Western Botanical

Demographic Study of Atriplex sp. Yeelirrie Station

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Cameco Australia

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19 McDonald Crescent Bassendean WA 6054
PO Box 3393 Bassendean WA 6942
T (08) 9270 0999 F (08) 6278 4988

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Client Name: Cameco Australia
Client Address: PO Box 748 Osborne Park WA 6017

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1. Executive Summary

Atriplex sp. Yeelirrie Station (L Trotter & A Douglas LCH 25025) is a geographically restricted species known from the Yeelirrie Station pastoral lease. It is listed as Threatened Flora under the Wildlife Conservation Act (WA) (1950). Previous surveys for *Atriplex* sp. Yeelirrie Station undertaken by Western Botanical for BHP Billiton during an assessment of environmental values of the Yeelirrie Orebody found two naturally occurring populations: (i) the Western Population of 80,510 plants within Study Area 1 (the Resource Area) and (ii) the Eastern Population of 190,656 plants in Study Area 3 on the eastern border of Yeelirrie Station with Albion Downs Station. An estimated 50 scattered plants, the Rehabilitation Population, within a rehabilitated former stockpile area south of the Western Resource Area were noted and an occurrence in rehabilitation near the former Communications Tower site was also reported (Western Botanical 2011).

The demography of *Atriplex* sp. Yeelirrie Station populations within Western Population and the Rehabilitation Population were assessed over a three day period (19th to 21st August 2014). A visit to the Eastern Population was limited to making a description of the habitat and a brief observation of plants within the population on 22nd August.

Rainfall in the months preceding the field survey showed little effective rainfall except for two tropical rain bearing depressions in January (102 mm in two events) and a substantial (54.4 mm) winter rainfall event, largely over 4 days in May.

Five vegetation units were described across three study sites:

- Rehabilitated Laydown Area, the "Rehabilitation Population", with *Atriplex* sp. Yeelirrie Station – one relatively homogeneous area.
- Western Baseline *Atriplex* sp. Yeelirrie Station Population, the "Western Population", with two vegetation types:
    - one supporting *Atriplex* sp. Yeelirrie Station; and
    - the other being the fringing vegetation complexes to the north characterised by *Lycium australe*, *Eucalyptus gypsophila*, *Melaleuca xerophila* and/or *Eragrostis* sp. Yeelirrie Calcrete (S. Regan LCH 26770).
- Eastern Baseline *Atriplex* sp. Yeelirrie Station Population, the "Eastern Population", with two vegetation types:
    - one supporting *Atriplex* sp. Yeelirrie Station; and
    - the other being the adjacent *Lawrencia helmsii* shrubland on low gypsum rises.

Species presence and dominance within each vegetation community that was assessed is presented in Table 4. This shows the rehabilitated vegetation on non-saline well drained sandy loam soil has a relatively high species richness of 41 species. Species composition is typical of (i) the undisturbed adjacent *Acacia ayersiana* mulga woodland vegetation on hardpan plains (HPMS vegetation association of Western Botanical, 2011) and (ii) the addition of a wide range of chenopods that are typically included in minesite rehabilitation in the Goldfields of W.A.

This contrasts strongly with the relatively low species richness of the naturally occurring vegetation communities supporting *Atriplex* sp. Yeelirrie Station on the saline smectite clay soils: six species in the Western Population and nine species in the Eastern Population (both mapped as CApS community in Western Botanical, 2011). Four species within the Rehabilitation population are also found in the Western Population: two of the dominant species from the latter population *Atriplex* sp. Yeelirrie Station and *Lawrencia densiflora,* the annual herb *Zygophyllum glaucum* and the ubiquitous relatively weedy annual species *Salsola tragus*. The *Atriplex* sp. Yeelirrie Station and *Lawrencia densiflora* are also dominant species found at the Eastern Population.

Twelve species were recorded in the August 2014 studies but were not recorded in the field works forming the basis for the Western Botanical 2011 report. These should be added to the cumulative species list for the tenements. None of these have conservation listing.

Of the overall 55 species recorded in this assessment and of the 12 novel species recorded, two are of taxonomic interest: *Eragrostis* sp. Yeelirrie Gypsum (G Cockerton LCH35671) and *Vittadinia dissecta* var. *hirta*.

One hundred and nine individuals of *Atriplex* sp. Yeelirrie Station plants were noted within the Rehabilitation Population. A summary and comparison of *Atriplex* sp. Yeelirrie Station plant statistics between the Rehabilitation Population and Western Population shows that:

- There was no significant difference in the ratio of male to female plants at either the Rehabilitation Population or the Western Baseline Population.
- There was no significant difference in the proportion of plants scored as juvenile vs mature at either the Rehabilitation Population or the Western Baseline Population.
- Plants in the Rehabilitation Population were significantly larger in all dimensions. Plants in rehabilitation were 24% taller, 99% wider and 75% broader than plants in the Western Population. Consequently, plants in rehabilitation had a larger overall plant volume (72%).
- However, plants in the Rehabilitation Population also had large portions of their canopies that were dead. When this was taken into account and the live volumes of plants were assessed, plants in the Rehabilitation Population had live canopies that were 42% smaller than those in the Western Population.

- As no plants in either the Rehabilitation Population or Western Population were flowering, there was no difference in flowering rate between these two sites. However, the mature plants at the Eastern Population were noted as flowering (and growing) vigorously. This is probably reflecting the increased soil moisture noted in soil samples taken at the Eastern Population.

- Plants holding fruiting bracteoles were scored on a scale of 0 to 3 (nil to large amounts of fruits on the plant). Plants in the Rehabilitation Population scored 239% higher for the number of plants holding fresh fruits on the plant and had a higher score (252%) for the amount of fresh fruits held on the plants compared to the Western Baseline Population. Some fruits were dissected in-situ at the Rehabilitation Population and were found to consistently have a firm, robust viable seed within. The fruits collected from plants under the DRF permit issued have not yet been assessed for seed fill, viability or germinability.

- There was no difference in the frequency of plants holding older fruits and no difference in the abundance of older fruits held on plants between populations.

The following inferences can therefore be drawn from this data:

1. *Atriplex* sp. Yeelirrie Station can grow in habitats other than the naturally occurring smectite clay. Sex ratios in the Rehabilitation Population are not significantly different from the Western Population which is around 50:50.

2. The rates of flowering and vegetative growth on plants can be related to prevailing soil moisture availability and seasonal conditions.

3. Plants appear to flower and set abundant fruits containing healthy seed in response to suitable seasonal conditions.

4. *Atriplex* sp. Yeelirrie Station plants grow to large mature sizes, flower and produce fruits and seeds both within their natural habitat and to a significantly larger degree in the Rehabilitation Population (in the sandy loam of the adjacent HPMS vegetation community).

5. *Atriplex* sp. Yeelirrie Station plants in the Rehabilitation Population take advantage of the good seasons to grow larger canopies, however, incur large proportionate deaths of their canopies during drought conditions compared to minimal loss of canopies in the Western Population.

6. Under favourable moisture conditions, seeds that are dislodged from the parent plants (i.e.: through trampling or grazing by cattle), can convert to seedlings of *Atriplex* sp. Yeelirrie Station at high rates. Survival rates beyond the young seedling stage have not been assessed. Low levels of natural seedling recruitment occur when seeds are retained on stems and not mechanically dislodged.

The data collected in this limited assessment and the observations of the inadvertent propagation of plants in rehabilitation in the Rehabilitation Population at the southern stockpile area are supportive of likely successful rehabilitation and translocation of *Atriplex* sp. Yeelirrie Station. Fruits containing what appear to be viable seeds are abundantly produced on plants though the continued viability and germinability of these over time have not yet been assessed using seeds collected in this program.

The results of the field investigations indicate that if germinable *Atriplex* sp. Yeelirrie Station seed is applied to a variety of soil types, plants are likely to establish given reasonable seasonal conditions. However, differences in performance including size of mature plants, relative health and integrity of the canopies, flowering and fruiting phenologies may vary in relation to soil PSD and soil chemistry, seasonal conditions and plant available soil water regimes. Subsequent generations of plants may be slow to establish if seeds are not mechanically dislodged from parent plants due to the indehiscent nature of the fruiting bracteoles.

Geoff Cockerton

25.11.2014

2. Introduction

2.1. Project Background

Atriplex sp. Yeelirrie Station (L Trotter & A Douglas LCH 25025) is a geographically restricted species known from the Yeelirrie Station pastoral lease. It is listed as Threatened Flora under the Wildlife Conservation Act (WA) (1950). Previous surveys for *Atriplex* sp. Yeelirrie Station undertaken by Western Botanical for BHP Billiton during an assessment of environmental values of the Yeelirrie Orebody found two naturally occurring populations: (i) the Western Population of 80,510 plants within Study Area 1 (the Resource Area) and (ii) the Eastern Population of 190,656 plants in Study Area 3 on the eastern border of Yeelirrie Station with Albion Downs Station. An estimated 50 scattered plants, the Rehabilitation Population, within a rehabilitated former stockpile area south of the Western Resource Area were noted and an occurrence in rehabilitation near the former Communications Tower site was also reported (Western Botanical 2011).

The purpose of this survey was to:

(i) Accurately assess the numbers of *Atriplex* sp. Yeelirrie Station within the previously rehabilitated stockpile area;

(ii) Assess the reproductive state and seed producing capacity of plants within each population; and

(iii) Assess the demography of the populations at each site with an emphasis on the age classes reflecting observable recruitment success.

(iv) Correlate the observed population characteristics with soil characteristics at each site.

The demography of *Atriplex* sp. Yeelirrie Station populations within the Western Population and the Rehabilitation Population at the former stockpile area to the south were assessed over a three day period (19th to 21st August 2014). A visit to the Eastern Population was limited to making a description of the habitat and a brief observation of plants within the population on 22nd August. Soil profile descriptions and samples were taken by Tim Duff (Cameco) at each site. Soil characteristics were analysed by Soilwater Consultants and an interpretation of the lab analysis was undertaken by Mr. Doug Blandford for Western Botanical.

