % in well-drained areas was categorised as unconstrained land, whilst land with slopes of 1 - 5 % in well-drained areas was classified as marginally suitable land. Depending on the specific nature of the development, land classified as marginally suitable may require the input of environmental mitigation measures.

A total of 51 ha was classified as constrained land, which constitutes 25 % of the project area. This comprised land with slopes of greater than 5 % and/or with poor drainage. These areas may require additional inputs in terms of design, planning and on-going management, depending on the proposed plans for subdivision. Areas assessed as constrained land may be incorporated into the subdivision design on the condition that minimum lot sizes and areas of unconstrained land per lot can be accommodated, as prescribed in Clause 11.1.1 of the Northern Territory Planning Scheme. Modification works (e.g. drainage and/or fill works) may also be required to reduce the constraints presented by those areas considered steep (slopes >5 %) or poorly drained.

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1 Introduction

EcOz Environmental Consultants (EcOz) was engaged by the Department of Lands, Planning and the Environment (DLPE) to undertake a Land Suitability Assessment (LSA) for Sections 3281, 4229 and 4231 Hundred of Bagot. The main focus of this work was to survey the boundaries of land constrained by slopes and poor drainage and map the extent of unconstrained land within the parcels to determine suitability for the proposed future Holtze subdivision. Field investigations of soil and vegetation were undertaken to determine on-site constraint boundaries.

Sections 3281, 4229 and 4231 Hundred of Bagot are referred to henceforth in this report as the 'project area'.

1.1 Land suitability guidelines

The Northern Territory (NT) Land Suitability Guidelines (DLPE 2013) define land suitability as:

'The fitness of a given area for land utilisation type (or land use), or the degree to which it satisfies the land user.'

The NT guidelines address seven land suitability categories, including:

- Drainage
- On-site wastewater management
- Erosion risk
- Soil salinity
- Acid sulphate soils
- Storm tide flooding
- Riverine flooding.

These categories are then assigned suitability classes according to characteristics identified through a review of existing land information and field investigations. Suitability classes 1-2 are considered to be generally 'unconstrained', while suitability classes 3-5 are considered to varying degrees to be 'constrained'. Land classified as suitability classes 3-5 (constrained) may prevent development from proceeding or require additional inputs in terms of design, planning and on-going management (DLPE 2013).

1.2 Development details

The project area is located between the Stuart Highway, Taylor Road and Wallaby Holtze Road, immediately east of Palmerston and approximately 20 km south of Darwin (Figure 1-1). The majority of the parcels are currently zoned as Rural Living (RL), with a small portion in the south-east of Section 4231 zoned as Proposed Main Road (PM). The NT Planning Scheme states the following in relation to land zoned as Rural Living:

- The primary purpose of Zone RL (Rural Living) is to provide for a range of activities including residential, agricultural and other rural activities
- The larger lot sizes in this zone (minimum 2 ha) facilitate the separation between potentially incompatible uses and restrict closer settlement
- If lots are un-sewered, provision for the disposal of effluent must be made on-site so that the effluent does not pollute ground or surface waters, and subdivision design must allow for a minimum of 1 ha of unconstrained land per lot.

This report discusses the results of the desktop and field assessments of the project area. It presents an assessment of the suitability of various sections of the parcels for subdivision, with respect to the land suitability categories outlined by the NT Land Suitability Guidelines (DLPE 2013).

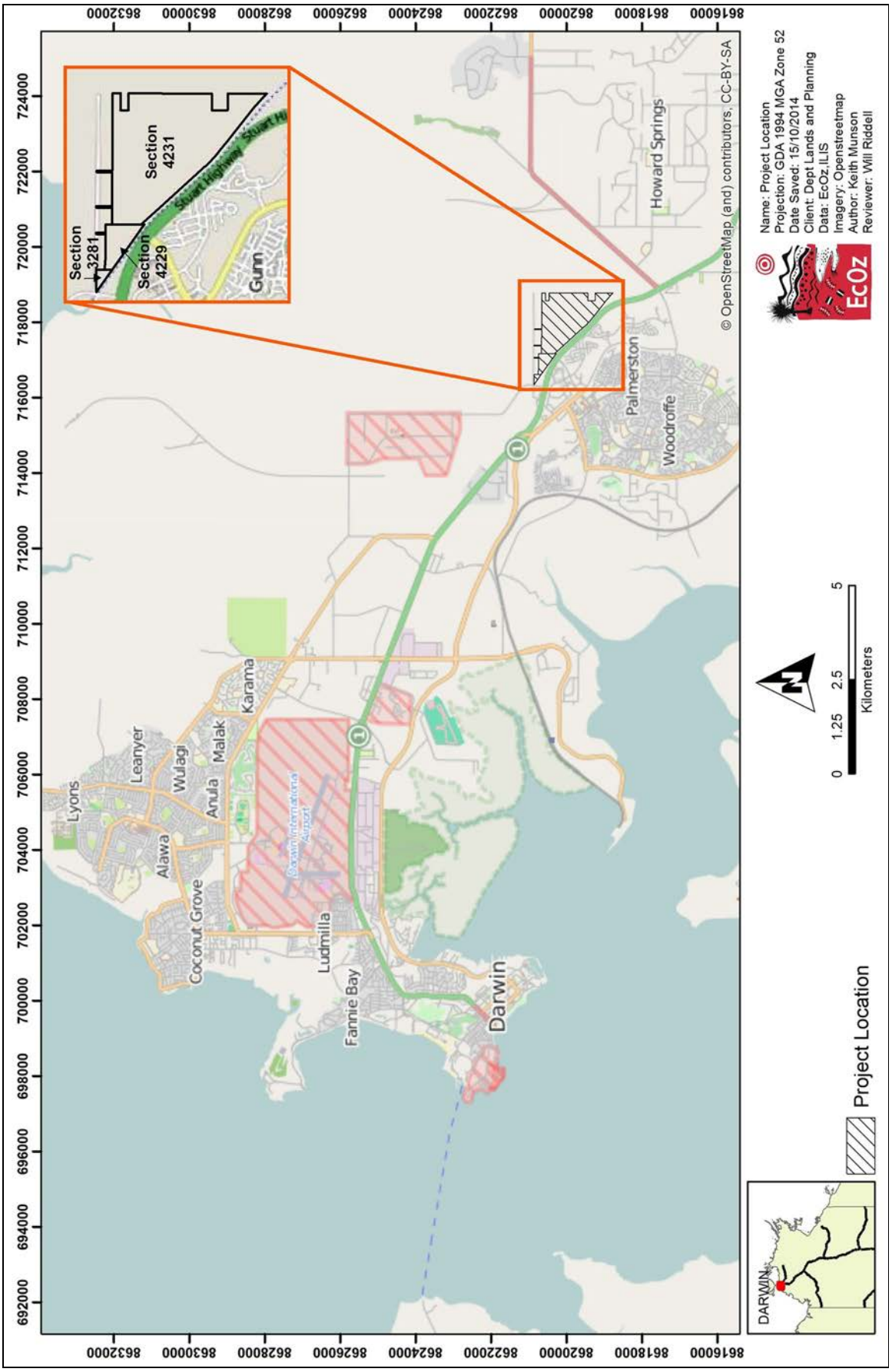

Figure 1-1. Map showing project area location

2 Land Suitability Assessment

The environmental assessment of the project area involved an initial desktop review, followed by an on-site assessment. The desktop review included zoning, existing land unit mapping, slope, wastewater risk mapping and potential presence of threatened flora and fauna. The site assessment was undertaken to ground truth the findings from the desktop review and identify any further environmental constraints that may influence the proposed subdivision.

2.1 Desktop review

The desktop review used available aerial photography and online land information databases in order to identify potential environmental constraints. Recent Google Earth imagery (2013) was used to assess the current land use, vegetation community boundaries and the extent of existing development within the project area and surrounding areas.

The online NT Government resource 'NR Maps', and associated metadata, was used to source the following:

- Cadastral boundaries
- 1:25,000 Greater Darwin land unit data
- Acid Sulfate Risk Categories for the Greater Darwin Area
- Palmerston Area Storm Surge Inundation for 2100.

Contour data (1 m) for the area was also supplied directly by DLPE.

An assessment of environmental constraints identified through analysis of data listed above was undertaken in accordance with requirements of relevant NT Government documents including:

- NT Planning Scheme
- NT Land Suitability Guidelines 2013
- NT Land Clearing Guidelines 2010

2.1.1 Climate

Climate data was sourced from the Bureau of Meteorology's Yarrawonga weather station (station number 014210), located approximately 1 km from the project area. The climate of the project area is characterised by a wet season (October to April) with high humidity and rainfall, and a dry season (May to September) with lower humidity and very little to no rainfall. During the monsoon period in January and February, the project area would experience frequent heavy rainfall and flooding in lower lying areas. The area typically receives around 1664 mm of rain each year (median) with more than 95 % occurring during the wet season. January is the wettest month of the year, with an average of 410 mm of rainfall.

Mean maximum temperatures range from 30.6 °C in June to 33.3 °C in November. July is the coolest month of the year, with an average minimum temperature of 19.3 °C.

Mean monthly rainfall and mean minimum and maximum monthly temperatures are displayed below in Figure 2-1.

