Figure 1-1: Mt Mulgine Project Location Plan

Legend

- Main road
- Tenements
- Warriedar pastoral lease

0 105 210 420 630 840 Kilometers

1:120,000

ems@animalplantmineral.com.au / (08) 6296 5155

1.2 SCOPE OF WORK

Animal Plant Mineral Pty Ltd (APM) was engaged by TGN to design and execute vegetation and fauna surveys to facilitate approval of the Mt Mulgine Project. The scope included a Level 2 vegetation survey and Level 1 fauna survey. The time of the survey was not optimal for annual flora and, though collections of annual flora were made, the focus of the current survey was on the mapping of vegetation of the Project area. Additional survey work is proposed following significant rainfall in 2017.

The methodology for the biological survey was determined by Principal Ecologist Dr Mitchell Ladyman and the survey scope was then ratified through liaison with the Department of Parks and Wildlife (DPaW).

1.3 BACKGROUND AND SUPPORTING INFORMATION

Species considered to be of national conservation significance are protected under the *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act 1999). Under this Act, activities that may have a significant impact on a species of national conservation significance must be referred to the Department of Environment (DoE) for assessment. In WA, all native flora and fauna species are protected under the *Wildlife Conservation Act 1950* (WC Act). Flora and Fauna species that are considered rare, threatened with extinction or have high conservation value are specially protected by four schedules in this Act (see Appendix 1). The DPaW also classifies some flora under four different Priority codes and fauna under five different Priority codes (Appendix 1).

Some species of fauna are covered under the 1991 Australian and New Zealand Environment Conservation Council (ANZECC) Convention (Commonwealth(Cth)), while certain birds are listed under the 1974 Japan and Australian Migratory Bird Agreement (JAMBA) (Cth) and the 1986 China and Australian Migratory Bird Agreement (CAMBA) (Cth). More recently Australia and the Republic of Korea agreed to develop a bilateral migratory bird agreement similar to the JAMBA and CAMBA. The Republic of Korea-Australian Migratory Bird Agreement (ROKAMBA) was entered into force in 2007. All migratory bird species listed in the annexes to these bilateral agreements are protected in Australia as Matters of National Environmental Significance (MNES) under the EPBC Act 1999.

1.4 EXISTING ENVIRONMENT

The Project lies within the Shire of Perenjori. Land use in the area is predominantly pastoralism, in particular grazing. The Project tenements are partially located within the former Warriedar pastoral station, which is now managed by the DPaW. Some conservation areas are present in the broader region, along with unallocated crown land and crown reserves (Desmond and Chant, 2001). The Project area contains no registered Aboriginal heritage places and two 'other heritage places'. Ethnographic sites and isolated artefacts have been identified within the Project tenements. No European heritage places are within the Project area.

1.4.1 Climate

The Project is located within the bioregion Murchison of WA on the Yilgarn craton, which is characterised by hot dry summers and cold winters.

The nearest Bureau of Meteorology (BoM) weather station is at Paynes Find (BoM Site Number: 007139), approximately 70 km east of the Project area. The Paynes Find station has been recording rainfall since 1919 and temperature since 1975. Average monthly and annual rainfall and temperature are presented in Table 1-1.

Recorded data suggests that the Project area is likely to receive close to 289 millimetres (mm) of rain on an annual basis and experience temperatures ranging between 5.5 degrees Celsius (°C) and 37.3°C (the lowest and highest monthly averages recorded) (BoM, 2016a). January is the hottest month with a mean maximum temperature of 37.3 °C and mean minimum of 21°C. July is the coolest month with a mean maximum temperature of 18.5 °C and mean minimum of 5.5°C (BoM, 2016a) (Table 1-1). Figure 1-2 illustrates the Project area is subject to climate typical of the region, with hot summers and wet winters.

Table 1-1: Rainfall and temperature averages for Paynes Find Weather Station (007139)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean Rainfall (mm)	19.8	23.4	25.5	26.1	37.3	41.0	35.4	27.0	14.3	10.5	10.8	12.6
Mean Max Temp (°C)	37.3	36.5	32.9	28.4	23.1	19.3	18.5	20.1	23.8	27.8	31.7	35.0
Mean Min Temp (°C)	21.0	21.2	18.1	14.3	9.5	6.7	5.5	6.0	8.0	11.5	15.4	18.4

Source: BoM, 2016a

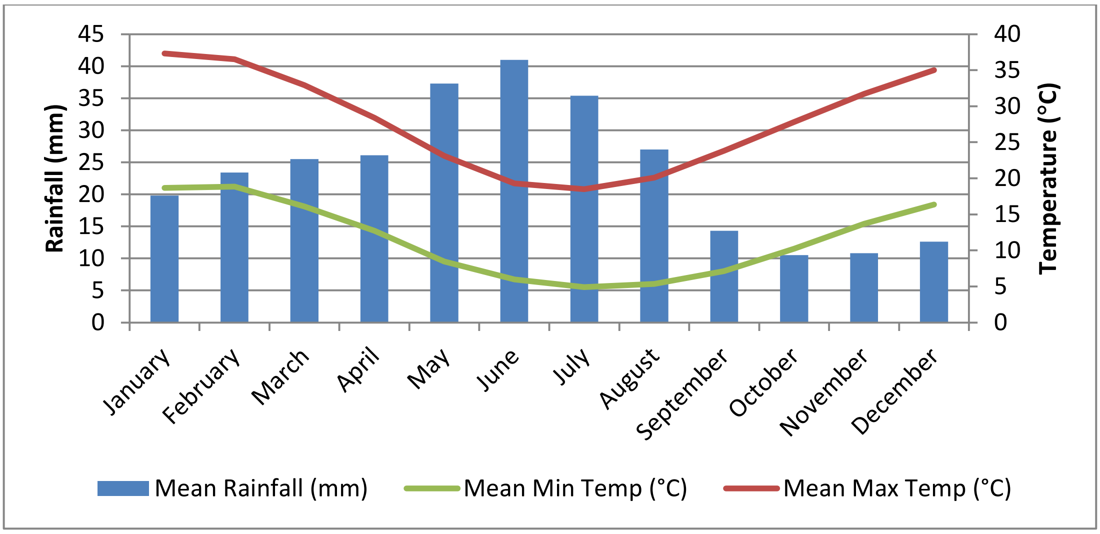

Figure 1-2: Paynes Find Weather Station Meteorological Data (BoM, 2016a)

1.4.2 Biogeographic Regionalisation

The Interim Biogeographic Regionalisation for Australia (IBRA) (version 7.1) classifies the Australian continent into regions (bioregions) of similar geology, landform, vegetation, fauna and climate characteristics (Thackway and Cresswell, 1995). The mapping completed by Beard (1975) provides the basis for the IBRA bioregions. IBRA mapping (Version 7.1), places the Project within the Yalgoo Bioregion.

The Yalgoo Bioregion is characterised by low woodlands to open woodlands of *Eucalyptus, Acacia* and *Callitris* on red sandy plains of the Western Yilgarn Craton and southern Carnarvon Basin. Mulga, Callitris,-*E. salubris,* and Bowgada open woodlands and scrubs occur on earth to sandy-earth plains in the western Yilgarn Craton.

The Yalgoo Bioregion is further subdivided into the Edel (YAL01) and Tallering (YAL02) sub-regions. The Project lies entirely within the Tallering sub-region, one of the few sub-regions not previously described by IBRA.

1.4.3 Land Systems

The land system approach to the management of rangelands results from the identification of recurring patterns of topography, soil and vegetation and involves their use in land use and catchment planning. Four land systems have been mapped within the Project area by Payne *et al.* (1998):

Graves: Basalt and greenstone rises and low hills, supporting eucalypt woodlands with prominent saltbush and bluebush understoreys.

Moriarty: Low greenstone rises and stony plains supporting halophytic and acacia shrublands with patchy eucalypt overstorys.

Norie: Granite hills with exfoliating domes and extensive tor fields supporting acacia shrublands.

Singleton: Rugged greenstone ranges with dense casuarina and acacia shrublands.

1.4.4 Surface Water

The Project area is located within the greater Yara Monger catchment. Some drainage flows to the west although drainage the Project area flows in an easterly direction towards Monger's Lake chain (Soil Water Consultants, 2012). On a local scale, surface water generally flows west and north east from Mt Mulgine into broader southern and eastern drainage paths respectively. Incised flow channels are common and the steeper terrain results in less potential for flooding (Soil Water Consultants, 2012).