2.2. Previous surveys

The numbers and distribution of *Atriplex* sp. Yeelirrie Station, focusing on the two naturally occurring populations, were assessed and reported in Western Botanical (2011). In addition to the two major naturally occurring populations of *Atriplex* sp. Yeelirrie Station, the Western Population within the Resource Area and the Eastern Population near the boundary with Albion Downs Station, Western Botanical also reported two small occurrences of the species in

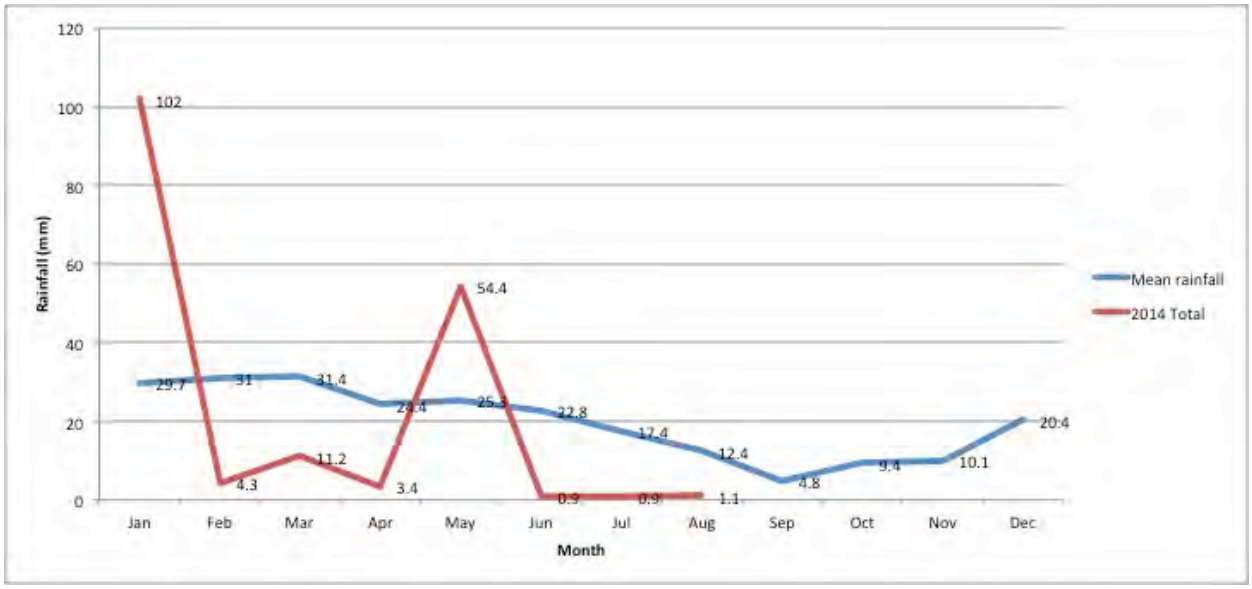
rehabilitated areas adjacent to the orebody population near the Western Population. At that stage, approximately 8% of plants in the Western Population had fruit, 8% had male flowers only, and 15% of plants appeared to be dead (or aestivating), Western Botanical (2011).

2.3. Current Survey

2.4. Physical Environment

Yeelirrie Station lies within the East Murchison (Mur 1) Biogeographic Subregion within the Eremaean botanical province. Vegetation is characterised by Mulga on hardpan plains, Spinifex on sandplains and chenopod shrublands in saline parts of paleochannels and salt lake margins. The climate of the region is described as dry Mediterranean with hot summers subject to thunderstorms and occasional cyclone events; and cool winters with variable rainfall. Average annual rainfall is 240 mm with 56% being recorded in the hotter summer months. Rainfall in the months preceding the field survey showed little effective rainfall except for two tropical rain bearing depressions in January (102 mm in two events) and a substantial (54.4 mm) winter rainfall event, largely over 4 days in May, Figure 1.

Figure 1. Rainfall at Yeelirrie, 2014 vs long term mean.



3. Methods

Three areas supporting *Atriplex* sp. Yeelirrie Station were assessed:

- "Western Population". Naturally occurring baseline population in the Western Resource Area (WRA) within Study Area 1;
- "Rehabilitation Population" in the former stockpile area, south of the WRA within Study Area 1;
- "Eastern Population". Naturally occurring baseline population in Study Area 3, approximately 32 km south-east of the Resource Area in Study Area 1 and adjacent to Albion Downs Station.

At the Western Population and Rehabilitation Population sites, the following measurements were taken:

- Description of vegetation with representative photographs;
- Full list of associated species compiled with specimens of selected taxa taken for reference or verification at the WA Herbarium;
- Individual plants located using GPS, +/- 5m accuracy (Rehabilitation Population only);
- Plants within the Western Population were all included within a 20 x 20 m quadrat;
- Plants labelled with numbered aluminium tag (all plants in the Rehabilitation Population and around half of the plants in the Western Population – due to limited numbered tags and time being available);
- Plant height, width (widest axis) and depth (measured at perpendicular to width), all measured to the nearest cm;
- Plants scored as Live Mature, Live Juvenile, Dead;
- Flowering of plants scored as 0 (nil), 1 (few), 2 (many), 3 (large amount);
- The amount of seed held on plants was assessed as 0 (nil), 1 (few), 2 (many), 3 (large amount) within two age categories:
    - Fresh Seed – those fruits with fresh, non-weathered bracts; and
    - Old Seed (those fruits with weathered bracts).

Examples of each seed category (Fresh vs Old seed) are presented in Figures 2 and 3.

Figure 2. Fresh Seed, non-weathered bracts

Figure 3. Old Seed, weathered bracts

At the Eastern Population, time limitations meant that only a brief assessment could be made and no measurements of *Atriplex* plants were made. However, a site description, a full list of associated species and comments on the condition of the population were made.

At all sites, soil sample profile descriptions and soil samples were taken by Tim Duff, Cameco, with subsequent particle size distribution (PSD) analyses being conducted by Soilwater Consultants. An analysis of the soil chemistry and test results was provided by Mr Doug Blandford of DC Blandford & Associates for Western Botanical.

All GPS locations were recorded using a hand held Garmin GPS with an estimated positional error of 5m. Photographs were taken at 10 MP image size using a Pentax SLR digital Camera. All flora not readily identified in the field, including annual species, were collected for verification at the WA Herbarium.

At both the Rehabilitation Population and the Western Population, an estimated 200 fresh fruits and 200 older weathered fruits were collected from each of 5 female plants for seed fill, viability and germination testing. It is therefore estimated that approximately 4,000 fruits, each potentially containing 1 seed, have been collected. Seed was collected under DRF Permit 35-1415 issued to Geoff Cockerton, Western Botanical. The testing has not been conducted at this stage.

Statistical analysis of *Atriplex* population parameters was conducted by Dr David Leach using SPSS version 22 (IBM Corporation 2013) to detect any significant differences of measured and calculated variables between the Western Baseline Population and the Rehabilitation Population. Non-parametric statistical tests were chosen as the majority of variables were binary or possessed heterogeneous variance (Levene Statistic, $p<0.05$). The general p-value of 0.05 was used for all tests.

Ratio variables (plant height, width, depth, total volume, alive volume, and percent alive canopy) were analysed with Mann-Whitney U tests. Binary variables (sex, alive/dead, adult/young, flowering status, old fruit presence, new fruit presence) were analysed using Binary Logistic Regression. While old fruit abundance and new fruit abundance (0-4 scale rating) were analysed using Multiple Linear Regression.

An analysis of the species composition of each of the vegetation communities described was undertaken using PATN analysis. However, due to the small sample size and low number of species in the communities other than the Rehabilitation Population, the analysis was neither meaningful nor helpful. A larger data set with replication would be required to undertake this analysis. Species presence and dominance are presented in Table 1 to 3 and relationships between communities are readily noted in the Species vs Sites table presented in Table 4.

4. Results

4.1. Site Descriptions

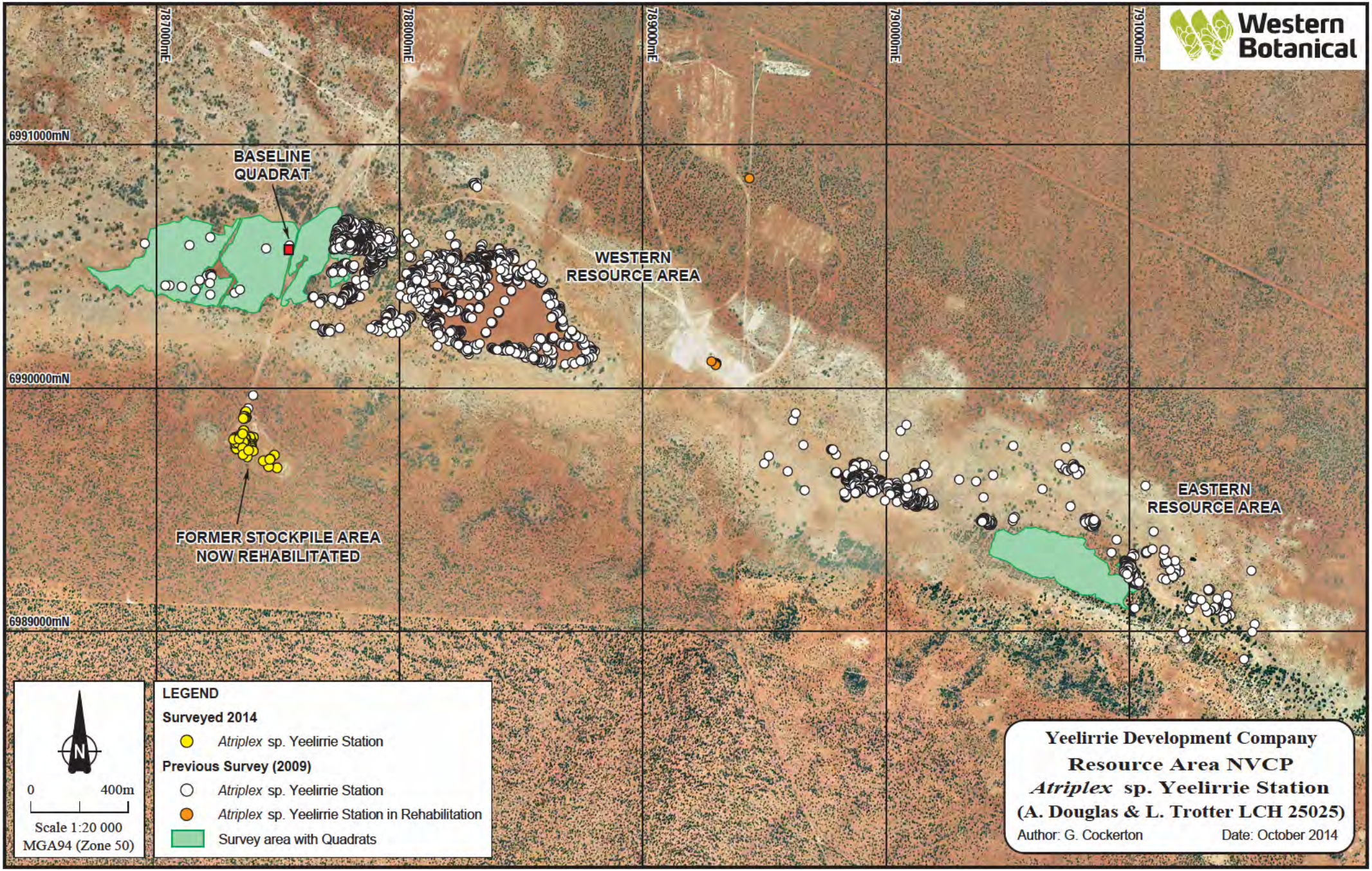
Site descriptions of the three sites assessed (two with two adjacent communities each described) are presented below. These are:

- Rehabilitated Laydown Area with *Atriplex* sp. Yeelirrie Station, the Rehabilitation Population, – one relatively homogeneous area.
- Western Baseline *Atriplex* sp. Yeelirrie Station Population, the Western population, – two vegetation types:
    - one supporting *Atriplex* sp. Yeelirrie Station; and
    - the other being the fringing vegetation complexes to the north characterised by *Lycium australe, Eucalyptus gypsophila, Melaleuca xerophila* and/or *Eragrostis* sp. Yeelirrie Calcrete (S. Regan LCH 26770).
- Eastern Baseline *Atriplex* sp. Yeelirrie Station Population, the Eastern Population, – two vegetation types:
    - one supporting *Atriplex* sp. Yeelirrie Station; and
    - the other being the adjacent *Lawrencia helmsii* shrubland on low gypsum rise.