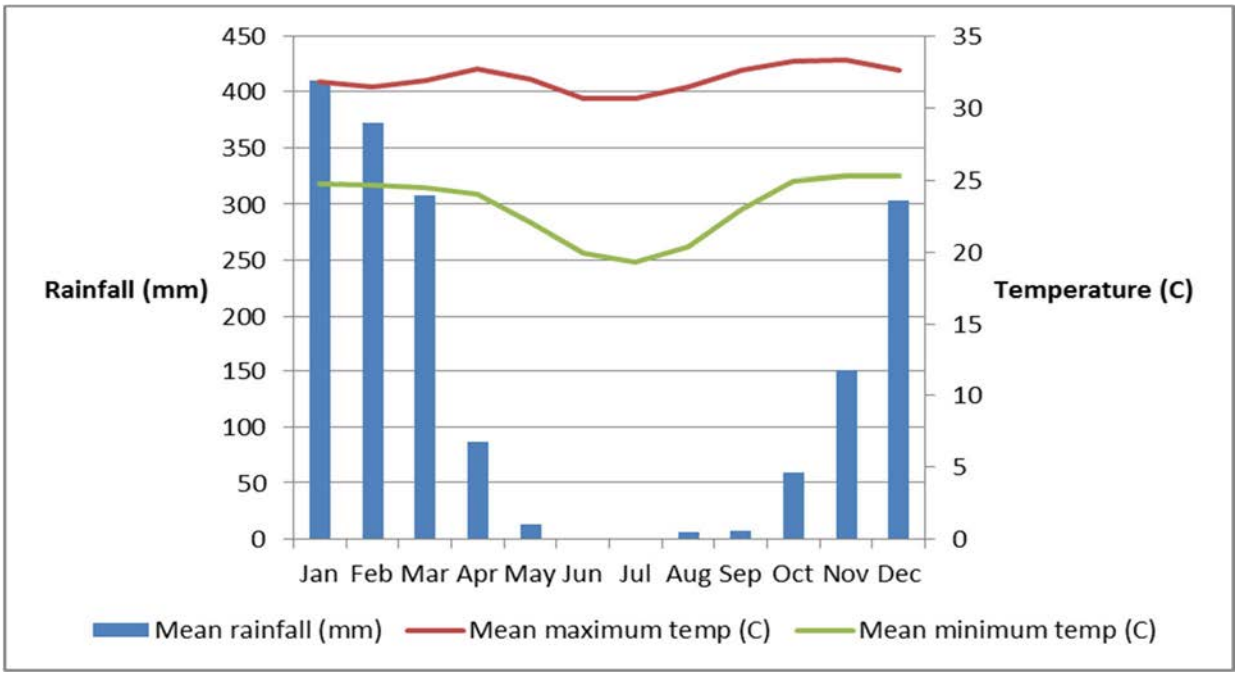

Figure 2-1. Graph of mean monthly rainfall and temperature range for Yarrawonga weather station (BOM 2014)

2.1.2 Land unit description

Mapping by Fogarty et al. (1984) shows seven land units occurring in the project area. Land Unit 3c (gently undulating upland surface) is the most abundant, covering most of the northern portion of the project area.

Land units were determined by mapping from aerial photographs at a scale of 1:15 000 using landform and vegetation patterns, followed by field sampling at designated sites to confirm the preliminary mapping and to determine the nature of soils and vegetation properties (Fogarty et al. 1984).

The project area consists flat to gently upland surfaces in the north that slope steeply into drainage lines in the south-eastern section. The lowland drainage areas comprise the upper reaches of the Mitchell Creek catchment.

Land units are described below in Table 2-1 and shown in Figure 2-2.

Table 2-1. Land Units within the project area

Land Unit	Description	Soil	Veg description	Slope	Drainage
1c	Rises and short steep slopes	Leptic Rudosols	Woodland of *Eucalyptus miniata*, *Corymbia bleeseri* over *Sorghum* spp.	5 - 15%	Nil to Low Level of Seasonal Soil Waterlogging
2b2	Sideslopes	Brown Kandosols	Low Open to Open Woodland of mixed species over sparse grasses	2 - 5%	Nil to Low Level of Seasonal Soil Waterlogging
3a	Flat to gently undulating upland surfaces	Red Kandosols	Open Forest of *Eucalyptus tetrodonta*, *E. miniata* over mixed grasses	0.5 - 2%	Nil to Low Level of Seasonal Soil Waterlogging
3b	Flat to gently undulating upland surface	Brown Kandosols	Woodland of *Eucalyptus miniata*, *E. tetrodonta* over *Sorghum* spp.	0.5 - 2.5%	Nil to Low Level of Seasonal Soil Waterlogging
3c	Gently undulating upland surface	Brown Kandosols	Woodland of *Eucalyptus miniata*, *E. tetrodonta* over *Sorghum* spp.	1 - 3%	Nil to Low Level of Seasonal Soil Waterlogging
3e	Flat to gently undulating upland surface	Kandosolic Redoxic Hydrosols	Woodland of *Corymbia polycarpa*, *Erythrophleum chlorostachys* over mixed grasses; wet season watertable	0.5 - 2%	Moderate to High Level of Seasonal Soil Waterlogging
4c	Gentle lower slopes	Kandosolic Redoxic Hydrosols	Open Forest of *Eucalyptus* spp. over mixed grasses; wet season watertable	0.5 - 1.5%	Moderate to High Level of Seasonal Soil Waterlogging

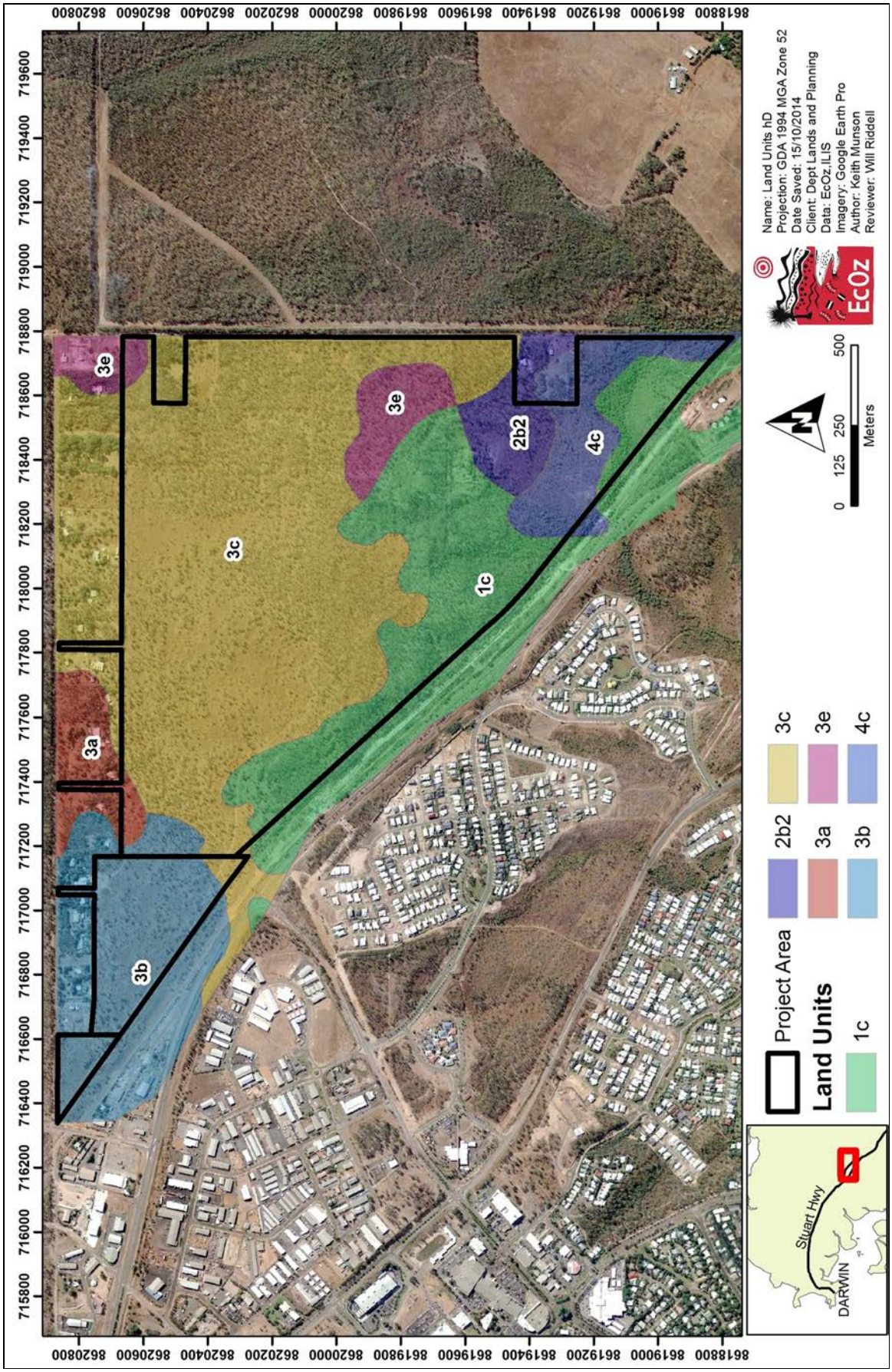

Figure 2-2. Map showing land units of the project area

2.1.3 Slope

Slopes within the project area were calculated with the QGIS geographic information system, using 1 m contour data for the area supplied by DLPE. Point elevation data was calculated for the area with the extract nodes geometry tool, A Digital Elevation Model (DEM) was created from these data using the raster interpolation tool. The QGIS interpolation tool offers two interpolation methods; Triangular Irregular Network (TIN), and Inverse Distance Weighted (IDW). Both methods were assessed and it was determined that the linear TIN interpolation with a cell size of 10 m^2 produced a better DEM. The quality of the IDW interpolation was lower, as the distribution of the sample data was uneven. The terrain was then analysed using the slope tool in QGIS with a Z factor of 1.0, to create a slope map for the area.

