09

Biodiversity

9. Biodiversity

9.1 Introduction

This chapter describes the flora, vegetation and fauna present in the study area, including a description of biodiversity values at the species and ecosystem level, and in a local and regional context. This chapter also describes the potential direct and indirect impacts of the project on local and regional biodiversity, including TPWC listed threatened flora and fauna species. Mitigation measures that will be implemented in order to minimise the impact of project construction and operation area documented.

Section 5.4.1 of the Terms of Reference (TOR) for the preparation of an environmental impact assessment issued by the NT EPA for the Project provided the following environmental objective in relation to biodiversity:

> *The Project will maintain the conservation status, diversity, geographic distribution and productivity of flora and fauna, at the species and ecosystem levels, through the avoidance or management of adverse impacts.*

This chapter addresses the biodiversity values, as required in the TOR for the project.

The delegate of the Commonwealth Minister has determined that the project is a controlled action that has the potential to significantly impact listed threatened species and communities (under Sections 18 and 18A of *the Environment Protection and Biodiversity Conservation Act 1999* – EPBC Act). The project will be assessed under the Bilateral Agreement between the NT and Commonwealth governments.

Matters of National Environmental Significance (MNES) and other matters protected under the EPBC Act are discussed separately in Chapter 10. This chapter provides the environmental context and the detailed habitat information that is the background to a discussion of the impact on MNES.

Detailed flora and fauna assessments are provided in Appendix M and Appendix N respectively.

The total study area for flora and vegetation assessment is approximately 5, 692 ha (Figure 9-1). The study area for fauna, assessed on foot, vehicle and helicopter covered more than 110,000 ha (Figure 9-2) and included:

- approximately 65,000 ha in the Reynolds Range and Hann Range (both ranges are far larger than the area assessed) where targeted threatened species surveys (Chapter 10) were carried out for Black-footed Rock-wallaby, and
- 41,568 ha of the broader borefield area.

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0 2 4 6 8

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 53

N

LEGEND

- Water Bores
- Existing Roads
- Existing Access Track
- Waterways
- Study Area
- Borefield Area

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Study area (flora and vegetation) Figure 9-1

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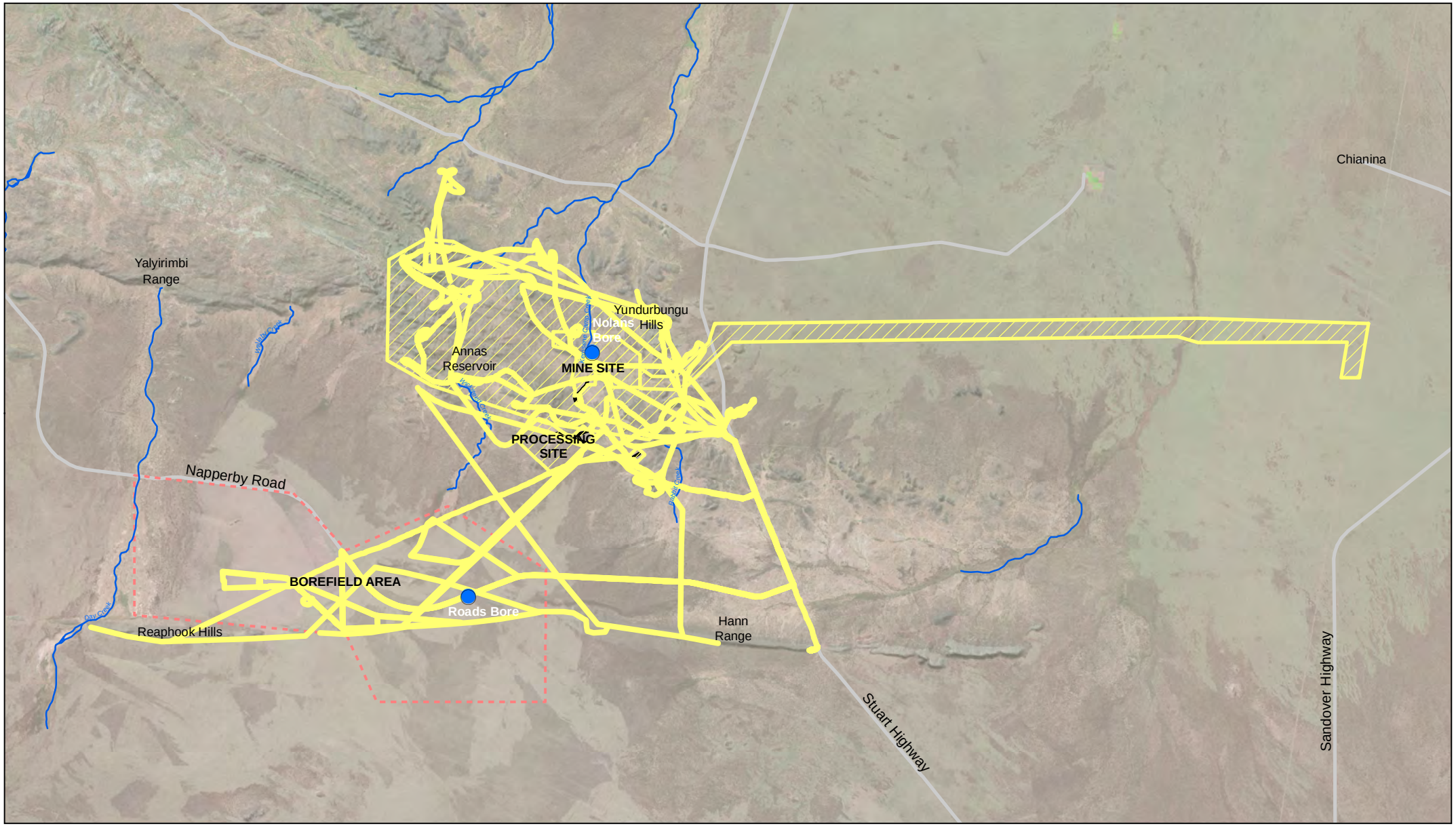
Level 5 66 Smith Street Darwin NT 0800 Australia **T** 61 8 8982 0100 **F** 61 8 8981 1075 **E** drwmail@ghd.com **W** www.ghd.com

Data source: GA - Imagery (2008), Roads, Waterways, Placenames (2015). ESRI - Shaded Relief (2009). ARL - Water Bores, Proposed Pipelines, Borefield Area, Proposed Mine Site, Treatment Plant and Accommodation Village (2015). Created by: CW, CM



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Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 53

N

LEGEND

- Water Bores
- Existing Roads
- Existing Access Track
- Waterways
- Study Area
- Borefield Area

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Study area (fauna)

Figure 9-2

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Level 5 66 Smith Street Darwin NT 0800 Australia **T** 61 8 8982 0100 **F** 61 8 8981 1075 **E** drwmail@ghd.com **W** www.ghd.com

Data source: GA - Imagery (2008), Roads, Waterways, Placenames (2015). ESRI - Shaded Relief (2009). ARL - Water Bores, Proposed Pipelines, Borefield Area, Proposed Mine Site, Treatment Plant and Accommodation Village (2015). Created by: CW, CM

9.2 Bioregional context

The study area is located within the Burt Plain Bioregion, on the Aileron and Napperby pastoral stations which have been used for grazing since the early 1880s.

The bioregion covers an area of 73,605 km^2, which represents approximately 5% of the Northern Territory (NRETAS 2005). It is characterised by arid to semi-arid plains and low rocky ranges with some of Australia's best established and most extensive mulga (*Acacia aneura*) and other acacia woodlands (NRETAS 2005). Geologically the bioregion lies over the Arunta Province, Tennant Inlier, and small areas of Georgina, Wiso and Ngalia basins, with metamorphic, plutonic, and sedimentary rocks of Precambrian age.

One of the distinguishing features of the Burt Plain Bioregion is the predominance of earthy, alluvial soils as opposed to sandplains and sand dunes. It also has a relatively high density of mountain ranges, in the east, north and west of the bioregion.

In the Reynolds Range, northwest of the Nolans site (Figure 1-6), Mt Thomas reaches 1113 m. Running parallel and to the north of the Reynolds Range are the Anmatjira and Yundurbulu Ranges, both with peaks over 1000 m above sea level (asl) and with significant long-term freshwater springs. These ranges generate the major north flowing rivers of the study area.

Running south from the Reynolds Range are Napperby Creek and also Gidyea and Day creeks, which carry water about 50 km to the ephemeral Lake Lewis and the surrounding swamps. The mean annual rainfall data shows a regional area of relatively high rainfall in the area of the Reynolds, Anmatjira and Yundurbulu Ranges, however there are no permanent natural waters in the creeks running north and south, despite the mountains.

There are five broad vegetation types that have been mapped within the bioregion (Wilson *et al.* 1990), the most abundant being Acacia woodland. Other broad vegetation types recorded within the bioregion include Eucalyptus low woodland with tussock grass understory, Eucalyptus woodland with hummock grass understory, Hummock grassland and Tussock grassland (NRETAS 2005).

The Burt Plain Bioregion is known to contain more than 1100 flora species and 350 fauna species. However, the bioregion is one of the most poorly documented bioregions in the Northern Territory in terms of its biodiversity values (Neave *et al.* 2006), and it is consequently recognised as a national priority bioregion for conservation planning. Less than 0.3% of the bioregion is reserved in National Parks and other conservation reserves (NRETAS 2005).

There are 16 sites of botanical significance within the Burt Plain Bioregion, none of which occur within or near the study area (Neave *et al.* 2006). There are six sites in the bioregion that are listed in the directory of important wetlands. None of these are within or near the Nolans site.

There are no sites of conservation significance in or near the study area. Lake Lewis site of conservation significance is 30 km to the west.

Potential and existing threats to biodiversity that have been identified within the bioregion include exotic flora, introduced animals, fire, erosion, land clearing, grazing and mining (Neave *et al.* 2006). Much of the bioregion has been impacted by a range of broadscale processes such as grazing by livestock and/or feral animals, feral predators and weed infestations.

Exotic species are widespread and there are fifteen declared weed species currently listed under the *Northern Territory Weeds Management Act 2001* known to occur in the Burt Plain Bioregion. Other exotic plants species, most notably buffel and couch grass, also pose significant threats to some habitats.

9.2.1 Fauna and Habitat Characteristics (Neave *et al* 2006)

The fauna and flora habitat of the Burt Plain Bioregion are characterised by the following:

- Vegetation is predominantly mulga and other acacia woodlands with short grasses and forbs, and spinifex grasslands.
- Of the 1100 flora species, three are listed as vulnerable under the *Territory Parks and Wildlife Conservation Act* (TPWC Act) and one is listed as vulnerable under the EPBC Act. Additionally, 64 species are listed as data deficient, 41 listed as near threatened in the Northern Territory, and seven listed as endemic to the bioregion have been recorded.
- Much of the Burt Plain Bioregion was burnt in the summer months in 2001 and 2002. This wildfire period followed very wet years in 2000 and 2001. Fire appears to have been insignificant at other times i.e. between 1997 and 2005. Major fires in this period occurred between April and November and were probably less intense. As with other central Australian bioregions, the overall condition of the Burt Plain Bioregion is masked by a very strong rainfall effect, with degradation sometimes difficult to detect following a series of good seasons. Much of the bioregion has been impacted by grazing livestock and/or feral animals, feral predators and weed infestations. There are 19,500 records for 359 vertebrate species for the Burt Plain Bioregion. The majority of these are:
  - Birds (16,341 records and 183 species; 51.0% of all species)
  - Mammals (1,643 records and 63 species; 17.5% of species)
  - Reptiles (1,436 records and 104 species; 29.0% of species)
  - Frogs (80 records and 9 species; 2.5% of species).
- Although this species list appears comprehensive, the animals of the Burt Plain Bioregion are relatively poorly known and documented. Furthermore, an understanding of the habitat requirements of many species and species assemblages is limited.
- From a national and Northern Territory perspective, no extant vertebrate species are considered endemic to the bioregion.
- The Burt Plain Bioregion has suffered a substantial reduction in its mammal fauna over the last century. There are ongoing declines of some bird and mammal populations. Introduced predators are widespread. At least 15 of the 54 indigenous mammal species recorded from the bioregion are extinct or no longer occur in the bioregion. Several others have suffered population declines. Between two atlas projects conducted by Birds Australia (in the late 1970s and early 1980s, and again in the late 1990s and early 2000s), the Hooded Robin was found to have suffered a substantial decline. Several other birds are suspected to have undergone significant declines in the bioregion since European colonisation.

9.2.2 Previous disturbance and site history

The local area around the Nolans site has been used as grazing land for many years. There is evidence of clearing and disturbance associated with livestock primarily in the vicinity of Nolans Bore. This bore, including cattle yards, was for a long time the only stock watering point in a 15 km^2 area. As a consequence, vegetation in and around the bore has suffered significant long term degradation.

Vegetation clearing within and surrounding the Nolans site also has been associated with construction of a gas pipeline, the development of the Stuart Highway and a range of other roads and tracks.

An abrupt tree-line surrounding the paddock north-east of Nolans Bore suggests that that area (approximately 20 ha) has been cleared for grazing. Mineral exploration activity has also contributed to localised losses of native vegetation, in association with drilling, vehicle access etc.

9.3 Methodology

9.3.1 Desktop review

The following databases and literature sources were reviewed prior to conducting the field investigations:

- The Northern Territory Herbarium (Holtze) Database – to identify flora species previously recorded within a 20 km radius of the study area (DLRM 2015)
- The Department of Land Resource Management (DLRM) Fauna Atlas database was used to identify actual records of all fauna species known to occur within 10 km of the study area
- Commonwealth Department of the Environment (DotE) Protected Matters Search Tool (PMST) – to identify Matters of National Environmental Significance (MNES) listed under the EPBC Act potentially occurring in the locality (20 km radius) in February 2015
- Northern Territory land systems/vegetation mapping of the Southern Alice Springs District (NRETAS 2000)
- Aerial imagery – for preliminary vegetation map and to help stratify the placement of flora quadrats for the field survey
- Bureau of Meteorology online data (BOM 2015)
- Mapping of Sites of Conservation Significance in the Northern Territory (DLRM 2015)
- A fauna species list for the Burt Plain Bioregion
- Past survey reports to identify additional flora and fauna species records in or near the study area since 2006 and
- Other literature relevant to the study as part of the desktop assessment.

A number of ecological assessments for the Nolans Project have been completed over the period 2006 to 2015. These are summarised in Table 9-1. Baseline flora and fauna surveys were most recently undertaken from 27 April to 3 May 2015, and the methodology is detailed in the sections below.

Table 9-1 Summary of flora and fauna assessment at the Nolans Site 2006 to 2015

Date	Reference	Description
4 – 7 May 2006	Low Ecological Services	Flora and fauna survey of mine site.
21 – 24 November 2006	Low Ecological Services	Flora and fauna survey of mine site.
16-25 August 2010	GHD	Flora survey of the mine site and transport corridor (transport corridor no longer proposed).
30 August – 8 September 2010	GHD	Baseline fauna survey of mine site and a proposed haul route (note: haul route no longer included in proposed project footprint).

Date	Reference	Description
6 to 8 December 2011	GHD	Flora survey of the transport corridor (transport corridor no longer proposed), power station and accommodation village.
8 – 9 December 2011	GHD	Targeted Black-footed Rock-wallaby (MacDonnell Ranges race) survey of mine site only.
27 April – 3 May 2015	GHD	Flora and Baseline fauna survey of current project area incl. mine site, processing site, accommodation facility, access roads, utilities corridor (potable water pipeline, process water supply pipeline, power line corridor) and borefield area.
23 – 26 July 2015	GHD	Targeted surveys for Black-footed Rock-wallaby in the eastern end of the Reynolds Range, Hann Range, Reaphook Hills and outcrops in between.
21 – 23 July 2015.	GHD	The borefield area targeted surveys were undertaken to detect presence of any threatened species including the Great Desert Skink, Brush-tailed Mulgara and Greater Bilby.

9.3.2 Flora and vegetation assessment

Flora survey included local vegetation community mapping and botanical inventories; and an assessment of the condition of flora and vegetation communities within the study area.

A random-stratified approach was used to survey a representative range of floristic communities and habitats across the study area. Sampling units were determined based on vegetation and geology characteristics and mapping. Survey methods included flora quadrats, rapid check sites and random meander. Locations of survey quadrats were recorded with handheld GPS unit.

Due to the size of the study area and access limitations, the entire site could not be assessed during the field survey. Therefore, a subset of the study area was ground-truthed and the remaining extent of vegetation communities was mapped by extrapolation and interpretation of aerial imagery.

Flora survey techniques used in the baseline surveys were consistent with the *Northern Territory Guidelines and Field Methodology for Vegetation Survey and Mapping* (Brocklehurst *et al.* 2007). All surveys were conducted in accordance with TPWC Act permits issued to GHD by the Northern Territory Parks and Wildlife Commission.

A detailed description of the field survey methodology for flora and vegetation is contained in Appendix M.

9.3.3 Fauna assessment

Prior to the field investigations, aerial imagery and maps were used as a basis for initial selection of sites for flora and survey. Results from previous survey, where available was used as a basis for preliminary selection of sites for fauna survey.

Sites were then ground-truthed on the first day at the site, to verify their vegetation/habitat characteristics, or to move them to more appropriate locations (e.g., away from heavily disturbed areas). The choice of sites was made in an effort to maximise the likelihood of detecting fauna, including threatened species.

Special consideration was given to habitats that were considered most likely to support threatened fauna species and/or populations listed under the EPBC Act and/or TPWC Act, in

accordance with the NT EPA TOR. These included, but were not limited to Black-footed Rock-wallaby (*Petrogale lateralis* MacDonnell Ranges race), Great Desert Skink (*Liopholis kintorei*) and Greater Bilby (*Macrotis lagotis*). These species, and fauna assessment relating to threatened species, are discussed in more detail in Chapter 10.

Weather

The conditions encountered during the surveys were generally acceptable for baseline fauna surveys, particularly daytime temperatures and conditions. However, the wet 24-hour period during 2010 and the relatively cool nights in the early part of the 2015 survey are considered likely to have resulted in less fauna activity than would otherwise be expected.

Survey techniques

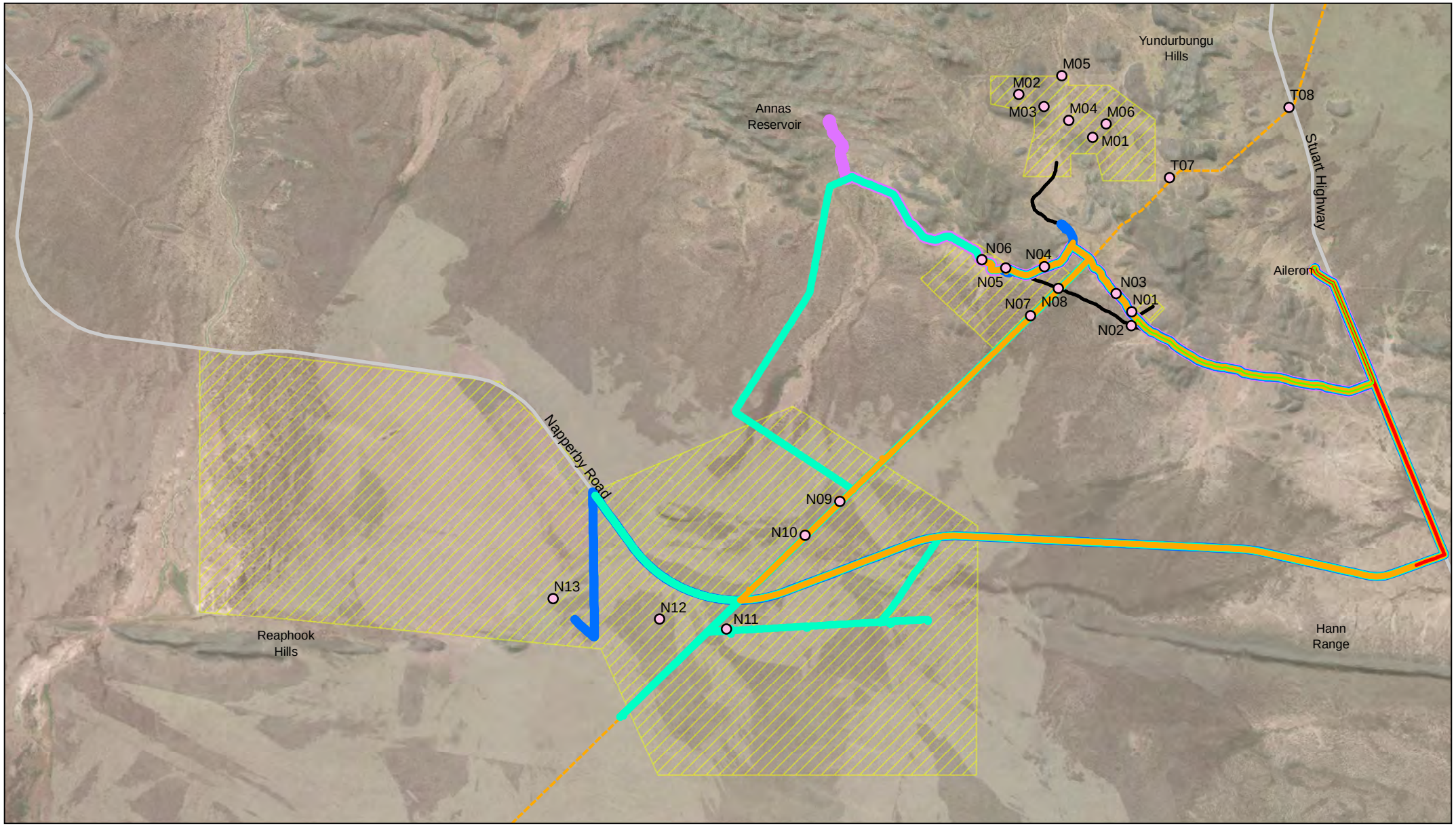
Survey techniques followed the *Standard terrestrial vertebrate survey methods used by the Department of Land Resource Management*. The survey methodologies employed summarised in Table 9-2 and survey effort is illustrated in Figure 9-3 and Figure 9-4.