These areas are depicted on the map presented in Figure 4.

Figure 4. Populations of *Atriplex* sp. Yeelirrie Station assessed.

Author: G. Cockerton ~ Drawn: CAD Resources ~ Tel 9246 3242 ~ URL www.cadresources.com.au ~ Oct 2014 ~ A4 ~ Rev: B ~ CAD Ref g1697_F06_17.dgn ~ Imagery: Landgate (March 2009)



4.1.1. Rehabilitation Population of *Atriplex* sp. Yeelirrie Station

The Rehabilitation Population of *Atriplex* sp. Yeelirrie Station lies within the rehabilitated former Stockpile Area lies some 650 m south of the Western Resource Area monitoring quadrat adjacent to the central baseline track. The 6.2 ha site was rehabilitated in 2004 by WMC Resources Ltd using Rally Revegetation as the revegetation contractor. It remains unknown at this stage what the composition of the seed mix may have been or from where it was obtained (provenance). It is also unknown if *Atriplex* sp. Yeelirrie Station seed was collected locally and spread on site though the supply of local provenance seed did form part of the seed supply tender for the program at the time. The area was deep ripped on an east-west alignment. The area is now well vegetated with both perennial and annual species. Scattered mature individuals of *Atriplex* sp. Yeelirrie Station are present, mostly in the north-western 30% of the rehabilitated area.

Vegetation Description: Scattered *Acacia* species (*Acacia ayersiana* 1.5m, A. *pruinocarpa* 1.5m, *A. burkittii* 1.5m, *Acacia aneura* (sens. lat.) 1.5m, PFC 2% with occasional *Eremophila longifolia* to 2.5m, PFC < 1% over shrubs of *Ptilotus obovatus* (typical goldfields form) 0.5m, *Zygophyllum eremaeum* 0.5m, *Maireana georgei* 0.5m, *M. pyramidata* 0.7m, *Atriplex* sp. Yeelirrie Station (in western 30% mostly), PFC 15% with occasional clumps of hummocked grasses *Triodia basedowii* 0.5 / 1.0m, PFC < 1%. Annual herbs include *Atriplex semilunaris* 0.4m, *Ptilotus nobilis* (formerly *P. exaltatus*) 0.6m, PFC 5 to 25%, Figures 5, 7. The species composition of rehabilitation at the former stockpile area is presented in Tables 1 and 4.

Figure 5. Vegetation within the rehabilitated stockpile area, from the north-west corner, looking south-east (image 5286).

The soil is a non-saline (EC 7.94 mS/m bulk sample) hard setting coarse pale red sandy loam with a pH of 8.0 at the surface and around 7.2 from 10 to 40 cm depth, Figure 6. The soil surface has an estimated 20% cover of calcrete gravel and stones, including some mineralised rocks containing carnetite, likely influencing surface pH, however, calcrete is not native within the upper soil profile. The soil profile was dry at the time of assessment with moisture content varying from 1.6% at the surface to 3.2% at 20 to 40 cm. The bulk sample soil particle size distribution (PSD) values for this site indicate 90.3% sand, 1.1% silt and 8.6% clay, Appendix 3. At the time of assessment, the soil has plant available water of 11%, which is relatively low in comparison to the soils supporting the two natural populations of *Atriplex* sp. Yeelirrie Station.

Soil sampling, data and photographs provided by Cameco, Figure 6.

Site 1

Location: Rehab population (near plant 43, Zone: 50, Easting: 787360mE, 6989779mN)

Date: Wednesday 20th August 2014

Notes: massive red loamy sand with some calcrete at the surface. Very dry soil within no noticeable clay content. Roots were noticeable at final depth. The area was previously an ore stockpile that has been rehabilitated.

Samples:

Lab ID 39051 – 0 to 10cm

Lab ID 39052 – 10 to 20cm

Lab ID 39053 – 20 to 40cm

Lab ID 39054 – bulk

Lab ID 39055 – bulk

Figure 6. Soil profile at the rehabilitated stockpile site (Tim Duff, Cemeco)

The enigmatic presence of *Atriplex* sp. Yeelirrie Station at this site is difficult to conclusively explain. The potential for wind dispersal of the *Atriplex* seed from the Western Population adjacent is considered low as the plant is an indehiscent bradysporous species, holding the seed tightly on the stems. It is considered more likely that plant material holding seeds was transferred to the site by WMC Resources in development and operation of the ore stockpile through the movement of soil and plant material and the successful establishment of plants here may well have preceded the 2004 revegetation program.

Table 1. Species composition of rehabilitation at the former stockpile area.

Species	Frequency
Acacia aneura (sens. lat.)	occasional
Acacia ayersiana	common
Acacia burkittii	common
Acacia macraneura	occasional
Acacia pruinocarpa	occasional
Acacia ramulosa subsp. ramulosa	occasional
Acacia tetragonophylla	occasional
Acetosa vesicaria *	common
Aristida contorta	common
Atriplex codonocarpa	common
Atriplex semilunaris	common and widespread
Atriplex sp. Yeelirrie Station (Douglas & Trotter LCH 25025)	Occasional (109 plants noted) numbered tags 1 to 109
Calandrinia sp.	occasional, common on margins of rehab area

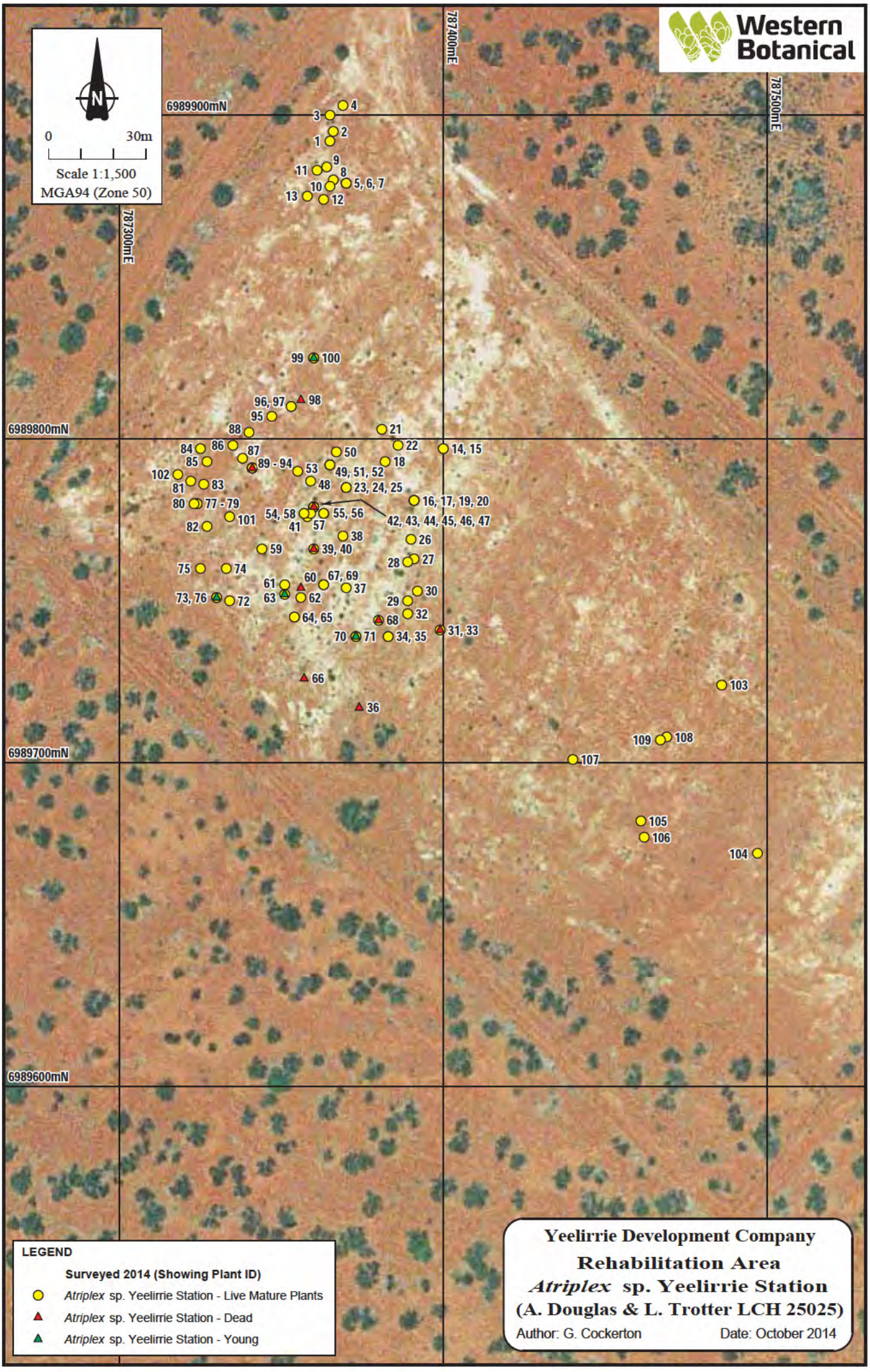
Species	Frequency
Lawrencia densiflora	common
Dissocarpus paradoxus	common and widespread
Enneapogon caerulescens	common
Eragrostis dielsii	common
Eragrostis eriopoda	occasional, common on margins of rehab area
Eragrostis sp. Yeelirrie Calcrete (S. Regan LCH 26770)	4 plants noted
Eremophila longifolia	common
Euphorbia australis	occasional
Euphorbia drummondii	common
Grevillea berryana	occasional
Maireana tomentosa subsp. tomentosa	common
Maireana tomentosa subsp. red fruits	common
Maireana georgei	common and widespread
Maireana pyramidata	common and widespread
Marsdenia australis	occasional
Ptilotus nobilis (formerly P. exaltatus)	common and widespread
Ptilotus obovatus	common
Salsola tragus	common
Sclerolaena densiflora	common and widespread
Sclerolaena diacantha	common and widespread
Sclerolaena cuneata	common and widespread
Senna artemisioides subsp. filifolia	common
Solanum lasiophyllum	common
Solanum nummularium	common
Swainsona sp. (not collected)	common
Vittadinia dissecta var. hirta	common and widespread
Zygophyllum aurantiacum subsp. aurantiacum	common and widespread
Zygophyllum glaucum	common

The one hundred and nine individuals of *Atriplex* sp. Yeelirrie Station plants noted within the Rehabilitation Population were each marked with a galvanised fence dropper, each with a numbered aluminium tag affixed. Tags were located on the northern side of the plant on the edge of the live canopy, Figure 7. Plant tag numbers 1 to 109 (109 plants). The locations of these are depicted on the map in Figure 8.

Figure 7. Image 5319, looking southwards, showing labelling of *Atriplex* sp. Yeelirrie Station plants within the Rehabilitation Population in the former stockpile area.

Note the remnant calcrete at surface which is not inherent in the soil profile.

Figure 8. *Atriplex* sp. Yeelirrie Station plants within the Rehabilitation Population.