2.1.4 Wastewater risk mapping

Risk maps provided by the Department of Health indicate that most of the project area is mapped as 'Moderate Risk' in relation to onsite wastewater management. The remaining portions are mapped as 'High Risk'. This land is mostly confined to the southern section of the project area, including either side of the drainage line and on steep sloping areas (Figure 2-4).

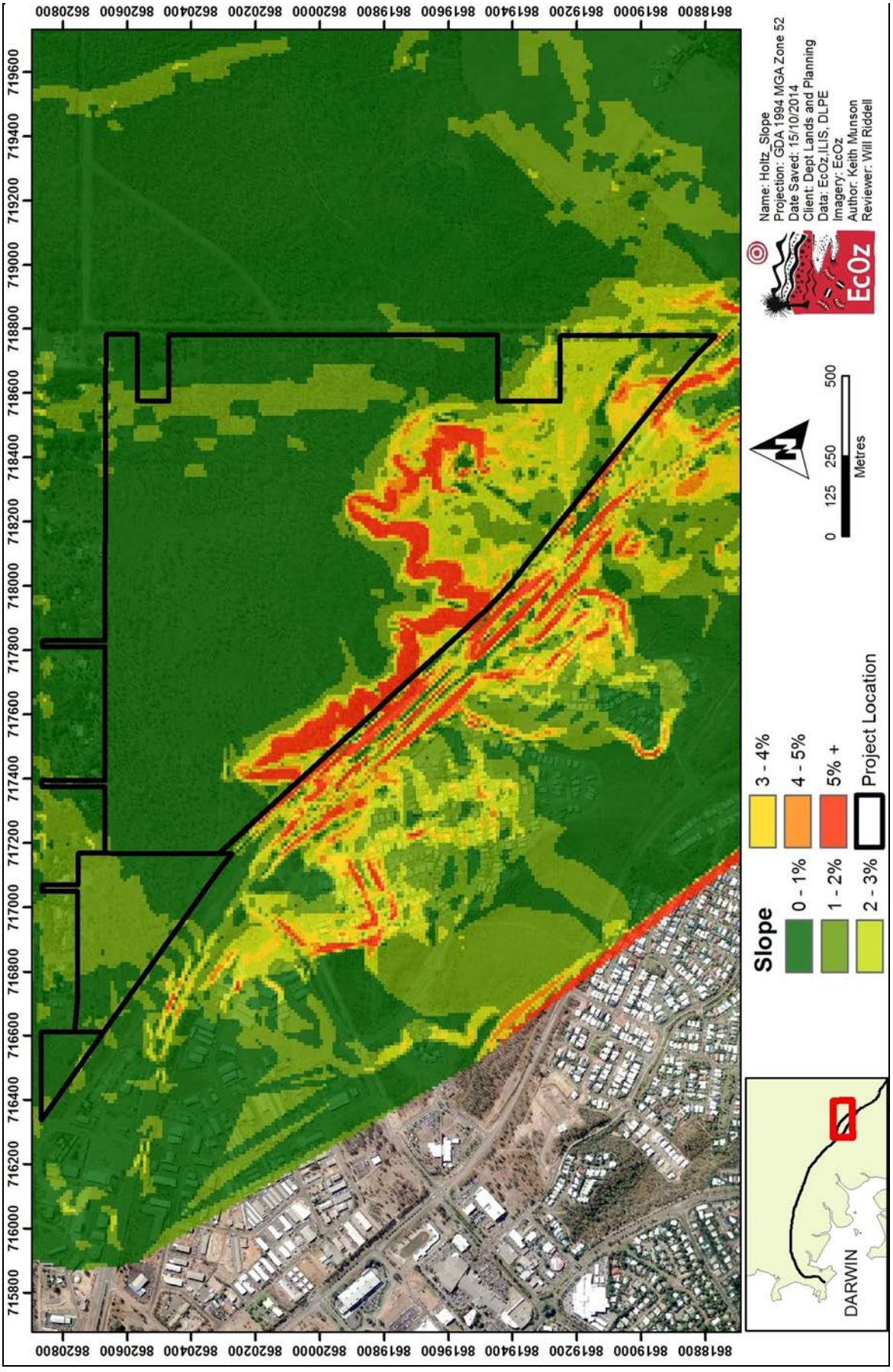

Figure 2-3. Map showing slopes within the project area

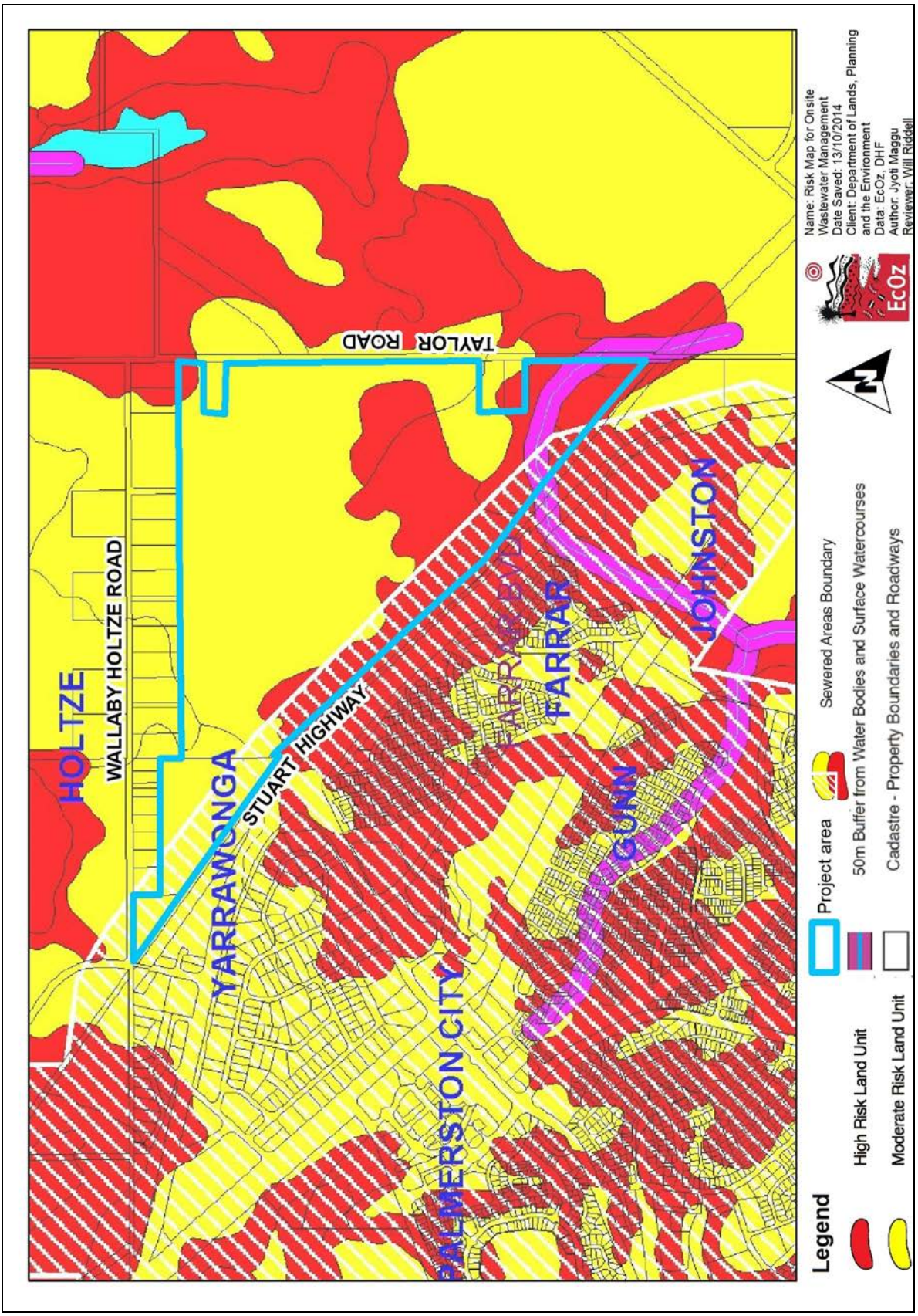

Figure 2-4. Risk map for onsite wastewater management (Department of Health)

2.1.5 Threatened species assessment

A preliminary desktop assessment of threatened flora and fauna species potentially occurring within the project area was undertaken. A search of the Protected Matters database identified threatened species listed under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) that could potentially be found within the property and surrounding areas, while a search of Northern Territory Fauna Atlas and Herbarium Database (NT Department of Land Resource Management) records within the Darwin Coastal Bioregion was used to source information on species listed under the *Territory Parks and Wildlife Conservation Act* (TPWC Act).