Table 9-2 Summary of fauna survey effort at sites during the 2010 and 2015 baseline fauna surveys

Survey	2010: Mine Site Area	2010: Haul Route	2015 survey
Survey Type	**6 survey sites (M01 to M06)** **31 Aug to 8 Sept 2010**	**6 transects (T07 to T12)** **2 to 8 Sept 2010**	**13 survey sites (N01 – N13)** **27 April to 3 May 2015**
Habitat assessment	Each survey site – ~1 hour ~25 km of driven tracks ~4 person hours investigating elsewhere	Each survey site – ~1 hour ~60 km of driven tracks ~4 person hours investigating elsewhere	Conducted over approximately two person-hours per site, investigating quadrat area through various survey methods
Pitfall trapping	Sites M01, M04, M05, M06 – 3 nights, 4 trap lines each with one bucket Sites M02 & M03 – 3 nights, 2 trap lines each with one bucket 60 trap-nights	Site T07 – one night, 4 trap lines each with one bucket Site T08 – 4 nights, 4 trap lines each with one bucket 20 trap-nights	Four 10m pitfall traplines, each with one bucket, for ten sites (N01 – N10), checked twice daily for four days and nights 160 trap-nights
Funnel trapping	Sites M01, M04, M05, M06 – 3 nights, 4 trap lines each with 2 funnels (and one bucket) Sites M02 & M03 – 3 nights, 2 trap lines each with 2 funnels (and one bucket) Sites M02 & M03 – 3 nights, 2 trap lines each with 3 funnels 156 trap-nights	Site T07 – one night, 4 trap lines each with 2 funnels (and one bucket) Site T08 – 4 nights, 4 trap lines each with 2 funnels (and one bucket) Sites T09 to T12 – 3 nights, 4 trap lines each with 3 funnels 184 trap-nights	Ten sites (N01 – N10), each with four 10m pitfall traplines, each trapline with two funnels (and one bucket), for four nights. Ten sites (N01 – N10), each with two funnel traplines (two funnels on each) over four nights. Four 10m traplines (each with two funnel traps) for three sites (N11 – N13). 504 trap-nights in total
Elliot trapping	Six sites (M01 – M06) - 20 traps at each, for 3 days and nights, checked twice daily 360 trap-nights	Site T07 - 20 traps for 2 days and one night Site T08 - 20 traps for 4 days and nights, checked twice daily Site T09 to T12 - 20 traps for 3 days and nights, checked twice daily 340 trap nights	Ten sites (N01 – N10), each with 20 baited Elliot traps for four nights. Three sites (N11 – N13), each with 10 Elliot traps for three sites, checked twice daily for four days and nights. 920 trap-nights

Survey	2010: Mine Site Area	2010: Haul Route	2015 survey
Survey Type	**6 survey sites (M01 to M06)** **31 Aug to 8 Sept 2010**	**6 transects (T07 to T12)** **2 to 8 Sept 2010**	**13 survey sites (N01 – N13)** **27 April to 3 May 2015**
"Anabat"®	All six sites (M01 – M06) – one unit for two nights 12 Anabat survey-nights in total	Sites T07, T09 to T11 – one unit for two nights Site T08 and T12 – one unit for one night 10 Anabat survey-nights in total	Eight sites, one survey-night at each (N02, N03, N04, N05, N08, N11, N13, waterhole near gate) 8 survey-nights in total
Remote surveillance cameras	All six sites (M01 – M06) – one unit for three nights 18 camera survey-nights in total	Site T07 – one unit for one night Site T08 – one unit for four nights Site T09 to T12 – one unit for three nights 17 camera survey-nights in total	Eleven units were deployed during the survey, each for at least 30 days and nights (N05, N06, N08, N11 and N13, three cameras at burrow/latrine site, and one along Fence track). At least 330 camera survey-nights in total
Active searches (diurnal)	Each site – two diurnal searches of 10+ minutes each Minimum of 2 hours active searching 8+ scats and 1 bone sample collected and sent for analysis	Each site – two diurnal searches of 10+ minutes each Minimum of 2 hours active searching 3+ scats and one bone collected and sent for analysis	Conducted opportunistically by at least one ecologist at sites and other locations, depending on conditions Minimum of 1.5 hours active searching per site
Active searches (nocturnal)	Each site – one nocturnal search of 10+ minutes each Minimum of 1 hour active searching	Each site – one nocturnal search of 10+ minutes each Minimum of 1 hour active searching	3 x three-hour nocturnal searches by four teams of two people at sites and other locations, including road spotlighting through study area and along existing access tracks Minimum of 72 person-hours active searching in total
Instantaneous bird counts	Each site – one nocturnal bird count; Diurnal counts: M01 - 6; M02, M03, M05 & M06 – 8; M04 - 10 54 instantaneous bird counts in total	Each site – one nocturnal bird count Diurnal counts: T07, T10 & T11 – 6; T08 – 8; T09 & T12 – 5 42 instantaneous bird counts in total	At least four 20 minute diurnal surveys at each site, incorporating 'instantaneous bird counts' 52 bird counts in total.

Survey	2010: Mine Site Area	2010: Haul Route	2015 survey
Survey Type	**6 survey sites (M01 to M06)** **31 Aug to 8 Sept 2010**	**6 transects (T07 to T12)** **2 to 8 Sept 2010**	**13 survey sites (N01 – N13)** **27 April to 3 May 2015**
Opportunistic (incidental) observations	Four zoologists over four 12 hour days during set-up and survey, total survey effort 192 hours 420+ observations recorded	Four zoologists over four 12 hour days during set-up and survey, total survey effort 192 hours 90 observations recorded	Eight zoologists and four rangers over the entire survey period (five 12-hour days during set-up and survey). Minimum of 720 person-hours of opportunistic observation.
Snail searches	Two zoologists targeting snail collection in areas of suitable habitat on two days (5-6 Sept 2010), plus opportunistically at other times. Minimum of 4 hours active searching	Four zoologists targeting snail collection in areas of suitable habitat on one day (7 Sept 2010), plus opportunistically at other times. Minimum of 4 hours active searching	Assessed / Collected opportunistically. Snails sent to NT Museum.



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0 2 4 6 8

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 53

N

LEGEND

- Fauna Sites
- Roads
- Gas Pipeline
- Access Roads

Survey Tracks

- Day 1
- Day 2
- Day 3
- Day 4
- Day 5
- Day 6
- Study Area

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2015 Baseline fauna survey effort nocturnal coverage of study area

Figure 9-3

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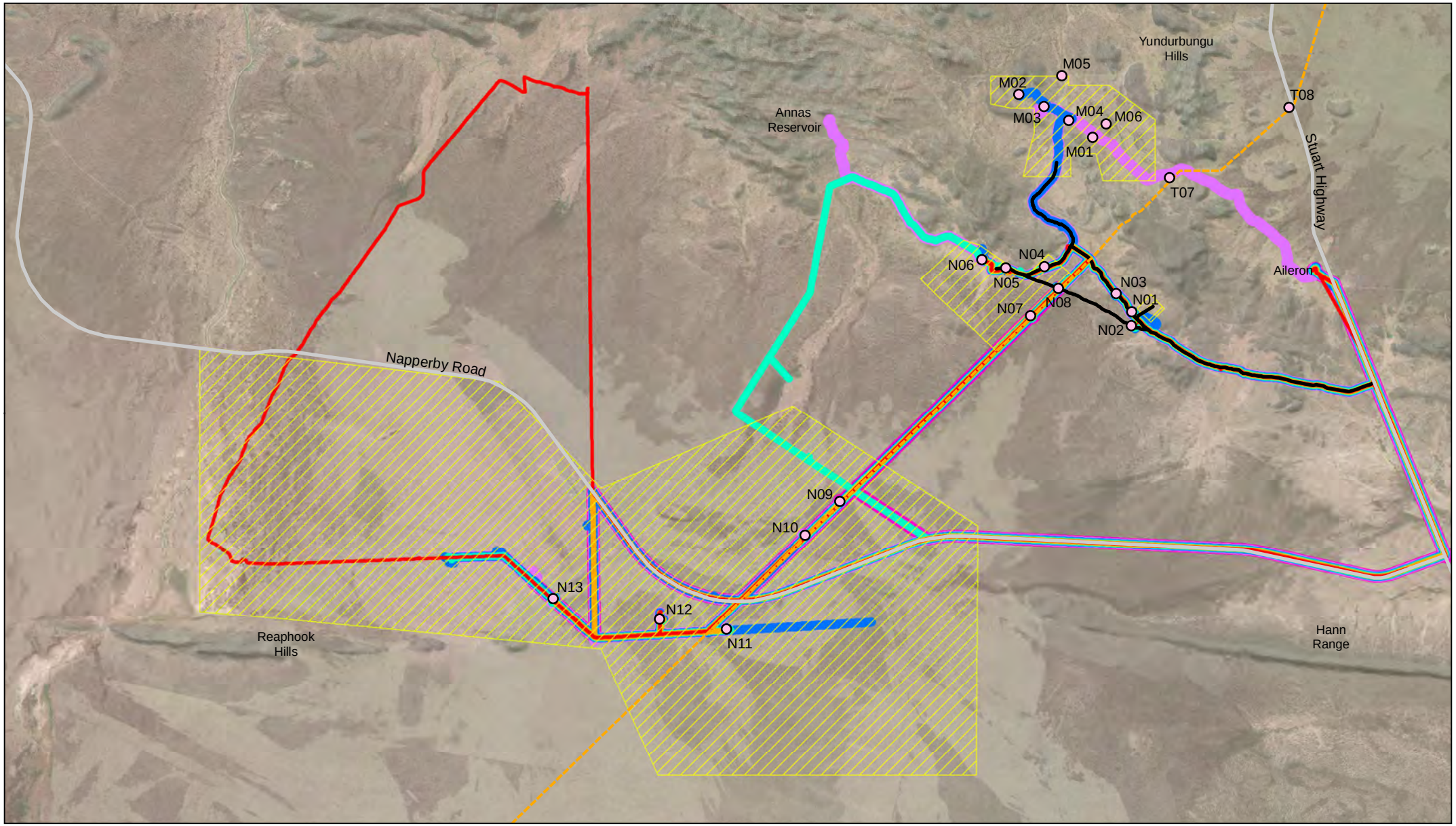
Level 5 66 Smith Street Darwin NT 0800 Australia **T** 61 8 8982 0100 **F** 61 8 8981 1075 **E** drwmail@ghd.com **W** www.ghd.com

Data source: GA - Imagery (2008), Roads, Gas Pipeline (2015). GHD - Fauna Survey Sites, Proposed Mine Site, Proposed Treatment Plant, Proposed Accommodation Village, Borefield Area (2015). Created by: CM



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0 2 4 6 8

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 53

N

LEGEND

- Fauna Sites
- Roads
- Gas Pipeline
- Access Roads

Survey Tracks

- Day 1
- Day 2
- Day 3
- Day 4
- Day 5
- Day 6
- Day 7

Study Area

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2015 Baseline fauna survey effort diurnal coverage of study area

Figure 9-4

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Level 5 66 Smith Street Darwin NT 0800 Australia **T** 61 8 8982 0100 **F** 61 8 8981 1075 **E** drwmail@ghd.com **W** www.ghd.com

Data source: GA - Imagery (2008), Roads, Gas Pipeline (2015). GHD - Fauna Survey Sites, Proposed Mine Site, Proposed Treatment Plant, Proposed Accommodation Village, Borefield Area (2015). Created by: CM

9.4 Results – flora and vegetation

9.4.1 Desktop assessment

The desktop assessment identified the following:

- There are no records of threatened flora species listed under the TPWC Act in the locality however there are six near threatened species, five species endemic to the Northern Territory and eight species recorded as being data deficient.
- There have been 19 exotic species recorded within the locality.
- There are ten threatened plant taxa known to occur in the Burt Plain Bioregion however based on an assessment of habitats within the study area it is unlikely that any of these species would occur in the study area.
- Previous surveys by Low Ecological Services (2007) recorded 185 flora species, of which none are listed as having conservation significance under the EPBC or TPWC Acts.
- The Northern Territory Government database (DRLM 2013) identifies four National Vegetation Information System vegetation types within the study area:
  - Corymbia low woodland/Acacia tall open shrubland/Eragrostis low open tussock grassland
  - Eucalyptus low open woodland/Acacia mid open shrubland/+Triodia low hummock grassland
  - Acacia tall open shrubland/Eragrostis low tussock grassland
  - Acacia mid open mallee woodland/Acacia mid sparse shrubland/+Triodia low hummock grassland.
- The PMST results did not identify any flora species listed under the EPBC Act that are known or predicted to occur in the locality.
- No EPBC Act-listed Threatened Ecological Communities are known or predicted to occur within or near the study area. Only one ecological community is listed in the Northern Territory as threatened under the EPBC Act (Arnhem Plateau Sandstone Shrubland Complex), and this does not occur within or near the study area.
- There are 67 sites of conservation significance across the Northern Territory; none of these occur within or near the study area.

9.4.2 Flora and vegetation survey

A combined total of 326 flora species, comprising 319 native species and 15 exotic species were recorded within the study area during the 2011 and 2015 survey periods.

The Poaceae (grass family, 73 species, 67 native; 6 exotic), Fabaceae (pea family, 40 species, 39 native, one exotic), Chenopodiaceae (32 native species) and Malvaceae (25 native species) were the most species-rich families recorded.

Flora species recorded within the study area and their associated vegetation communities are relatively common in the region with the exception of a few species. No threatened plants were recorded within the study area. Three species recorded within the study area are listed as near threatened (NT) and three species are listed as data deficient under the TPWC Act. An additional 11 species are noted to have bioregional significance.

The full list of plant species recorded within the study area is presented in Appendix M.

Vegetation communities

A total of 14 vegetation communities were identified within the study area. These vegetation communities each display a degree of variation which is to be expected given the influence of differing geology, soils, hydrology, fire regimes and grazing pressures. Despite these variations these communities have been defined based on similarities in landscape position, floristics, vegetation structure and patterns.

The dominant vegetation types within the study area are Mulga shrublands, which occur on alluvial fans and plains containing clayey red earths and Triodia hummock grasslands which grow on sandy plains. Vegetation across the study area is generally in good condition with little anthropologic disturbance and high species richness.

In more fertile riparian areas and associated floodplains there is clear evidence of impacts associated with cattle grazing including weed invasion, reduction in ground cover species richness and soil erosion. In particular, there is a high abundance of the invasive grass *Cenchrus ciliaris* (Buffel Grass). There are also several areas that have been cleared within the mine site and borefields area during geotechnical and hydrological investigations at these sites.

Vegetation communities identified and mapped within the study area and their relative abundance are summarised in Table 9-3 and their distributions shown in Figure 9-5.

A detailed description of each vegetation community present within the study area is provided in Appendix M.

Adjacent to the access road to the proposed accommodation village is a small Coolabah Swamp. Although this vegetation is not within the project site it has been included in the assessment as there is potential for this wetland to be indirectly impacted by the project.

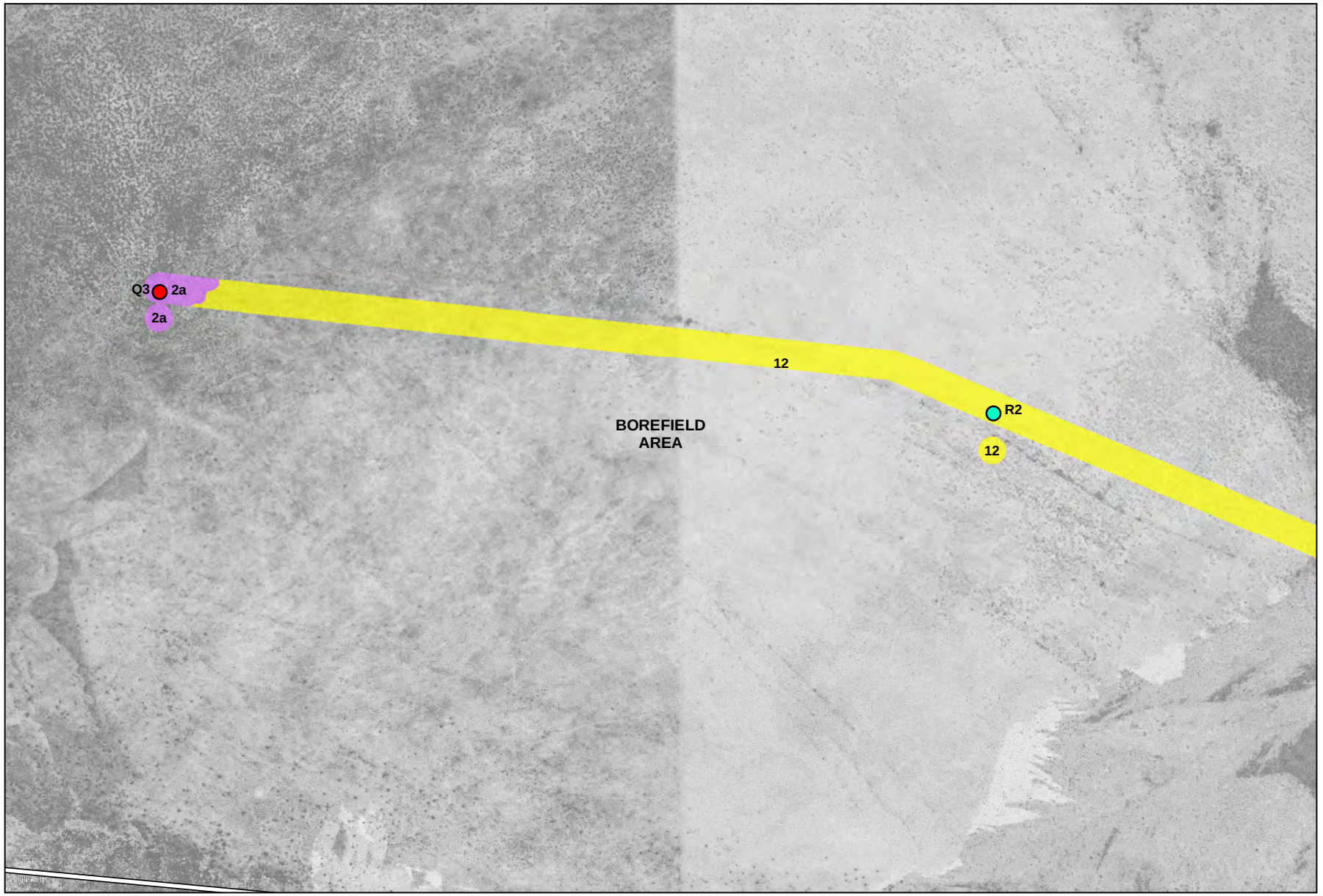
Table 9-3 Comparisons of vegetation communities within study area with Albrecht and Pitts (2004) vegetation types

Nolans Project 2010/11 and 2015 mapping		Area (ha)	% of study area	Albrecht and Pitts (2004) mapping	
Vegetation type	**Description**			**Vegetation type**	**Description**
1	Riparian woodland along water courses and drainage channels	261.1	4.6	22	Large sandy red gum creeklines
2a	Mulga shrubland on sandy red earths over spinifex	46.4	0.8	16	Mulga in valleys with red earth soils
2b	Mulga shrubland on sandy red earths over tussock grasses	1756.8	30.8	16	Mulga in valleys with red earth soils
2c	Mulga shrubland on sandy red earths over chenopods	41.6	0.6	16	Mulga in valleys with red earth soils
3a	Mixed woodland over tussock grasses on alluvial plains	780.2	13.7	17	Ironwood and fork-leaved corkwood on alluvial flats
3b	Mixed Woodland over spinifex on alluvial plains	31.2	0.5	N/A	Not described by Albrecht and Pitts 2004
3c	Mixed Woodland over a highly disturbed understorey dominated by *Cenchrus ciliaris*	21.8	0.4	N/A	Not described by Albrecht and Pitts 2004
4	*Triodia schinzii* hummock grassland on red clayey sands	0*	0*	N/A	Not described by Albrecht and Pitts 2004

5	Hakea/Senna shrubland on calcareous alluvial plains and low rises	232.5	4.1	N/A	Not described by Albrecht and Pitts 2004
6	Eucalyptus (mallee)/*Acacia kempeana* shrubland with Triodia on rocky slopes	59.9	1.0	1	Hillside spinifex and mallee on quartzite slopes
7	Acacia/Triodia shrubland on rocky outcrops	226.6	4.0	1 & 3	Hillside spinifex and mallee on quartzite slopes; hillside spinifex on hills of granite, gneiss or schist
8	Acacia/Senna shrubland on rocky gneiss or schist outcrops with no spinifex	3.2	0.05	4	Witchetty Bush and/or Mulga on rocky hills of granite, gneiss or schist
9	*Acacia kempeana* and/or Mulga shrubland on gravel	126.3	2.2	5	Witchetty Bush and/or Mulga on gravelly rises of granite, gneiss, schist or quartz
10	Claypans with chenopods and herbs	0.3	0.005	25	Claypans often with a fringing sandy herbfield
11	Cottonbush chenopod shrubland on highly erodible duplex soils	13.5	0.2	18	Needlebush and Cottonbush on erodible sandy-clay flats
12	*Triodia basedowii* hummock grassland on sand plains	851.9	14..9	14	Rises of loose sand with hard spinifex

13	Senna shrubland on quartz	16.6	0.3	8	Whitewood and Senna on gravelly rises associated with silcrete outcrop
14	Coolabah swamp associated with claypans	2.6	0.04	24	Coolabah associated with claypans
2a/2b	Mulga shrubland on sand red earths over tussock grasses / Mulga shrubland on sandy red earths over spinifex	1155.1	20.3	16	Mulga in valleys with red earth soils
2b/3a	Mulga shrubland on sandy red earths over tussock grasses / Mixed woodland over tussock grasses on alluvial plains	11.8	0.2	N/A	Not described by Albrecht and Pitts 2004
3a/12	Mixed woodland over tussock grasses on alluvial plains / Cottenbush chenopod shrubland on highly erodible duplex soils	20.2	0.4	N/A	Not described by Albrecht and Pitts 2004
3b/2b	Mixed woodland over spinifex on alluvial plains / Mulga shrubland on sandy red earths over tussock grasses.	25.6	0.4	N/A	Not described by Albrecht and Pitts 2004
TOTAL		**5704 ha**			

*This vegetation type was recorded only along the transport corridor that is no longer part of the study area.