Western Botanical
N
0
30m
Scale 1:1,500
MGA94 (Zone 50)
787400mE
787500mE
787300mE
6989900mN
6989800mN
6989700mN
6989600mN
LEGEND
Surveyed 2014 (Showing Plant ID)
Atriplex sp. Yeelirrie Station - Live Mature Plants
Atriplex sp. Yeelirrie Station - Dead
Atriplex sp. Yeelirrie Station - Young
Yeelirrie Development Company
Rehabilitation Area
Atriplex sp. Yeelirrie Station
(A. Douglas & L. Trotter LCH 25025)
Author: G. Cockerton
Date: October 2014
Author: G. Cockerton ~ Drawn: CAD Resources ~ Tel 9246 3242 ~ URL www.cadresources.com.au ~ Oct 2014 ~ A4 ~ Rev: B ~ CAD Ref g1697_F06_18.dgn ~ Imagery: Landgate (March 2009)

4.1.2. Western Population of Atriplex sp. Yeelirrie Station

Given the high density of *Atriplex* sp. Yeelirrie Station plants at the naturally occurring Western Population, assessment of a representative sample was conducted using a 20 x 20m quadrat. The quadrat is established on the western side of the main track that traverses the *Atriplex* sp. Yeelirrie Station population, and lies approximately 40 m west of the track. The quadrat is established on angles of 190 degrees / 280 degrees (magnetic) with 4 corner pegs left in place, Figures 9, 10.

The site is a saline (EC 380 mS/m bulk sample) red smectite clay flat supporting a Dwarf Scrub D (Muir 1977) of *Atriplex* sp. Yeelirrie Station 0.15 to 0.6m high x 0.1 to 1m wide, PFC 7% with associated annuals *Lawrencia densiflora* 0.3m (dominant), PFC 15 to 25% and *Zygophyllum glaucum* 0.1 to 0.4m, PFC 1 to 5% and occasional *Sclerolaena* sp. red leaves (not fully identified) 0.25m, *Salsola tragus* 0.5m, PFC < 1%. *Atriplex* sp. Yeelirrie Station is the only perennial species present within this vegetation community.

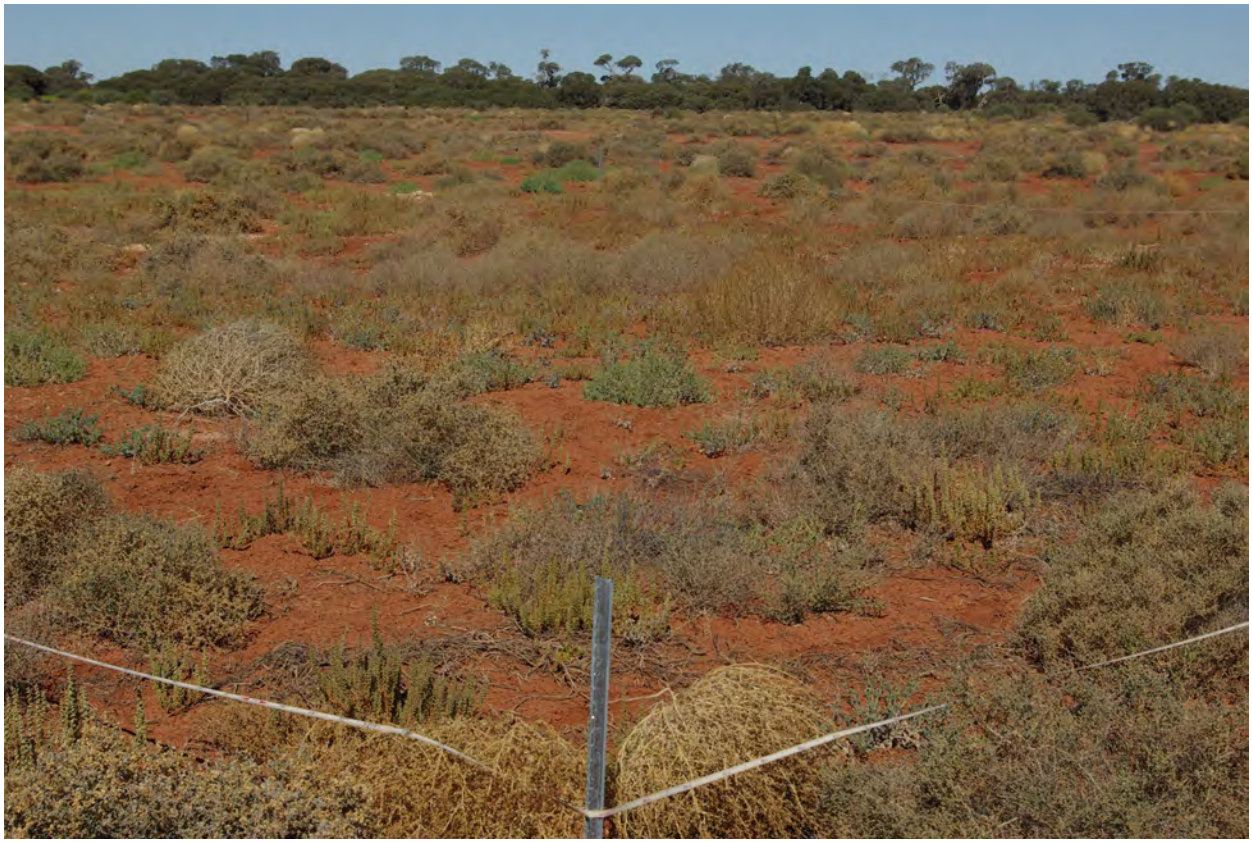


Figure 9. Baseline monitoring quadrat, looking from north-west peg looking south-east (image 5406).

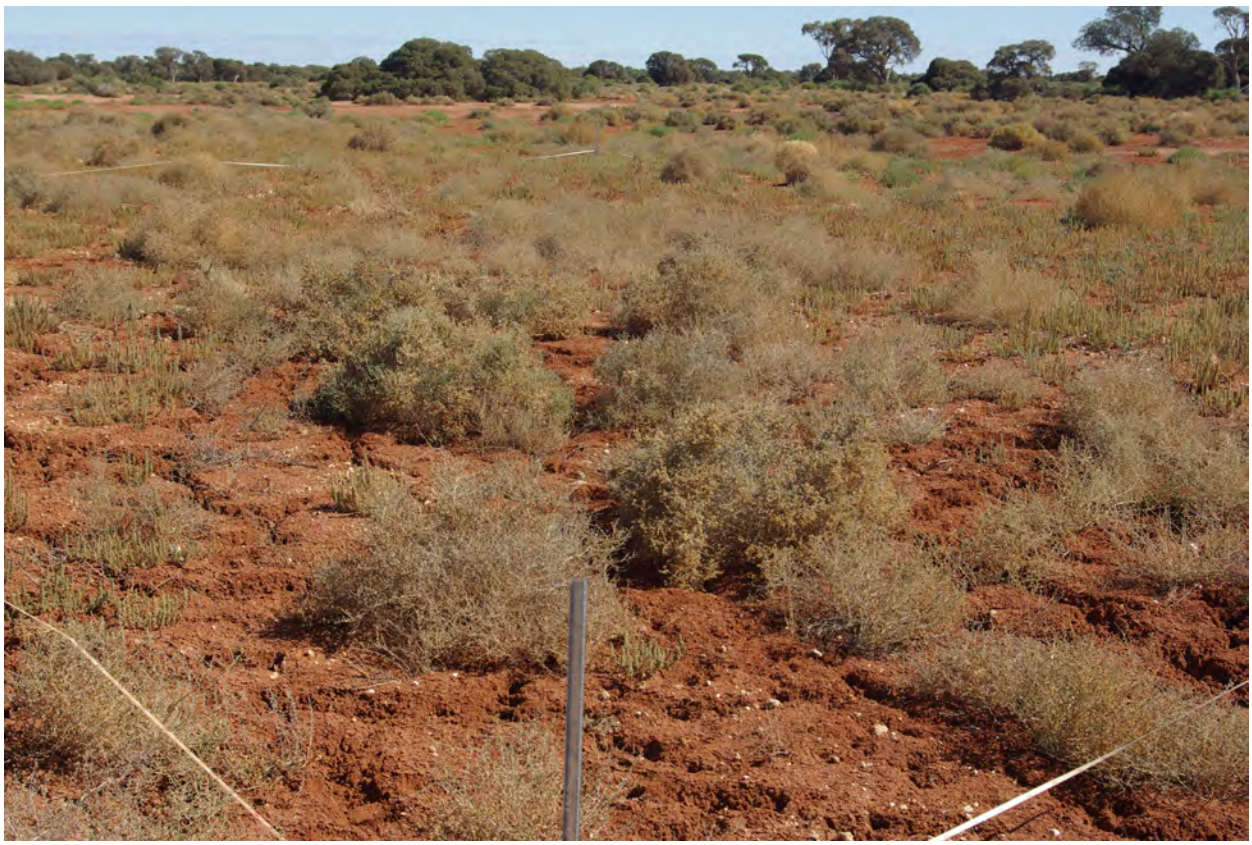


Figure 10. Baseline monitoring quadrat, 20 x 20 m, looking from north-east peg looking south-west (image 5409). The central baseline access track is some 40 m to the left of frame.

Soil is a saline (EC 97.4 mS/m) dark red, friable, sandy smectite clay at the surface (0 to 10 cm) which dries to a crumbly texture with aggregates 2 to 10 mm diameter. Soil below 10 cm is a saline (EC 332 to 494 mS/m) heavy sandy clay, aggregating into large clods to 20 cm diameter. Deep cracks occur when dry to a depth of at least 25cm, Figure 10 . The surface soil was dry at the time of assessment (7.2% moisture content), however was moist at depth with 14.9% and 20.5% moisture being recorded from 10 to 20 cm and 20 to 40 cm respectively. The bulk soil sample had a PSD of 50.9% sand, 14% silt and 35.1% clay. The clay content is very high and while the moisture record indicated 20.5% soil moisture with 19.5% plant available water. This contrasts with the relatively low clay content and higher plant available moisture at the Eastern Population and the very dry conditions in the Rehabilitation Population. Fine roots, presumably of *Atriplex* sp. Yeelirrie Station, were noted throughout the soil profile.

Calcrete gravel and rocks are present at the surface and representative soil profile sections through the site show that calcrete underlays the smectite clay at depths of 1 to 2 m (Cameco).

Figure 10. Soil surface at the Western *Atriplex* sp. Yeelirrie Station population (image 5408).

Soil sampling, data and photographs provided by Cameco, Figures 11 and 12.

Site 2

Location: Ore body population (GPS – next to plant 110)

Date: Thursday 21st August 2014

Notes: self mulching medium, strongly held clay with increase moisture content with depth.

Samples:

Lab ID 39056 – 0 to 10cm (dry friable clay)

Lab ID 39057 – 10 to 20cm (consolidated clays with some moisture)

Lab ID 39058 – 20 to 50cm (strongly held clays with high moisture content)

Lab ID 39059 – bulk

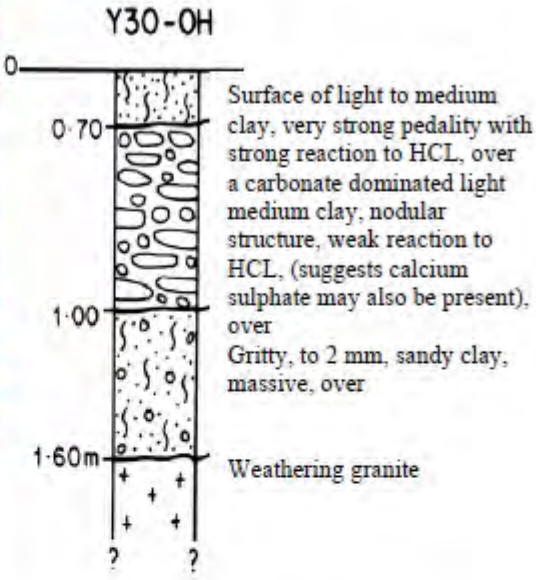
Lab ID 39060 – bulk

Figure 11. Soil profile within the Western Population (Tim Duff, Cameco)

Related information: *Site Y30 is typical of a clay flat within the Calcrete System. Here, 0.7 m of self mulching, medium to light medium, strongly pedal clay, overlies a nodular light medium clay with carbonates to 1.0 m which in turn overlies 0.6 m of gritty sandy clay. Weathering granite occurs at 1.6 m below the surface. The abrupt boundaries between horizons suggest that the horizonation is stratigraphic rather than pedologic.* (D. C. Blandford & Associates Pty Ltd, 2011).