1.4.5 Wetlands

The Project area does not include and is not in close proximity to any wetlands listed as Ramsar sites (Landgate, 2016).

1.4.6 Previous Surveys

Much of the Mt Mulgine area has previously been surveyed to facilitate the expansion of mining by Minjar Gold. Vegetation surveys have been undertaken by Woodman Environmental Consulting Pty Ltd (Woodman) (2003 and 2007), APM (2011, 2012) and Terratree Pty Ltd (Terratree) (2013). A fauna survey of the area was also undertaken by APM in 2012.

A summary of the surveys previously undertaken is provided in Table 1-2 below.

Table 1-2: Existing surveys of the Mt Mulgine Project Area

Aspect	Report Title	Consultant	Year	Purpose
Flora and Vegetation	Vegetation Survey of the Highland Chief and Monaco Areas, Minjar Gold Project.	Woodman	2003	Flora and vegetation survey for the expansion of mining operations.
	Minjar Gold Project. Camp, Trench and Bobby McGee Prospects Proposed Reverse Circulation (RC) Drilling. Flora and Vegetation Assessment.	Woodman	2007	Flora and vegetation survey for exploration activity.
	Minjar Gold Biological Survey. Minjar Gold Mine Expansion. Flora and Vegetation Assessment.	APM	2011	Flora and vegetation survey for the expansion of mining.
	Level 1 Flora and Vegetation Assessment and Targeted Search for Flora of Conservation Significance. Austin, Blackdog, Camp, Highland Chief, Keronima, Mugs Luck, Riley and Trench.	APM	2012	Flora and vegetation survey for the construction of expansion projects.
	Level 1 and 2 Flora and Vegetation Survey and Mapping Potential Habitat for the Threatened (Declared Rare) species *Stylidium scintillans*	Terratree	2013	Flora and vegetation survey and habitat mapping for *Stylidium scintillans.*
Terrestrial Fauna	Fauna Assessment. Austin, Blackdog, Bobby McGee, Bugeye, Camp, Highland Chief, Keronima, M1, Monaco, Mugs Luck, Riley, Silverstone, Trench and Windinne Well Projects.	APM	2012	Biological assessment surveys for the construction of expansion projects.

2 METHOLOGY

2.1 CONTRIBUTING AUTHORS

The Project survey scope was designed by APM Principal Biologist Dr Mitch Ladyman. The flora and vegetation survey and reporting was refined and executed by APM Senior Botanist James Tsakalos, with assistance from Environmental Scientist Loren Kavanagh. The field fauna survey work was executed by Dr Mitch Ladyman and Environmental Scientist Sarah Isbister, with the reporting component assimilated by Loren Kavanagh.

Technical review of the outputs were completed by Dr Mitch Ladyman and James Tsakalos.

2.2 DESKTOP METHODOLOGY

2.2.1 Database Searches

A search of the EPBC Act list of protected species was undertaken using the Protected Matters Search Tool (PMST) (DoE, 2016a) to identify flora, fauna and threatened ecological communities considered to be Matters of National Environmental Significance (MNES). This search covered an area within 10 km of the centre of the Project area (-29.17 S, 116.96 E). The results of the database search are presented in Appendix 2.

The NatureMap database (DPaW, 2016) was searched to produce a list of potentially occurring species within 10 km of the Project area using coordinates (-29.17 S, 116.96 E). This database has the most up to date species list based on flora and fauna licence returns from numerous surveys conducted in the area. The results of the database search are presented in Appendix 3.

A search of the Atlas of Living Australia (AoLA) (AoLA, 2016) was also undertaken to produce a list of fauna potentially occurring within a 10 km buffer of the Project area using coordinates -29.17 S, 116.96 E. The results of the database search are presented in Appendix 4.

A request was made for a search of the DPaW database for Threatened and Priority flora and fauna and the presence of Threatened Ecological Communities (TEC) or Priority Ecological Communities (PEC). This search was conducted based on a single point approximately centrally located in the Project area at -29.17 S, 116.96 E and included a 10 km buffer for flora, 35 km buffer for fauna and 30 km buffer for ecological communities. The results of the flora and fauna database searches are presented in Appendix 5 and Appendix 6 respectively.

2.3 FIELD SURVEY

2.3.1 Vegetation Survey Methodology

The vegetation field survey was undertaken from 8 to 12 of November 2016. Field personnel included Botanist James Tsakalos and Environmental Scientist Loren Kavanagh. The survey was designed in accordance with Environmental Protection Authority (EPA) Guidance Statement No. 51 (EPA, 2004a) and EPA Position Statement No. 3 (EPA, 2002) and was intended to comprise a Level 2 survey with respect to vegetation mapping and analysis, with intention of additional survey following mesic conditions to capture annual species and targeted rare flora survey.

Prior to commencing the fieldwork, aerial photography was used to determine potential quadrat locations in the Project area. Aerial photos were carried during fieldwork to confirm boundaries and extent of plant communities and landforms and to assist in refinement of the placement and positioning of quadrats.

A total of 38 quadrats were established in patches of visually homogenous vegetation types. Each quadrat was 20 m by 20 m as outlined in the Technical Guidelines for Flora and Vegetation Surveys for Environmental Impact Assessment (Freeman, Stack, Thomas and Woolfrey, 2015). The following information was collected at each quadrat using a standard recording sheet:

- Site description/landform;
- Slope aspect;
- Soil type and colour;
- Surface rock cover;
- Estimation of age since last fire;
- Vegetation condition (Keighery, 1994); and
- All vascular plant species present, height and foliage cover.

Plants with unknown or uncertain identities were collected and pressed on site. These plants underwent formal identification using combination of dichotomous keys, published descriptions, occurrence records and were compared against specimens housed at the Western Australian Herbarium to ensure correct identification. Table 2-1 below describes the Keighery vegetation condition rating scale.

Table 2-1: Vegetation condition rating scale (adapted from Keighery 1994)

Vegetation Condition	Description
E – Excellent	Pristine or nearly so, no obvious signs of damage caused by human activities since European settlement.
VG – Very Good	Some relatively slight signs of damage caused by human activities since European settlement. For example, some signs of damage to tree trunks caused by repeated fire, the presence of some relatively non-aggressive weeds, or occasional vehicle tracks.
G – Good	More obvious signs of damage caused by human activity since European settlement, including some obvious impact on the vegetation structure such as that caused by low levels of grazing or slightly aggressive weeds.
P – Poor	Still retains basic vegetation structure or ability to regenerate to it after very obvious impacts of human activities since European settlement, such as grazing, partial clearing, frequent fires or aggressive weeds.
VP – Very Poor	Areas that are completely or almost completely without native species in the structure of their vegetation; i.e. areas that are cleared or 'parkland cleared' with their flora comprising weed or crop species with isolated native trees or shrubs.

D – Completely Degraded	Areas that are completely or almost completely without native species in the structure of their vegetation; i.e. areas that are cleared or 'parkland cleared' with their flora comprising weed or crop species with isolated native trees or shrubs.

As a tool to assist in the description of vegetation pattern, environmental data from combination of remote sensing and modelling sources was obtained for each quadrat:

- Commonwealth Science and Industrial Research Organisation (CSIRO) Terrestrial Ecosystem Research Network (TERN) soil layers including;
    - Total nitrogen, total phosphorus, available water capacity, coarse fragments, bulk density, sand content, clay content, silt, pH, depth of regolith, depth of soil and effective cation exchange.
- National Aeronautics and Space Administration (NASA) Shuttle Radar Topography Mission (SRTM) digital elevation.
    - non-void filled SRTM image included where with the use of System for Automated Geoscientific Analyses (SAGA) (Quantum Geographic Information System (QGIS)) various indices were calculated including; Slope, aspect and topographic wetness index.

2.3.1.1 Data analyses

Data analyses involved three steps to screen data, define vegetation pattern and to link potential short term ecological drivers. Prior to vegetation analyse data were subject to pre-processing on combination of nearest neighbour distance in conjunction with inspection of releve data. The largest distance between two releves represents the most dissimilar releves. The composition of these releves was then viewed and decision made to keep or discard.