Based on existing records and a review of the habitat requirements of the state and federally-listed threatened species, 11 threatened species may exist in the project area. These species are listed in Table 2-2. Likelihood of occurrence was determined from available records and ecological knowledge of the area. While these species have been identified as potentially occurring within the project area, targeted surveys have not been performed to validate this. The majority of the species identified through the threatened species assessment are not endemic to the region and are generally broad ranging in their distribution. The project area is not likely to provide critical habitat for any of the species identified in Table 2-2.

The eastern subspecies of Partridge Pigeon (*Geophaps smithii smithii*) is the only threatened bird species that may occur within the project area. Partridge Pigeon occurs in lowland eucalypt open forests and woodlands, with grassy understoreys. The species is locally common in some areas of the Top End, but has been listed as Vulnerable due to a substantial population decline occurring across the Northern Territory. The reasons for this decline are not well-understood, though the main threatening process is believed to be altered fire regimes affecting grass seed availability (Woinarski 2006). The lower slopes of the south-east portion of Section 4229 comprise the most suitable habitat for Partridge Pigeon. The species was not detected during the site inspection.

Several of the mammals listed in Table 2-2 have experienced population declines across northern Australia. Inappropriate fire regimes and feral cats are identified as threatening process for Fawn Antechinus (*Antechinus bellus*), Brush-tailed Rabbit-rat (*Conilurus penicillatus*), Black-footed Tree-rat (*Mesembriomys gouldii*) and Pale Field-rat (*Rattus tunneyi*) (Young & Hill 2012; Hill 2012; Woinarski & Hill 2012; Young 2012). Habitat within the project area may be suitable for these species; however, the frequency of fire in the area may restrict their occurrence.

The arrival of Cane Toads (*Rhinella marina*) in the Top End has been linked with the decline of Northern Quoll (*Dasyurus hallucatus*), Plains Death Adder (*Acanthophis hawkei*) and Floodplain Monitor (*Varanus panoptes*) (Doody et al. 2009; Phillips et al 2010; Van Dam et al. 2002). The project area does not comprise of optimal habitat for Plains Death Adder and Floodplain Monitor and the presence of Cane Toads may restrict their occurrence. Northern Quoll was once common in many Eucalypt open forests; however, populations have collapsed in the Top End and the species is now most commonly found in rocky areas (Woinarski & Hill 2012).

The Howard River Toadlet (*Uperoleia daviesae*) is known from only a relatively small number of specimens in sandsheet heathland within the Howard and Elizabeth River Catchments close to Darwin (Ward et al. 2012). Riparian habitat in the south of the project area may constitute suitable habitat for the species.

Typhonium taylori is a small deciduous geophytic herb known only to occur on the Howard River Floodplain. The species occurs in seasonally saturated sandy soil in nutrient poor grass/sedgeland with occasional *Melaleuca viridiflora* (Kerrigan & Cowie 2006). Riparian habitat in the southern section of the project area may constitute suitable habitat for the species.

The threatened plant species *Cycas armstrongii* occurs within the project area. This species is discussed in Section 2.2.3.

Table 2-2. Threatened species that may occur within the project area

Group	Species	Common name	EPBC Status	TPWC Status
BIRDS	*Geophaps smithii smithii*	Partridge Pigeon (eastern)	Vulnerable	Vulnerable
MAMMALS	*Antechinus bellus*	Fawn Antechinus	-	Endangered
	Conilurus penicillatus	Brush-tailed Rabbit-rat	Vulnerable	Endangered
	Dasyurus hallucatus	Northern Quoll	Endangered	Critically Endangered
	Mesembriomys gouldii	Black-footed Tree-rat	-	Vulnerable
	Rattus tunneyi	Pale Field-rat	-	Vulnerable
REPTILES	*Acanthophis hawkei*	Plains Death Adder	Vulnerable	Vulnerable
	Varanus panoptes	Floodplain Monitor	-	Vulnerable
AMPHIBIANS	*Uperoleia daviesae*	Howard Springs Toadlet	-	Vulnerable
PLANTS	*Cycas armstrongii*	-	-	Vulnerable
	Typhonium taylori	-	Endangered	Endangered

2.2 On-site assessment

A site assessment was undertaken within the project area on 2-3 October 2014 by two EcOz Environmental Scientists to determine the environmental constraints of land. The main focus of this work was to survey the boundaries of land constrained by slopes and poor drainage and map the extent of unconstrained land.

The project area was traversed in a vehicle along existing tracks and on foot, using a hand-held GPS. Prior to the site assessment, aerial imagery was used to identify vegetation boundaries for subsequent ground-truthing on site. Vegetation within each vegetation-type boundary was described by assessing a representative 20 m x 20 m vegetation reference site, to determine the two dominant species and the height and percentage cover of each stratum, resulting in a vegetation description according to the NVIS Level 5 guidelines (Brocklehurst et al. 2007). Soil cores were taken within each vegetation reference site to a minimum depth of 0.5 m, to determine soil characteristics within each vegetation type. A detailed soil and vegetation assessment was undertaken at 10 sites (reference sites); while a rapid vegetation assessment was undertaken at six sites (check sites). The location of these sites is displayed in Figure 2-8.

Detailed vegetation and soil descriptions for each vegetation reference site are presented in Appendix A. Ground-truthing undertaken during the site assessment indicated that the existing mapped land units were largely accurate based on vegetation, land form, soil type and drainage. Updated land unit boundaries are presented in Section 2.2.6 below.

2.2.1 Vegetation communities

Three distinct vegetation communities were identified within the project area, the most abundant of which is the open Eucalypt forest/ woodlandVegetation types are described below in Table 2-3, with further detail of the vegetation structure and composition at each reference site provided in Appendix A.

Table 2-3. Vegetation types within the project area

Vegetation type	Site/s	Vegetation description
Open Eucalypt Forest / Woodland	VS1, VS2, VS3, VS4, VS8, VS9, VS10	*Eucalyptus tetrodonta, E. miniata* +/- *Erythrophleum chlorostachys* Open Forest, over *Sorghum intrans* and *Heteropogon triticeus.*
Low Open Corymbia/ Eucalypt Woodland	VS5, VS6, VS9	*Corymbia latifolia, E. tectificia* Low Woodland, over *Heteropogon triticeus* +/- *Sorghum intrans.*
Open Grevillea woodland / shrubland	VS7	*Grevillea pteridifolia, Pandanus spiralis* Open woodland / shrubland on drainage line

2.2.2 Soils assessment

Soil cores were taken at the 10 vegetation reference sites to assess soil characteristics and drainage potential. Depths ranged from a minimum of 0.5 m and a general maximum of 0.7 m

Brown kandosols occurred in the well-drained areas of the project area. Kandosol soils are typical of Eucalypt woodlands around Darwin with *Eucalyptus miniata* and *Eucalyptus tetrodonta* in the upper stratum (McKenzie et al. 2004). These soils are generally low in clay content (<20 %) and high in sand (>70 %), increasing in clay content with depth as they grade from sandy loams and loamy sands in the A horizon to loams in the B horizon.

Soils occurring on the steep slopes, lower slopes and riparian areas mostly comprised of hydrosol soils. Hydrosols are soils that are seasonally or permanently saturated, for at least 2-3 months in most years (Isbell 2002). These soils receive large amounts of water from runoff on the upper slopes of the project area. Land close to the creek line in the southern portion of the project area would be flooded during the wet season causing the soil to become saturated for extended periods.

The organosol soil was recorded on a steep slope at reference site VS10. This soil consisted of a peaty A horizon that was dark greyish brown in colour.

Soils that were excavated and assessed are described below in Table 2-4.