SITE Y30 Calcrete System

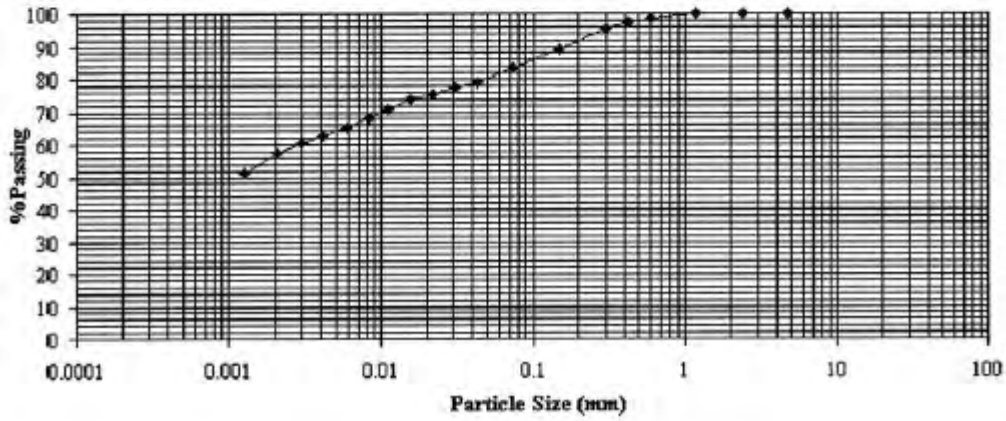
6990566 N
0787032 E



Summary:

Depth of sample 0-0.2 m

Strongly pedal light-medium clay (58%<2µm): moderately alkaline (pH 8.0): calcareous, low organic carbon (0.23%): deficient in P-Zn.
Boron at toxic levels (17 mg/kg).



BHP Billiton: Soils and Soil Landscapes: D.C.Blandford & Associates P/Ltd January, 2011 55

Figure 12. Soil profile description and PSD (DC Blandford & Associates, 2011)

Plants within the quadrat were each marked with a fence dropper peg, each peg being on northern perimeter of the canopy of the plant it identifies. Pegged plants are in the eastern third of the quadrat (the number of pegs and numbered tags was limited and we were unable to label all plants within the quadrat). Plant tag numbers within the quadrat are 110 to 181 (71 plants labelled), Figure 13. The species compositions of the two vegetation communities described at this site are presented in Tables 2 and 4.

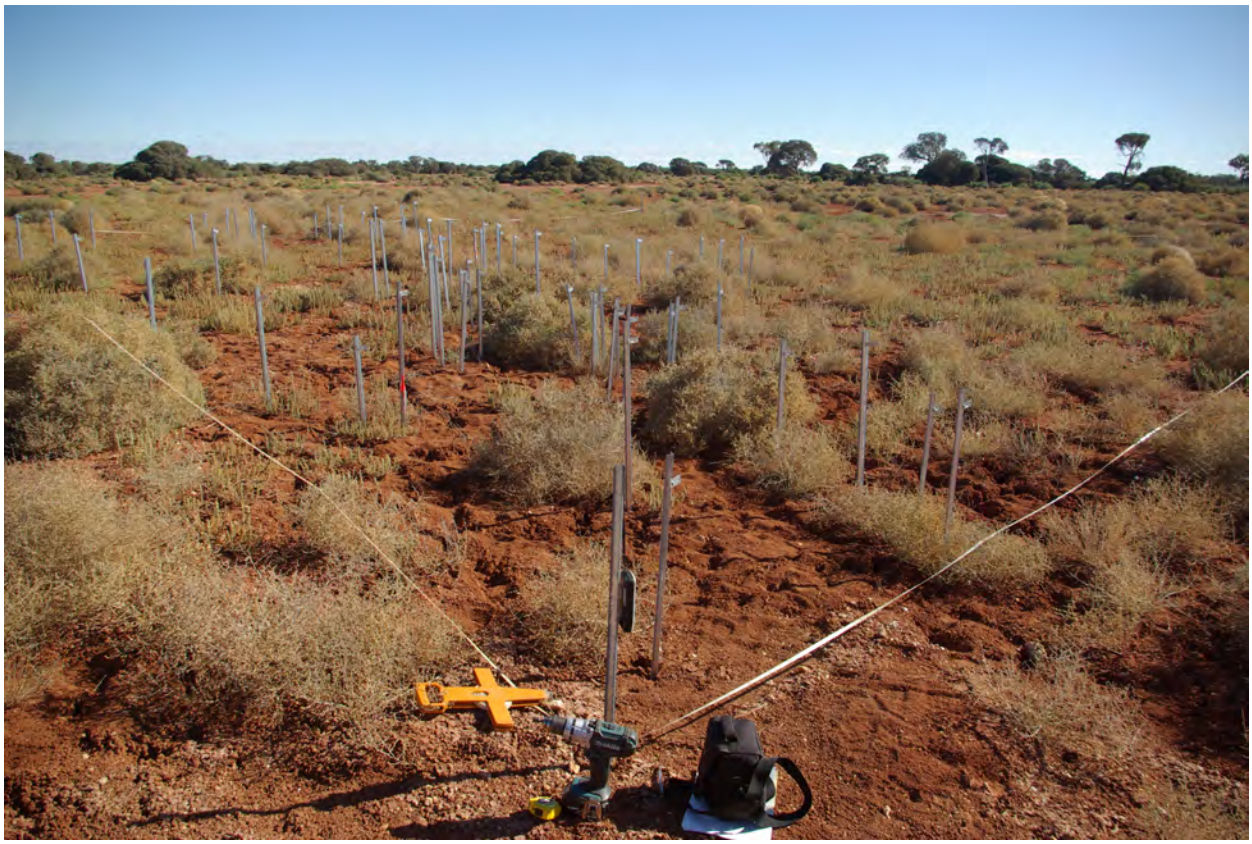


Figure 13. Labelled *Atriplex* sp. Yeelirrie Station plants in the eastern part of the quadrat (image 5410).

Table 2. Species composition of the two vegetation communities described at the Western *Atriplex* sp. Yeelirrie Station Population.

Species	Frequency
Atriplex sp. Yeelirrie Station population	
Atriplex sp. Yeelirrie Station (A. Douglas & L. Trotter LCH 25025)	codominant
Lawrencia densiflora	codominant
Zygophyllum glaucum	codominant
Sclerolaena sp. red leaves (not fully identified)	occasional
Salsola tragus	occasional
Eragrostis tenellula	occasional

Species	Frequency
Fringing vegetation complexes include:	
Lycium australe	common
Minuria cunninghamii	occasional
Sida intricata	occasional
Trichanthodium skirrophorum	occasional
Eucalyptus gypsophila	common
Melaleuca xerophila	common
Eragrostis sp. Yeelirrie Calcrete (S. Regan LCH 26770)	common

4.1.3. Eastern Population of Atriplex sp. Yeelirrie Station

The site supporting the Eastern Population of *Atriplex* sp. Yeelirrie Station is a complex playa lake system with low gypsum rises supporting *Lawrencia helmsii* shrubland and patches of red smectite clay in lower lying areas supporting *Atriplex* sp. Yeelirrie Station shrubland.

Atriplex sp. Yeelirrie Station Population:

Vegetation is described as Dwarf Scrub D *Atriplex* sp. Yeelirrie Station 0.05 to 0.5m, PFC 5 to 30% with *Lawrencia densiflora* 0.3m PFC 2%, occasional *Sclerolaena* sp. red leaves (not fully identified) 0.2m, PFC < 1%. Four different *Eragrostis* species were also present, Figure 12, Tables 3 and 4.

Figure 12. The Eastern Population of _Atriplex_ sp. Yeelirrie Station.

One of the perennial *Eragrostis* species present, here termed *Eragrostis* sp. Yeelirrie Gypsum (G. Cockerton LCH35671), appears to be a new undescribed species with no close matching specimens at the WA Herbarium. One specimen, *Sclerolaena* sp. red leaves, has not been fully identified at this stage.

The area is still subject to recent grazing by cattle and there is evidence of *Atriplex* sp. Yeelirrie Station and *Lawrencia densiflora* plants being extensively grazed and trampled. Significant regeneration of *Atriplex* sp. Yeelirrie Station observed with abundant seedlings 2 to 10 cm high, Figures 13, 14.

Mature plants of *Atriplex* sp. Yeelirrie Station were producing fruit, male plants with flowers and female plants with mature fruits on larger plants (generally over 0.5m high x 0.5m wide). This contrasts strongly with the population at the Western Population and also at the Rehabilitation Population where the plants were not flowering, suggesting there is a significantly greater moisture availability at the Eastern Population at the time of assessment.

Figure 13. Young plant of *Atriplex* sp. Yeelirrie Station at the Eastern Population site (image 5480).

Figure 14. Young seedlings of *Atriplex* sp. Yeelirrie Station growing around a dead, trampled plant. Trampled and dead plants and young seedlings are abundant at the Eastern Population site (image 5510).

The soil profile is characterised by 5 to 10 cm of dry crumbly red silty smectite clay overlaying extensive moist unconsolidated gypsiferous fine silty sand. The soil was saline (228 mS/m bulk sample), moist with 12.4% moisture recorded to 7 cm and with 24.4% and 22.9% moisture from 7 cm to 20 cm and 20 cm to 40 cm respectively. The bulk soil sample had the following PSD: 80.1% sand, 10.7% silt, 9.2% clay. The relatively lower level of clay here compared to the Western Baseline Population site means that plant available water is very high at 42%. The bulked soil samples had Boron levels of 16 and 18 mg/Kg and are considered toxic to most species.

Soil sampling, data and photographs provided by Cameco, Figures 15 and 16.

Site 3

Location: SE Population (Zone: 51, Easting: 224913mE, Northing: 6974502mN)

Date: Friday 22nd August 2014

Notes: medium red clay over a medium pallid (gypsum clay), moisture content increased with depth.

Samples:

Lab ID 39061 – 0 to 7cm (light to medium clay, dry and red)

Lab ID 39062 – 7 to 20cm (light pallid clay, moisture increasing with depth)

Lab ID 39063 – 20 to 40cm (light pallid clay, moisture increasing with depth)

Lab ID 39064 – bulk

Lab ID 39065 – bulk

Figure 15. Soil profile at the Eastern Population of *Atriplex* sp. Yeelirrie Station (Tim Duff, Cameco)

Figure 16. Landscape and vegetation at the Eastern Population of Atriplex sp. Yeelirrie Station (Tim Duff, Cameco)

Lawrencia helmsii Shrubland

The adjacent *Lawrencia helmsii* shrubland occurs on a slightly raised (estimated 10 cm above the smectite clay soil adjacent) but level gypsum soil. No *Atriplex* sp. Yeelirrie Station plants grow amongst the *Lawrencia*, instead scattered shrubs of *Atriplex vesicaria* subsp. *appendiculata* are present here, Figure 17.