Vegetation Community

1	Riparian woodland along water courses and drainage channels
2a	Mulga shrubland on sandy red earths over spinifex
2a / 2b	Mulga shrubland on sandy red earths over tussock grasses / Mulga shrubland on sandy red earths over spinifex
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2c	Mulga shrublands on sandy red earths over chenopods
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3a / 12	Mixed woodland over tussock grasses on alluvial plains / Cottonbush chenopod shrubland on highly erodible duplex soils
3b	Mixed woodland over spinifex on alluvial plains
3b / 2b	Mixed woodland over spinifex on alluvial plains / Mulga shrubland on sandy red earths over tussock grasses
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12	*Triodia basedowii* hummock grassland on sandplains
13	Senna shrubland on quartz
14	Coolabah swamp associated with claypans

1:40,000 @ A4

0 250 500 750 1,000

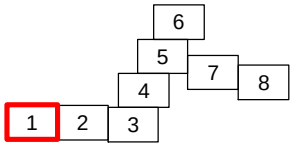
Metres

Map Projection: Universal Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 53

N

LEGEND

- Checksites
- Quadrats 2015
- Quadrats 2011
- Existing Roads
- Site Boundaries



Arafura Resources Limited
Nolans Project
Environmental Impact Statement

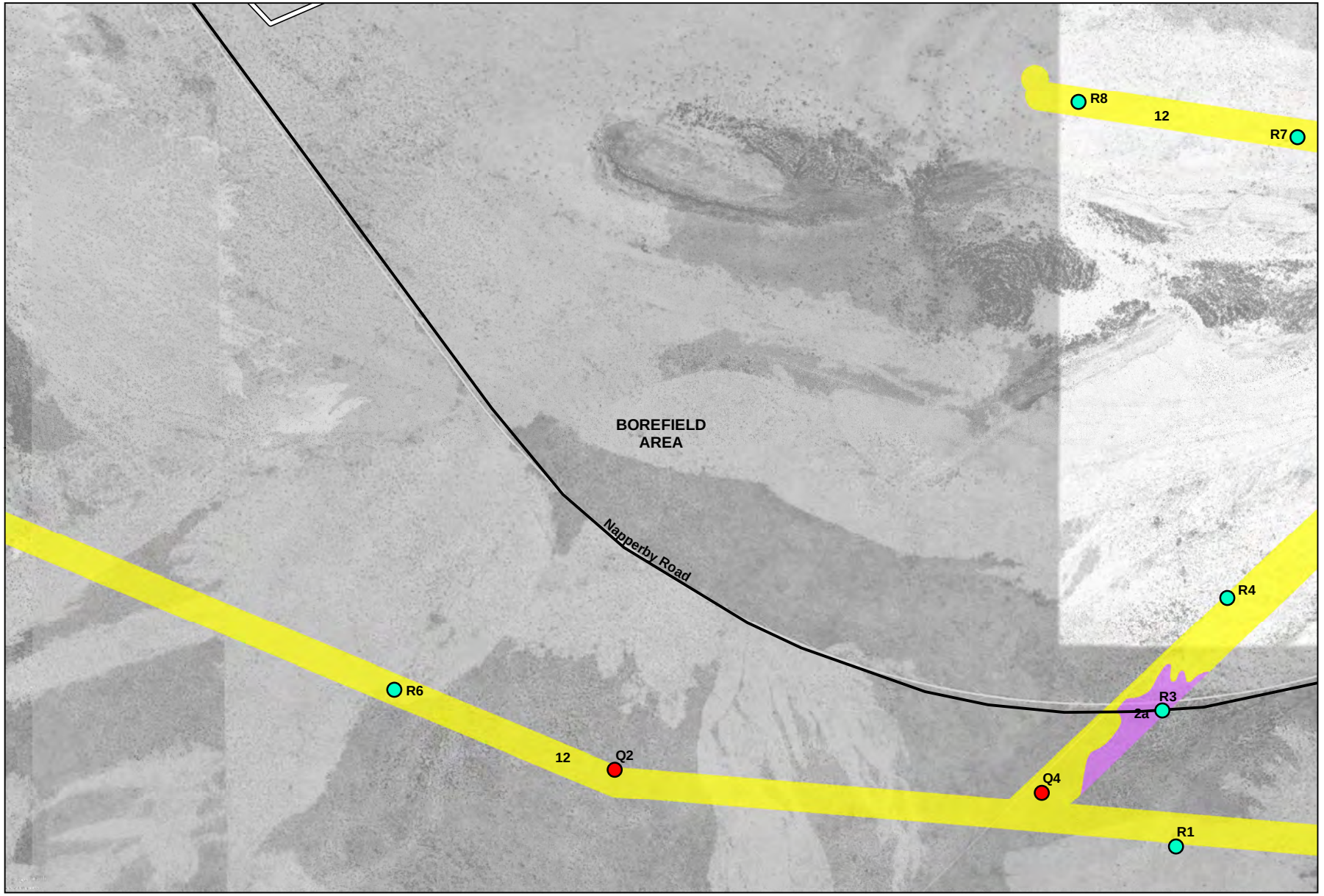
Job Number	4322301
Revision	0
Date	18 Mar 2016

Vegetation communities within the Study area Figure 9-5 (Page 1 of 8):

G:\43\22301\GIS\Maps\4322301_029_VegetationMappingQuadrats.mxd

Level 5 66 Smith Street Darwin NT 0800 Australia **T** 61 8 8982 0100 **F** 61 8 8981 1075 **E** drwmail@ghd.com **W** www.ghd.com

Data source: Google Earth Pro - Imagery (Date extracted: 16/06/2015). GA - Roads (2015). GHD - Vegetation Data (2015). Created by: CM



Vegetation Community

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13	Senna shrubland on quartz
14	Coolabah swamp associated with claypans

1:40,000 @ A4

0 250 500 750 1,000

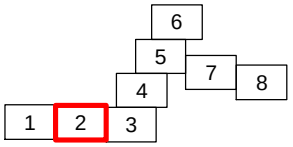
Metres

Map Projection: Universal Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 53

N

LEGEND

Checksites
Quadrats 2015
Quadrats 2011
Existing Roads
Site Boundaries



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Nolans Project
Environmental Impact Statement

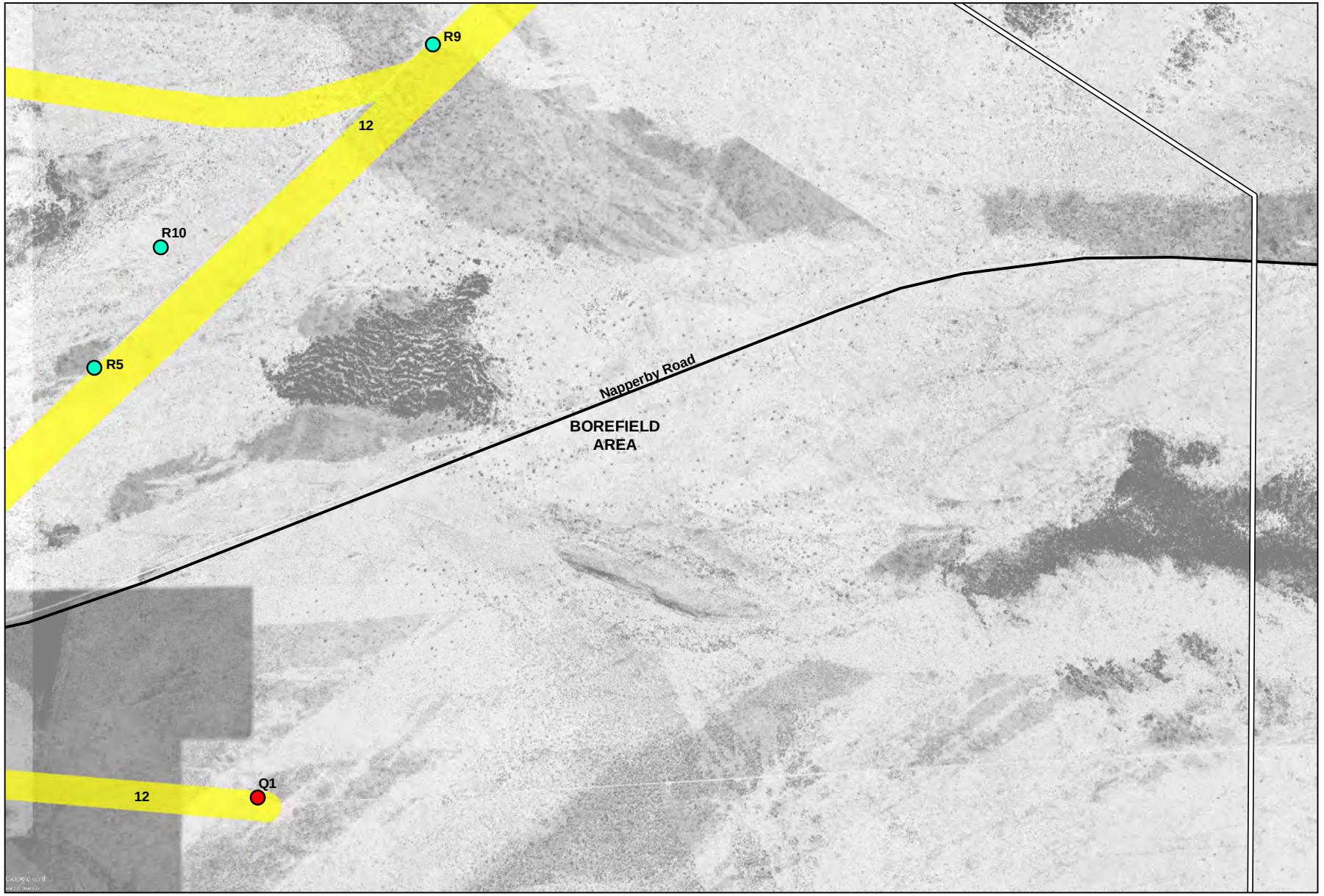
Job Number 4322301
Revision 0
Date 18 Mar 2016

Vegetation communities within the Study area Figure 9-5 (Page 2 of 8):

G:\43\22301\GIS\Maps\4322301_029_VegetationMappingQuadrats.mxd

Level 5 66 Smith Street Darwin NT 0800 Australia T 61 8 8982 0100 F 61 8 8981 1075 E drwmail@ghd.com W www.ghd.com

Data source: Google Earth Pro - Imagery (Date extracted: 16/06/2015). GA - Roads (2015). GHD - Vegetation Data (2015). Created by: CM



Vegetation Community

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1:40,000 @ A4

0 250 500 750 1,000

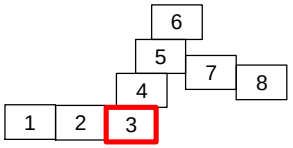
Metres

Map Projection: Universal Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 53

N

LEGEND

Checksites
Quadrats 2015
Quadrats 2011
Existing Roads
Site Boundaries



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Nolans Project
Environmental Impact Statement

Job Number 4322301
Revision 0
Date 18 Mar 2016

Vegetation communities within the Study area Figure 9-5 (Page 3 of 8):

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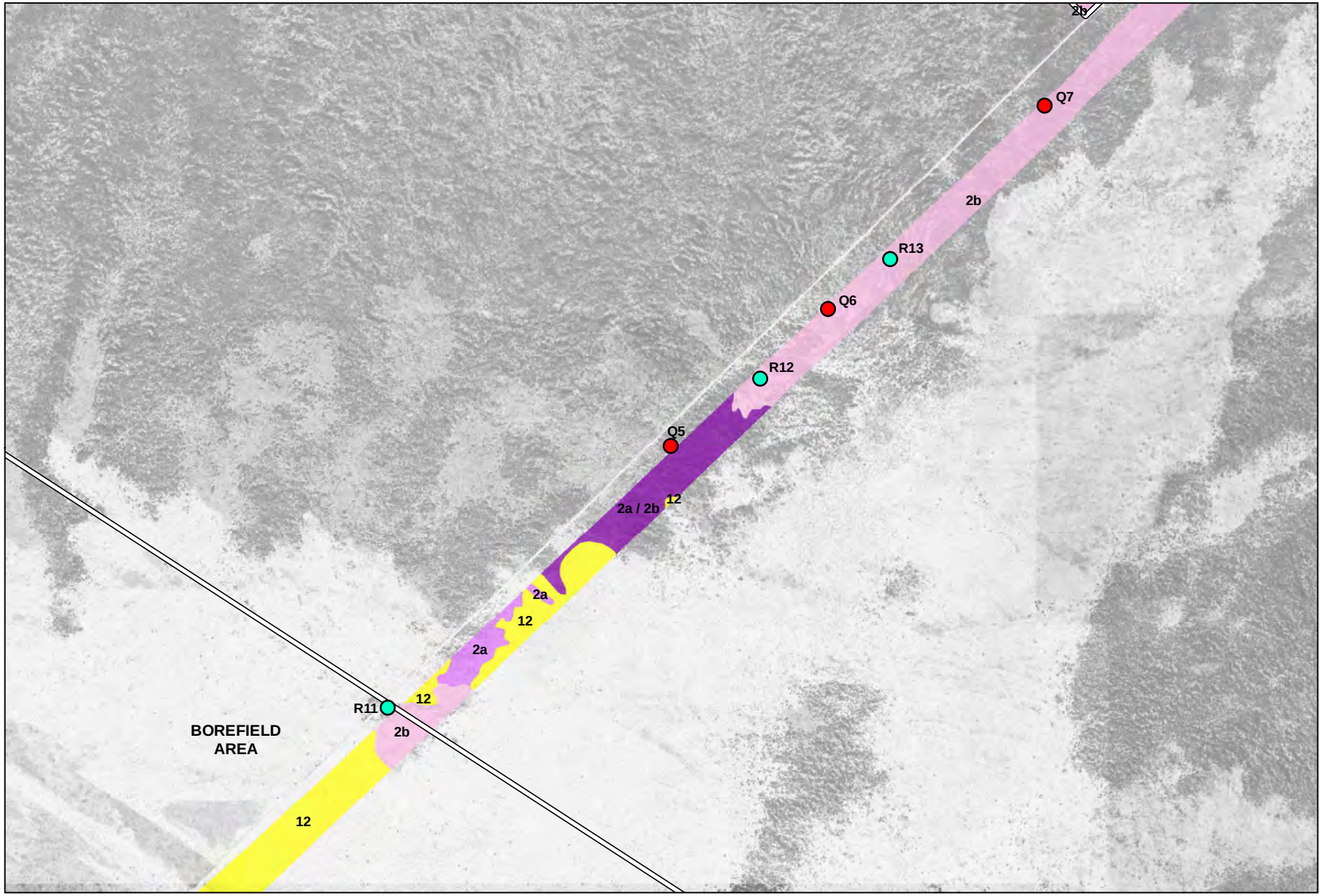
Data source: Google Earth Pro - Imagery (Date extracted: 16/06/2015). GA - Roads (2015). GHD - Vegetation Data (2015). Created by: CM



Vegetation Community

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1:40,000 @ A4

0 250 500 750 1,000

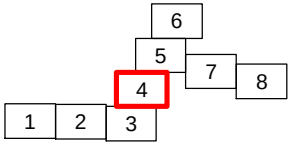
Metres

Map Projection: Universal Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 53

N

LEGEND

Checksites
Quadrats 2015
Quadrats 2011
Existing Roads
Site Boundaries



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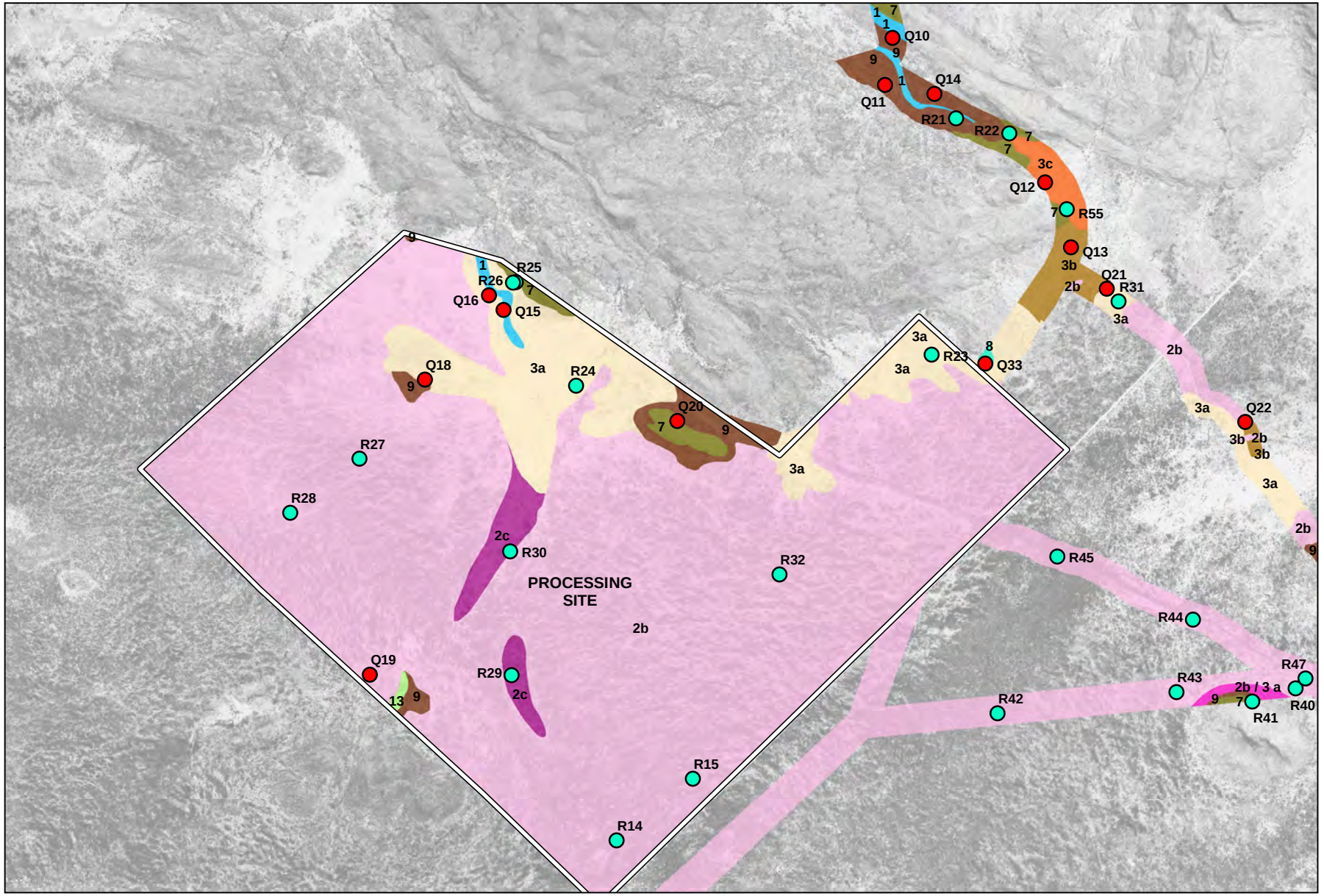
Revision 0
Date 18 Mar 2016