Table 2-4. Description of soils within the project area reference sites

Reference site	Horizon	Depth	Soil texture	Coarse aggregates (%)	Soil colour	Soil type
VS1	A1	0-15 cm	Sandy loam	30	Dark brown	Kandosol
	A3	15-30 cm	Sandy loam	20	Dark yellowish brown	
	B1	30-50 cm	Sandy loam	30	Strong brown	
VS2	A1	0-10 cm	Sandy loam	30	Strong brown	Kandosol
	A3	10-35 cm	Loam	20	Reddish brown	
	B1	35-70 cm	Loam	15	Yellowish red	
VS3	A1	0-15 cm	Sandy loam	40	Dark brown	Kandosol
	A3	15-30 cm	Sandy loam	30	Brown	
	B1	30-70 cm	Loam	20	Strong brown	
VS4	A1	0-10 cm	Loamy sand	2	Dark brown	Kandosol
	A3	10-30 cm	Sandy loam	0	Dark brown	
	B1	30-50 cm	Sandy loam	0	Dark brown	
	B2	50-70 cm	Loam	0	Reddish brown	
VS5	A1	0-15 cm	Loamy sand	70	Dark grey	Hydrosol
	A2	15-70 cm	Sand	70	Light olive brown	
VS6	A1	0-20 cm	Loamy sand	50	Dark grey	Hydrosol
	A2	20-40 cm	Loamy sand	70	Brown	
VS7	A1	0-10 cm	Loamy sand	0	Grey	Hydrosol
	A2	10-50 cm	Sand	0	Grey	
VS8	A1	0-15 cm	Sandy loam	40	Dark greyish brown	Kandosol
	A3	15-30 cm	Loam	15	Dark yellowish brown	
	B1	30-60 cm	Clay loam	50	Yellowish brown	
VS9	A1	0-15 cm	Loamy sand	50	Dark grey	Kandosol
	B1	15-35 cm	Sandy loam	60	Yellowish brown	
	B2	35-60 cm	Loam	60	Strong brown	
VS10	A1	0-10 cm	Sandy loam	20	Very dark grey	Organosol
	A2	10-40 cm	Sandy loam	5	Dark greyish brown	
	A21	40-60 cm	Loam	20	Very dark greyish brown	

2.2.3 Threatened species

One threatened species was recorded during the site inspection. *Cycas armstrongii* was observed throughout the project area, with highest densities in the upland areas (Figure 2-5). The species occurs mainly in open grassy woodland on yellow and red earths, in well-drained areas. It is locally abundant in woodlands within the Darwin Coastal bioregion. *Cycas armstrongii* has been listed as Vulnerable under the TPWC Act due to an anticipated reduction in population size, with one of the main threatening processes being land clearing due to the expansion of Darwin and surrounding rural areas (Kerrigan et al. 2006).

Figure 2-5. *Cycas armstrongii* in the project area

2.2.4 Erosion

Instances of rill and gully erosion were observed in several locations within the project area (Figure 2-6). Erosion was most common adjacent to dirt tracks in the south-east section of the project area, where slopes of 2-4 % occur. Slopes of greater than 5 % in some sections increase the erosion potential of the area.

Clearing of vegetation and ground disturbance associated with subdivision of the project area has potential to cause erosion. Erosion potential along property boundaries can be minimised through the establishment of adequate drainage and erosion/sediment controls during the initial land development and construction activities. The design and implementation of erosion controls should be in accordance with NT Government guidelines, such as:

- Erosion and Sediment Control Guidelines – Built Environment
- Erosion and Sediment Control Guidelines – Fact Sheet – Rural Development.

Figure 2-6. Image showing gully erosion next to dirt road

2.2.5 Weeds

Two declared weeds were recorded in the project area:

- Gamba Grass (*Andropogon gayanus*) (see Figure 2-7)
- Mission Grass (*Cenchrus polystachios*)

Both weeds are listed as Class B (spread to be controlled) and Class C (not to be introduced) under the NT *Weeds Management Act*. These weeds were observed in relatively low densities in some disturbed areas adjacent to tracks within the project area.

Gamba Grass and Mission Grass should be actively controlled to prevent its spread into other properties in the area. Development activities can increase the risk of spreading established weeds and introducing new weeds to the area. Weed hygiene practices should be implemented for vehicles and machinery during the establishment of development boundaries, fire breaks and housing allotments. Refer to the Northern Territory Weed Management Handbook 2009 for further information if required.

At a minimum, it is recommended that weed management include the following:

- Maintain good vehicle/equipment hygiene to avoid the spread of existing weed infestations during establishment of lot boundaries, access tracks, fences and firebreaks (including vehicle wash-downs, and avoiding driving through weed-infested areas).
- Any borrow material required should be sourced from weed free areas.
- Weed management regimes, such as spraying, should be implemented on all properties following subdivision.

Figure 2-7. Gamba Grass (*Andropogon gayanus*) observed in the project area

2.2.6 Updated land units

Land units described in Section 2.1.2 were determined by the Northern Territory Government at a scale of 1:25 000. These land units were delineated by mapping from aerial photographs and field sampling to determine the nature of soils and vegetation properties (Fogarty et al. 1984). The on-site assessment indicated that the existing mapped land units were largely accurate based on vegetation, land form and soil type, although some differences were observed.

Land unit 3a was found to be more extensive than was previously mapped, while land unit 3c was significantly smaller in area. These land units are broadly similar, with both consisting of *Eucalyptus tetrodonta* and *E. miniata* woodlands with kandosol soils. Land unit 1c is less extensive than previous mapping indicates. Results from the site assessment indicated that land unit 5b1 (Drainage lines within upland terrain) occurs in the south-east of the project area, which had not been previously mapped.

Updated land units are described below in Table 2-5 and displayed in Figure 2-8.

Table 2-5. Updated land unit description of project area

Land Unit	Description	Soil	Veg description	Slope	Drainage
1c	Rises and short steep slopes	Organosols	Woodland of *Eucalyptus tetrodonta, E. miniata*, over *S. intrans* and *H. triticeus.*	5 - 15%	Nil to Low Level of Seasonal Soil Waterlogging
2b2	Sideslopes	Hydrosols	Low Woodland of *Corymbia latifolia, E. tectificia* and *Grevillea pteridifolia* over *H. triticeus*	2 - 5%	Moderate level of Seasonal Soil Waterlogging
3a	Flat to gently undulating upland surfaces	Brown Kandosols	Open Forest of *Eucalyptus tetrodonta, E. miniata +/- Erythrophleum chlorostachys* over *S. intrans* and *H. triticeus*	0 - 2%	Nil to Low Level of Seasonal Soil Waterlogging
3b	Flat to gently undulating upland surface	Brown Kandosols	Open Woodland of *Eucalyptus tetrodonta, E. miniata +/- C. bleeseri*, over *S. intrans* and *H. triticeus.*	0.5 - 2.5%	Nil to Low Level of Seasonal Soil Waterlogging
3c	Gently undulating upland surface	Brown Kandosols	Low open woodland of *Corymbia latifolia* and *Eucalyptus tectifica* over *S. intrans* and *H. triticeus.*	0 - 2%	Nil to Low Level of Seasonal Soil Waterlogging
5b1	Drainage lines with upland terrains	Hydrosols	Open woodland/shrubland of *Grevillea pteridifolia* and *Pandanus spiralis* over mixed grasses	1-4 %	Very slow. High level of seasonal soil waterlogging

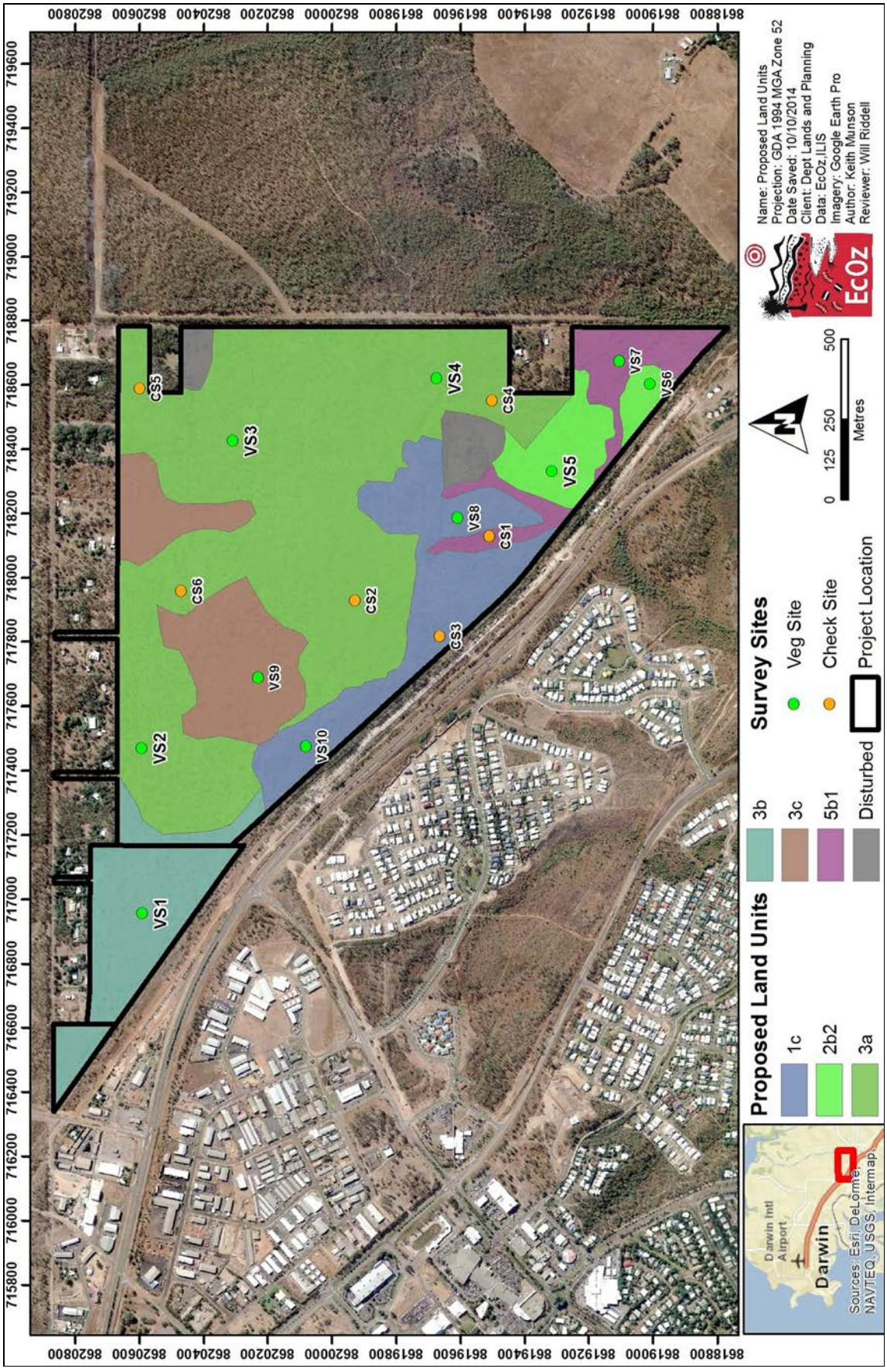

Figure 2-8. Map showing updated Land Units of project area and survey sites

3 Summary of Land Constraints

The Land Suitability Guidelines provide guidance for assessing the suitability of land and identifying potential constraints (DLPE 2013). Table 3-1 below lists the Land Suitability Categories, their definition in terms of constrained land as provided in the guidelines, and an assessment of suitability in relation to the proposed subdivision.