Step 1. Evaluation of classification techniques

Classification involves various choices of data transformation, distance measures and clustering algorithms. Each of these are known to constrain the data (in various ways) and to influence the resulting classification scheme presented. Much attention has been drawn into the determination of the optimal choice of transformation, distance and clustering to determine most robust and ecologically meaningful system of plant communities.

APM tested 30 different and most commonly used methods using the OptimClass 1 procedure (Tichy *et al*., 2010). The OptimClass 1 procedure was used to evaluate the different choices of classification techniques (S1). The OptimClass procedure uses the Fishers Phi coefficient (which considers within and between cluster species occurrences) to determine if a species is 'faithful'. A classification is good when there are large number of species which are 'faithful', where their distribution is within one cluster (community), and seen as bad if the species are dispersed across several communities. This process was initiated using the freely available JUICE program as interface between the vegetation data, PC-ORD (McCune and Mefford, 2006) and OptimClass. Additionally, this method was used to inform of the nested hierarchical structure of the data and serves toward delineation of communities, alliances and orders.

Step 2. Description of vegetation units

APM produced 'fingerprint' analyses of the vegetation units using JUICE (Tichý, 2002). The fingerprint analyses used defines three important descriptive vegetation descriptive features; (1) diagnostic species, those which occur within (mainly) one vegetation type, defined using Fisher's Phi coefficient value, (2) dominant species, or those which have a cover >25 (%) of above ground biomass within a plot, and (3) constant species which occur in 60 % of releves within a community. The fingerprint provides a consistent syllabus for description and comparison of the defined floristic communities.

Step 3. Determination of underlying vegetation patterns

APM conducted Canonical Correspondence Analyses (CCA) (Leps and Smilauer, 2003) using the robust choice of hierarchical classification with the environmental data. CCA is a powerful ordination tool used to relate underlying environmental drivers with second data matrix (vegetation) and can be used to assist in the description of vegetation pattern.

2.3.2 Terrestrial Vertebrate Fauna Survey Methodology

The fauna field survey was undertaken by Dr Mitch Ladyman (Principal Biologist), Sarah Isbister (Environmental Biologist) and Arlen Hogan-West (Graduate Biologist) from 22 - 26 November 2016. The survey was designed to meet the criteria of a Level 1 fauna survey, as defined in the EPA Guidance Statement No. 56 on terrestrial fauna surveys for environmental impact assessment (EPA, 2004b), Position Statement No. 3 (EPA, 2002) and as instructed by the DPaW.

The field survey targeted Malleefowl, Shield-backed Trapdoor Spider (SBTS) and Western Spiny-tailed Skink, three species protected under the EPBC Act and known to occur in the area. The survey utilised aluminium box traps, camera traps and acoustic recording devices. All opportunistic observations of other species were recorded. Table 2-2 outlines target fauna species and the method of trapping employed to determine presence / absence.

Table 2-2: Target fauna species and method of trapping

Fauna Species	Transect Observation	Thermal Trigger Fauna Cameras	Aluminium Box Traps	Hand Searching
*Leipoa ocellata (*Malleefowl*)*	X	X		
Idiosoma nigrum (Shield-backed Trapdoor Spider)				X
Egernia stokesii badia (Western Spiny-tailed Skink)	X	X	X	X

2.3.2.1 Acoustic monitoring

A total of two full spectrum lossless WAC0 format with Wildlife Acoustics SM2BAT bat detectors (sampling rate 384 kilohertz (kHz), trigger 6 decibels (dB) above background; 48 dB gain) were set to record the acoustic signatures of the microbats across the project area. Detectors were set up in strategic locations where the likelihood of detecting bats was significantly increased. Detectors were set to turn on automatically at sunset and off at sunrise (Table 2-3).

Table 2-3: Acoustic monitoring survey effort

Trap Location	No. of Traps	No. of Trap Nights	Total
SM26670	1	1	2
SM28066	1	2	3
Total	**2**	**3**	**5**

2.3.2.2 Thermal Trigger Fauna Cameras

Scout Guard SG560K-14mHD white light and Reconyx HC500 HyperFire™ Semi-Covert IR were set up in a drainage line (Table 2-4). The primary focus was on the Western Spiny-tailed Skink.

Table 2-4: Thermal trigger camera survey effort

Trap Location	No. of Traps	No. of Trap Nights	Total
TC001	1	2	2
TC002	1	2	2
TC003	1	2	2
TC005	1	2	2
Total	**4**	**8**	**8**

2.3.2.3 Aluminium Box Traps

A total of 136 aluminium box traps were set up in various arrays according to the habitat at each site (Table 2-5). Traps were set up in habitats likely to support the Western Spiny-tailed Skink. Some arrays were in a pseudo linear fashion following an intermittent drainage line, while others were placed around hollow logs or at the base of trees (Figure 2-1).

Table 2-5: Aluminium box trap survey effort

Trap Location	No. of Traps	No. of Trap Nights	Total
Site 1	18	4	72
Site 2	19	4	76
Site 3	19	4	76
Site 4	20	4	80
Site 5	20	4	80
Site 6	20	1	20
Site 7	20	1	20
Total	**136**	**22**	**424**

2.3.2.4 Short Range Endemics

Idiosoma nigrum mainly occurs on the upper to lower slopes of ranges, with only small numbers on the crest. *I. nigrum* has been identified in large numbers on plains, but within this area individuals were restricted to the banks of well-established drainage lines. Where the ranges are positioned in an east-west orientation the burrows can be found on the southern slope. This species prefers to make their burrows in heavy clay soils in open York Gum (*Eucalyptus loxophleba*), Salmon Gum (*E. salmonophloia*), Wheatbelt Wandoo (*E. capillosa*) woodland, with Jam (*Acacia acuminata*) forming a sparse understorey. A thin layer of permanent *Eucalyptus*, *Casuarina* and *Acacia* litter is required, within which the spiders forage (Main, 1987). Habitat of the Project area that met these criteria was classified as suitable for *I. nigrum*.

Other habitat containing some but not all major elements of suitable habitat was classified as marginal habitat.

Searches for *Idiosoma nigrum* SBTS were undertaken in areas of marginal and suitable habitat. Each search began with a transect to search for a burrow. Once one burrow was identified a targeted search was carried out, using the burrow as a centre point from which to radiate outwards. Up to six arms radiating 50 m from the burrow were determined using compass bearings, and each arm searched for more SBTS burrows. A total of five searches were undertaken by three field personnel.