Vegetation communities within the Study area Figure 9-5 (Page 4 of 8):

G:\43\22301\GIS\Maps\4322301_029_VegetationMappingQuadrats.mxd

Level 5 66 Smith Street Darwin NT 0800 Australia T 61 8 8982 0100 F 61 8 8981 1075 E drwmail@ghd.com W www.ghd.com

Data source: Google Earth Pro - Imagery (Date extracted: 16/06/2015). GA - Roads (2015). GHD - Vegetation Data (2015). Created by: CM



Vegetation Community

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1:40,000 @ A4

0 250 500 750 1,000

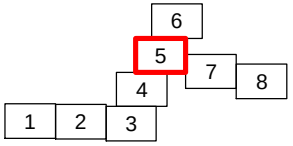
Metres

Map Projection: Universal Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 53

N

LEGEND

Checksites
Quadrats 2015
Quadrats 2011
Existing Roads
Site Boundaries



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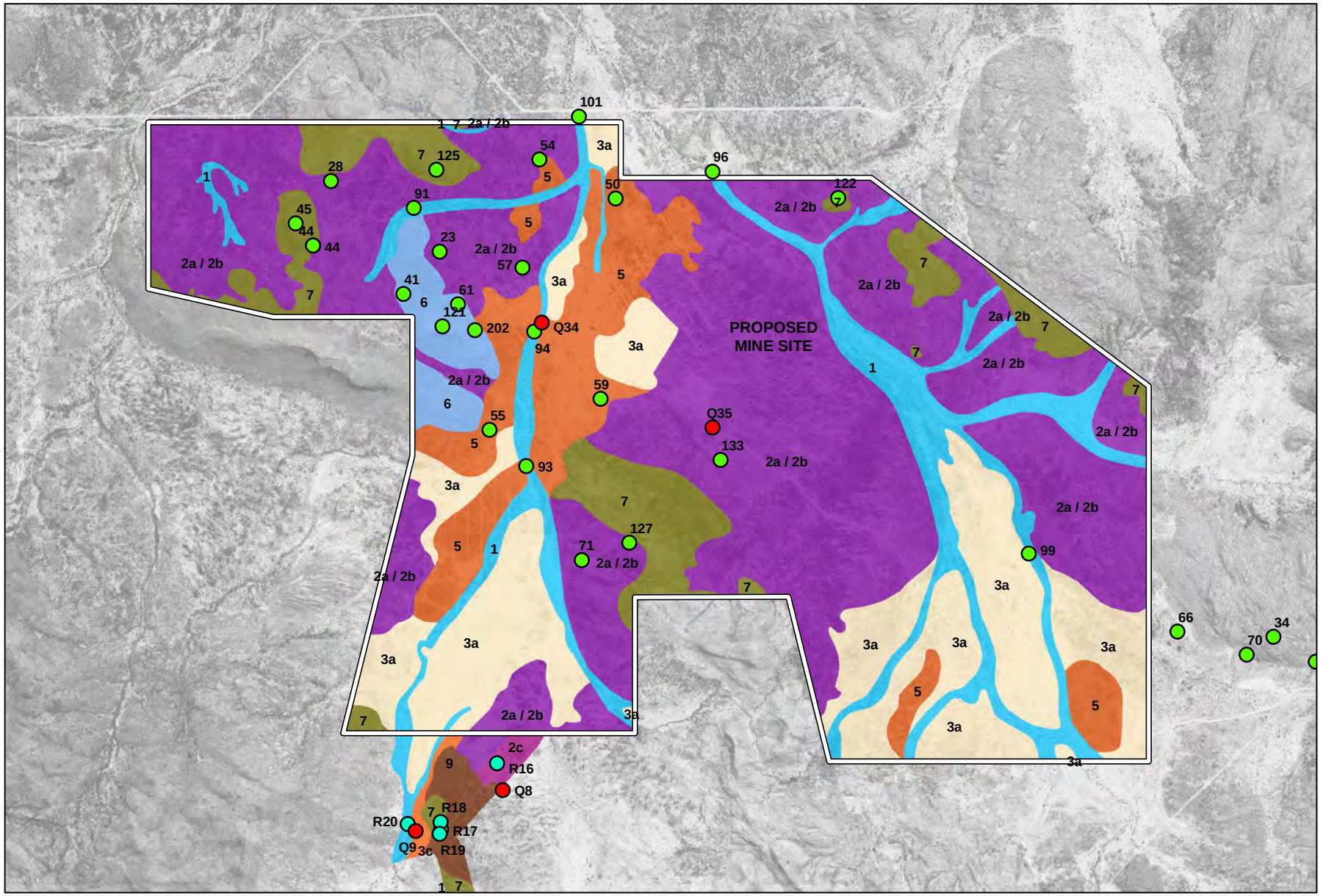
Revision 0
Date 18 Mar 2016

Vegetation communities within the Study area Figure 9-5 (Page 5 of 8):

G:\43\22301\GIS\Maps\4322301_029_VegetationMappingQuadrats.mxd

Level 5 66 Smith Street Darwin NT 0800 Australia T 61 8 8982 0100 F 61 8 8981 1075 E drwmail@ghd.com W www.ghd.com

Data source: Google Earth Pro - Imagery (Date extracted: 16/06/2015). GA - Roads (2015). GHD - Vegetation Data (2015). Created by: CM



Vegetation Community

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1:40,000 @ A4

0 250 500 750 1,000

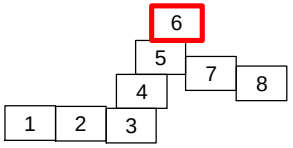
Metres

Map Projection: Universal Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 53

N

LEGEND

Checksites
Quadrats 2015
Quadrats 2011
Existing Roads
Site Boundaries



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Vegetation communities within the Study area Figure 9-5 (Page 6 of 8):

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Vegetation Community

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1:40,000 @ A4

0 250 500 750 1,000

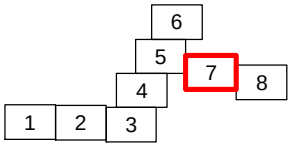
Metres

Map Projection: Universal Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 53

N

LEGEND

Checksites
Quadrats 2015
Quadrats 2011
Existing Roads
Site Boundaries



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Date 18 Mar 2016

Vegetation communities within the Study area Figure 9-5 (Page 7 of 8):

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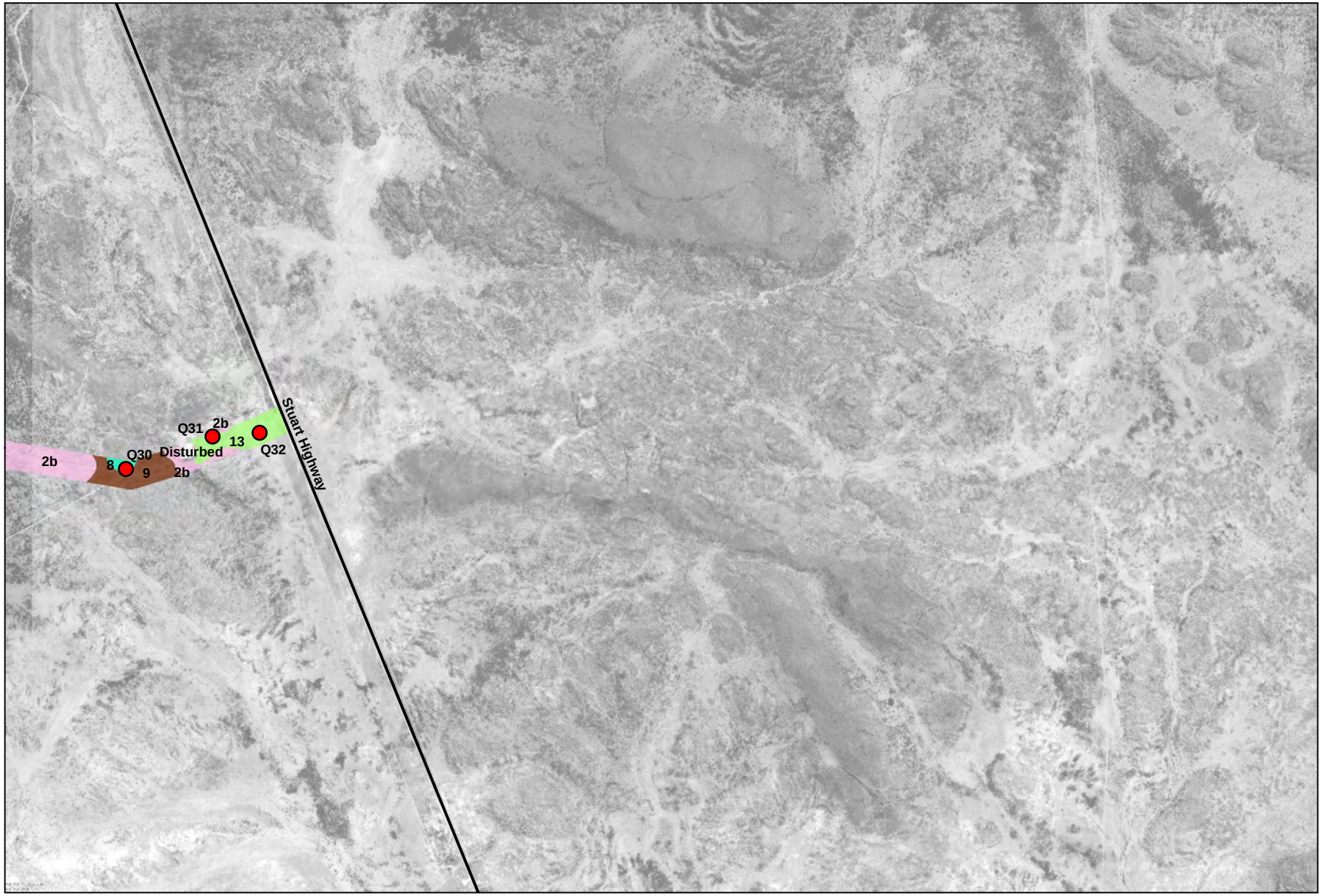

Vegetation Community

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2c	Mulga shrublands on sandy red earths over chenopods
3	Mixed Woodland over tussock grasses
3a / 12	Mixed woodland over tussock grasses on alluvial plains / Cottonbush chenopod shrubland on highly erodible duplex soils
3b	Mixed woodland over spinifex on alluvial plains
3b / 2b	Mixed woodland over spinifex on alluvial plains / Mulga shrubland on sandy red earths over tussock grasses
3c	Mixed woodland over a highly disturbed understorey dominated by *Cenchrus ciliaris*
5	Hakea/Senna Shrubland on Calcareous Alluvial Plains and Low Rises
6	Eucalyptus (mallee)/*Acacia kempeana*/Triodia Shrubland on Rocky Slopes
7	Acacia/Triodia shrubland on rocky outcrops
8	Acacia/Senna shrubland on rocky gneiss or schist outcrops with no spinifex
9	Acacia kempeana and /or mulga shrubland on gravel
10	Claypans with chenopods and herbs
11	Cottonbush chenopod shrubland on highly erodible duplex soils
12	*Triodia basedowii* hummock grassland on sandplains
13	Senna shrubland on quartz
14	Coolabah swamp associated with claypans

1:40,000 @ A4

0 250 500 750 1,000

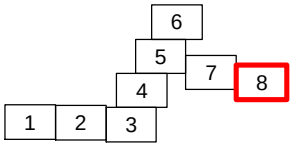
Metres

Map Projection: Universal Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 53

N

LEGEND

Checksites
Quadrats 2015
Quadrats 2011
Existing Roads
Site Boundaries



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Vegetation communities within the Study area Figure 9-5 (Page 8 of 8):

G:\43\22301\GIS\Maps\4322301_029_VegetationMappingQuadrats.mxd

Level 5 66 Smith Street Darwin NT 0800 Australia **T** 61 8 8982 0100 **F** 61 8 8981 1075 **E** drwmail@ghd.com **W** www.ghd.com

Data source: Google Earth Pro - Imagery (Date extracted: 16/06/2015). GA - Roads (2015). GHD - Vegetation Data (2015). Created by: CM

Vegetation condition

The study area contains a high level of vegetation/habitat diversity including hummock grasslands, shrublands, woodlands and riparian corridors. This is largely due to the wide range of landforms (watercourses, alluvial plains, aeolian plains, alluvial foothill fans, rocky hills), particularly within the mine site and processing plant area.

Species richness within the study area is relatively high with highest diversity recorded in areas of rocky outcrops and mulga shrublands although plant species were well represented across the study area.

The native vegetation in the study area is in good condition. This conclusion is based on the high local-scale species richness, the presence of multiple age classes of woody species, the low incidence of exotic species in many of the vegetation communities and the abundant flowering activity noted in *Triodia* and *Senna* populations during the 2010 surveys. This flowering activity was presumably in response to the above average rainfall received in the months leading up to the survey.

Vegetation clearing and fire

The vegetation is largely intact with minimal vegetation lost due to clearing although there is some evidence of native vegetation clearing associated with mineral and geotechnical exploration in the vicinity of Nolans Bore and within the borefields area. Small amounts of vegetation clearing have also occurred for construction of Darwin to Alice Springs gas pipeline and unsealed tracks throughout the study area as well as livestock management.

There is some evidence of recent fire within the study area in 2015, in particular vegetation communities 3 and 7 (Mixed woodlands on alluvial plains and Acacia/Triodia shrubland on rocky outcrops).

Exotic species

A total of fourteen exotic species were recorded during the field survey (refer to Table 9-4 and Figure 9-6). With the exception of *Cenchrus ciliaris (*Buffel Grass) these species generally occurred in very small numbers across the study area.

One of these species (*Tribulus terrestris*) is listed as a Class B (spread must be controlled) and Class C (not to be introduced to the NT) noxious weeds under the *Weeds Management Act* (WM Act). This species was found in low abundance throughout all vegetation types within the study area. It is likely that this species is spread by cattle and vehicle movement.

Overall there is a low to moderate level of infestation of exotic species within the study area with the most prevalent species being Buffel Grass. This species was recorded predominantly within floodplain and riparian vegetation types and in areas that have been disturbed by cattle and/or by mineral exploration.

Table 9-4 Exotic species recorded within the study area

Species Name	Common Name	Legislative status (WM Act)
Tribulus terrestris s.lat.	Caltrop	Listed as a Class B and Class C Noxious Weed
Bidens bipinnata	Cobblers Pegs	Not listed
Cenchrus ciliaris	Buffel Grass	Not listed
Chloris barbata	Purple-top Chloris	Not listed
Chloris virgata		Not listed
Citrullus lanatus	Paddy Melon	Not listed
Cynodon dactylon var. *dactylon*	Couch Grass	Not listed
Digitaria ciliaris	Summer Grass	Not listed
Eragrostis barrelieri	Pitted Lovegrass	Not listed
Eragrostis trichophora		Not listed
Eragrostis minor	Malvastrum	Not listed
Malvastrum americanum		Not listed
Vachellia farnesiana var. *farnesiana*	Mimosa Bush	Not listed
Sonchus oleraceus	Milk Thistle	Not listed

Buffel Grass invasion has been identified as a major threat to biodiversity within the Burt Plain Bioregion (Neave *et al* 2006). *Cynodon dactylon* (Couch Grass) has also been recognised as a potentially serious environmental weed posing a significant threat to biodiversity in the region (Neave *et al* 2006).

The most abundant and widespread weed throughout the study area was *Cenchrus ciliaris* (Buffel Grass) and although not listed under any of the schedules of the Northern Territory's WM Act Buffel Grass is an invasive weed that is known to spread rapidly in arid and semi-arid regions of Australia (Miller *et al* 2010). Relative covers of Buffel Grass across the study area are shown in Figure 9-6.

Soil disturbance associated with proposed mining activity has the potential to accelerate the spread of Buffel Grass and other exotic species throughout the study area.

Other taxa present within the study area that have been identified as having the potential to impact on biodiversity - although to a significantly lesser degree that Buffel and Couch Grass - include *Malvastrum americanum, Eragrostis barrelieri* and *Eragrostis trichophora* (Neave *et al* 2006). These species are present in low numbers throughout the study area and were confined to riparian areas and associated floodplains.

1:40,000 @ A4

0 250 500 750 1,000

Metres

Map Projection: Universal Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 53

N

LEGEND

Eragrostis tricophora
Existing Gas Pipeline
Roads
Indicative Gas Pipeline Corridor
Site Boundaries

Buffel Grass (%)

< 5%
6 - 40%
41 - 70%
71 - 100%

6 5 7 8 4 1 2 3

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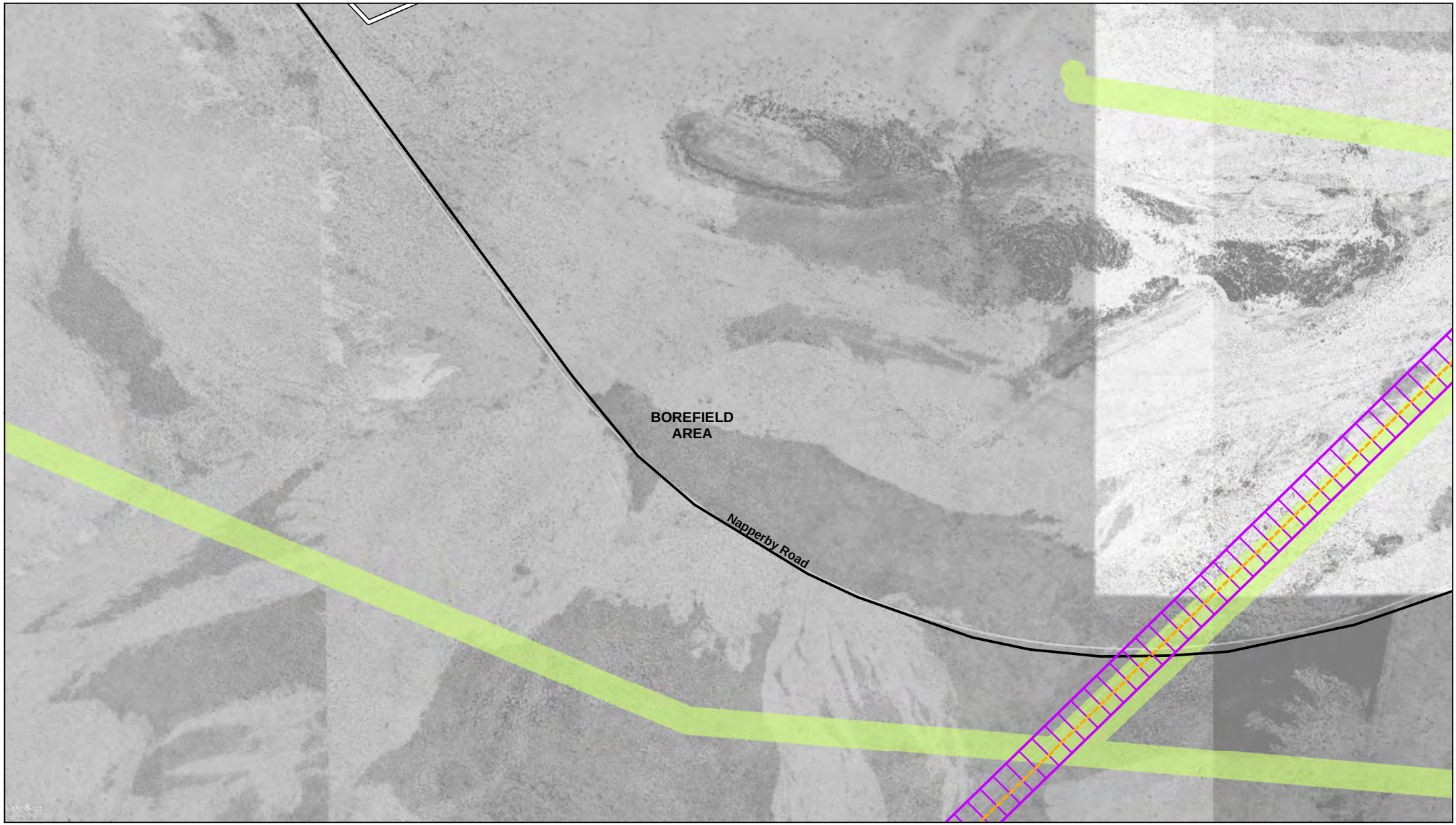
Buffel grass present in the Study area

Figure 9-6 (Page 1 of 8)

G:\43\22301\GIS\Maps\4322301_030_WeedMapping.mxd

Level 5 66 Smith Street Darwin NT 0800 Australia **T** 61 8 8982 0100 **F** 61 8 8981 1075 **E** drwmail@ghd.com **W** www.ghd.com