Vegetation here is described as Open Dwarf Scrub C *Lawrencia helmsii* to 1m, PFC 5 to 7 % with *Atriplex vesicaria* subsp. *appendiculata* 0.3m, *Sclerolaena fimbriolata* 0.3m and four *Eragrostis* spp., PFC < 1%, Tables 3 and 4. Soil surface is pale brown crusted gypsum. No soil sample was taken for assessment.

Eragrostis sp. Yeelirrie Gypsum (G. Cockerton LCH35671) is also present amongst the *Lawrencia* plants on the gypsum soil.

Figure 17. *Lawrencia helmsii* shrubland adjacent to the *Atriplex* sp. Yeelirrie Station community at the Eastern Population (image 5527).

Table 3. Species composition of the vegetation communities noted at the Eastern Population of *Atriplex* sp. Yeelirrie Station.

Species	Frequency
Atriplex sp. Yeelirrie Station vegetation species composition:	
Atriplex sp. Yeelirrie Station (Douglas & Trotter LCH 25025)	codominant
Lawrencia densiflora	codominant
Sclerolaena sp. red leaves	occasional
Eragrostis sp. Yeelirrie Calcrete (S. Regan LCH 26770)	occasional
Eragrostis dielsii	occasional
Eragrostis sp. Yeelirrie Gypsum (G Cockerton LCH 35671)	occasional
Eragrostis falcata	occasional
Trichanthodium skirrophorum	occasional
Atriplex holocarpa	occasional
Lawrencia helmsii shrubland	
Lawrencia helmsii	dominant
Atriplex vesicaria subsp. appendiculata	occasional
Sclerolaena fimbriolata	occasional
Eragrostis sp. Yeelirrie Calcrete (S. Regan LCH 26770)	occasional
Eragrostis sp. Yeelirrie Gypsum (G Cockerton LCH 35671)	occasional
Eragrostis falcata	occasional
Enneapogon caerulescens	occasional

4.1.4. Species Composition Comparisons

Species presence and dominance within each vegetation community that was assessed is presented in Table 4. This shows the rehabilitation vegetation on non-saline well drained sandy loam soil has a high species richness of 41 species. Species composition is typical of (i) the undisturbed adjacent *Acacia ayersiana* mulga woodland vegetation on hardpan plains (HPMS vegetation Association of Western Botanical, 2011) and (ii) the addition of a wide range of chenopods that are typically included in minesite rehabilitation in the Goldfields of W.A.

This contrasts strongly with the relatively low species richness of the naturally occurring vegetation communities supporting *Atriplex* sp. Yeelirrie Station on the saline smectite clay soils: six species in the Western Population and nine species in the Eastern Population (both mapped as CApS community in Western Botanical, 2011). Four species within the Rehabilitation Population are also found in the Western Population: *Atriplex* sp. Yeelirrie Station and *Lawrencia densiflora,* the annual herb *Zygophyllum glaucum* and the ubiquitous relatively weedy annual species *Salsola tragus*. The *Atriplex* sp. Yeelirrie Station and *Lawrencia densiflora* are also dominant species found at the Western Population and the Eastern Population.

Table 4. Species comparison between the five vegetation communities described.

Species	Rehabilitated Stockpile Area	Western Atriplex Population	Western Atriplex population Fringing Vegetation complex	Eastern Atriplex population	Eastern Atriplex population Fringing Lawrencia Shrubland
Acacia aneura	1				
Acacia ayersiana	1				
Acacia burkittii	1				
Acacia macraneura	1				
Acacia pruinocarpa	1				
Acacia ramulosa subsp. ramulosa	1				
Acacia tetragonophylla	1				
Acetosa vesicaria *	1				
Aristida contorta	1				
Atriplex codonocarpa	1				
Atriplex semilunaris	1				
Atriplex sp. Yeelirrie Station (Douglas & Trotter LCH 25025)	1	1		1	
Calandrinia sp. Indet. (not collected)	1				
Lawrencia densiflora	1	1		1	
Dissocarpus paradoxus	1				

Species	Rehabilitated Stockpile Area	Western Atriplex Population	Western Atriplex population Fringing Vegetation complex	Eastern Atriplex population	Eastern Atriplex population Fringing Lawrencia Shrubland
Enneapogon caerulescens	1				1
Eragrostis dielsii	1			1	1
Eragrostis eriopoda	1				
Eragrostis sp. Yeelirrie Calcrete (S. Regan LCH 26770)	1		1	1	
Eremophila longifolia	1				
Euphorbia australis	1				
Euphorbia drummondii	1				
Grevillea berryana	1				
Maireana tomentosa subsp. tomentosa	1				
Maireana tomentosa subsp. red fruits	1				
Maireana georgei	1				
Maireana pyramidata	1				
Marsdenia australis	1				
Ptilotus nobilis (formerly exaltatus)	1				
Ptilotus obovatus	1				
Salsola tragus	1	1			
Sclerolaena densiflora	1				
Sclerolaena diacantha	1				
Sclerolaena obliquicuspis	1				
Senna artemisioides subsp. filifolia	1				
Solanum lasiophyllum	1				
Solanum nummularium	1				
Swainsona sp.	1				
Vittadinia dissecta var. hirta	1				
Zygophyllum aurantiacum subsp. aurantiacum	1				
Zygophyllum glaucum	1	1			
Sclerolaena sp. (red leaves)		1		1	

Species	Rehabilitated Stockpile Area	Western Atriplex Population	Western Atriplex population Fringing Vegetation complex	Eastern Atriplex population	Eastern Atriplex population Fringing Lawrencia Shrubland
Eragrostis tenellula		1			
Lycium australe			1		
Minuria cunninghamii			1		
Sida intricata			1		
Trichanthodium skirrophorum			1	1	
Eucalyptus gypsophila			1		
Melaleuca xerophila			1		
Eragrostis sp. Yeelirrie Gypsum (G Cockerton LCH35671)				1	1
Eragrostis falcata				1	1
Atriplex holocarpa				1	
Lawrencia helmsii					1
Atriplex vesicaria subsp. appendiculata					1
Sclerolaena fimbriolata					1
Species Richness	**41**	**6**	**7**	**9**	**7**

Total number of species collected: 55

Key:
"1" in a cell indicates presence.
Grey shaded cells indicate dominance / common occurrence.

4.1.5. Novel species records for Yeelirrie Station.

Twelve species were recorded in the August 2014 studies, Table 5, but were not recorded in the field works forming the basis for the Western Botanical 2011 report. These should be added to the cumulative species list for the tenements.

Of these, two taxa are of taxonomic interest:

- *Eragrostis* sp. Yeelirrie Gypsum (G Cockerton LCH35671) is a potential new species. It keys to the annual *Eragrostis pergracilis* but the specimen collected is a long lived clumping perennial. Taxonomic revision of the good material collected is warranted. It

was found growing in the *Lawrencia helmsii* shrubland on gypsum and in the Eastern Population of *Atriplex* sp. Yeelirrie Station.

- *Vittadinia dissecta* var. *hirta* is a perennial shrub to 0.4m and was collected in the rehabilitated stockpile area. The specimen is a good match for this species which has a very odd distribution in Australia and the record at Yeelirrie is a significant distance from most other collections. It is known from four regions in W.A.: the mid-west near Geraldton, the Central Pilbara, the Coolgardie bioregion south of Yeelirrie and in Central Australia. Also in SA, Vic, NSW and Qld.

Table 5. Novel species records for the Yeelirrie tenement

Species	Comment
Atriplex holocarpa	Common and widespread annual species
Eragrostis falcata	Widespread in W.A.
Eragrostis sp. Yeelirrie Gypsum (G. Cockerton LCH35671)	Potential new species, keys to the annual *Eragrostis pergracilis* but the specimen collected is a long lived clumping perennial.
Lawrencia densiflora	Common and widespread annual species of clayey soils, annual.
Maireana tomentosa subsp. red fruits	Informal name for this species. Widespread in Murchison region of W.A. Taxonomy of *Maireana* needs revision to include this and other species.
Maireana tomentosa subsp. tomentosa	This sub species not specifically recorded before at Yeelirrie, however, is widespread in W.A.
Sclerolaena fimbriolata	Common and widespread perennial species of gypsum soils.
Sida intricata	Common and widespread perennial species of clayey soils.
Trichanthodium skirrophorum	Widespread annual in W.A.
Vittadinia dissecta var. hirta	Previously reported *Vittadinia sulcata* and *V. eremaea* from Yeelirrie (Western Botanical 2011). Specimen is a good match for *Vittadinia dissecta* var. *hirta* but this species has a very odd distribution in Australia and the record at Yeelirrie is a significant distance from most other collections. Perennial shrub to 0.4m, collected in the rehabilitated stockpile area.
Zygophyllum glaucum	Common and widespread annual species in W.A.
Zygophyllum glaucum	Common and widespread annual species in W.A.

4.1.6. Species not fully identified

Two species were not fully identified; (i) a *Calandrinia* species at the Rehabilitation site was small immature and had little chance of positive identification and was not collected, (ii) A *Sclerolaena* species with red leaves that was collected with the *Atriplex* sp. Yeelirrie Station plants at both the Western Population and the Eastern Population has not yet been fully identified.

4.1.7. Weeds

Ruby Dock, *Acetosa vesicaria*, is well established in the revegetation at the former stockpile site.

4.2. Comparative Analysis

4.2.1. Species composition of *Atriplex* sp. Yeelirrie Station vegetation communities.

The vegetation supporting populations of *Atriplex* sp. Yeelirrie Station on the smectite clay soil are characteristically species poor. Six species were recorded at the Western Population and nine species were recorded at the Eastern Population with a total of 11 species recorded in total across the two sites. This indicates that the vegetation comprises highly specialised flora able to tolerate the specific soil and hydrological conditions presented by the soil and landscape position. The Western Population effectively grows on a deep profile of smectite clay with a pH of 8.83 at the surface to 8.37 at 20 to 40 cm depth, while the Eastern Population grows on a thin veneer of smectite clay (~10 cm), pH of 8.19 at the surface over gypsiferous sand, silt and light pallid clay wit a pH of 8.43 at 20 to 40 cm. DC Blandford & Associates (2011) states that the smectite clay is stratigraphic rather than pedologic at the Western Population, *i.e.* has been transported to and deposited at this site. This may also apply at the Eastern Population.

Only three species, *Atriplex* sp. Yeelirrie Station, *Lawrencia densiflora* and *Sclerolaena* sp. red leaves (not fully identified as yet) are found at both sites, Table 4. This indicates that the site conditions are subtly yet sufficiently different to influence the species composition either by exclusion of some species or by chance. An example of the latter could be the suspected new species *Eragrostis* sp. Yeelirrie Gypsum (G Cockerton LCH35671) which is present amongst the *Lawrencia helmsii* plants on gypsum but is also present amongst the *Atriplex* plants which grow on shallow smectite clay over gypsum adjacent at the Eastern Population.