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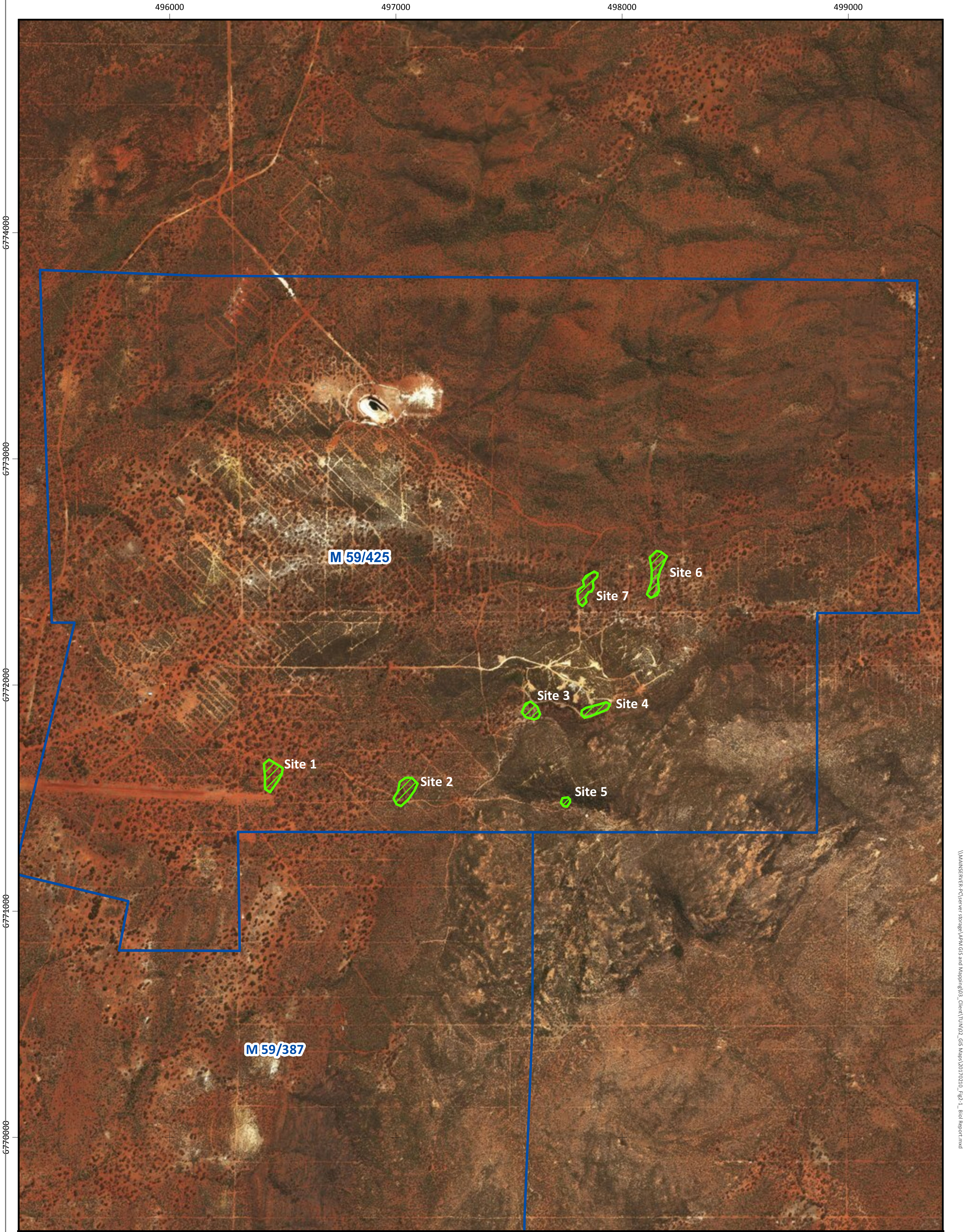

Figure 2-1: Fauna Trap Locations

Legend

Trap site

Tenements

0 0.5 1 2 3 4 Kilometers

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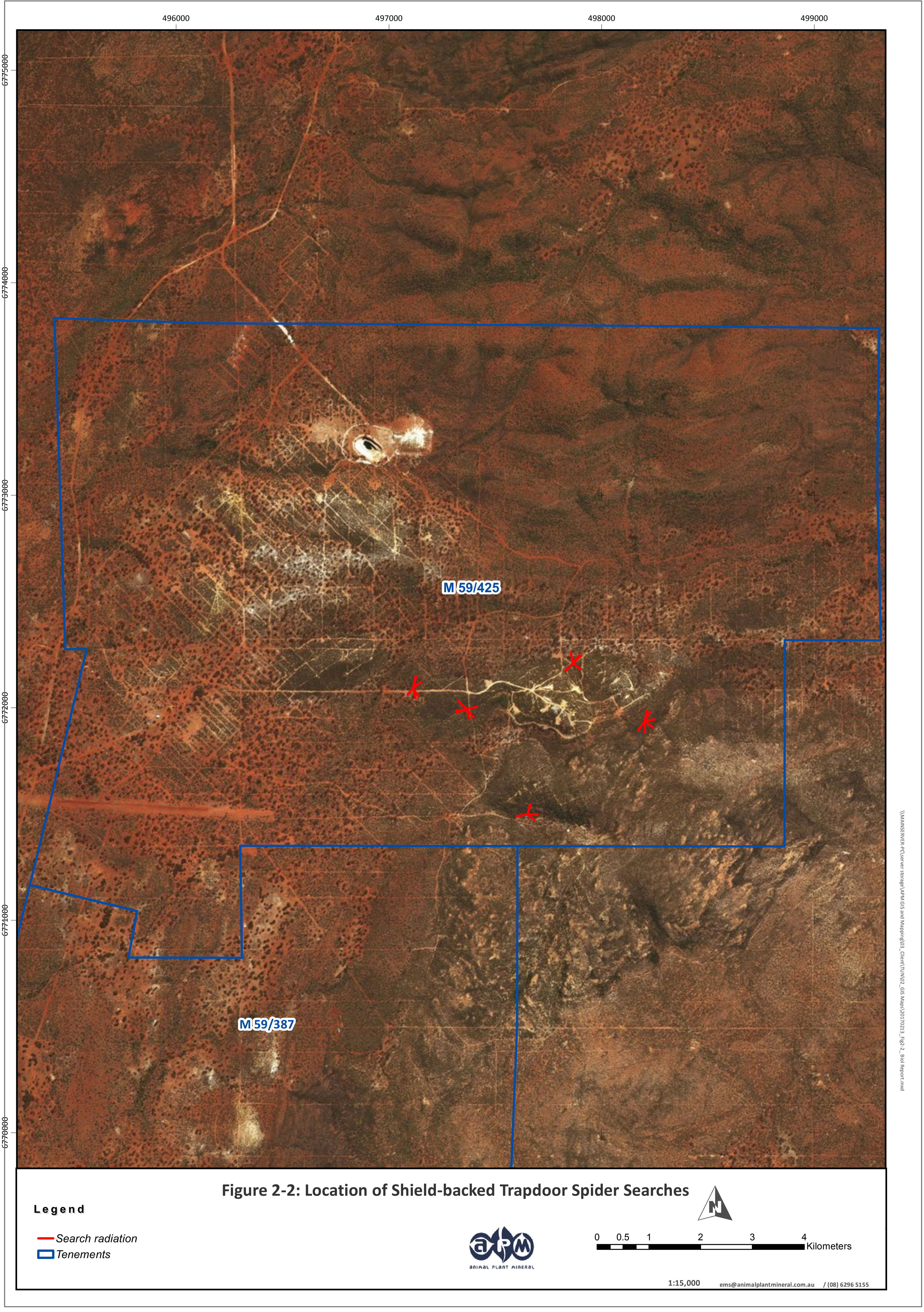

Figure 2-2: Location of Shield-backed Trapdoor Spider Searches

2.3.2.5 Transect Observation

Nocturnal Transects

Nocturnal searching comprised vehicle-based searches of all roads and tracks throughout the Project area. Searches commenced after sunset (approximately 7pm) and typically lasted for more than one hour. On all occasions hand held spotlights were used to detect arboreal or volant nocturnal fauna, including possums and owls, and vehicle headlights and spotlights were used to detect ground dwelling reptiles and hawking nocturnal birds that are often found roosting on the track.

Diurnal Transects

Searches for Malleefowl nests were undertaken by walking transects in suitable habitat. The beginning of each transect was marked with a hand held Global Positioning System (GPS) unit. Transects were walked by three personnel, each searching a 20 metre (m) swath width. The location of Malleefowl mounds identified during the search was recorded with a GPS. The areas searched are shown in Figure 2-3.

Movement between traps and sites on foot increases the likelihood of detection of scats and secondary evidence of fauna. All evidence observed during daily systematic trap clearing was recorded.