Data source: Google Earth Pro - Imagery (Date extracted: 16/06/2015). GA - Roads (2015). GHD - Vegetation Data, Eragrostis tricophora (2015). Created by: CM



1:40,000 @ A4

0 250 500 750 1,000

Metres

Map Projection: Universal Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 53

N

LEGEND

Eragrostis tricophora
Existing Gas Pipeline
Roads
Indicative Gas Pipeline Corridor
Site Boundaries

Buffel Grass (%)

< 5%
6 - 40%
41 - 70%
71 - 100%

1 2 3 4 5 6 7 8

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Buffel grass present in the Study area

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G:\43\22301\GIS\Maps\4322301_030_WeedMapping.mxd

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1:40,000 @ A4

0 250 500 750 1,000

Metres

Map Projection: Universal Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 53

N

LEGEND

Eragrostis tricophora
Existing Gas Pipeline
Roads
Indicative Gas Pipeline Corridor
Site Boundaries

Buffel Grass (%)

< 5%
6 - 40%
41 - 70%
71 - 100%

1 2 3 4 5 6 7 8

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Buffel grass present in the Study area

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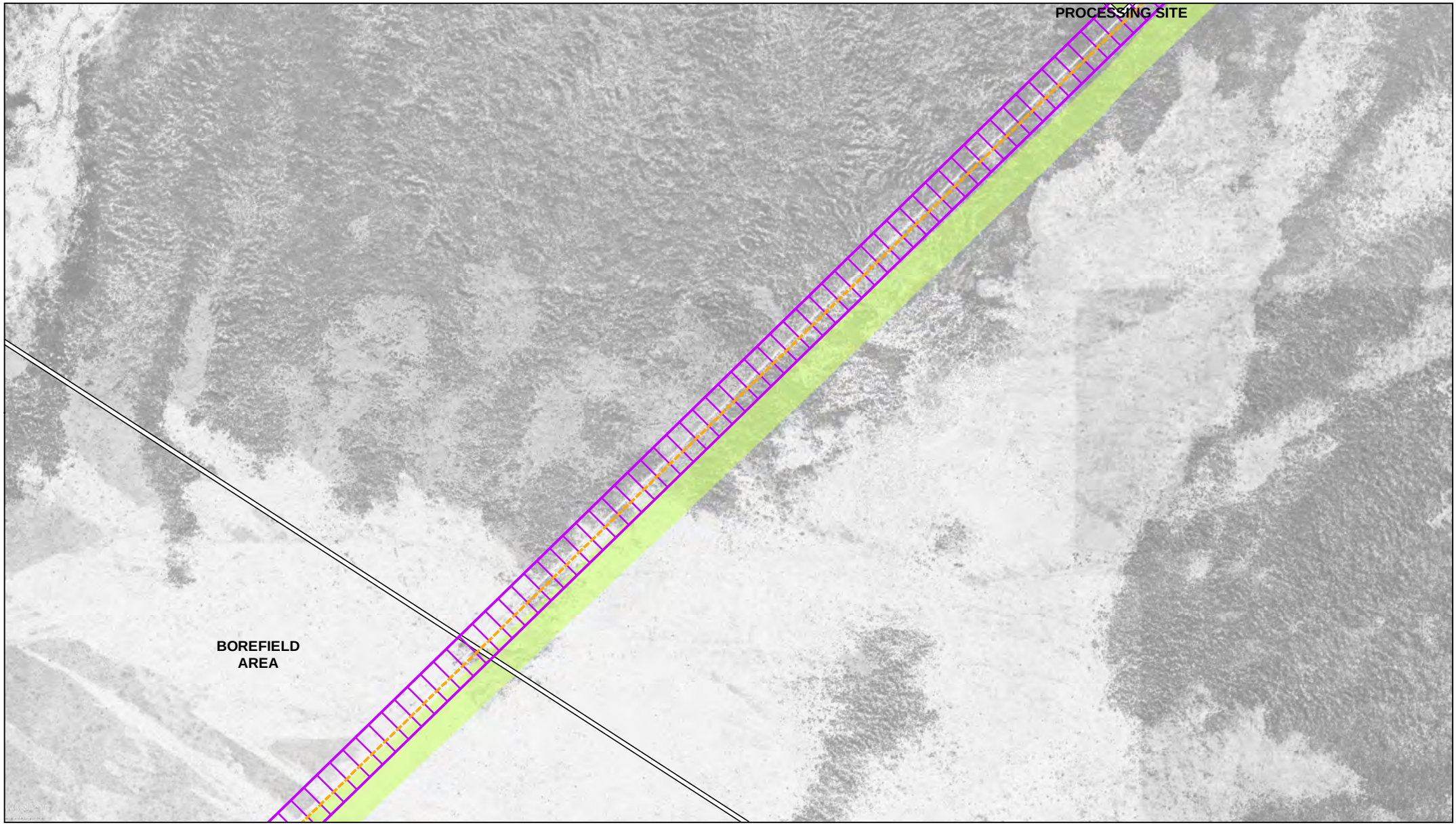
G:\43\22301\GIS\Maps\4322301_030_WeedMapping.mxd

Level 5 66 Smith Street Darwin NT 0800 Australia **T** 61 8 8982 0100 **F** 61 8 8981 1075 **E** drwmail@ghd.com **W** www.ghd.com

Data source: Google Earth Pro - Imagery (Date extracted: 16/06/2015). GA - Roads (2015). GHD - Vegetation Data, Eragrostis tricophora (2015). Created by: CM



1:40,000 @ A4

0 250 500 750 1,000

Metres

Map Projection: Universal Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 53

N

LEGEND

Eragrostis tricophora
Existing Gas Pipeline
Roads
Indicative Gas Pipeline Corridor
Site Boundaries

Buffel Grass (%)

< 5%
6 - 40%
41 - 70%
71 - 100%

6
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Buffel grass present in the Study area

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G:\43\22301\GIS\Maps\4322301_030_WeedMapping.mxd

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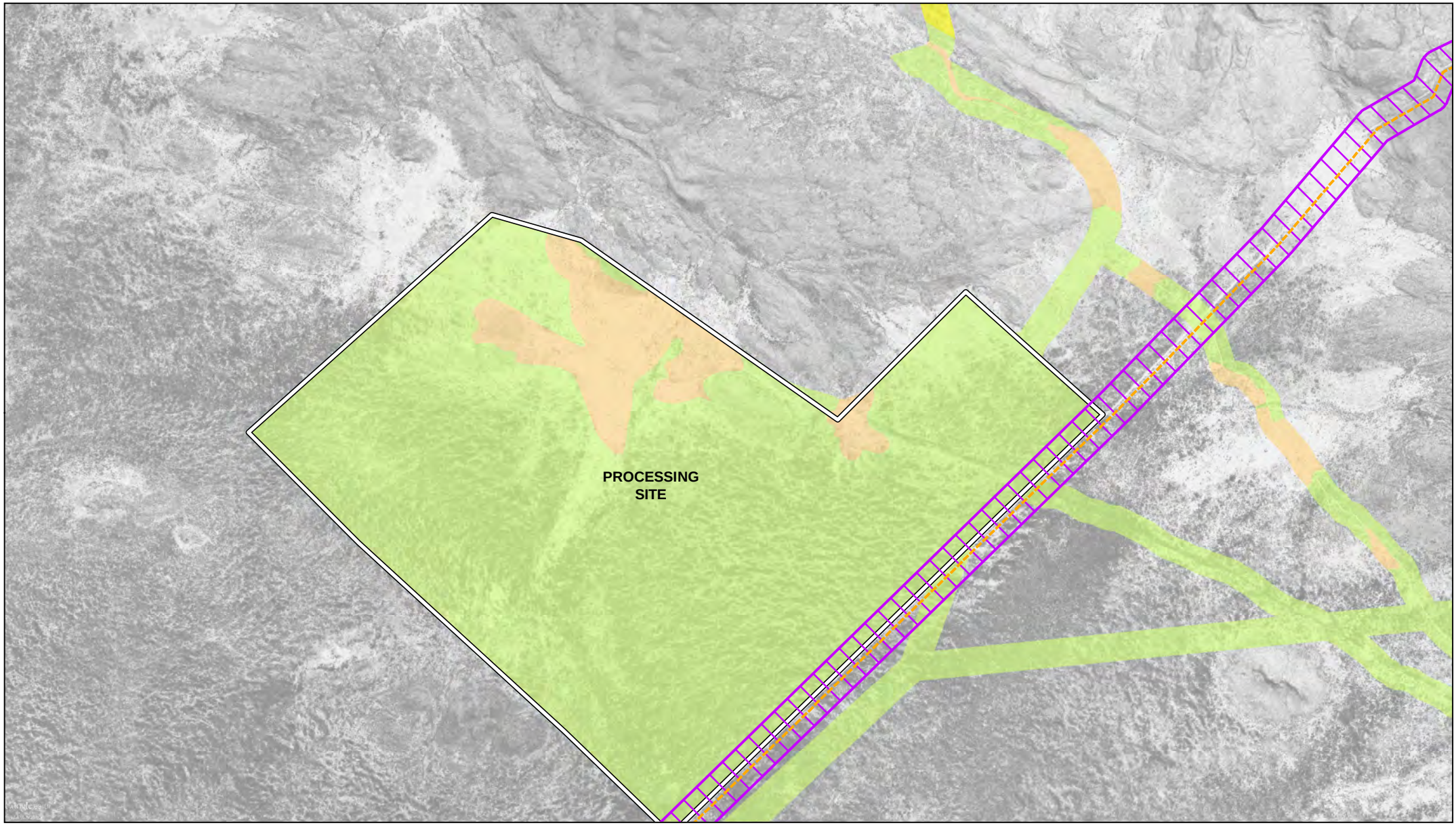
Data source: Google Earth Pro - Imagery (Date extracted: 16/06/2015). GA - Roads (2015). GHD - Vegetation Data, Eragrostis tricophora (2015). Created by: CM



1:40,000 @ A4

0 250 500 750 1,000

Metres

Map Projection: Universal Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 53

N

LEGEND

Eragrostis tricophora
Existing Gas Pipeline
Roads
Indicative Gas Pipeline Corridor
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1 2 3 4 5 6 7 8

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Buffel grass present in the Study area

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G:\43\22301\GIS\Maps\4322301_030_WeedMapping.mxd

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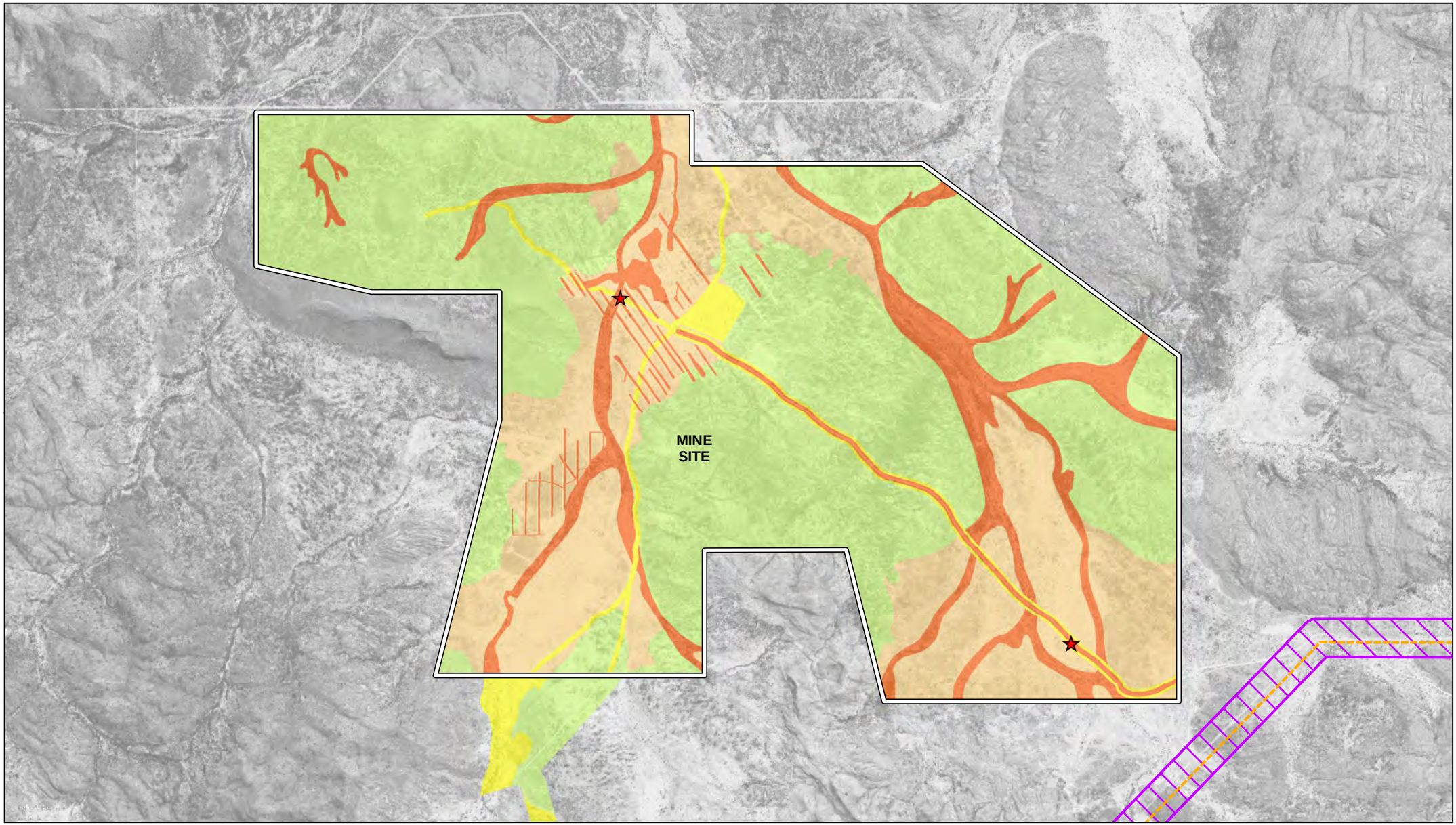
Data source: Google Earth Pro - Imagery (Date extracted: 16/06/2015). GA - Roads (2015). GHD - Vegetation Data, Eragrostis tricophora (2015). Created by: CM



1:40,000 @ A4

0 250 500 750 1,000

Metres

Map Projection: Universal Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 53

N

LEGEND

Eragrostis tricophora
Existing Gas Pipeline
Roads
Indicative Gas Pipeline Corridor
Site Boundaries

Buffel Grass (%)

< 5%
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1 2 3 4 5 6 7 8

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Buffel grass present in the Study area

Figure 9-6 (Page 6 of 8)

G:\43\22301\GIS\Maps\4322301_030_WeedMapping.mxd

Level 5 66 Smith Street Darwin NT 0800 Australia **T** 61 8 8982 0100 **F** 61 8 8981 1075 **E** drwmail@ghd.com **W** www.ghd.com

Data source: Google Earth Pro - Imagery (Date extracted: 16/06/2015). GA - Roads (2015). GHD - Vegetation Data, Eragrostis tricophora (2015). Created by: CM

1:40,000 @ A4

0 250 500 750 1,000

Metres

Map Projection: Universal Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 53

N

LEGEND

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Indicative Gas Pipeline Corridor
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1 2 3 4 5 6 7 8

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Buffel grass present in the Study area

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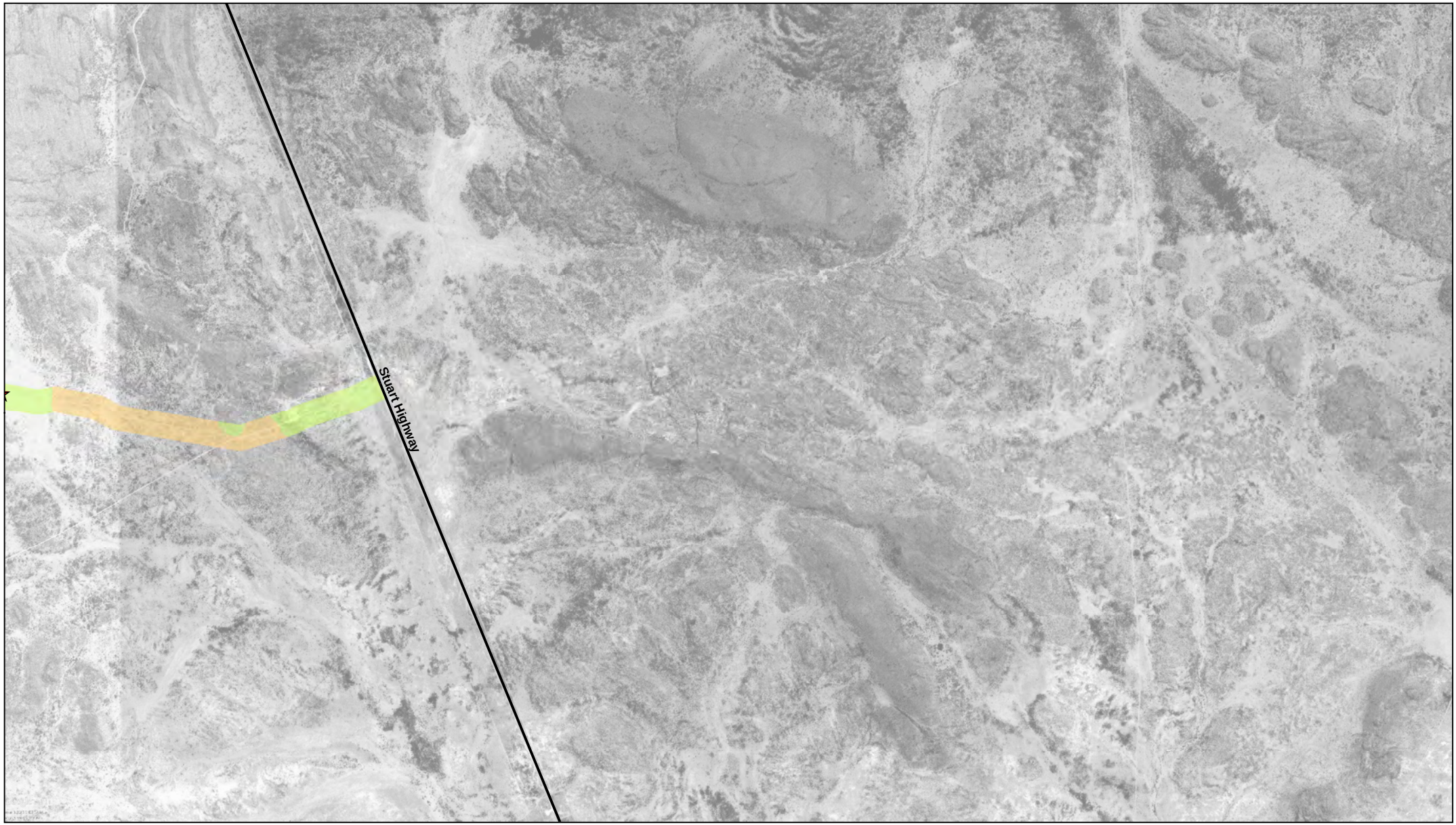
G:\43\22301\GIS\Maps\4322301_030_WeedMapping.mxd

Level 5 66 Smith Street Darwin NT 0800 Australia **T** 61 8 8982 0100 **F** 61 8 8981 1075 **E** drwmail@ghd.com **W** www.ghd.com

Data source: Google Earth Pro - Imagery (Date extracted: 16/06/2015). GA - Roads (2015). GHD - Vegetation Data, Eragrostis tricophora (2015). Created by: CM



1:40,000 @ A4

0 250 500 750 1,000

Metres

Map Projection: Universal Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 53

N

LEGEND

Eragrostis tricophora
Existing Gas Pipeline
Roads
Indicative Gas Pipeline Corridor
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1 2 3 4 5 6 7 8

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Buffel grass present in the Study area

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G:\43\22301\GIS\Maps\4322301_030_WeedMapping.mxd

Level 5 66 Smith Street Darwin NT 0800 Australia **T** 61 8 8982 0100 **F** 61 8 8981 1075 **E** drwmail@ghd.com **W** www.ghd.com

Data source: Google Earth Pro - Imagery (Date extracted: 16/06/2015). GA - Roads (2015). GHD - Vegetation Data, Eragrostis tricophora (2015). Created by: CM

9.4.3 Flora and communities of conservation significance

No flora species listed under the EPBC Act have been recorded or are predicted to occur within 20 km of the study area. There are three species listed under the EPBC Act that are known to occur within 100 km of the study area (*Macrozamia macdonnellii*, *Olearia macdonnellensis* and *Eleocharis papillosa*) however it is highly unlikely that any of these species would occur within the study area due to the lack of suitable habitat.

There were no communities of national significance known or predicted to occur within 100 km of the study area.

The DLRM herbarium database search identified 412 plant taxa known to occur within 20 km of the study area. Under the TPWC Act, 390 are of 'least concern' (i.e. widespread and abundant taxa), eight are 'not evaluated', eight are 'data deficient' and six are listed as 'near threatened' (Holtz 2015).

Nationally and territory significant flora

No flora species listed as threatened under the EPBC or TPWC Acts were recorded within the study area during this or previous surveys of the study area.