The Rehabilitation Population of *Atriplex* sp. Yeelirrie Station is found on a deep profile of hard setting sandy loam and the bulk of the 41 species present are characteristic either of the adjacent undisturbed *Acacia ayersiana* Shrubland or are species that were introduced in the rehabilitation program (*Maireana* and *Atriplex* species). Only four species within the rehabilitation vegetation are also found in the Western Baseline population; *Atriplex* sp. Yeelirrie Station, *Lawrencia densiflora*, *Zygophyllum glaucum* and the relatively weedy native species *Salosla tragus*.

4.2.2. Comparison of measured parameters of *Atriplex* sp. Yeelirrie Station.

Rehabilitation Population

Atriplex sp. Yeelirrie Station plants within the Rehabilitation Population were mostly large mature plants that demonstrated large plant size and female plants held substantial amounts of fruiting bracts. While both older and fresh seed was collected for assessment, the seed fill percentage has not yet been established. Of the 109 plants located within the fenced boundary, 100 plants were alive, 95 were mature and 5 were juvenile. Nine dead plants were recorded and labelled. Of those that could be sexed, 52 were male and 54 were female with 3 juvenile plants unable to be sexed. None were flowering while 73 plants had at least some fruiting bracteoles present.

Western Population

Within the 20 x 20m quadrat established in the Western Population, 72 *Atriplex* sp. Yeelirrie Station plants were labelled and measured. Of these, 65 were mature and 7 were juvenile. No dead plants were recorded although some dead plants were noted more widely within the vegetation community outside the quadrat. Of the live plants, 16 were male and 29 were female while 27 were unable to be sexed as they had no flowers or fruits present and may represent either male or juvenile individuals. Forty five plants held either old dried flowers or were carrying fruiting bracteoles.

Eastern Population

While no statistics were gathered at the Eastern Population, the following were noted:

- *Atriplex* sp. Yeelirrie Station plants showed evidence of significant current grazing and trampling by cattle with many dead plants noted;
- *Atriplex* sp. Yeelirrie Station plants had vigorous foliage cover with abundant new shoots;
- Large numbers of seedlings 5 to 10 cm in height of *Atriplex* sp. Yeelirrie Station were observed, sometimes in densities of over 100 plants per square metre.

Table 6. Summary statistics, *Atriplex* sp. Yeelirrie Station, Rehabilitation Population vs Western Population.

Variable	Western Population Mean	Rehabilitation Population Mean	% Difference (Rehab vs Western)	p-value	Result	Direction
Sex (m=1 f=2)	1.64	1.51	-8%	0.129	Not Significant	
Dead/Alive (0-1)	1.00	0.92	-8%	0.997	Not Significant	
Adult/Young (1-2)	1.10	1.05	-5%	0.184	Not Significant	
Flowering	Not tested - no plants were flowering at either location					
Height (cm)	35	43.36	24%	0.000	Significant	Higher
Width (cm)	61.28	122.21	99%	0.000	Significant	Higher
Depth (cm)	58.96	103.13	75%	0.000	Significant	Higher
Volume (All) m3	0.2232	0.6888	209%	0.000	Significant	Higher
Volume (Alive) m3	0.2223	0.3826	72%	0.001	Significant	Higher
Canopy Alive %	0.99	0.60	-40%	0.000	Significant	Lower
Old Fruit Presence (0-1)	0.63	0.53	-16%	0.218	Not Significant	
New Fruit Presence 0-1)	0.18	0.61	239%	0.000	Significant	Higher
Old Fruit Abundance (0-3)	0.99	1.03	4%	0.818	Not Significant	
New Fruit Abundance (0-3)	0.42	1.48	252%	0.000	Significant	Higher

5. Discussion

A summary and comparison of Atriplex sp. Yeelirrie Station plant statistics between the Rehabilitation Population and Western Population is presented in Table 6. This analysis shows that:

- There was no significant difference in the ratio of male to female plants at either the Rehabilitation Population or the Western Baseline Population.
- There was no significant difference in the proportion of plants scored as juvenile vs mature at either the Rehabilitation Population or the Western Baseline Population.
- Plants in the Rehabilitation Population were significantly larger in all dimensions. Plants in rehabilitation were 24% taller, 99% wider and 75% broader than plants in the Western Baseline Population. Consequently, plants in rehabilitation had a larger overall plant volume (72%).
- However, plants in the Rehabilitation Population also had large portions of their canopies that were dead. When this was taken into account and the live volumes of plants were assessed, plants in the Rehabilitation Population had live canopies that were 40% smaller than those in the Western Baseline Population.
- As no plants in either the Rehabilitation Population or Western Population were flowering, there was no difference in flowering rate between these two sites. However, the mature plants at the Eastern Baseline Population were noted as flowering (and growing) vigorously. This probably reflected the increased soil moisture noted in soil samples taken at the Eastern Baseline Population.
- Plants holding fruiting bracteoles were scored on a scale of 0 to 3 (nil to large amounts of fruits on the plant). Plants in the Rehabilitation Population scored 239% higher for the number of plants holding fresh fruits on the plant and had a higher score (252%) for the amount of fresh fruits held on the plants compared to the Western Population. The Western Population had a large proportion of plants (37.5%) that had no fruits at all indicating that they were either male (but not flowering) or were juvenile and not yet reproductive.
- Some fruits were dissected in-situ at the Rehabilitation Population and were found to consistently have a firm, robust viable seed within. The fruits collected from plants under the DRF permit issued have not yet been assessed for seed fill, viability or germinability.
- There was no difference in the frequency of plants holding older fruits and no difference in the abundance of older fruits held on plants between populations.

The following inferences can therefore be drawn from this data:

1. *Atriplex* sp. Yeelirrie Station can grow in habitats other than the naturally occurring smectite clay. Sex ratios in the Rehabilitation Population are not significantly different from the Western Baseline Population with is around 50:50.

2. The rates of flowering and vegetative growth on plants can be related to prevailing soil moisture availability and seasonal conditions.

3. Plants appear to flower and set abundant fruits containing healthy seed in response to suitable seasonal rainfall conditions and suitable soil moisture regimes.

4. *Atriplex* sp. Yeelirrie Station plants grow to large mature sizes, flower and produce fruits and seeds both within their natural habitat and to a significantly larger degree in the Rehabilitation Population (in the sandy loam of the adjacent HPMS vegetation community).

5. *Atriplex* sp. Yeelirrie Station plants in the Rehabilitation Population take advantage of the good seasons to grow larger canopies, however, incur large proportionate deaths of their canopies during drought conditions compared to minimal loss of canopies in the Western Population.

6. Under favourable moisture conditions, seeds that are dislodged from the parent plants (i.e.: through trampling or grazing by cattle), seedlings of *Atriplex* sp. Yeelirrie Station can establish at high rates. Survival rates beyond the young seedling stage have not been assessed. Low levels of natural seedling recruitment occur when seeds are retained on stems and not dislodged.

5.1.1. Implications for rehabilitation and translocation

The data collected in this limited assessment and the observations of the inadvertent propagation of plants in the Rehabilitation Population at the southern stockpile area is supportive of likely successful rehabilitation and translocation of *Atriplex* sp. Yeelirrie Station.

Fruits containing what appear to be viable seeds are abundantly produced on plants though the continued viability and germinability of these has not been assessed using seeds collected in this program. Western Botanical's former revegetation services division, Landcare Services, undertook a limited seed viability and germinability trials on seed lots collected in 2010 (Landcare Services 2011). This showed fresh seed excised from the enclosing bracts had a 96% viability and 78% germinability while older seeds had a slightly reduced 79% viability and 73% germinability. Seeds remaining in the bract had a significantly reduced germination rate of 0% for fresh seed and 22% for older seed. This indicates that there is a chemical dormancy and

inhibition of germination conferred by the enclosing bracts which is slowly broken down in the ageing process.

The results of the field investigations indicate that if germinable *Atriplex* sp. Yeelirrie Station seed is applied to a variety of non-saline soil types, plants are likely to establish given reasonable seasonal conditions. However, differences in performance including size of mature plants, relative health and integrity of the canopies, flowering and fruiting phenologies may vary in relation to soil PSD and soil chemistry, seasonal conditions and plant available soil water regimes. Subsequent generations of plants may be slow to establish if seeds are not artificially dislodged from parent plants due to the indehiscent nature of the fruiting bracteoles.

6. Acknowledgments

Dr David Leach, Western Botanical, for conducting the statistical analyses and final plant identifications for the difficult taxa.

Mr Doug Blandford for interpretation of the soil test data.

Mr Tim Duff, Cameco, for assistance with the field works and provision of the soil profile data and photographs.

Mr Malcolm Trudgen for review of *Vittadinia* specimens collected.

7. Bibliography

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- Landcare Services (2011) *Atriplex sp. Yeelirrie Station (L. Trotter & A. Douglas 25025) Seed Collection Program Report February 2011.* Consultants report prepared for URS Australia and BHP Billiton Yeelirrie Development Company. Report Ref LCS693.
- Muir (1977) Vegetation Classification System
- WA Herbarium's reference Herbarium and Main Collection
- Western Botanical (2011) *Flora and Vegetation Survey Baseline Report February 2011.* Consultants report prepared for URS Australia and BHP Billiton Yeelirrie Development Company. Report Ref WB653.

Appendix 1. Data

Population	Plant Tag #	Easting	Northing
Rehabilitation	1	787365	6989892
Rehabilitation	2	787366	6989895
Rehabilitation	3	787365	6989900
Rehabilitation	4	787369	6989903
Rehabilitation	5	787370	6989879
Rehabilitation	6	787370	6989879
Rehabilitation	7	787370	6989879
Rehabilitation	8	787366	6989880
Rehabilitation	9	787364	6989884
Rehabilitation	10	787365	6989878
Rehabilitation	11	787361	6989883
Rehabilitation	12	787363	6989874
Rehabilitation	13	787358	6989875
Rehabilitation	14	787400	6989797
Rehabilitation	15	787400	6989797
Rehabilitation	16	787391	6989781
Rehabilitation	17	787391	6989781
Rehabilitation	18	787382	6989793
Rehabilitation	19	787391	6989781
Rehabilitation	20	787391	6989781
Rehabilitation	21	787381	6989803
Rehabilitation	22	787386	6989798
Rehabilitation	23	787370	6989785
Rehabilitation	24	787370	6989785
Rehabilitation	25	787370	6989785
Rehabilitation	26	787390	6989769
Rehabilitation	27	787391	6989763
Rehabilitation	28	787389	6989762
Rehabilitation	29	787389	6989750
Rehabilitation	30	787392	6989753
Rehabilitation	31	787399	6989741
Rehabilitation	32	787389	6989746
Rehabilitation	33	787399	6989741
Rehabilitation	34	787383	6989739
Rehabilitation	35	787383	6989739
Rehabilitation	36	787374	6989717
Rehabilitation	37	787370	6989754
Rehabilitation	38	787369	6989770
Rehabilitation	39	787360	6989766
Rehabilitation	40	787360	6989766
Rehabilitation	41	787358	6989776
Rehabilitation	42	787360	6989779
Rehabilitation	43	787360	6989779