In accordance with the Land Suitability Guidelines, the suitability class rating is based on the most constrained rating that occurs within the project area (i.e. highest suitability class number, indicating lowest suitability), irrespective of the proportion of land found to be within a given suitability class. For example, despite most of the project area being well-drained, the suitability class rating relating to drainage is 'Class S4 – Not Suitable', due to the poorly drained areas in the south-east portion.

The project area is located next to residential developments and can likely be connected to existing sewerage systems, therefore the on-site wastewater management suitability class may not be relevant to subdivision of the project area.

Table 3-1. Land suitability categories and assessment of the project area

Land Suitability Category	Constrained Land Definition	Assessment	Suitability Class
Drainage	Areas that are wet or saturated either at, above or close to the land surface for a period of weeks to months (per year) as a result of rainfall, landscape function and/or position or soil hydrology factors.	The majority of the project area, including all of the upper slope areas that comprise of updated land units 3a, 3b and 3c; are well-drained (see Figure 2-8). These areas have Kandosol soils generally consisting of sandy loams in the A horizon and loams in the B horizon. The soils are dry and exhibit no mottling, indicating good drainage. This area qualifies as **Class S2 – Moderately Suitable**. Most of the land within updated land unit 1c has slopes of greater than 5 %. Soils within this land unit varied, with imperfectly drained organosol soil recorded at reference site VS10, and well-drained kandosol soil recorded at VS8. This area qualifies as **Class S3 – Marginally Suitable**. The updated land units 2b2 and 5b1 receive rainfall runoff from the upper slopes and subsequently contain hydrosolic soils that are seasonally or permanently saturated. This section of the project area also contains a creek line that would flood during the monsoon season. This area qualifies as **Class S4 – Not Suitable**.	**Class S4 – Not Suitable**
On-site Wastewater Management	Soils that have one or more of: • Slopes greater than 5 % • Imperfectly to very poorly drained • Contain minimal clay (20 %) at depth • Shallow soils (<0.5 m)	The upper slopes of Land Units 3a, 3b and 3c comprise well-drained, deep kandosol soils. Slopes are mostly 0-1 %, with some areas having slopes of 1-2 %. These areas qualify as **Class S2 – Moderately Suitable**. Updated land units 2b2 and 5b1 contain poorly drained hydrosol soils with slopes of 1-5 %. These areas qualify as **Class S4 – Not Suitable** due to poorly drained soils.	**Class S4 – Not Suitable**

Land Suitability Category	Constrained Land Definition	Assessment	Suitability Class
	• Extensive exposed rock (>10 %) • Greater than 25 % gravel	Updated land unit 1c and the disturbed area contain imperfectly drained soils and slopes of greater than 5 %. This area qualifies as **Class S3 – Marginally Suitable** due to imperfectly drained soils.	
Erosion Risk	Soil landscapes that have a moderate to very high erosion risk	The suitability of land in relation to erosion risk is determined by slope, which is shown in Figure 2-3. Areas with a slope of 0-1 % qualify as **Class S2 – Moderately Suitable**. Most of these areas occur on the upper slopes within updated land units 3a, 3b and 3c. Areas with a slope of 1-5% qualify as **Class S3 – Marginally Suitable**. This includes most of updated land units 2b2 and 5b1 and part of 1c. Areas with a slope of more than 5 % qualify as **Class S4 – Not Suitable**. This includes most of updated land unit 1c.	**Class S4 – Not Suitable**
Soil Salinity	Soil salinity >4 dS/m ECe	Field measurements of soil salinity were not taken. Brown kandosol soils of the Top End generally have EC of less than 0.1 dS/m (McKenzie et al. 2004). Hydrosol soils in the southern section of the project area are created by drainage from upslope areas and flooding due to seasonal rainfall, not rising tides. These soils are classified as non-saline.	**Class S1 – Highly Suitable**
Acid Sulphate Soils (ASS)	Soils with greater than 0.02 % oxidisable sulphur is present	ASS are commonly found in estuarine and near-coastal environments. Mapping by the Department of Infrastructure, Planning and the Environment (DIPE) confirms that the project area occurs outside of areas of moderate and high risk of ASS.	**Class S1 – Highly Suitable**
Storm Tide Flooding	Coastal areas below Primary Storm Tide inundation extent	Storm Surge Inundation maps provided by the Department of Land Resource Management (DLRM) show that the project area does not occur within the primary or secondary storm surge zone.	**Class S1 – Highly Suitable**
Riverine Flooding	Land below the 1 % AEP flood level	Floodplain maps provided by DLRM do not cover the project area. The project area occurs close to the coast, with the largest nearby river system being the Elizabeth River located approximately 8 km away. Flooding due to rising river in not considered a risk.	**Class S1 – Highly Suitable**

The most significant limiting factors in relation to the proposed subdivision are the erosion risk due to high slopes, and poorly drained land in the south-east of the project area.

Slopes in the updated land unit 1c are greater than 5 % in some areas, giving the project area an overall class suitability rating of 'Class S4 – Not Suitable'. Other sections of the project area have slopes of 1-5 %, which qualifies as 'Class S3 – Marginally Suitable' land. These ratings indicate that the land is constrained.

Land within updated land units 2b2 and 5b1 is rated as 'Class S4 – Not Suitable' due to poor drainage and associated hydrosol soils. These areas contain a drainage line fringed with *Grevillea pteridifolia*, *Melaleuca nervosa* and *Pandanus spiralis,* indicating seasonal waterlogging.

3.1.1 Land suitability

The project area has been divided into three suitability classes in relation to the proposed subdivision:

- Unconstrained land
- Marginally suitable land (constrained)
- Not suitable land (constrained)

Figure 3-1 shows the distribution of each suitability class within the project area. The NT Land Suitability Guidelines categorise land with a slope 0.75 – 5 % as 'Class S3 – Marginally Suitable' land in relation to erosion risk. These sections of land are categorised as constrained and requiring additional inputs in terms of design, planning and on-going management to be used for subdivision. Slopes of 0.75 – 5 % represents a broad criterion, causing land that would otherwise be appear to be unconstrained to be classified as constrained. Slopes of 0.75 – 2% are not particularly steep in the context of the surrounding landscape and may not represent high erosion risk. While the Land Suitability Guidelines stipulate that additional inputs are required for these areas, such inputs may not be necessary, or may be minimal in scale. Discretion is therefore necessary regarding the extent of environmental controls necessary for land classified as marginally suitable.

Land with slopes of greater than 5 % or with poor drainage is classified as constrained land and will require additional inputs for subdivision. Land with slopes of 0 - 1 % in well-drained areas have been categorised as unconstrained land.