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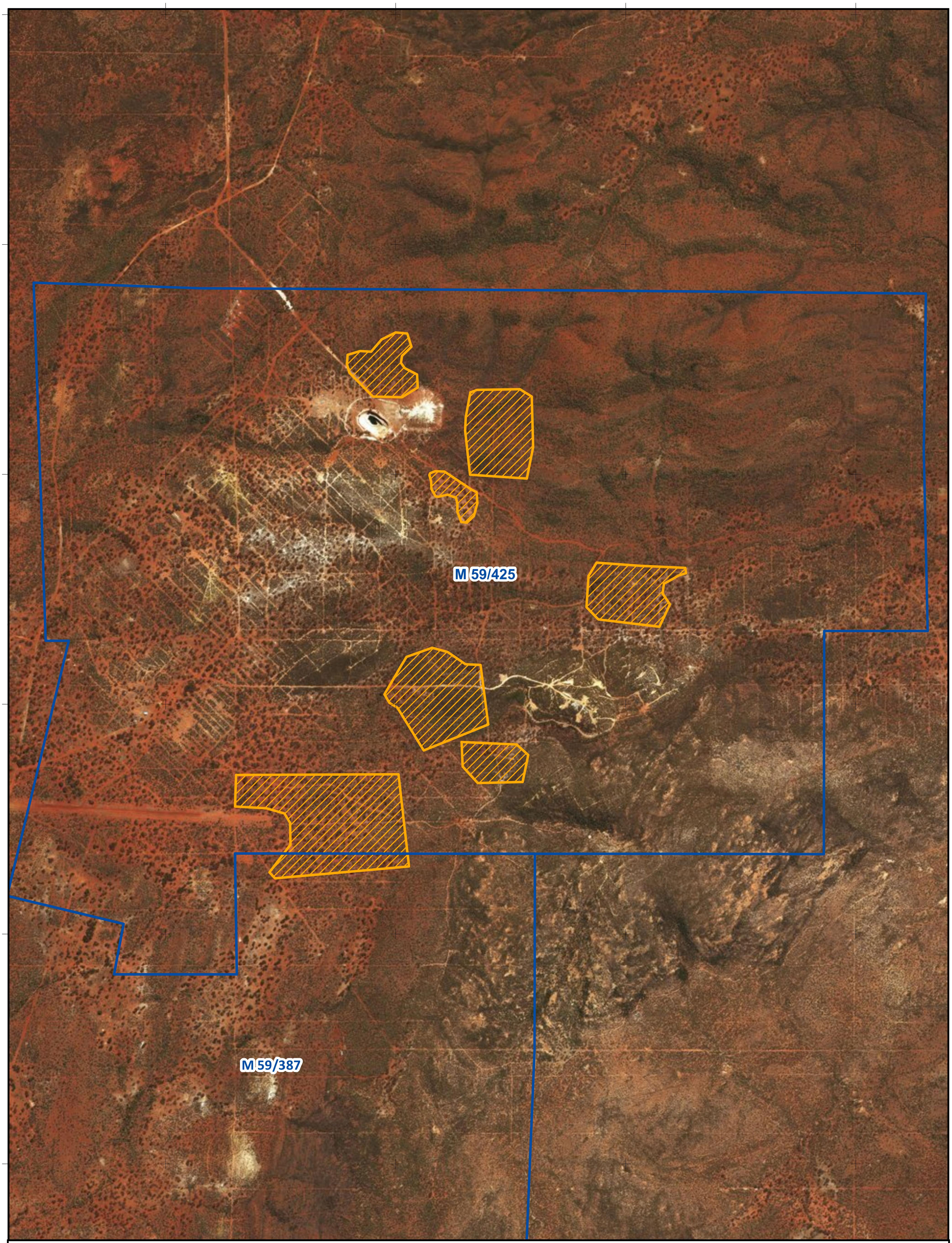

Figure 2-3: Malleefowl Search Areas

Legend

Search area

Tenements

0 0.5 1 2 3 4 Kilometers

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1:15,000

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3 VEGETATION RESULTS

3.1 DESKTOP SURVEY

3.1.1 Climate

Leading up to the survey period, monthly total rainfall was above average for May, June, July and August. Rainfall in September and October was below the average by 12.1 mm and 5.7 mm respectively (BoM, 2016a; BoM, 2016b). Figure 3-1 illustrates total and mean monthly rainfall at Paynes Find in the six months prior to the survey.

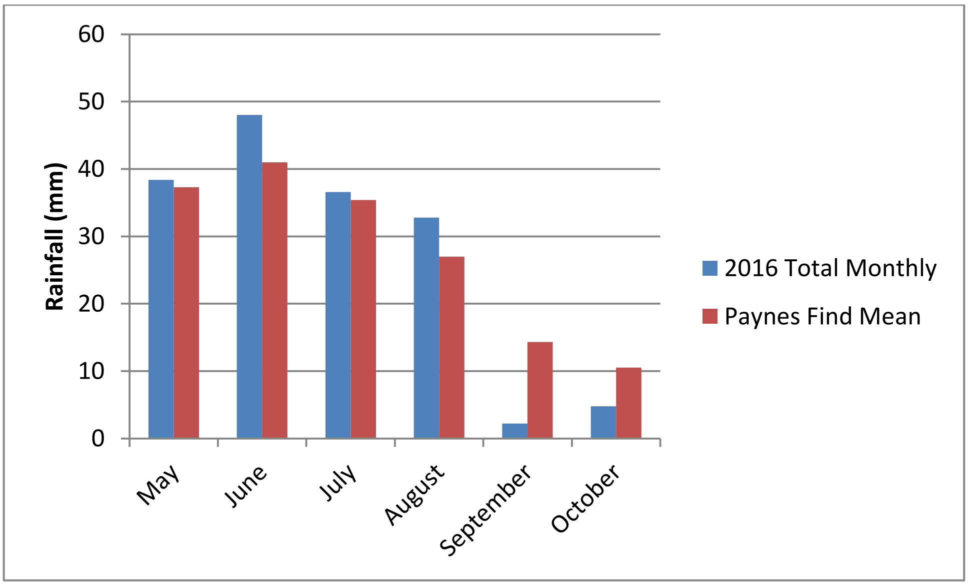

Figure 3-1: Monthly Paynes Find Mean Rainfall Leading up to the Survey

3.1.2 Previous Surveys

The vegetation survey undertaken by Woodman in 2003 identified seven vegetation units in the western half of the Project area. Most of the vegetation was in very good condition. Woodman concluded the vegetation was likely to be well represented in the region due to the same landforms occurring on neighbouring pastoral leases (Woodman, 2003). The vegetation communities are described in Table 3-1 and form a basis for comparison with the work undertaken for the present survey.

Table 3-1: Vegetation communities previously mapped in the Mt Mulgine Project Area

Vegetation Unit Code	Description
Thickets and Scrubs	
T1	Thicket to Dense Thicket dominated by *Acacia ramulosa* var. *ramulosa* over a Low Scrub of mixed species over Herbs on red loamy soils with some gravel.
T2	Thicket to Scrub dominated by *Acacia acuminata* over Dwarf Scrub or Herbs on red loamy-clay.
T4	Thicket to Scrub dominated by *Melaleuca hamata*, *Allocasuarina acutivalvis* ?subsp. *prinsepiana* and *Acacia* species on red loamy-clay on rocky ground.
Woodlands	
W1	Open Low Woodland of mixed *Eucalyptus* species over Thicket to Scrub of *Acacia* species over a Dwarf Scrub of mixed species over Herbs on red loamy soils with gravel.
W2	Open Low Woodland of *Eucalyptus salmonophloia* and *Eucalyptus loxophleba* subsp. *supralaevis* over Open Scrub on red silty clay with quartz pebbles.
W4	Low Woodland of *Eucalyptus sheathiana* and *Eucalyptus ?striaticalyx* over Low Scrub of mixed shrubs over Open Herbs on red loamy-clay on rocky ground.
W9	Low Woodland to Scrub dominated by *Allocasuarina acutivalvis* ?subsp. *prinsepiana* on red-brown soils on rocky ground.

Source: Woodman (2003)

3.1.3 Conservation Significant Vegetation Communities

Four PECs and one TEC listed under the WC Act were identified as occurring within 30 km of the Project area:

- 'Blue Hills (Mount Karara/Mungada Ridge/Blue Hills) vegetation complexes (banded ironstone formation (BIF))' (Priority 1 PEC – WC Act);
- 'Minjar and Chulaar Hills vegetation complexes (BIF) (Priority 1 PEC – WC Act);
- 'Mount Gibson Range vegetation complexes (BIF)' (Priority 1 PEC – WC Act);
- 'Ninghan calcrete groundwater assemblage type on Moore palaeodrainage on Ninghan Station' (Priority 1 PEC – WC Act); and
- 'Warriedar Hill/Pinyalling vegetation complexes' (BIF) (Priority 1 PEC – WC Act).

3.1.4 Introduced Flora

Two invasive plant taxa listed as MNES were identified by the PMST as likely to occur in the vicinity of the Project area; *Cenchrus ciliaris* (Buffel-grass) and *Eichhornia crassipes* (Water hyacinth).

3.2 FIELD SURVEY

3.2.1 Vegetation Communities

The survey recorded 117 flora taxa belonging to 79 genera. Prior to analyses, all annual species were removed as they were mostly of low quality where applied field names were likely forming aggregate. Therefore, analyses were reliant on shrub / perennial vegetation considered as dominant and were persistent within the landscape. The analyses were thus conducted on a total of 59 species belonging to 35 genera. Following pre-processing of the data an additional two releves considered outliers following nearest neighbour method were removed (Figure 3-2).