The survey identified three flora species listed as near threatened and three species listed as data deficient under the TPWC Act. These species area listed in Table 9-5.

Table 9-5 Near threatened and data deficient species recorded within the study area

Species name	Common name	Status under TPWC Act	Location details
Abutilon lepidum	-	Near threatened	Recorded growing near the base of rocky outcrops within vegetation community 7.
Acacia aneura var. *conifera*	Christmas Tree Mulga	Data deficient	Recorded in low numbers growing on alluvial plains.
Digitaria hystrichoides	Curly Umbrella Grass	Near threatened	Recorded just outside the study area adjacent to a Coolabah Swamp. Within this patch there were approximately 100 individuals of this species.
Euphorbia ferdinandii	Caustic Weed	Data deficient	Sixteen records, mostly in Mulga shrubland and *Triodia* grassland communities along the proposed access tracks.
Eragrostis lanicaulis	-	Data deficient	Recorded at one location within the study area (Quadrat 8), where it was found growing in low abundance within alluvial woodland.

Species name	Common name	Status under TPWC Act	Location details
Vittadinia obovata	-	Near threatened	Three individuals recorded growing on a rocky outcrop near Quadrat 33.

Regionally significant flora

Within the study area 326 species were recorded. This represents 28% of species known to occur within the Burt Plain Bioregion (BRT).

Eleven species listed as having conservation significance in the Burt Plain Bioregion were recorded within the study area. These species have conservation significance due to them being either at the limit of their range or being rare in the bioregion (DLRM 2015). These species and their regional conservation codes are listed in Table 9-6.

Table 9-6 Species with bioregional significance recorded within the study area

Species Name	Common Name	Regional Conservation Code DLRM 2015)
Maireana aphylla	Cottonbush, Leafless Bluebush	BRT (northern range limit)
Maireana scleroptera		BRT (northern range limit)
Convolvulus remotus		BRT (apparently rare)
Swainsona phacoides s.lat.	Dwarf Swainsona, Woodland Swainsona	BRT (northern range limit)
Prostanthera striatiflora	Striped Mint-bush	BRT (northern range limit)
Acacia murrayana	Colony Wattle, Murrays Wattle	BRT (northern range limit)
Aristida arida		BRT (northern range limit)
Aristida hygrometrica	Northern Kerosene Grass, Corkscrew Grass	BRT (apparently rare, disjunct)
Thyridolepis mitchelliana	Window Mulga Grass, Mulga Mitchell Grass, Mulga Grass	BRT (northern range limit)
Oldenlandia mitrasacmoides subsp. *mitrasacmoides*		BRT (southern range limit)
Spartothamnella teucriiflora	Mulga Stick-plant, Scented Stick-plant	BRT (northern range limit)

Nationally and regionally significant vegetation communities

No nationally or regionally significant vegetation communities were recorded within the study area.

Dominant vegetation communities within the study area include mulga communities on red earths, woodlands on alluvial flats and hummock grasslands on sand plains. Most of the vegetation types present within the study area are well represented within the Burt Plain Bioregion, however less than 1% of the Burt Plain Bioregion is conserved within reserves; and thus vegetation communities within the study area are poorly represented in conservation reserves, e.g. hummock grassland 0.01%, Acacia woodland 0.05%, Eucalyptus low woodland with tussock grass understorey 0.01% (NRETAS 2005).

There are also a number of less common vegetation communities that occur in small patches or along linear drainage lines throughout the study area. These include mixed woodlands dominated by bean trees (*Erythrina vespertilio*) and riparian vegetation.

Despite most of the vegetation types within the study area being well represented in the bioregion, Neave et al (2006) recognise that common vegetation types can be regarded as having conservation significance if they meet any of the following criteria:

- Habitat with high species richness that supports a high abundance of native species, and or is structurally complex
- Habitat supporting species of high conservation values (e.g. threatened species, endemic species, poorly reserved species and/or rare species)
- Habitat that is of good quality (i.e. its compositional and structural integrity and ecological processes have not been undermined)
- Habitat that is poorly reserved.

A number of vegetation communities within the study area would meet one or more of these criteria.

These communities include:

- V2 - Mulga shrubland on red earths
- V5 - Hakea/Senna shrubland on calcareous alluvial plains
- V7 - Acacia shrubland with Triodia hummocks on rocky outcrops
- V8 - Rocky or gravelly gneiss or schist outcrops with no spinifex
- V12 - *Triodia basedowii* hummock grassland on sandplains
- V14 - Coolabah swamps associated with claypans (located 80 to 100 m to the south of main access road, approximately 2 km before the accommodation village)

9.5 Results – fauna

9.5.1 Fauna desktop

The desktop assessment revealed records of 185 species within 20 km of the Nolans site (DLRM database, June 2015). These include 17 species of mammal, 121 species of bird, 44 species of reptile and three species of amphibian.

Of the 17 mammals recorded historically in the area (90 records in total), three of them have been recorded only once, and a further four have been recorded only twice. Only eight mammal species have been recorded five times or more. This indicates a relative lack of survey for mammals across the area, except perhaps for insectivorous bats.

Of the 121 bird species recorded historically in the area (1,416 records in total), 44 of them (36.4%) have been recorded ten times or more. This suggests a relatively low level of bird survey effort (or recorded effort) across the region, but it also reflects the sparse and nomadic nature of many bird species across arid habitats, particularly as seasonal conditions change habitats.

Of the 44 reptiles recorded historically in the area (146 records in total), 29 of them (65.9%) have been recorded twice or less, and 22 (50%) have been recorded only once. Only nine reptile species (20.5%) have been recorded five times or more. This indicates that many of the reptile observations are likely to have been from targeted reptile surveys. However, the most-common-reptile list includes none of the larger, more obvious or more iconic species (e.g. Bearded Dragon, Black-headed Python, Thorny Devil), which suggests that many observations of more common fauna have not been included in the DLRM database.

9.5.2 Fauna survey

A total of 124 indigenous terrestrial vertebrate fauna species were recorded during the GHD 2010 baseline fauna survey, including 16 mammals, 78 birds, 27 reptiles, two frogs and one invertebrate. Three introduced fauna species (all mammals) were also recorded.

A total of 130 indigenous terrestrial vertebrate fauna species were recorded during the GHD 2015 baseline fauna survey, including 21 mammals, 78 birds, 28 reptiles, two frogs and one invertebrate. Five introduced fauna species (all mammals) were recorded also.

Table 9-7 summarises fauna identified within the study area during both field surveys in 2010/2011 and 2015.

Table 9-7 Fauna identified within the study area during field surveys

Fauna	Native species	Non-native species	Listed under EPBC Act	Listed under TPWC Act
Mammals	25	5	Black-footed Rock-wallaby, *Petrogale lateralis*	Spectacled Hare-wallaby, *Lagorchestes conspicillatus*; Northern Nailtail Wallaby, *Onychogalea unguifera* Black-footed Rock-wallaby, *Petrogale lateralis* Brush-tailed Mulgara, *Dasycercus blythi*
Birds	103	3	0	Australian Bustard, *Ardeotis australis* Emu, *Dromaius novaehollandiae* Bush Stone-curlew, *Burhinus grallarius* Flock Bronzewing, *Phaps histrionica*
Reptiles	41	0	Great Desert Skink, *Liopholis kintorei*	Great Desert Skink, *Liopholis kintorei*
Frogs	3	0	0	0
Other	Targeted searches for snails and snail shells in apparently suitable habitat failed to detect the threatened species.			

Sampling effectiveness

Compared with the DLRM database results, which are considered to accurately reflect the species that occur within the Nolans site, there is a higher than expected proportion of mammals, and similar proportions of birds and reptiles. The species counts (total, and by group), suggest that the survey methods and effort have effectively sampled the region's fauna, given how closely they match those that have been recorded in the DLRM database (Table 9-8).

The species counts (total and by group) from this assessment, other assessments (i.e. Low 2007, Milligan 1980) and the DLRM database fall short of those recorded for the Burt Plain Bioregion (Table 9-8). This is because the Burt Plain Bioregion covers an enormous area and spans a range of habitats that do not occur within the vicinity of the study area. Thus, the Burt Plain list does not provide the most appropriate benchmark for fauna diversity for this assessment, but it provides useful context in some aspects of fauna diversity, and is referred to where appropriate.

There are varying levels of overlap in species detected for the different groups (i.e., despite similar aggregates, it is not necessarily the same species being detected).

Table 9-8 Overall counts of species (by group) detected during different surveys and in comparison to DLRM records as a gauge of sampling effectiveness

Group	2010 GHD survey	2015 GHD survey	Total (GHD)	Low Ecol 2006	DLRM database	Burt Plain Bioregion
Mammals	19 (3)	26 (5)	30 (5)	18 (3)	17 (5)	63 (9)
Birds	78	78	103	51	121	183 (1)
Reptiles	27	28	41	7	44	104 (1)
Frogs	2	2	3	0	3	9
Invertebrates	1	1	2?	1	0	0
Total	**127 (3)**	**135 (5)**	**179 (5)**	**77 (3)**	**185 (5)**	**359 (11)**

*Non-native species in parentheses, and included in cell totals.

Fauna Diversity and abundance

Detailed information relating to fauna diversity results across the study area is contained in Appendix N, however the results are summarised below. Across both of the surveys undertaken by GHD (2010 and 2015):

- 25 native and five non-native mammal species were identified within the Study area, including Short-beaked Echidna (*Tachyglossus aculeatus*) and Dingo (*Canis lupus*)
- Five species of macropod [Black-footed Rock-wallaby (*Petrogale lateralis*), Euro (*Macropus robustus*), Red Kangaroo (*Macropus rufus*), Northern Nailtail Wallaby (*Onychogalea unguifera*) (scats and tracks) and Spectacled Hare-wallaby (*Lagorchestes conspicillatus*) (tracks)
- Seven species of native small mammal [Brush-tailed Mulgara (*Dasycercus blythi*), Fat-tailed Dunnart (*Sminthopsis crassicaudata*), Stripe-faced Dunnart (*Sminthopsis macroura*), Lesser Hairy-footed Dunnart (*Sminthopsis youngsoni*), Fat-tailed

Pseudantechinus (*Pseudantechinus macdonnellensis*), Sandy Inland Mouse (*Pseudomys hermannsburgensis*) and Spinifex Hopping-mouse (*Notomys alexis*)

- Potentially 11 species of microchiropteran (*insectivorous*) bat [Gould's Wattled Bat (*Chalinolobus gouldii*), Chocolate Wattled Bat (*Chalinolobus morio*), Hairy-nosed Freetail Bat (*Mormopterus eleryi*), Inland Freetail Bat (*Mormopterus petersi*), Lesser Long-eared Bat (*Nyctophilus geoffroyi*), Yellow-bellied Sheathtail Bat (*Saccolaimus flaviventris*), Inland Broad-nosed Bat (*Scotorepens balstoni*), Little Broad-nosed Bat (*Scotorepens greyii*), White-striped Freetail Bat (*Tadarida australis*), Inland Forest Bat (*Vespadelus baverstocki*), and Finlayson's Cave Bat (*Vespadelus finlaysoni*)
- Five species of non-native mammals [Camel (*Camelus dromedarius*), Cat (*Felis catus*), European Rabbit (*Oryctolagus cuniculus*), House Mouse (*Mus musculus*) and Red Fox (*Vulpes vulpes*)]. Cattle (*Bos taurus* and *Bos indicus*) were also seen but not recorded
- 103 native (and zero non-native) bird species were identified. Each survey (i.e., 2010 and 2015) resulted in the detection of 78 bird species, with 68% overlap in species detected. These counts are similar but greater than the numbers of birds detected in previous surveys by Green 2010 (69 species), Low 2007 (50 species) and Milligan 1980 (62 species)
- Fewer than expected waterbirds (8 of 16), reflecting the seasonal or intermittent nature of wetlands and waterbird movements in arid Australia, and the fact that the surveys for this assessment were done at generally dry times of year
- Across surveys undertaken by GHD (2010 and 2015), 41 native (and zero non-native) reptile species were identified within the study area. Each survey (i.e., 2010 and 2015) resulted in the detection of similar reptile species numbers (27 and 28 respectively)
- The reptile sub-group that was obviously underrepresented during the 2010 and 2015 surveys was the elapid snakes. Only one small snake species was detected (Little Spotted Snake, *Suta punctata*), and no large snakes were detected, which is unusual for site visits involving multiple days, multiple teams, working across a large area with extended working hours
- Across surveys undertaken by GHD (2010 and 2015), three native (and zero non-native) frog species were identified within the study area, all of which have been recorded historically in the Burt Plain Bioregion. Nine frog species are known to occur within the Burt Plain Bioregion
- One species of snail was identified during the 2010 and 2015 surveys (and during the survey by Low Ecological 2007): the non-threatened Camaenid land snail (*Sinumelon expositum*).

Fauna habitats

Historical clearing is localised and typically confined to relatively small pastoral infrastructure sites. Fauna habitats are broadly grouped as follows:

- Mulga woodland
- Spinifex grassland on sandplain
- Rocky rises
- Acacia and mallee shrubland/woodland
- Riparian woodland
- Non-spinifex grassland (occasionally with sparse open woodland).

These fauna habitats are described in Appendix N with a brief description of their occurrence within the study area, their habitat attributes, and their relationship to the vegetation communities.

There is variation in habitat characteristics across the study area. In many parts of the study area specific fauna habitats merge or form mosaics with other fauna habitats to some degree (e.g. areas of mulga woodland contain small treeless areas that are dominated by spinifex grassland).

Patterns of species richness and habitat specificity

Table 9-9 summarises patterns of species richness for the different habitat types. This kind of analysis shows fauna species richness across the Nolans site. Habitat specificity results are summarised below and discussed in more detail in Appendix N.

Table 9-9 Counts of fauna species (by group) detected during baseline GHD surveys in the sampled habitats

Habitat Group	Mulga woodland	Sandplain spinifex grassland	Rocky rises	Shrubland/ woodland	Riparian woodland	Open grassland (non-spinifex)	Total
2010 only							
No. sites	4	3	2	1	1	1	12
Mammals	14 (2)	6 (1)	7	3 (1)	2	2	19 (3)
Birds	47	24	46	40	37	20	78
Reptiles	12	9	12	3	2	2	27
Frogs	1	0	0	0	1	0	2
Invertebrates	0	0	1	1	0	0	1
Total	**74 (2)**	**39 (1)**	**66**	**47 (1)**	**42**	**24**	**127 (3)**
2015 only							
No. sites	4	5	2	2	0	0	13
Mammals	18 (2)	16 (4)	8	11	-	-	26 (5)
Birds	47	42	28	41	-	-	78
Reptiles	6	17	9	5	-	-	28
Frogs	0	0	2	0	-	-	2
Invertebrates	0	0	1	0	-	-	1
Total	**71 (2)**	**75 (4)**	**48**	**57**	**-**	**-**	**135 (5)**
Combined (2010 & 2015)							
No. sites	8	8	4	3	1	1	25
Mammals	24 (4)	18 (4)	11	13 (1)	2	2	30 (5)
Birds	64	51	53	63	37	20	103

Habitat Group	Mulga woodland	Sandplain spinifex grassland	Rocky rises	Shrubland/ woodland	Riparian woodland	Open grassland (non-spinifex)	Total
Reptiles	13	20	16	7	2	2	41
Frogs	1	0	2	0	1	0	4
Invertebrates	0	0	2	1	0	0	3
Total	**102 (4)**	**89 (4)**	**84**	**84 (1)**	**42**	**24**	**179 (5)**

*Non-native species in parentheses, and included in cell totals.

Overall, mulga woodland was the most species rich habitat with 102 fauna species detected (including four non-native mammals) during the two survey periods, and was influenced by a high diversity of mammals and birds.

Spinifex-dominated grassland on sandplain was also species-rich fauna habitat with 89 fauna species detected (including four non-native mammals) during the two survey periods. However, the richness detected was inconsistent between surveys. Sandplain spinifex habitat clearly supports a high diversity of fauna, but detecting that fauna is dependent on specific location and environmental conditions. A very high proportion of fauna detected in sandplain spinifex habitat was found only in that habitat.

Rocky habitats were moderately species-rich with 84 fauna species detected during the two survey periods. Reptiles in particular were relatively species rich in rock habitats, particularly in 2010. Larger rocky rises and ranges are more likely to support rocky habitat specialists (e.g. Black-footed Rock-wallaby, *Petrogale lateralis*). A reasonably high proportion of fauna detected in rocky habitat was found only in that habitat. This indicates a relatively high degree of specificity among fauna that use rocky habitats.

Shrubland/woodland was found to be a moderately species-rich fauna habitat with 84 fauna species detected. Birds dominated this habitat (63 species found), however, there was a relatively low diversity of reptiles (three species recorded). Shrubland/woodland habitat is likely to support a higher diversity of fauna than was detected, but detecting that fauna is likely to be dependent on search effort, specific location of sites and environmental conditions encountered.

Riparian woodland was found to support a remarkably high richness of bird species (37 species), but low richness in other vertebrate groups: two species of mammal, two species of reptile, one species of frog. This may be due in part to this habitat's susceptibility to flooding. If a fauna species cannot move from the watercourse during high-flow periods, which in arid areas tend to be intermittent and largely unpredictable, then it is likely to be killed. If it is breeding in that habitat at the time of a flood, then its breeding effort is also likely to fail.

Non-spinifex grassland was found to have a relatively low fauna species richness (24 species in total). More than 80% of species were birds (20 species), with two mammals and two reptiles. All other species detected in grassland were found also in other habitats.

Overall, 71 of the 179 (39.6%) of fauna species were detected in one habitat only. This represents very high overall habitat specificity for fauna in the area.

Introduced species

Twelve introduced fauna species are identified for the study area (Table 9-10).

All of the mammals are known to be capable of invading natural environments, and are generally considered to be responsible for major impacts on Australia's natural environment. Of

the ten mammals identified, five have been recorded previously on the DLRM database (i.e., within 20 km of the study area), and six were detected during the baseline survey by GHD in April/May 2015. Cattle are present as an agricultural asset, but all others are present as feral animals.

The introduced fauna that occurs at the Nolans site is likely to have had, and to continue to have, an adverse impact on the area's ecology.

Table 9-10 Introduced (non-native) fauna species identified for the study area

Common name	Scientific name	Burt Plain Bioregion	DLRM database	PMST report	Low Ecol 2006	GHD Baseline survey
Mammals						
Dog	*Canis lupus familiaris*			x		
House Mouse	*Mus musculus*	x	x	x	x	x
Red Fox	*Vulpes vulpes*	x		x		x
Cat	*Felis catus*	x		x	x	x
European Rabbit	*Oryctolagus cuniculus*	x	x			x
Donkey	*Equus asinus*	x				
Horse	*Equus caballus*	x	x			
Camel	*Camelus dromedarius*	x	x	x		x
Cattle	*Bos taurus*	x	x	x	x	x
Goat	*Capra hircus*	x				
Birds						
Rock Dove	*Columba livia*	x		x		
Reptiles						
Asian House Gecko	*Hemidactylus frenatus*	x		x		
Total	***12***	**11**	**5**	**8**	**3**	**6**

BPB – Burt Plain Bioregion; DLRM – Department of Land and Resource Management; PMST – Protected Matters Search Tool; GHD – detected during 2010 or 2015 surveys.

9.6 Potential impacts

9.6.1 Overview

This section will identify the full range of potential direct and indirect impacts on flora and vegetation and fauna presented by the project. These include potential impacts during

construction and/or during operations. The construction period is expected to last up to 30 months, and mining and processing operations will continue for a period of 41 years following construction.

The layout of the proposed Nolans site is shown in Chapter 3, and shows the three principal areas comprising the mine site, processing plant and borefield; in addition to accommodation village, utilities corridors and access road.

Construction activities will include all areas of the Nolans site and comprise earthworks, mine site pre stripping and top soil stockpiling, vegetation clearing, construction of infrastructure including waste storage facilities, drainage infrastructure and building pads for modular building structures, construction of roads and access tracks.

Construction activities have the potential to impact on flora and vegetation and fauna:

- Through clearing of vegetation and associated direct loss of breeding or foraging habitat during construction, and potential killing of individual fauna
- Through alteration of hydrological regimes associated with earthworks and associated changes to land surface areas and/or construction of linear infrastructure and/or other impediments to surface flows
- Through erosion and/or sedimentation resulting from vegetation clearing during construction.

Operational activities will include mining, processing and storage of waste rock and tailings/residue materials and water extraction from the borefield. Operational activities have the potential to impact on flora and vegetation and fauna:

- Through the introduction of new exotic flora or fauna species and/or spread of existing exotic flora or fauna species into new areas
- Though changes to fire regimes in local vegetation communities
- Though groundwater drawdown from the borefield and/or changes to groundwater flows impacting groundwater dependent ecosystems
- Through contamination of water resources
- Through dust and/or noise and/or light emissions from the project

These potential impacts are discussed in further detail below.

The maximum disturbance areas for the project are summarised in Table 9-11.