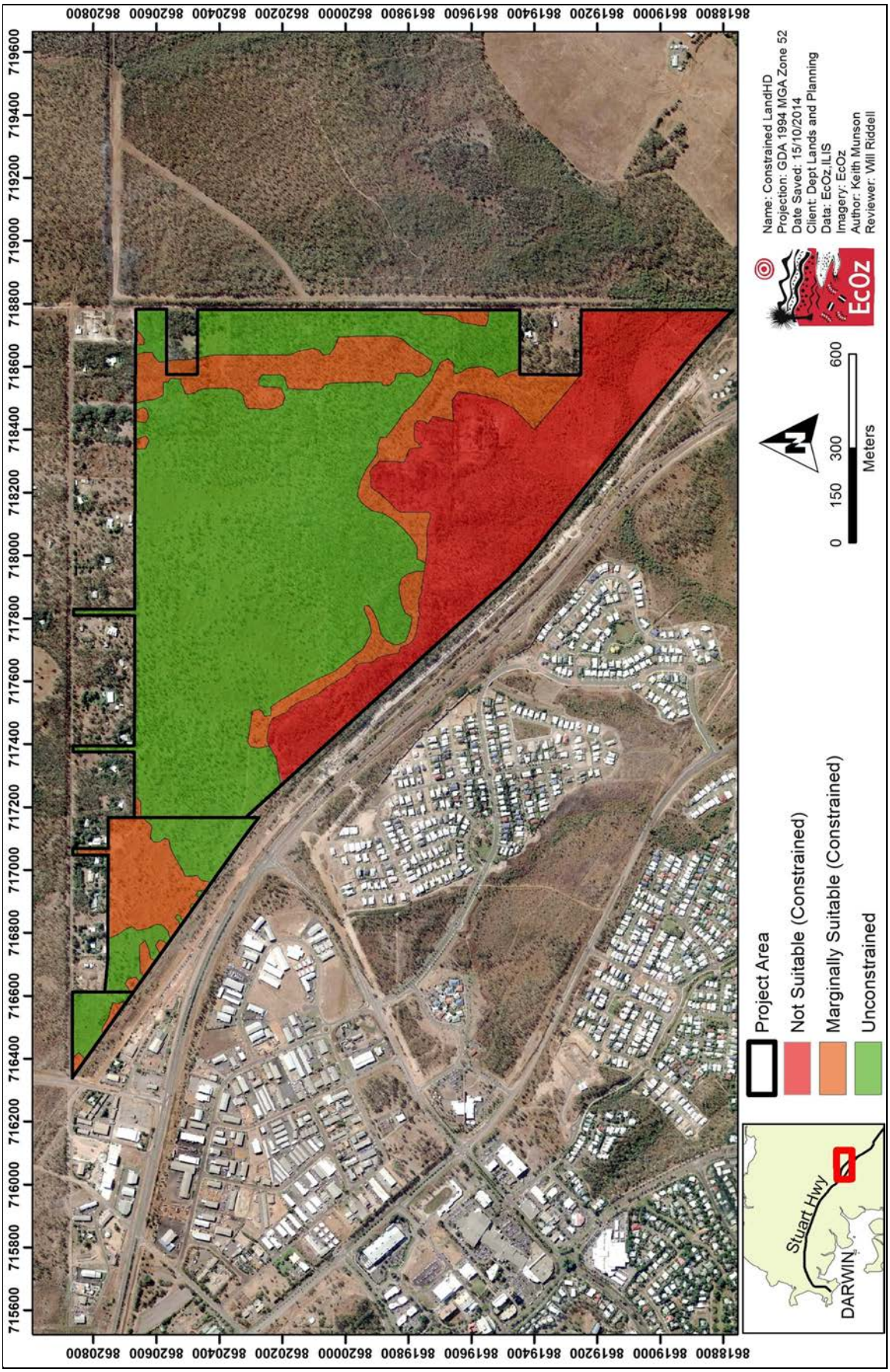

Figure 3-1. Map showing constrained land within the project area

4 Summary and Recommendations

The desktop and site assessment of Sections 3281, 4229 and 4231 Hundred of Bagot identified three land suitability classes within the project area: unconstrained land, marginally suitable land and constrained land. These land suitability classes are based on an assessment of land form, soils, drainage and vegetation types, and associated characteristics such as erosion risk. The project area has been mapped according to land suitability (see Figure 3-1), with a total of 54 ha classified as constrained land which would likely require additional inputs in terms of design, planning and on-going management if it is to be used for subdivision.

Land classified as marginally suitable may require additional inputs, including erosion and sediment control measures to reduce constraints posed by the slope of the land. It is also possible that some areas that have been assessed as constrained may be modified (e.g. drainage and/or fill works) to reduce the constraints posed to subdivision.

Land clearing activities within the area will potentially impact on *Cycas armstrongii*, which is listed as Vulnerable under the TPWC Act. Applications for clearing must demonstrate consideration of the presence of threatened species, and there may be opportunity for re-location of individual plants prior to clearing.

Clearing of vegetation and ground disturbance associated with subdivision of the project area has potential to cause erosion. This can be minimised through the establishment of adequate drainage and erosion/sediment controls during the initial land development and construction activities.

Gamba Grass (*Andropogon gayanus*) and Mission Grass (*Cenchrus polystachios*) should be actively controlled to prevent their spread into other properties in the area. Development activities can increase the risk of spreading established weeds and introducing new weeds to the area. Weed hygiene practices should be implemented for vehicles and machinery during the establishment of development boundaries and housing allotments.

In accordance with the NT Planning Scheme Clause 10.2, clearing within the subdivision would trigger the requirement for consent. In order to obtain consent for clearing of vegetation, any proposal would need to address the following requirements:

- Be based on land capability and suitability for intended use
- Avoid or manage impacts on environmentally significant or sensitive vegetation
- Avoid or manage impacts on drainage areas, wetlands and waterways
- Account for habitat fragmentation and impacts on native wildlife corridors
- Avoid or manage impacts on highly erodible soils
- Maintain 25 m buffers around drainage lines.

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Appendix A – Reference Site and Check Site Descriptions

Reference Site	VS1		
Vegetation Type	Open Eucalypt woodland	**Vegetation Description**	*Eucalyptus tetrodonta, E. miniata +/- C. bleeseri* Open Woodland, over *S. intrans* and *H. triticeus.*
Ground cover	Gravel 80% Vegetation 10% Litter 10%	**Land Unit**	3b

North

East

South

West

Vegetation

Upper Stratum **Cover: 10%** **Height range: 10-15 m** **Average height: 12 m**	**Mid Stratum** **Cover: 5%** **Height range: 2-8 m** **Average height: 5 m**	**Ground Stratum** **Cover: 5%** **Height range: 0-2 m** **Average height: 0.5 m**
Eucalyptus tetrodonta (5%)	*Planchonia careya (3%)*	*Sorghum intrans*
Eucalyptus miniata (3%)	*Acacia latescens (2%)*	*Heteropogon triticeus*
Corymbia bleeseri (2%)		

Soil

Slope	1-2%
Aspect	North-west
Drainage	Moderately well drained

Horizon	Depth	Colour	Texture	Coarse aggregates (%)	Soil type
A1	0-15 cm	Dark brown	Sandy loam	30	Kandosol
A3	15-30 cm	Dark yellowish brown	Sandy loam	20	
B1	30-50 cm	Strong brown	Sandy loam	30	

Reference Site	VS2		
Vegetation Type	Open Eucalypt Forest	**Vegetation Description**	*Eucalyptus tetrodonta, E. miniata +/- Erythrophleum chlorostachys* Open Forest, over *S. intrans* and *H. triticeus.*
Ground cover	Litter 70% Vegetation 5% Bare soil 10%	**Land Unit**	**3a**

North

East

South

West

Vegetation

Upper Stratum **Cover: 60%** **Height range: 12-18 m** **Average height: 15 m**	**Mid Stratum** **Cover: 10%** **Height range: 5-8 m** **Average height: 7 m**	**Ground Stratum** **Cover: 5%** **Height range: 0-1 m** **Average height: 0.5 m**
Eucalyptus tetrodonta (40%)	*Erythrophleum chlorostachys (5%)*	*Sorghum intrans*
Eucalyptus miniata (10%)	*Livistona humilis (2%)*	*Heteropogon tritiecus*
Erythrophleum chlorostachys (10%)	*Buchanania obovata (1%)*	*Cycas armstrongii*

Soil

Slope	Flat (0%)
Aspect	North
Drainage	Moderately well drained

Horizon	Depth	Colour	Texture	Coarse aggregates (%)	Soil type
A1	0-10 cm	Strong brown	Sandy loam	30	Kandosol
A3	10-35 cm	Reddish brown	Loam	20	
B1	35-70 cm	Yellowish red	Loam	15	

Reference Site	VS3		
Vegetation Type	Open Eucalypt Forest	**Vegetation Description**	*Eucalyptus tetrodonta, E. miniata +/- Erythrophleum chlorostachys* Open Forest, over *S. intrans* and *H. triticeus.*
Ground cover	Vegetation 80% Litter 20%	**Land Unit**	**3a**

North

East

South

West

Vegetation

Upper Stratum **Cover: 50%** **Height range: 12-18 m** **Average height: 15 m**	**Mid Stratum** **Cover: 10%** **Height range: 5-10 m** **Average height: 8 m**	**Ground Stratum** **Cover: 90%** **Height range: 0-2.5 m** **Average height: 1 m**
Eucalyptus tetrodonta (20%)	*Planchonia careya (3%)*	*Sorghum sp.*
Eucalyptus miniata (10%)	*Livistona humilis (3%)*	*Heteropogon triticeus*
Corymbia bleeseri (5%)	*Buchanania obovata (3%)*	*Cycas armstrongii*

Soil

Slope	Flat (0%)
Aspect	East
Drainage	Moderately well drained

Horizon	Depth	Colour	Texture	Coarse aggregates (%)	Soil type
A1	0-15 cm	Dark brown	Sandy loam	40	Kandosol
A3	15-30 cm	Brown	Sandy loam	30	
B1	30-70 cm	Strong brown	Loam	20	

Reference Site	VS4		
Vegetation Type	Open Eucalypt Forest	**Vegetation Description**	*Eucalyptus tetrodonta, E. miniata +/- Erythrophleum chlorostachys* Open Forest, over *S. intrans* and *H. triticeus.*
Ground cover	Litter 80% Vegetation 20%	**Land Unit**	**3a**