Step 1. Evaluation of classification techniques

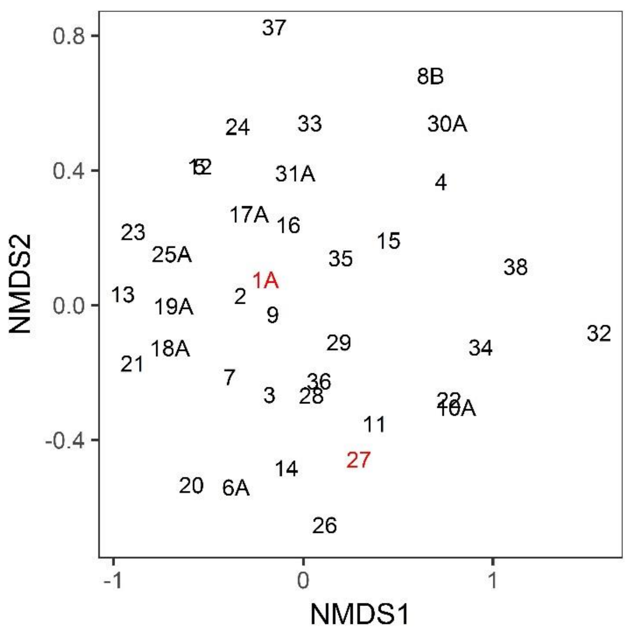

Figure 3-2: Suggested Outlying Quadrats

Figure 3-3 illustrates the nine top performing classification methods identified by OptimClass 1.

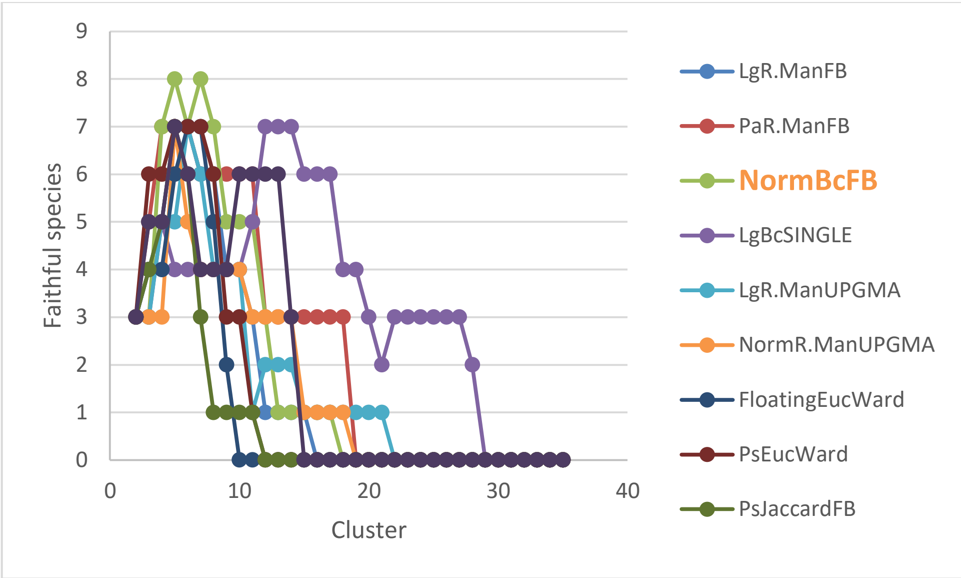

Figure 3-3: Top Performing Classification Methods

The classification technique involving No transformation (Norm), Bray-Curtis distance and Flexible beta (-0.25) clustering was used for subsequent analyses. Further the results suggest the taxa can be assigned to ten communities nested into five alliances Figure 3-4..

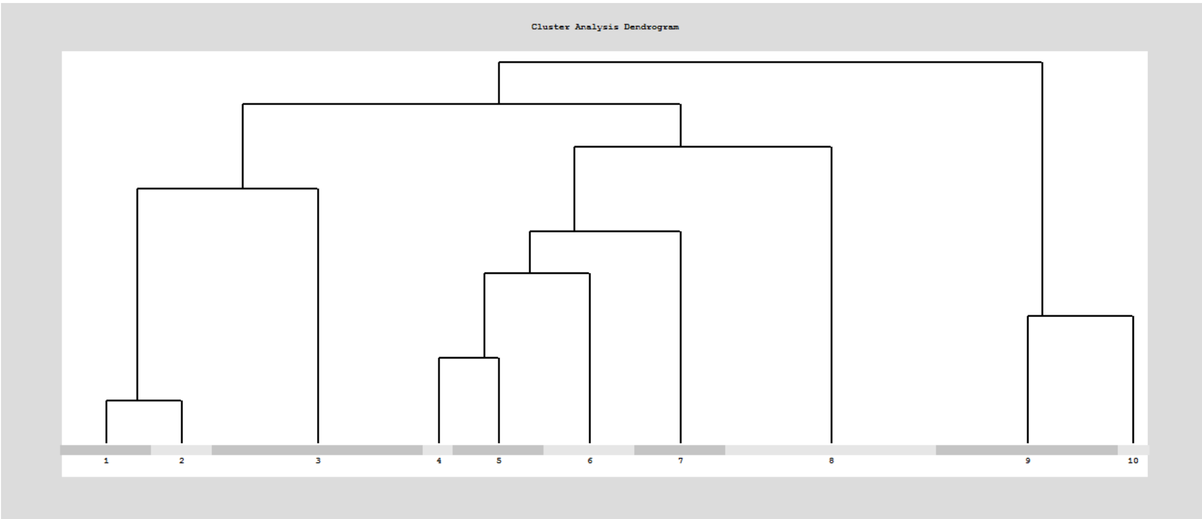

Figure 3-4: Dendrogram of Tungsten Phytosociological Data Produced using No Data Transformation, Bray-Curtis Distance and Flexible Beta (-0.25) Clustering Algorithm

The program for vegetation classification 'JUICE' was used to produce final classifications and community descriptions (fingerprint). Fingerprints describe the floristic communities including diagnostic (using Fishers Phi co-efficient), constant (occurring in more than 60% of the quadrats within the community) and dominant (with a cover >25% within the quadrat) species.

CCA (Ter Braak, 1986) were then undertaken to assist in the ecological interpretation of the floristic communities. This analysis utilises the phytosociological and environmental data. Results of the analyses are shown in Figure 3-5. Communities of the MMP are situated within sand to sandy loam area of the soil texture gradient adopted from Minasny and McBratney (2001) and Holbeche (2008) (Figure 3-6).

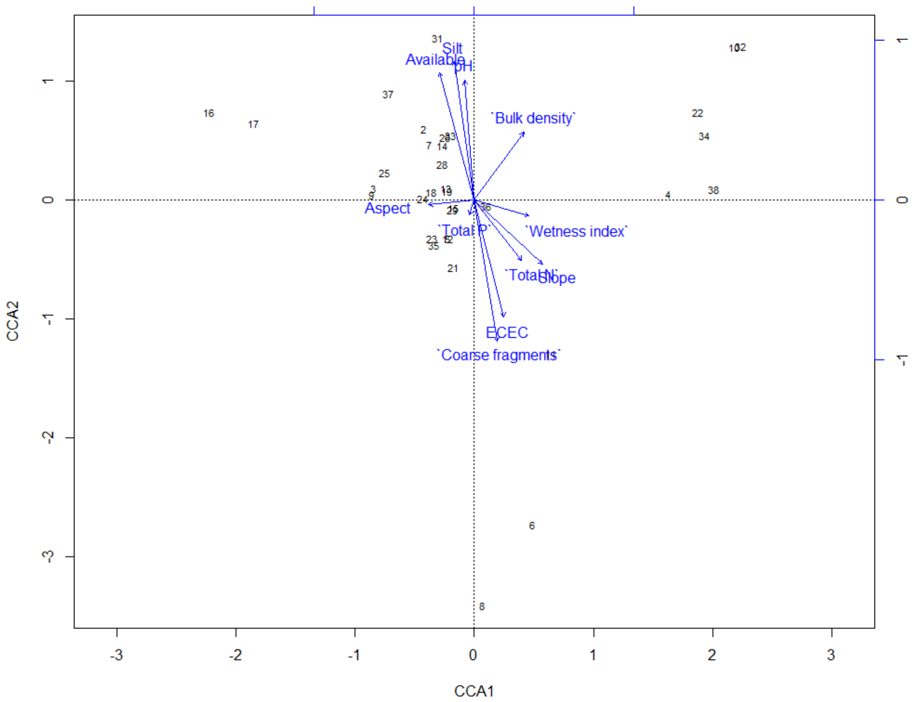

Figure 3-5: CCA of the Project Area using Environmental and Phytosociological Data