Table 9-11 Maximum area of impact over LOM

Item	Estimated Disturbance Area (ha)
Mine site	2,263
Processing site	1,587
Accommodation village	32
Access roads	125
Access track / utilities corridor	154
Total	**4,161**

The level of risk posed to biodiversity values by each source of impact was assessed using standard qualitative risk assessment procedures, which has been described in Chapter 5 (Risk

assessment). The risk associated with each potential impact is detailed in the risk matrix, which is contained in Appendix F.

9.6.2 Impacts on flora and vegetation

Site establishment and clearing of vegetation

Clearing of an estimated 4,161 ha of native vegetation would be required for construction of the mine site pit, waste rock dump, processing site, water supply pipe, tailings storage facility, accommodation village, access roads, mine infrastructure and stockpile sites.

Areas to be cleared for construction will be grubbed of trees and larger vegetation, with material collected and stored for reuse in rehabilitation. Topsoil, where present, will be removed and stored for future use in rehabilitation. Where necessary, stockpiles will be protected with erosion and sediment control structures and stabilised to prevent excessive wind erosion.

The areas of each vegetation community to be impacted by the project are provided in Table 9-12.

Vegetation clearing in these communities will involve removal of a moderately diverse range of non-threatened native plants, including mature trees. The average species richness within vegetation communities present within the Nolans site varies from 51 (+/- 1) within Acacia/ Triodia shrubland on rocky outcrops, to 11 species within Claypans with chenopod and herbs. However, none of the vegetation communities within the Nolans site are considered to have significant levels of species richness or structural complexity.

Vegetation communities present within the Nolans site are well represented in the Burt Plain Bioregion. The two most common vegetation communities in the bioregion, Mulga shrublands on sandy red earths (VT 2) and mixed woodland over tussock grasses (VT 3a) together comprise 78 % of the vegetation proposed to be impacted within the Nolans site.

There are a number of less common vegetation communities in the bioregion that occur in small patches or along linear drainage lines throughout the Nolans site. These include Riparian woodland (VT 1), Cottonbush chenopod shrubland (VT 11), Eucalyptus (Mallee)/Acacia kempeana shrubland with Triodia on rocky slopes (VT 6) and Claypans with chenopods and herbs (VT10). These communities are not considered to be rare or threatened at a regional scale.

None of the vegetation communities to be cleared as a result of the project are listed as threatened under the EPBC or TPWC Act.

Measures to minimise the impacts of vegetation clearing are provided in Section 9.7.2. With the implementation of these measures, the residual risk is expected to be low.

Table 9-12 Vegetation communities impacted by the project

Vegetation code	Vegetation community	Area to be impacted (ha)	% of Nolans site
V*	**Description**		
1	Riparian woodland along water courses and drainage channels	239.96	5.77

Vegetation code	Vegetation community	Area to be impacted (ha)	% of Nolans site
2a	Mulga shrubland on sandy red earths over spinifex	5.90	0.14
2b	Mulga shrubland on sandy red earths over tussock grasses	1411.45	33.92
2c	Mulga shrubland on sandy red earths over chenopods	34.82	0.84
3a	Mixed woodland over tussock grasses	657.18	15.79
3b	Mixed woodland over spinifex	10.97	0.26
3c	Mixed woodland over a highly disturbed understorey dominated by **Cenchrus ciliaris*	6.46	0.16
4	*Triodia schinzii* hummock grassland on red clayey sands	0.00	0.00
5	Hakea/Senna shrubland on calcareous alluvial plains and low rises	232.49	5.59
6	Eucalyptus (mallee)/*Acacia kempeana* shrubland with Triodia on rocky slopes	59.86	1.44
7	Acacia/Triodia shrubland on rocky outcrops	205.99	4.95
8	Rocky gneiss or schist outcrops with no spinifex	0.37	0.01
9	Acacia kempeana and/or Mulga shrubland on gravel	44.44	1.07
10	Claypans with chenopods and herbs	0.12	0.00
11	Cottonbush chenopod shrubland on highly erodible duplex soils	3.55	0.09
12	*Triodia basedowii* hummock grassland on sand plains	105.39	2.53
13	Senna shrubland on quartz	5.96	0.14

Vegetation code	Vegetation community	Area to be impacted (ha)	% of Nolans site
14	Coolabah woodland on claypans	0.00	0.00
2a/2b	Mulga shrubland on sand red earths over tussock grasses / Mulga shrubland on sandy red earths over spinifex	1112.43	26.73
2b/3a	Mulga shrubland on sandy red earths over tussock grasses / Mixed woodland over tussock grasses on alluvial plains	5.23	0.13
3a/12	Mixed woodland over tussock grasses on alluvial plains / Cottenbush chenopod shrubland on highly erodible duplex soils	5.05	0.12
3b/2b	Mixed woodland over spinifex on alluvial plains / Mulga shrubland on sandy red earths over tussock grasses.	13.35	0.32
	Disturbed	0.59	0.01
TOTAL		**4161.56**	**100**

Edge effects

Edge effects can occur where changes in vegetation or landscape can cause changes in vegetation structure or habitat conditions at or near the boundary between areas. Removal of vegetation can result in edge effects such as changes in levels of light and wind etc. Often it is exotic species that will colonise the edges of cleared areas.

The Nolans site is already exposed to the impacts of exotic species such as Buffel Grass, which is present through much of the area. The development of the Nolans Project provides additional opportunities for the creation of edge effects as a result of clearing.

Consequences are likely to include the introduction or spread of weed species and dust to new areas of vegetation, which are currently less affected by these impacts, reducing flora and fauna habitat values in the newly exposed edge areas.

With the implementation of mitigation measures however, including a weed management plan, the residual risk of significant impact associated with edge effects is expected to be low.

Alteration of hydrological regimes

Project activities including earthworks, construction of buildings, changes to land surface areas and other impediments to surface flows associated with infrastructure development and construction of linear infrastructure has the potential to impact on flora and vegetation communities directly or indirectly through alteration of surface and sub-surface flows.

The construction of areas of hardstand and linear infrastructure may interfere with natural surface water flows by blocking or disrupting the movement of water across the landscape. Additionally, the proposed mining operation may impact surface water flows through changes to areas of natural inundation, increased concentration of flows and/or disruption to sheet flow patterns.

Flow pathways including drainage channels, distributed channels and sheet flow areas may be impacted thus directly affecting downstream sensitive vegetation. The key vegetation that is vulnerable to such changes in environmental flow are the vegetation communities that are at least partially dependent on surface water flows including sheet flow i.e. Mulga shrubland (VT 1) and the riparian vegetation along Kerosene Camp Creek and within drainage channels (VT 2).

Approximately 19.2% of the Nolans site is comprised of riparian areas and floodplains that may be subject to seasonal inundation or surface water flows at least occasionally. Haul roads and access roads will need to cross a relatively large number of ephemeral creeks the majority of which have small upstream catchments (typically less than 3 km^2).

A reduction in surface water flows during rainfall periods may result in additional water stress for individual plants and may, in the long term, result in the death of individual species leading to alterations to community composition.

Engineering controls and additional mitigation measures provided in Section 9.7.7 will reduce the residual risk of significant impact to low.

Soil erosion

Erosion and sedimentation due to the stripping of vegetation and construction activities has the potential to impact Kerosene Camp Creek and associated drainage lines through the release of sediments from site during flow events. This may result in impacts to riparian vegetation along the creek and drainage lines.

Concentrated and/or altered hydrology in the construction footprint could further exacerbate the mobilisation and transport of sediment. Potential impacts on flora and vegetation contained in creeks and drainage lines may include increases in stream sediment load, changes in channel form and integrity and/or changes in stream hydrology.

Soil erosion may result in impacts to water quality, instream hydrology and stream habitat integrity. Potential impacts on flora and vegetation contained in creeks and drainage lines may include increases in stream sediment load, changes in channel form and integrity and/or changes in stream hydrology.

Soil protection measures will be implemented during construction and operation of the mine site including the preparation of an Erosion and Sediment Control Plan (ESCP) and progressive rehabilitation of disturbed surfaces (Appendix X, ESCP). The residual risk is expected to be low.

Based on observations and results from rising stream samplers. there is evidence that these systems are already subject to high sediment loads during rainfall events and that the incremental additional load resulting from construction will have little additional impact.

Introduction and/or spread of invasive species

Construction activities have the potential to introduce or increase the spread of weeds via the transportation of seeds on vehicle tyres and machinery, movement or stockpiling of soil and inappropriate waste management. The removal of vegetation would also result in the creation of new exposed edges that are likely to be susceptible to weed invasion (see Section 9.7.4).

Weed species known to be present within the Nolans site are listed in Table 9-4. *Tribulus terrestris* is listed as a declared weed under the *Weeds Management Act 2001* and *Cenchrus*

ciliaris (Buffel Grass) has been identified as high threat environmental weeds in the Burt Plain Bioregion due to it being a highly invasive species. Buffel Grass has the potential to increase fire severity due to its ability to accumulate higher amounts of combustible biomass compared to native understory species.

Cynodon dactylon (Couch Grass) is also present in low abundance along drainage lines within the Nolans site. This species poses a significant threat to biodiversity in the region due to its ability to rapidly proliferate and spread along drainage systems and out-compete native plant species.

The remainder of the introduced species recorded within the Nolans site are unlikely to have significant impacts on ecosystems as they are present in relatively low numbers and frequency and are not considered to be highly invasive.

Mitigation measures are outlined in Section 9.7.4. A Weed Management Plan (Weed MP) would also be developed for the project (Appendix X). With the implementation of these measures, the residual risk is expected to be medium.

Changes to fire regime

Construction and operational activities, particularly hot works, are potential ignition sources. As are controlled burns that may be necessary to minimise fuel loads around project infrastructure. Without adequate fire management in place, there is potential for these activities to result in uncontrolled bushfires.

Although fire has an influential role in arid zone ecology and is a necessary ecological process in some habitats, too frequent fire can have detrimental impacts on vegetation communities. For instance, fires that are too frequent or too hot have the potential to impact vegetation composition and flora diversity, with some species unable to reach reproductive maturity if time since fire is too short. Additionally, unseasonal fire (i.e. late dry season), or fire in habitats that don't respond well to fire, can also result in detrimental impacts to vegetation composition and flora diversity.

A fire management plan would be prepared for the Project as detailed in Section 9.7.6 and Appendix X. The residual risk is therefore expected to be low.

Lowering of the water table

The Southern Basins borefield will be established within the alluvial aquifer of the Burt and eastern Whitcherry basins. A number of supply bores with standby bores will provide water for the first four years of the project with additional bores to be installed from year 5 if water supply demand increases. Extraction of approximately 4.5GL to 6GL per annum over the life of the project is predicted to occur.

Additionally, at the mine site, water in the Nolans pit will be pumped during the mining process. This water will be used for the project for dust suppression or in processing.

Groundwater modelling undertaken to predict the likely extent of groundwater drawdown from abstraction (Chapter 8) predicts maximum drawdown is likely to be up to 6 m below current levels within the vicinity of the borefields area and tens of meters immediately surrounding the mine site. At the borefield the modelled groundwater drawdown is very large in terms of its extent., whilst at the mine site drawdown is very large at the pit site, but is likely to have very steep gradient due the low permeability of the rock mass surrounding the orebody. i.e the lateral extent of the drawdown is not significant (Chapter 8)

Groundwater dependent vegetation in discharge zones and floodout areas would be susceptible to rapid changes in groundwater levels, in particular riparian woodlands, which are likely to be at least partially dependant on groundwater. In particular the *Eucalyptus camaldulensis* (River red

gum) and *Corymbia aparreninja* (Ghost Gum) growing along creeks and drainage lines may be impacted; particularly if the drawdown occurs quickly, or the level of drawdown is large.

Changes to the water table can result in changes in surface vegetation and habitat characteristics. Lowering of the water table has the potential to result in a decline in availability of water to ecosystems including riparian vegetation resulting in loss of habitat for species relying on riparian habitat.

The extent of the impact to riparian vegetation will be greatest immediately adjacent to the pit and decrease radially with distance from the pit. A reasonable estimate for the down gradient extent of this has been made, based on the both the modelled drawdown cone and the point where Kerosene Camp Creek receives additional surface water flow from adjacent catchments (which is likely to in part mask this impact) at the confluence with Nolans Creek. This is length of Kerosene Camp Creek beyond the mining area, that is unlikely to capable of maintaining the current riparian vegetation, beyond the mining area is less than approximately one kilometre.

At this point the groundwater model predicts a drawdown of two metres during mining but approaches 20 m in the long-term closure model (1,000 years).Impacts are likely to be insignificant as far away as Day Creek, to the west of the borefields, Modelled drawdown from the borefield peaks in the order of 1.5 m over the LOM in the vicinity of Day Creek (Chapter 8) and rebounds rapidly once pumping ceases. It is likely that this level of drawdown over 40 odd years is something to which the riparian vegetation would adapt

further predictive groundwater modelling during operations will allow Arafura to better determine the likelihood of impact on sensitive vegetation and to allow management practices at the borefield to be modified accordingly. With the implementation of measures provided in Section 9.7.7, the residual risk is expected to be medium.

Diversion of Kerosene Camp Creek

Kerosene Camp Creek, which currently traverses the centre of the proposed mine site is a potential source of uncontrolled inflow to the open pit. If unmitigated, the open pit has the potential to capture 30% of the runoff that currently reaches the Woodforde River from Kerosene Camp Creek and Nolans Creek during flow events.

Due to the proposed location of the open pit on the flow path of Kerosene Camp Creek, it will be necessary to divert Kerosene Camp Creek. A western route has been selected to locate the planned diversion away from proposed mining and concentrating activities at the mine site. The diversion will be designed to prevent surface water from the creek entering the open pit during storm rainfall events up to and including a 1 in 1000-year ARI event.

The diversion of Kerosene Camp Creek in the mine site area will result in some landform disturbance and an altered hydrological regime in the old creek bed and in the new creek alignment. This may cause impacts on riparian flora and vegetation downstream of the diversion, including:

- Changes in surface and sub-surface flow downstream of the diversion resulting in impacts on riparian and ephemeral ecosystems and vegetation dependent on overland flows
- Loss or changes in the composition of riparian vegetation associated with the old creek channel due to the reduction in water flow. Some of this vegetation will be within the minesite footprint and would be therefore cleared as a result of mining operations
- Loss of vegetation due to the construction of the new diversion.

With the implementation of mitigation measures provided in Section 9.7.7, the residual risk is expected to be medium.

Contamination of surface and groundwater

There are several risks associated with the construction and operation of the project that could lead to contamination of surface and/or groundwater, and consequent potential impacts on flora and vegetation. These include:

- Contamination of ephemeral creeks/ drainage lines or the groundwater caused by embankment failure or overtopping and subsequent uncontrolled release from waste storage ponds including the residue storage facilities (RSFs) at processing site and/or the tailings storage facility (TSF) at the mine site
- Inappropriate storage and handling of hazardous substances at the mine site and the processing site may also result in uncontrolled release, spills or passive discharge into drainage lines
- Release to groundwater or drainage channels of seepage from waste rock dumps.

Other potential sources of contaminants to surface and groundwater include:

- Contamination via sediment runoff from areas stripped of vegetation or from soil stockpiles during flow events
- Runoff from hardstand areas, including roads, processing areas and site facilities
- Run off from waste treatment areas (including the water treatment plant, wastewater treatment plant, and landfill facilities)
- Leakage or spillage of hydrocarbons from pipelines, vehicles, wash down areas and workshops, refuelling bays and fuel, oil and grease storages.

There are a number of sensitive riparian habitats close to the development footprint, including Kerosene Camp Creek and its associated drainage lines. These areas are sensitive receptors for any adverse impacts on soil and water quality potentially arising from the Project.

Possible embankment overtopping of TSF containing beneficiation tailings during rain events, leading to an uncontrolled release of liquor may result in immediate inundation of flora within the flow path of overtopped embankment. Secondary longer term impacts might include vegetation dieback associated with the contamination of surrounding land and ephemeral creeks.

A number of design controls and mitigation measures have been included to minimise the potential for the release of contaminants into the environment. The site will be designed so that there will be no process or contaminated water stream discharged to the environment. Clean water will be diverted around the site. All reagents will be stored in bunded areas. Hydrocarbons

will be store in self bunded tanks or lined and bunded storage areas. Tailings and residue dams will be engineered structures in accordance with relevant standards and will be managed to ensure that the risk of discharge is very low.

An erosion and sediment control plan (ESCP) and a water management plan will be implemented. The implementation of these plans, combined with design measures, is expected to result in a low residual risk.

Dust emissions

Dust is a potential problem for mining projects in regions that experience extended dry periods. Central Australia exhibits an arid and unpredictable climate characterised by extended periods without rain. The mining process, drilling, blasting, excavation, handling of materials and movement of machinery is likely to result in dispersion of particulates and dust.

Dust deposition on leaf surfaces may physically affect individual plants such as by blocking and/or damaging stomata or abrasion of the leaf surface or cuticle which may impact on metabolic processes. Dust can also contribute to cumulative effects such as drought stress on already stressed plants which may in turn lead to the loss of individual plants and longer term changes to vegetation structure and composition.

Whilst the impacts from dust are unlikely to result in the loss of vegetation communities per se, dust has the potential to add an additional stressor to individual plants or plant communities that may be impacted by the effects of weeds or frequent fire, for example.

Impacts on vegetation from dust are likely to be relatively minor and largely restricted to areas adjacent to and downwind of the mine site. A dust management plan will be prepared as part of the EMP for the project (Appendix X). The residual risk is therefore expected to be low.

Radiation

The Nolans Project involves mining and processing of rare earths with which radioactive isotopes are closely associated. Arafura has conducted a radiological risk assessment for flora in the region and found any potential impacts to be negligible. Refer to Chapter 12 for more details.

9.6.3 Impacts on fauna

Potential impacts of radiation on fauna and the level of risk is detailed in Appendix P.

Clearing of breeding and/or foraging habitat

An estimated maximum of 4161 hectares of vegetation over the LOM may be cleared as a result of the project. This equates to around 2.77% of the habitats of this study area.

In all parts of the study area, clearing of areas of habitat, or high impact disturbance to habitat, could potentially result in:

- Killing/injuring fauna
- Displacement of fauna
- Disruption to nesting/roosting/foraging habitats and/or behaviour
- Reduction of area of fauna habitat locally and/or regionally
- Habitat fragmentation
- Erosion and sedimentation resulting from vegetation clearing
- Degradation of surface water quality due to erosion of soils and landforms

- Increasing likelihood of weed establishment in cleared areas.

The diversion of Kerosene Camp Creek and an altered hydrological regime in the old creek bed and in the new creek alignment may cause indirect impacts on fauna through the loss of habitats as a result of changes in surface and sub-surface flow.

Construction of linear infrastructure (e.g. access roads and water supply pipelines) through natural habitat may result in:

- Habitat fragmentation, particularly for small ground-dwelling fauna
- Introduction and/or spread of exotic plants (weeds)
- Increase in the area of habitat used by non-native predators, by creation of tracks.

The areas to be cleared will form small islands of cleared habitat in a near continuous landscape of native vegetation. The clearing area is bounded to the south by the Reaphook Hills and Hann Range, and the Stuart Highway to the east. The proposed project as planned will not cause any fragmentation of habitat.

Specific impacts on habitat of EPBC listed threatened species within the study area are described in Chapter 10. The fauna as a whole is similarly likely to experience no significant effects from the clearing and infrastructure development itself, with other impacts discussed below such as vehicle strike and the introduction of exotic predators likely to be more important for future management.

The risk of impacts from clearing would likely not be amenable to detection at the population level, and thus has been rated as low.

Specific mitigation measures may need to be implemented for species with very small known populations such as the Great Desert Skink in the south-west of the study area (See Chapter 10). The active warren is not currently part of the proposed development and this would need to remain through protection of this location.

Dust generated by mining and processing activities

Dust is a potential problem for projects in regions that experience extended dry periods. Central Australia exhibits an arid and unpredictable climate that can extend for periods of months without rain. Potential impacts of dust/emissions on fauna can include:

- Degradation/loss of fauna habitat from detrimental impacts of dust deposition on flora species and vegetation communities
- Degradation/loss of water source for fauna resulting from degradation of surface water quality due to dust deposition/sedimentation.

The following activities are identified as potentially the main generators of dust:

- Uncontrolled dispersion of particulates and dust from the concentrator (comminution and beneficiation circuits) at the mine site, resulting in dispersion of particulate, gas or dust
- Operation of RE processing units, sulfuric acid plant and gas fired generators at the processing site results in dispersion of particulate, gas or dust
- Haulage and transport of material within the mine site, along haul roads and tracks resulting in dispersion of particulate, gas or dust
- General site movements over unsealed surfaces resulting in dispersion of particulate, gas or dust

- Wind erosion mobilising dust from exposed surfaces, such as pits, WRDs, tailings and residue storage facilities, laydown areas, stockpiles, roads and sites of vegetation clearing.
- Drilling, blasting, excavation, movement of vehicles and handling of materials results in dispersion of particulates and dust, particularly from the mine site, and consequent soil, surface/groundwater contamination.