North

East

South

West

Vegetation		
Upper Stratum **Cover: 50%** **Height range: 12-18 m** **Average height: 15 m**	**Mid Stratum** **Cover: 10%** **Height range: 5-10 m** **Average height: 8 m**	**Ground Stratum** **Cover: 90%** **Height range: 0-2.5 m** **Average height: 1 m**
Eucalyptus tetrodonta (40%)	*Livistona humilis (4%)*	*Sorghum intrans*
Eucalyptus miniata (15%)	*Buchanania obovata (1%)*	*Heteropogon triticeus*
Erythrophleum chlorostachys (5%)		

Soil

Slope	Flat (0-1%)
Aspect	East
Drainage	Moderately well drained

Horizon	Depth	Colour	Texture	Coarse aggregates (%)	Soil type
A1	0-10 cm	Dark brown	Loamy sand	2	Kandosol
A3	10-30 cm	Dark brown	Sandy loam	0	
B1	30-50 cm	Dark brown	Sandy loam	0	

Reference Site	VS5		
Vegetation Type	Low Eucalypt Woodland	**Vegetation Description**	*Corymbia latifolia, E. tectificia* Low Woodland, over *S. intrans* and *H. triticeus.*
Ground cover	Vegetation 50% Litter 20% Gravel 30%	**Land Unit**	**2b2**

North

East

South

West

Vegetation

Upper Stratum **Cover: 20%** **Height range: 5-10 m** **Average height: 8 m**	**Mid Stratum** **Cover: 10%** **Height range: 1-2m** **Average height: 1.5m**	**Ground Stratum** **Cover: 50%** **Height range: 0.2-1.0m** **Average height: 0.8m**
Corymbia latifolia (15%)	*Xanthostemon paradoxus (4%)*	*Sorghum intrans*
Eucalyptus tectifica (3%)	*Livistona humilis (4%)*	*Heteropogon triticeus*
Terminalia grandiflora (2%)	*Grevillea pteridifolia (2%)*	

Soil

Slope	2-3%
Aspect	East
Drainage	Poorly drained

Horizon	Depth	Colour	Texture	Coarse aggregates (%)	Soil type
A1	0-15 cm	Dark grey	Loamy sand	70	Hydrosol
A2	15-70 cm	Light olive brown	Sand	70	

Reference Site	VS6		
Vegetation Type	Low Eucalypt Woodland	**Vegetation Description**	*Corymbia latifolia, E. tectificia* Low Woodland, over *H. triticeus*
Ground cover	Vegetation 10% Litter 10% Gravel 80%	**Land Unit**	**2b2**

North

East

South

West

Vegetation		
Upper Stratum **Cover: 10 %** **Height range: 8-12 m** **Average height: 10 m**	**Mid Stratum** **Cover: 5 %** **Height range: 2-5 m** **Average height: 2 m**	**Ground Stratum** **Cover: 30 %** **Height range: 0.2-1.0m** **Average height: 0.8m**
Corymbia latifolia (3%)	*Livistona humilis (3%)*	*Heteropogon triticeus*
Eucalyptus miniata (3%)	*Pandanus spiralis (1%)*	*Petalostigma quadriloculare*
Eucalyptus tectifica (3%)	*Grevillea pteridifolia (1%)*	

Soil

Slope	3-4 %
Aspect	North
Drainage	Poorly drained

Horizon	Depth	Colour	Texture	Coarse aggregates (%)	Soil type
A1	0-20 cm	Dark grey	Loamy sand	50	Hydrosol
A2	20-40 cm	Brown	Loamy sand	70	

Reference Site	VS7		
Vegetation Type	Open woodland/shrubland	Vegetation Description	*Grevillea pteridifolia, Pandanus spiralis* Open woodland/shrubland on drainage line
		Land Unit	5b1

North

East

South

West

Vegetation		
Upper Stratum Cover: 0 %	**Mid Stratum Cover: 10 % Height range: 3-8 m Average height: 6 m**	**Ground Stratum Cover: 50 % Height range: 0.2-0.5 m Average height: 0.3 m**
	Pandanus spiralis	*Dapsilanthus sp.*
	Grevillea pteridifolia	*Melaleuca nervosa*

Soil

Slope	2-3 %
Aspect	South
Drainage	Poorly drained

Horizon	Depth	Colour	Texture	Coarse aggregates (%)	Soil type
A1	0-10 cm	Grey	Loamy sand	0	Hydrosol
A2	10-50 cm	Grey	Sand	0	

Reference Site	VS8		
Vegetation Type	Eucalypt Woodland	**Vegetation Description**	*Eucalyptus tetrodonta, E. miniata* Woodland, over *S. intrans* and *H. triticeus.*
		Land Unit	**1c**

North

East

South

West

Vegetation		
Upper Stratum **Cover: 40 %** **Height range: 15-20 m** **Average height: 16m**	**Mid Stratum** **Cover: 10 %** **Height range: 2-8 m** **Average height: 3m**	**Ground Stratum** **Cover: 50 %** **Height range: 0.5 – 1.5m** **Average height: 1.0m**
Eucalyptus tetrodonta (20%)	*Xanthostemon paradoxus (6%)*	*Heteropogon triticeus*
Eucalyptus miniata (20%)	*Planchonia careya (2%)*	
Corymbia bleeseri	*Buchanania obovata 2%)*	

Soil

Slope	2-3 %
Aspect	South-east
Drainage	Moderately well drained

Horizon	Depth	Colour	Texture	Coarse aggregates (%)	Soil type
A1	0-15 cm	Dark greyish brown	Sandy loam	40	Kandosol
A3	15-30 cm	Dark yellowish brown	Loam	15	
B1	30-60 cm	Yellowish brown	Clay loam	50	

Reference Site	VS9		
Vegetation Type	Low Open Woodland	**Vegetation Description**	*Corymbia latifolia, E. tectifica* Low Open Woodland, over *S. intrans* and *H. triticeus.*
		Land Unit	**3c**

North

East

South

West

Vegetation

Upper Stratum **Cover: 5 %** **Height range: 8-12 m** **Average height: 10 m**	**Mid Stratum** **Cover: 2 %**	**Ground Stratum** **Cover: 80 %**
Eucalyptus tetrodonta (4%)	*Livistona humilis*	*Sorghum intrans*
Eucalyptus miniata (1%)	*Calytrix exstipulata*	*Triodia bitextura*
Eucalyptus bleeseri (1%)	*Cochlospermum fraseri*	

Soil

Slope	0-1 %
Aspect	-
Drainage	Moderately well drained

Horizon	Depth	Colour	Texture	Coarse aggregates (%)	Soil type
A1	0-15 cm	Dark grey	Loamy sand	50	Kandosol
B1	15-35 cm	Yellowish brown	Sandy loam	60	
B2	35-60 cm	Strong brown	Loam	60	

Reference Site	VS10		
Vegetation Type	Open Forest	**Vegetation Description**	*Eucalyptus tetrodonta, E. miniata* Woodland, over *S. intrans* and *H. triticeus.*
		Land Unit	**1c**

North

East

South

West

Vegetation		
Upper Stratum **Cover: 60 %** **Height range: 15-20 m** **Average height: 10 m**	**Mid Stratum** **Cover: 20 %** **Height range: 1.5-8 m**	**Ground Stratum** **Cover: 70 %**
Eucalyptus miniata (40%)	*Erythrophleum chlorostachys (15%)*	*Mnesithea rottboellioides*
Eucalyptus tetrodonta (10%)	*Livistona humilis (3%)*	*Sorghum intrans*
Lophostemon lactifluus (10%)	*Planchonia careya (2%)*	

Soil

Slope	~10 %
Aspect	South-east
Drainage	Imperfectly drained

Horizon	Depth	Colour	Texture	Coarse aggregates (%)	Soil type
A1	0-10 cm	Very dark grey	Sandy loam	20	Organosol
A2	10-40 cm	Dark greyish brown	Sandy loam	5	
A21	40-60 cm	Very dark greyish brown	Loam	20	

Check site	CS1
Site description	Drainage line
Vegetation	*Pandanus spiralis*, *Lophostemon lactifluus*, *Planchonia careya*
Slope	1-2 %

North

East

South

West

Check site	CS2
Site description	Open forest, slope 5%
Vegetation	*Eucalyptus tetrodonta*, *Eucalyptus miniata*, *Livistona humilis*
Slope	0-1 %

North

East

South

West

Check site	CS3
Site description	Lower slope, minor drainage line
Vegetation	*Eucalyptus tetrodonta*, *Livistona humilis*, *Pandanus spiralis*, *Lophostemon lactifluus*
Slope	4-5 %

North

East

South

West

Check site	CS4
Site description	Woodland
Vegetation	*Eucalyptus tetrodonta*, *Eucalyptus miniata*, *Livistona humilis*, *Cycas armstrongii*
Slope	1-2 %

North

East

South

West

Check site	CS5
Site description	Open forest
Vegetation	*Eucalyptus tetrodonta, Eucalyptus miniata, Livistona humilis, Cycas armstrongii*
Slope	1-2 %

North

East

South

West

Check site	CS6
Site description	Open woodland, tall trees
Vegetation	*Eucalyptus tetrodonta, Eucalyptus miniata, Erythrophleum chlorostachys*, *Livistona humilis*
Slope	0 %

North

East

South

West