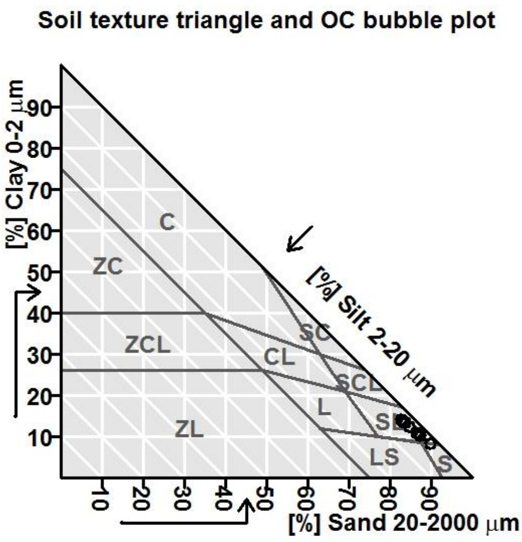

Figure 3-6: Position of Communities along Soil Texture Gradient

Sand, clay and silt box plots of the floristic communities indicated vegetation communities 1 to 5 and 8 had very similar soil properties. However, the properties of soil from Communities 7, 9 and 10 differed to the other communities (Figure 3-7). The vertical grey line indicates community mean and the shaded area is +/- 1 standard deviation.

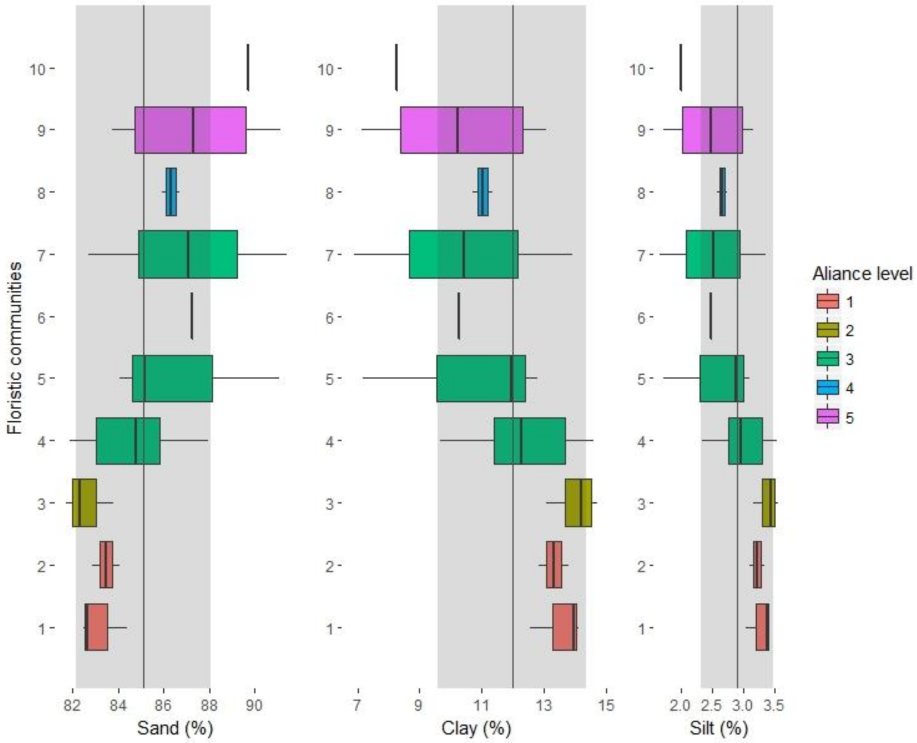

Figure 3-7: Sand, Silt and Clay Box Plots of Floristic Communities

Analyses of coarse fragments, bulk density, effective cation exchange capacity and total nitrogen properties indicated most communities had similar soil properties. However, these soil properties were notably different in Community 9. Vegetation communities 3 and 7 also had higher bulk density and coarse fragments respectively. Coarse fragments were also much higher in Community 10 than those of other communities. Results of the box plots are shown in Figure 3-8.

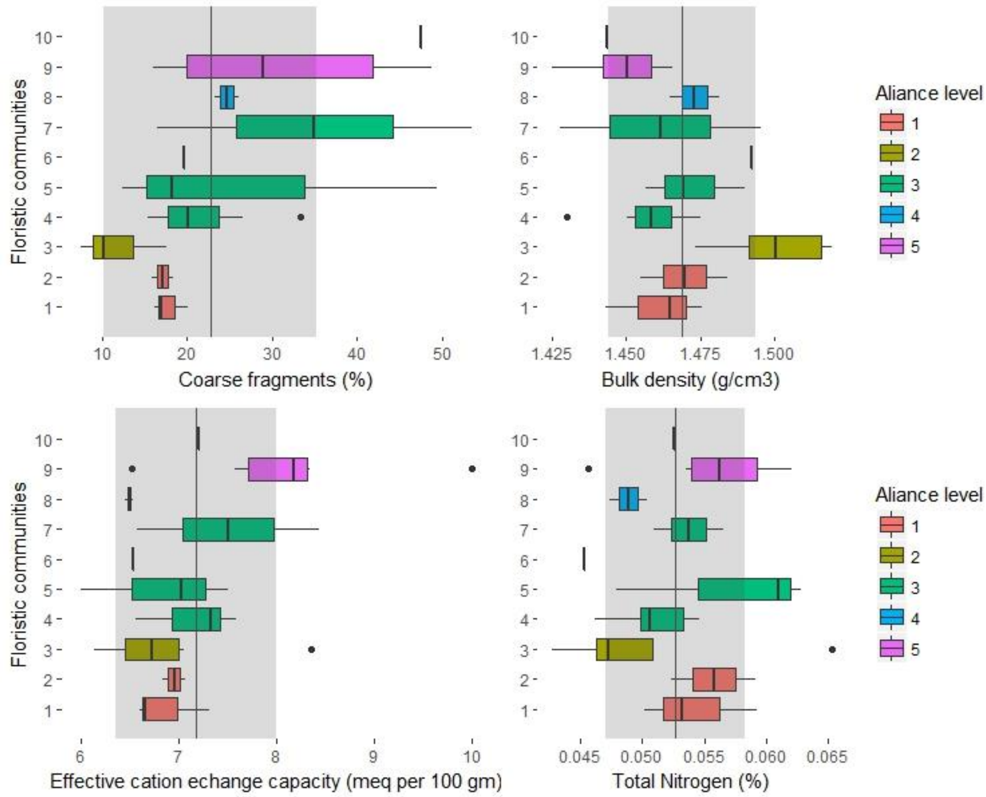

Figure 3-8: Coarse Fragments, Bulk Density, Effective Cation Exchange Capacity and Total Nitrogen Box Plots of Floristic Communities

The final alliances and vegetation communities from the analyses are described in Table 3-2 to Table 3-6. Vegetation communities of the Project area are shown in Figure 3-9.