It is likely that a range of fauna that exist within the vicinity of the proposed mine site could be adversely impacted by dust generated by mine operations. This would include birds, small ground-dwelling mammals and possibly small reptiles. Populations of Black-footed Rock-wallaby which occur within 2 km of the mine site could be subjected to low levels of dust (Chapter 10).

Mitigation measures as discussed in Section 9.7.8 would be implemented to keep dust levels to a minimum. The residual risk of impact associated with dust is low.

Noise and vibration generated by mining and processing activities

Disturbance to fauna associated with generation of unexpected and/or excessive noise from mining and processing activities during construction can result in the displacement of fauna and disruption to nesting/roosting/foraging behaviour. Displacement of fauna into sub-optimal habitats could increase their susceptibility to predation and competition.

It is likely that faunal communities in the immediate vicinity of the mine site would be most acutely affected by the mining operations, including drilling, blasting and excavations that may result in audible airborne and ground borne noise and/or vibration.

. It is quite likely that noise generated by the mine could preclude fauna movements through the mine site as has occurred previously, however particularly noisy activities would likely occur during diurnal periods when fauna e.g. rock-wallabies are sheltering, and noise would be somewhat buffered by their rocky, elevated habitat.

Increased vehicle noise in the borefield could have some localised and isolated low-level impacts however most of these species are nocturnal and their activity patterns would unlikely be adversely impacted by activity in the borefield at night. Vehicle passage in this area would be infrequent for maintenance purposes and may only occur on a weekly basis.

With mitigation measures in place the risk of impact associated with noise and vibration has been assessed as being low.

Artificial light generated by mining and processing activities

Light plays a critical role in ecology. It determines activity levels of diurnal and nocturnal fauna, it assists predators in their hunting success, and some light sources attract invertebrate fauna that attract and are then preyed on by other fauna. Localised disturbance to nocturnal fauna associated with generation of light in mining and processing areas can cause the following impacts on fauna:

- Local displacement of fauna (i.e., nocturnal fauna moves away from brightly lit areas)
- Increased susceptibility of fauna to predation (e.g., prey species find it harder to remain concealed in brightly lit areas)
- Disruption to nesting/roosting behaviour (e.g., bright lights may awaken diurnal species).
- Disorientation of migrating birds (e.g. Longcore et al. 2008)
- Attraction and disorientation of amphibians (Buchanan 2006)
- Disorientation of bats (e.g. Stone et al., 2009; Polak 12011)

- Attraction of and enhanced mortality of insects (e.g. Yoon et al., 2010; Ferreira and Scheffrahn 2011; Fox 2012)
- Alteration of bird calling behaviour (e.g. Kepempenaers et al., 2010; Loncore 2010)
- Breeding behaviour of amphibians (e.g. Baker and Richardson 2005)
- Small mammal activity rhythms (e.g. Rotics et al., 2011).

It is likely that faunal communities in the immediate vicinity of the mine site and mine operations would be most acutely affected by the project and could experience periods of prolonged lighting that could impact on 'normal' nocturnal behaviours. The residual risk of artificial light impacting fauna has been assessed as being low.

Unplanned wildfire

The Nolans Project introduces a range of potential sources of fire. Vehicles, machinery, hot works, switchgear, transformers, HV power and personnel provide potential ignition sources that could lead to fire.

In addition to the potential for wildfire to result in death or injury to fauna, indirect impacts such as fauna displacement and impacts on nesting/roosting or foraging habitats may also occur. The loss of vegetation could lead to subsequent erosion and impacts on water sources utilised by fauna.

The impacts of too frequent, hot and extensive fires are well documented in the arid zone of central Australia (Woinarski *et al.* 2007) which would be consistent with the project area. A number of the threatened species recorded within the study area are adversely affected by too frequent and extensive fires. Large-scale, intense wildfires from a lack of patch burning can devastate or fragment local populations of Great Desert Skink (Woinarski *et. al.* 2007). Wildfire within Black-footed Rock-wallaby habitat is also a major impact on populations as it burns food plants such as Spearbush and fig rendering habitats unsuitable for periods of time (Dr J. Read *pers. comm.*).

There is great potential for the proposal to lead to increased wildfire in the study area in the event that appropriate mitigation measures are not implemented. It is expected that all of the threatened species either known or potentially occurring within the study area would be affected by fire (both positive and negative impacts).

Controlled and strategic cool patch burns of spinifex sandplain habitat could have positive outcomes for species such as Greater Bilby (promotes food plants). Extensive burns (not patchy) of Great Desert Skink and Black-footed Rock-wallaby habitat could be detrimental as the fire would remove important shelter and food resources.

There is limited information regarding the response to fire for the Brush-tailed Mulgara. Woinarski 2007 does mention that changes fire regimes may have been a factor in the historic decline of mulgaras. Removal of ground layer vegetation is thought to leave mulgaras more vulnerable to predation (Kortner et al. 2007).

For other species, too, extensive frequent fire may reduce ground-layer vegetation cover which could increase the chance of predation by cats/foxes (Dr R. Paltridge *pers. comm.*).

Too frequent, hot and extensive wildfire is unlikely to benefit fauna in the study area and surrounds, whereas localised cool patch burns are likely to be beneficial. The residual risk of wildfire impacting fauna has been assessed as being medium. A fire management plan is included (Appendix X).

Introduction and/or spread of exotic plants and animals

Transport of materials, vehicle movements and inappropriate waste management allows for introduction of new weeds and spread of existing weeds during construction and operations. These can cause:

- Local decline in habitat quality
- Displacement of fauna from habitats as habitat quality deteriorates
- Invasion of fauna species that are attracted to the weed species (e.g. cattle with Buffel Grass)
- Impacts on conservation significant fauna (i.e., threatened species)
- Changes in fuel load, resulting in changes to fire frequency and intensity.

Creation of new roads and tracks and inappropriate management of waste (garbage) allows for introduction or spread of pest animal species. This can cause:

- Increased predation pressure (particularly on threatened species) by opening up of new areas to feral predators such as cats or red foxes
- Increased competition (particularly on threatened species) by natural areas becoming invaded by aggressive and dominating native and pest species
- Large-scale decline in habitat quality as natural areas are trampled and grazed increasingly by non-native species that have the potential to alter ecological processes.

Feral (and native) predators appear to be common within the study area, with several recordings of foxes, cats and dingoes during the field assessment within the bore site. Each of these species was also recorded on the mine site.

It will be important that with an increase in people on site, that putrescent waste is contained and managed within a predator-proof fence to prevent access (access to easily obtain food resources could allow predators to increase in abundance).

On the assumption that appropriate mitigation measures are implemented the residual risk associated with the introduction of weeds and feral animals has been assessed as medium.

Radioactivity

Arafura has conducted a radiological risk assessment for fauna in the region and found potential impacts from the proejct to be negligible. Refer to Chapter 12 (Radiation) for more detail.

Poisoning of fauna from drinking contaminated water

Wildlife ingestion or exposure to supernatant material at mine site or processing site is documented in the Australian literature (Ryan and Shanks 1996).

Effects can be immediate or cumulative. Consumption of contaminated water by fauna can cause:

- Death or harm
- Disruption to breeding success
- Knock-on effects, by attracting predators/scavengers to ill/dead fauna.

The Nolans Project TSF/RSFs will be small (approx. 244.03 ha) and will likely contain free-standing supernatant water.

There would be an extremely low chance that passing Princess Parrots or other threatened species would stop for a drink at a TSF/RSF. There is a low potential for other non-threatened fauna to access the water at these facilities.

Lowering or contamination of the water table

Changes to the water table can lead to changes in surface vegetation and habitat characteristics, particularly those communities reliant on surface water runoff and groundwater (e.g. riparian vegetation). Lowering or contamination of the water table has the potential to cause the following indirect impacts on fauna:

- Impacts on vegetation that rely on groundwater or surface water flows, in turn leading to reduction in available habitat
- Contamination of ephemeral waterways and subsequently groundwater in the broader area from uncontrolled release resulting in impacts on ecosystem health and/or public water supply
- Unnatural inundation of fauna habitats.

In this project, the water table (and therefore fauna habitat) could be impacted in the following areas and in the following ways:

- Progressive water table drawdown should an unsustainable groundwater extraction rate be applied tothe Southern Basins borefield
- Mine void results in a long-term source of contaminated (saline) water with the potential to contaminate groundwater
- Embankment failure or overtopping of TSF at mine site and RSFs at the processing site, due to slope instability or an extreme wet weather event (all of which could damage fauna habitat)
- Inappropriate storage and handling of hazardous substances on the mine site or processing site resulting in uncontrolled release, spills or passive discharge.

Lowering of the water table due to groundwater drawdown could occur within the mine site, processing facility and borefield, however only the mine site appears to support Groundwater Dependent Ecosystems (GDEs) such as riparian River Red Gum communities. The above-listed potential impacts will be carefully monitored, managed and controlled during mine operations, rehabilitation and closure phases.

Fauna are unlikely to be directly impacted by water table impacts. However, residual and ‘knock on’ impacts could occur but there is a low risk that any of these species could consume contaminated water.

Injury and death from collisions with vehicles

Creation and use of new roads and tracks through fauna habitats can lead to increased likelihood of collisions with fauna, particularly at night, when nocturnal fauna can become dazed by a vehicle’s bright lights.

There is potential for several of the species that occur within the borefield site to be occasionally struck and killed by vehicles moving in the area. However, the majority of the threatened species that are known or have the potential to occur in the study area are nocturnal, and would only be affected by vehicles travelling at night. Most mining activity is schedule to occur in daylight hours and only the concentrator at the mine site will operate 24 hours a day. This will substantially reduce vehicle movements between the mine site and processing site and

therefore reduce the risk of this occurring. Mitigation discussed in Section 9.7.12 would likely involve the implementation of speed limits and possibly the reduction in vehicle travel at night.

9.7 Mitigation measures

Mitigation measures will be required to control, reduce or eliminate impacts of project activities on flora and fauna and their habitat. Monitoring may be required for some aspects, to evaluate level of impact and effectiveness of mitigation.

This section provides guidance on the types of mitigation and monitoring that will be considered for the construction and operations phases of the project. All mitigation and monitoring efforts will be described in detail in a Biodiversity Management Plan (Appendix X), prior to impact activities taking place.

9.7.1 Avoidance of impacts

Detailed Project design will consider options for aligning infrastructure footprints to avoid or minimise clearing of vegetation. In particular, the Project will aim to avoid where possible, sensitive vegetation types such as riparian vegetation and or sites where listed threatened species are known to occur.

The design will also seek to minimise modifications to surface water flows that would cause vegetation stress, or the proliferation of introduced flora species.

Selection of appropriate ANCOLD risk category and adherence to relevant design standards for the provision of adequate storage capacity, spillway capacity and freeboard allowance will minimise risk of storage facility failure or overtopping.

Engineering controls that maintain existing surface water flows will be incorporated into road and infrastructure designs. Given the relatively small variation in relief across the Nolans site, these practices will also provide other benefits such as erosion control whilst maintaining natural surface water flows.

Design features that recognise the need to maintain existing surface water flows include the installation of at-grade flood ways where the access road crosses a water course, and culverts to maintain flows under the access road where the drainage line is well defined (i.e. along Kerosene Camp and Rabbit creeks).

The diversion of stream flow from areas upstream of the processing plant by means of flood protection bunds and/or shallow drainage ditches will be implemented. The design of these structures will adhere to relevant design standards and it is assumed that the height of pond embankments will be sufficient to prevent ingress from external flood runoff during an event that is compatible with the design of its water containment capacity.

9.7.2 Mitigation of Impacts associated with land clearing

The amount of land disturbance and vegetation clearing will be minimised. Construction personnel would be briefed during inductions regarding the conservation value of surrounding habitats and their responsibilities with regard to protecting these habitats during construction.

Additional control measures will include:

- Procedures for demarcating the limits of clearing and no-go areas
- Staged clearing of vegetation to minimise areas of bare ground and clear land only as required and in accordance with ESCP
- Construction and clearing would be limited to during non-breeding periods where reasonable and feasible

- Consideration of a cool, well managed fuel reduction burns of all habitats to be cleared to allow fauna to have the chance to escape prior to clearing of vegetation, or pre-clearing fauna surveys would be conducted prior to construction of the mine with qualified ecologists on site to capture and translocate animals that are found during the clearing process
- Strict fire prevention management protocols to prevent wildfire during clearing activities
- Use of already-disturbed areas (rather than undisturbed areas) wherever possible (e.g. lay down areas for construction)
- Development and implementation of a land stabilisation and revegetation strategy
- Progressive revegetation of cleared land as activities are completed

9.7.3 Mitigation of impacts associated with soil erosion

A draft ESCP has been developed as a sub plan to the EMP (Appendix X) including:

- Installation of erosion and sediment control measures prior to construction
- Regular inspection of erosion and sediment control measures, particularly following rainfall events, to ensure their ongoing functionality
- Runoff from disturbed and rehabilitated areas diverted into sediment ponds and not discharged into the natural system before monitoring
- Constructing adequate bunds around potential contamination sources, to contain contaminated water in the event of heavy rainfall
- Runoff from ROM pad, stockpiles and workshops would be directed to sediment basins
- Siting of stockpiles away from natural drainage channels
- Staged clearing of vegetation to minimise areas of bare ground and clear land only as required and in accordance with ESCP
- Avoid land clearing for construction during the wet season
- Minimise surface water infiltration, water runoff and groundwater seepage
- Preparation of a Water Management Plan for construction activities
- Spill clean-up and emergency management procedures developed and implemented
- Personnel to be trained in the use of spill kits and emergency response procedures.

9.7.4 Mitigation of impacts associated with weeds

A Weed MP will be prepared and include the following:

- Information regarding type and location of weeds of concern within the Nolans site
- Description of sensitive receivers (such as native vegetation and waterways)
- Measures to prevent the spread of weeds, including hygiene procedures for equipment, footwear and clothing
- Mitigation measures to minimise the spread of weeds such as ensuring that any machinery entering the Nolans site is free of weed seed. This would typically be managed through inspections and the use of vehicle wash down stations
- Keeping vehicles to established tracks and roads, and limiting the use of vehicles off-road

- Areas supporting existing weed infestations, or vulnerable to weed infestation, will be avoided where practicable
- Protocols for weed removal prior to vegetation clearing so that vegetative material would be clean and able to be mulched and reused directly on site.
- Weed disposal protocols
- Ongoing control of new weed outbreaks
- Annual monitoring of the Nolans site (including rehabilitated areas) and surrounding vegetation to identify new weed populations and monitor the effectiveness of weed control measures
- Topsoil from weed affected areas will be stockpiled in a designated area with appropriate signage and bunding. Weed infested topsoil will be treated as required to eradicate weeds prior to re-spreading in rehabilitation areas
- All staff and contractors will be informed of weed hygiene measures and weed reporting requirements during the site induction

9.7.5 Mitigation of impacts associated with predatory and feral animals

- Waste management to limit invasion/colonisation by dingoes and Black Rat (*Rattus rattus*). This will also be particularly important for the Black-footed Rock-wallaby population near the mine site as any on-site garbage waste will need to be held in a securely fenced compound to prevent the scavenging of waste material and potential population increases in both feral and native predators
- Investigate innovative new passive baiting and trapping methods such as the newly developed ‘Feral Cat Grooming Trap
- Undertaking monitoring of feral fauna species, including dingos, to determine if a pest eradication program is required. This will be managed through the Pest Monitoring and Control Plan in the Biodiversity management plan (BMP).

9.7.6 Mitigation of impacts associated with fire

Development and implementation of a Fire Management Plan (FMP) including:

- Establishment and maintenance of fire breaks around high-risk areas / activities
- All welding, cutting and grinding works undertaken will require approval via an internal hot works permit system
- Active fire management and vegetation reduction program where necessary;
- Installation / implementation of fire detection and suppression systems including dedicated fire extinguishers,
- All site personnel will be required to undertake fire control training, including the correct use of extinguishers
- All mobile equipment to be fitted with fire suppression systems
- All vehicles are required to carry a fire extinguisher and two-way radio
- Emergency response procedures, team and equipment
- Establishment of dedicated fire water system on site.
- Strict fire prevention management protocols to prevent wildfire during clearing activities

- Erosion control in waterways, if fire should occur and results in loss of vegetation that otherwise stabilises soil/sediments
- Undertake active fire management and the use of cool-season control burns if needed

9.7.7 Mitigation of impacts associated with water flows

Development and implementation of a Water Management Plan (WMP) including:

- Undertake predictive groundwater flow modelling to confirm the extent of groundwater drawdown
- Establish ground water monitoring bores to assess impacts over time on water table
- Visual monitoring of vegetation potentially at risk of impact from a lowering of the water table
- If significant impacts are identified, consider mitigation options. This could include modification of the pumping regime to manage groundwater levels.

9.7.8 Mitigation of impacts associated with dust

Development and implementation of a Dust Management Plan (DMP) would include as a minimum, application of industry dust control measures including:

- Use of water sprays on haul roads, unsealed surfaces, covering of exposed loads where practicable and maintaining moisture levels in bulk loose construction materials
- Minimising hauling and vehicle travel in conditions when wind strength results in spatially extensive and heavy dust deposition in surrounding habitats
- Reduced vehicle speeds for high-use areas/roads
- Minimise open areas exposed to wind erosion
- Wetting of ore before crushing and design controls such as use of hooded crusher, covered conveyor and an enclosed high pressure roller grinding (HPRG)
- Topsoil striping to occur only during suitable wind and weather conditions
- Review of wind directions and wind speeds prior to drilling, blasting or excavation of materials
- Minimise time between top soil stripping and construction/mining operations
- Progressive reinstatement of WRDs and cleared land as construction works are completed
- Controlled emissions release via stack and scrubber- Ongoing dust deposition monitoring program.

9.7.9 Mitigation of impacts associated with noise

- Minimising noise wherever possible
- Limiting high-impact noise, such as blasting, to daylight hours only to reduce the impact on nocturnal fauna

9.7.10 Mitigation of impacts associated with artificial light

- Limiting artificial light to areas where it is essential
- Turning off lights when not required

- Limiting the escape of light into surrounding areas of fauna habitat (i.e. using shields/deflectors)
- Ensuring that artificial lighting is not directed upwards or laterally (i.e. should be directed towards the ground)
- Use of lower rather than higher lighting installations
- Use of lower wavelengths of light wherever possible, i.e. red/yellow lights
- Use of light intensities that are as low as possible without reducing safety or efficiency
- Avoiding painting large structures bright or reflective colours and minimise use of bright or reflective construction materials and finishes for large structures.

9.7.11 Mitigation of impacts associated with tailings dam water ingestion

- The reduction of impacts of TSF/RSFs on wildlife by following best practice guidelines currently recommended for the Northern Territory where practicable
- The reduction of the attractiveness of the dam landscape for wildlife via design that includes, but is not limited to, the reduction of the dam surface area, removing dam bank vegetation, creating steep dam walls, providing alternative adjacent 'fauna friendly' water sources, and avoiding the creation of islands in the dam
- Fencing off the TSF and RSFs to prevent ground-based fauna from accessing the water
- Looking into, where possible, implementing appropriate bird-deterrent methods to keep waterbirds and birds of prey away.

9.7.12 Mitigation of impacts associated with fauna injury and death from collisions with vehicles

To minimise and mitigate the effects of increased road traffic or increased road network on the threatened species populations the following actions are recommended;

- Keep the proposed road network to a minimum and upgrade and utilise existing vehicle tracks
- Reduce speed limits and install speed reduction infrastructure such as whoa-boys and speed humps
- Provide road safety and awareness training to all staff and contractors with respect to safe driving in areas where native wildlife occurs
- Implementing and enforcing speed restrictions in high-use areas
- Limiting the movement of vehicles at night (between the period of one hour before dusk to one hour after dawn)
- Monitoring roadkill for threatened species
- Documenting location and time of day of roadkill within the study area, to determine high-risk periods or locations (additional mitigation may be required)
- Fatigue management for vehicle operators
- Development and implementation of a Traffic Management Plan.

9.7.13 Rehabilitation strategies

- Areas not required for ongoing operations will be progressively rehabilitated

- Locate and design landforms to be rehabilitated to optimise blending with the surrounding topography
- Topsoil will be stripped and stockpiled in a designated area, to prevent erosion or run-off
- Minimise soil erosion particularly on the batters of the WRD
- Stockpile vegetative material and topsoil for later use
- Minimise length of stockpiling of vegetation and topsoil
- Seeds collected for the rehabilitation program will be sourced locally, within a 20 km radius of the Nolans site, wherever possible.
- Annual monitoring of rehabilitation areas would be undertaken prior to, and following completion of rehabilitation
- If monitoring identifies that completion criteria are not being met, additional rehabilitation and monitoring would be completed until such criteria are met.

Rehabilitated areas will be monitored to ensure the success of the rehabilitation programme and impacts from mining activities. Monitoring of rehabilitated sites would be undertaken annually until completion criteria have been met. The monitoring would assess the species diversity, plant density and community structure against agreed completion criteria, which include:

- Species richness, species diversity and plant density of the restored community exceeds the median in the range of values established for baseline vegetation communities
- Dominant species in the restored community are also dominant in the baseline vegetation communities.