Table 3-2: Vegetation communities of Alliance A in the Mt Mulgine Project Area

Alliance A	
Description	*Eucalyptus sp. A*[1] , open woodland on mixed *Acacia* shrubland, dominated by *Austrostipa scabra* and *Ptilotus obovatus*
Diagnostic species:	*Acacia andrewsii, Acacia ramulosa, Acacia tetragonophylla, Austrostipa elegantissima, Austrostipa scabra, Austrostipa variabilis, Cuscuta agg., Enchylaena tomentosa, Eremophila clarkei, Eriachne pulchella, Eucalyptus sp. A, Exocarpos aphyllus, Lobelia rhytidosperma, Maireana georgei, Ptilotus obovatus, Scaevola spinescens, Sclerolaena diacantha, Senna artemisioides subsp. filifolia, Senna artemisioides subsp. petiolaris, Sida calyxhymenia, Sida ectogama, Solanum agg.*
Constant species:	*Austrostipa variabilis, Ptilotus obovatus, Solanum agg.*
Dominant species:	*Austrostipa scabra, Ptilotus obovatus.*
Habitat:	Sandy loam soils
Communities	
Community 1	*Eucalyptus sp. A*, open woodland on mixed *Acacia andrewsii, Enchylaena tomentosa, Maireana georgei* & *Ptilotus obovatus* shrubland over *Austrostipa variabilis* grassland.
Community 2	*Ptilotus obovatus* & *Scaevola spinescens* shrubland over *Austrostipa scabra* grassland.
Photo plate:	

[1] Formal identification to be confirmed

Table 3-3: Vegetation communities of Alliance B in the Mt Mulgine Project Area

Alliance B	
Description	*Eucalyptus* sp. *A* woodland over mixed *Acacia* spp. including dominating *A. ramulosa* and *Eremophila* shrublands with *Eremophila clarkei, E. decipiens* and *E. oldfieldii*
Diagnostic species:	*Acacia andrewsii, Acacia exocarpoides, Acacia ramulosa, Acacia tetragonophylla, Arthropodium dyeri, Austrostipa elegantissima, Dianella revoluta, Eremophila clarkei, Eremophila decipiens subsp. decipiens, Eremophila oldfieldii, Eucalyptus sp. 1 JT ID, Exocarpos aphyllus, Grevillea didymobotrya subsp. didymobotrya, Jacksonia sp., Maireana georgei, Maireana trichoptera, Ptilotus obovatus, Ptilotus helipteroides, Ptilotus divaricatus, Rhagodia drummondii, Sclerolaena diacantha, Senna artemisioides subsp. filifolia, Senna artemisioides subsp. petiolaris, Sida calyxhymenia, Solanum agg., Stenopetalum sp.*
Constant species:	*Acacia ramulosa, Acacia tetragonophylla, Austrostipa elegantissima, Eucalyptus sp. A, Maireana georgei, Maireana trichoptera, Ptilotus obovatus, Rhagodia drummondii*
Dominant species:	*Acacia ramulosa, Eucalyptus sp. A*
Habitat:	Sandy loam soils (See Fig. 4), small course fragments, high bulk density & total nitrogen higher than average.
Communities	
Community 3	Alliance B does not split into separate community at lower hierarchical levels, and is also named Community 3.
Photo plate:	

Table 3-4: Vegetation communities of Alliance C in the Mt Mulgine Project Area

Alliance C	
Description	*Acacia* shrublands dominated by *A. assimilis* and *A. ramulosa*, interspersed with combination of myrtaceous shrubs including *Melaleuca eleuterostachya* and *M. stereophloia*, and *Allocasuarina dielsiana*.
Diagnostic species:	*Acacia acuminata, Acacia assimilis, Acacia exocarpoides, Acacia ramulosa, Acacia tetragonophylla, Allocasuarina dielsiana, Austrostipa scabra, Austrostipa variabilis, Borya sphaerocephala, Cuscuta agg , Dianella revoluta, Dodonaea inaequifolia, Eremophila alternifolia, Eremophila georgei, Eriachne benthamii, Lobelia rhytidosperma, Melaleuca eleuterostachya, Melaleuca stereophloia, Ptilotus obovatus, Ptilotus helipteroides, Sida ectogama, Solanum agg.*
Constant species:	*Acacia ramulosa, Acacia tetragonophylla, Cuscuta agg.*
Dominant species:	*Acacia assimilis, Acacia ramulosa*
Habitat:	Sandy loam soils occur across all communities with exception of Community 7 (C7). Communities 4, 5 & 6 contain small (below average) coarse fragments whilst C7 contains larger fragments.
Communities	
Community 4	*Acacia ramulosa* and *A. assimilis* woodland over *A. tetragonophylla, Melaleuca eleuterostachya*, *M. stereophloia*, and *Allocasuarina dielsiana* shrubs.
Community 5	Mixed shrubland of *Pimelea avonensis*, *Hybanthus floribundus* subsp. *curvifolius, Acacia acuminata*, *Eremophila granitica* and *Cryptandra imbricata. Acacia acuminata* and *Allocasuarina* not forming dominant (>25%) shrub layer.
Community 6	Mixed shrublands with *Eremophila decipiens* subsp. *decipiens, Ptilotus helipteroides* and *Senna artemisioides subsp. filifolia over Eriachne pulchella grassland. Acacia spp.* not forming dominant shrubland strata.
Community 7	*Allocasuarina dielsiana* and *Acacia acuminata* open woodland over *Melaleuca eleuterostachya*, *Eremophila oldfieldii* and *Thyridolepis multiculmis* shrubland.

Photo plate:	 A: Community 4, B: Community 5, C: Community 6, D: Community 7

Table 3-5: Vegetation communities of Alliance D in the Mt Mulgine Project Area

Alliance D	
Description	*Acacia acuminata, Allocasuarina dielsiana* and *Melaleuca stereophloia* dominated woodlands over mixed *Acacia* spp.
Diagnostic species:	*Acacia acuminata, Acacia tetragonophylla, Allocasuarina acutivalvis subsp. prinsepiana, Allocasuarina dielsiana, Arthropodium dyeri, Austrostipa elegantissima, Austrostipa scabra, Austrostipa variabilis, Bulb sp., Cryptandra imbricata, Cryptandra sp., Cuscuta agg , Dianella revoluta, Dodonaea inaequifolia, Eremophila granitica, Eremophila alternifolia, Eremophila clarkei, Eremophila georgei, Eremophila oldfieldii, Eriachne pulchella, Grevillea didymobotrya subsp. didymobotrya, Hybanthus floribundus subsp. curvifolius, Jacksonia sp., Melaleuca eleuterostachya, Melaleuca nematophylla, Melaleuca stereophloia, Pimelea avonensis, Ptilotus obovatus, Sida calyxhymenia, Solanum agg , Stenopetalum sp., Thyridolepis multiculmis*
Constant species:	*Acacia acuminata*
Dominant species:	*Acacia acuminata, Allocasuarina dielsiana, Melaleuca stereophloia*
Habitat:	Flat, sandy loam soils.
Communities	
Community 8	Alliance D does not split into separate community at lower hierarchical levels and is also named Community 8.
Photo plate:	

Table 3-6: Vegetation communities of Alliance E in the Mt Mulgine Project Area

Alliance E	
Description	*Acacia latior* & *Allocasuarina campestris* dominated woodlands over *Gastrolobium laytonii, Melaleuca nematophylla* and *M. scalena* shrubs over *Eriachne* grasses.
Diagnostic species:	*Acacia assimilis, Acacia latior, Allocasuarina campestris, Allocasuarina dielsiana, Arthropodium dyeri, Borya sphaerocephala, Calycopeplus paucifolius, Cryptandra sp., Cuscuta agg., Eriachne benthamii, Eriachne pulchella, Gastrolobium laytonii, Melaleuca nematophylla, Melaleuca scalena, Micromyrtus sp., Philotheca deserti, Thyridolepis multiculmis*.
Constant species:	*Acacia latior, Calycopeplus paucifolius, Philotheca deserti*
Dominant species:	*Acacia latior, Allocasuarina campestris*
Habitat:	Sandy soils, with above average (%) exposed aggregate.
Communities	
Community 9	*Acacia latior* dominated woodlands over *Gastrolobium laytonii, Calycopeplus paucifolius* and *Philotheca deserti* low open shrublands over *Eriachne benthamii* grass.
Community 10	*Allocasuarina campestris* dominated woodlands over *Micromyrtus sp. A, Cryptandra sp.* and *Calycopeplus paucifolius* low open shrubland over *Eriachne pulchella* low open grassland.
Photo plate:	 A: Community 9, B: Community 10, C: Community 9 soil profile, D: Community 10 soil profile

3.2.2 Vegetation Condition

Vegetation in the Project area has been disturbed historically through mining and exploration activities. Previous workings and numerous access tracks are evident throughout the Project area. However, the vegetation has had time to recover and its condition was predominately ‘Very Good’. The exception to this was the vegetation of Mt Mulgine which was in ‘Good’ condition. Figure 3-10 illustrates vegetation condition of the Project area.