Population	Plant Tag #	Easting	Northing
Rehabilitation	44	787360	6989779
Rehabilitation	45	787360	6989779
Rehabilitation	46	787360	6989779
Rehabilitation	47	787360	6989779
Rehabilitation	48	787359	6989787
Rehabilitation	49	787365	6989792
Rehabilitation	50	787367	6989796
Rehabilitation	51	787365	6989792
Rehabilitation	52	787365	6989792
Rehabilitation	53	787355	6989790
Rehabilitation	54	787357	6989777
Rehabilitation	55	787363	6989777
Rehabilitation	56	787363	6989777
Rehabilitation	57	787359	6989777
Rehabilitation	58	787357	6989777
Rehabilitation	59	787344	6989766
Rehabilitation	60	787356	6989754
Rehabilitation	61	787351	6989755
Rehabilitation	62	787356	6989751
Rehabilitation	63	787351	6989752
Rehabilitation	64	787354	6989745
Rehabilitation	65	787354	6989745
Rehabilitation	66	787357	6989726
Rehabilitation	67	787363	6989755
Rehabilitation	68	787380	6989744
Rehabilitation	69	787363	6989755
Rehabilitation	70	787373	6989739
Rehabilitation	71	787373	6989739
Rehabilitation	72	787334	6989750
Rehabilitation	73	787330	6989751
Rehabilitation	74	787333	6989760
Rehabilitation	75	787325	6989760
Rehabilitation	76	787330	6989751
Rehabilitation	77	787324	6989780
Rehabilitation	78	787324	6989780
Rehabilitation	79	787324	6989780
Rehabilitation	80	787323	6989780
Rehabilitation	81	787322	6989787
Rehabilitation	82	787327	6989773
Rehabilitation	83	787326	6989786
Rehabilitation	84	787325	6989797
Rehabilitation	85	787327	6989793
Rehabilitation	86	787335	6989798

Population	Plant Tag #	Easting	Northing
Rehabilitation	87	787338	6989794
Rehabilitation	88	787340	6989802
Rehabilitation	89	787341	6989791
Rehabilitation	90	787341	6989791
Rehabilitation	91	787341	6989791
Rehabilitation	92	787341	6989791
Rehabilitation	93	787341	6989791
Rehabilitation	94	787341	6989791
Rehabilitation	95	787347	6989807
Rehabilitation	96	787353	6989810
Rehabilitation	97	787353	6989810
Rehabilitation	98	787356	6989812
Rehabilitation	99	787360	6989825
Rehabilitation	100	787360	6989825
Rehabilitation	101	787334	6989776
Rehabilitation	102	787318	6989789
Rehabilitation	103	787486	6989724
Rehabilitation	104	787497	6989672
Rehabilitation	105	787461	6989682
Rehabilitation	106	787462	6989677
Rehabilitation	107	787440	6989701
Rehabilitation	108	787469	6989708
Rehabilitation	109	787467	6989707
Baseline Assessment Quadrat			
north-west corner of 20 x 20 m quadrat		787537	6990578
Baseline, Western Resource Area	110		
Baseline, Western Resource Area	111		
Baseline, Western Resource Area	112		
Baseline, Western Resource Area	113		
Baseline, Western Resource Area	114		
Baseline, Western Resource Area	115		
Baseline, Western Resource Area	116		
Baseline, Western Resource Area	117		
Baseline, Western Resource Area	118		

Population	Plant Tag #	Easting	Northing
Baseline, Western Resource Area	119		
Baseline, Western Resource Area	120		
Baseline, Western Resource Area	121		
Baseline, Western Resource Area	122		
Baseline, Western Resource Area	123		
Baseline, Western Resource Area	124		
Baseline, Western Resource Area	125		
Baseline, Western Resource Area	126		
Baseline, Western Resource Area	127		
Baseline, Western Resource Area	128		
Baseline, Western Resource Area	129		
Baseline, Western Resource Area	130		
Baseline, Western Resource Area	131		
Baseline, Western Resource Area	132		
Baseline, Western Resource Area	133		
Baseline, Western Resource Area	134		
Baseline, Western Resource Area	135		
Baseline, Western Resource Area	136		
Baseline, Western Resource Area	137		
Baseline, Western Resource Area	138		
Baseline, Western Resource Area	139		
Baseline, Western Resource Area	140		
Baseline, Western Resource Area	141		
Baseline, Western Resource	142		

Population	Plant Tag #	Easting	Northing
Area			
Baseline, Western Resource Area	143		
Baseline, Western Resource Area	144		
Baseline, Western Resource Area	145		
Baseline, Western Resource Area	146		
Baseline, Western Resource Area	147		
Baseline, Western Resource Area	148		
Baseline, Western Resource Area	149		
Baseline, Western Resource Area	150		
Baseline, Western Resource Area	151		
Baseline, Western Resource Area	152		
Baseline, Western Resource Area	153		
Baseline, Western Resource Area	154		
Baseline, Western Resource Area	155		
Baseline, Western Resource Area	156		
Baseline, Western Resource Area	157		
Baseline, Western Resource Area	158		
Baseline, Western Resource Area	159		
Baseline, Western Resource Area	160		
Baseline, Western Resource Area	161		
Baseline, Western Resource Area	162		
Baseline, Western Resource Area	163		
Baseline, Western Resource Area	164		
Baseline, Western Resource Area	165		

Population	Plant Tag #	Easting	Northing
Baseline, Western Resource Area	166		
Baseline, Western Resource Area	167		
Baseline, Western Resource Area	168		
Baseline, Western Resource Area	169		
Baseline, Western Resource Area	170		
Baseline, Western Resource Area	171		
Baseline, Western Resource Area	172		
Baseline, Western Resource Area	173		
Baseline, Western Resource Area	174		
Baseline, Western Resource Area	175		
Baseline, Western Resource Area	176		
Baseline, Western Resource Area	177		
Baseline, Western Resource Area	178		
Baseline, Western Resource Area	179		
Baseline, Western Resource Area	180		
Baseline, Western Resource Area	181		

Appendix 2. Locations of *Atriplex* sp. Yeelirrie Station plants marked in this assessment.

Population	Plant Tag #	Sex	Height (cm)	Width (cm)	Depth (cm)	Alive Canopy	Alive Volume (m^3)	Flowering Score (0 to 3)	Fruiting Score (0 to 3)			Live	Dead	Young
									Fresh Yr1	Old Yr2	Comments			
Rehabilitation	1	f	63	162	95	0.8	0.775656	0	3	3	healthy plant	1		
Rehabilitation	2	f	53	196	110	0.7	0.799876	0	2	2	healthy plant	1		
Rehabilitation	3	m	28	85	68	0.2	0.032368	0	0	0	mostly dead	1		
Rehabilitation	4	m	47	120	100	0.9	0.5076	0	1	1	healthy, not fruiting	1		
Rehabilitation	5	m	27	85	70	0.95	0.1526175	0	1	1	healthy, few fruits	1		
Rehabilitation	6	m	48	118	110	0.9	0.560736	0	1	1	healthy, few fruits	1		
Rehabilitation	7	f	61	160	140	0.4	0.54656	0	3	3	live part of plant healthy and fruiting	1		
Rehabilitation	8	m	32	125	80	0.8	0.256	0	1	0		1		
Rehabilitation	9	m	56	90	85	1	0.4284	0	1	1	under Acacia burkittii 1m tall	1		
Rehabilitation	10	f	60	260	160	0.6	1.4976	0	3	3	has 2 Zygophyllum aurantiacum growing within the clump	1		
Rehabilitation	11	m	45	175	110	0.45	0.3898125	0	1	0	Ruby Dock around perimeter of plant	1		
Rehabilitation	12	m	54	155	160	0.9	1.20528	0	0	0	Lots of old male flowers	1		
Rehabilitation	13	m	45	200	180	0.6	0.972	0	0	0	dead in the center of plant	1		
Rehabilitation	14	m	55	230	195	0.25	0.6166875	0	0	0	mostly dead plant	1		

Population	Plant Tag #	Sex	Height (cm)	Width (cm)	Depth (cm)	Alive Canopy	Alive Volume (m^3)	Flowering Score (0 to 3)	Fruiting Score (0 to 3)			Live	Dead	Young
Rehabilitation	15	f	55	130	130	0.7	0.65065	0	2	2		1		
Rehabilitation	16	f	53	255	220	0.15	0.445995	0	3	3	central part of plant alive	1		
Rehabilitation	17	f	55	130	115	0.85	0.6989125	0	2	2		1		
Rehabilitation	18	m	40	85	60	0.85	0.1734	0	0	1	rooted stem on ground on the northern side of plant near peg,	1		
Rehabilitation	19	f	55	230	165	0.4	0.8349	0	2	3		1		
Rehabilitation	20	m	68	165	125	0.4	0.561	0	0	0		1		
Rehabilitation	21	m	60	125	115	0	0	0	1	1	center of plant largely dead	1		
Rehabilitation	22	f	45	255	200	0.3	0.6885	0	3	3		1		
Rehabilitation	23	m	52	185	150	0.8	1.1544	0	1	1		1		
Rehabilitation	24	f	60	175	165	0.5	0.75075	0	2	3		1		
Rehabilitation	25	f	38	120	105	1	0.756	0	3	3		1		
Rehabilitation	26	m	35	100	95	0.5	0.1805	0	1	1		1		
Rehabilitation	27	f	25	115	100	0.1	0.04025	0	1	3	mostly dead, lots of very old fruit	1		
Rehabilitation	28	m	34	68	45	0.05	0.003825	0	0	1	mostly dead plant	1		
Rehabilitation	29	f	48	80	70	0.2	0.03808	0	1	3		1		
Rehabilitation	30	m	40	115	85	0.6	0.2346	0	1	0		1		
Rehabilitation	31	m	45	125	110	0.35	0.2165625	0	0	0		1		
Rehabilitation	32	m	57	135	125	0.7	0.6733125	0	1	1		1		

Population	Plant Tag #	Sex	Height (cm)	Width (cm)	Depth (cm)	Alive Canopy	Alive Volume (m^3)	Flowering Score (0 to 3)	Fruiting Score (0 to 3)			Live	Dead	Young
Rehabilitation	33	f	20	50	40	0	0	0	0	3	**Dead plant**, flattened plant, lots of very old seed, adjacent to plant #31			
Rehabilitation	34	f	50	110	110	0.5	0.3025	0	3	3		1		
Rehabilitation	35	f	80	130	125	0	0	0	0	3	**Dead plant** but has a slender Atriplex semilunaris growing in the center of the dead plant.	1		
Rehabilitation	36	m	36	86	74	0.15	0.0343656	0	0	0	open, sparse plant		1	
Rehabilitation	37	f	60	230	210	0.15	0.4347	0	1	2	live in the center of the plant only	1		
Rehabilitation	38	f	45	220	185	0.05	0.091575	0	1	3	live in the south-east and western fringes only	1		
Rehabilitation	39	m	35	80	80	0	0	0	0	1	**Dead plant**		1	
Rehabilitation	40	m	35	90	80	0.95	0.2394	0	1	0		1		
Rehabilitation	41	m	35	80	70	0.8	0.1568	0	0	0		1		
Rehabilitation	42	f	50	110	110	0.8	0.484	0	2	2	very small fruit	1		
Rehabilitation	43	f	38	102	98	0.65	0.2469012	0	2	3	very small fruit	1		
Rehabilitation	44	f	45	135	130	0.4	0.3159	0	2	3	very small fruit	1		
Rehabilitation	45	m	46	85	75	0.98	0.287385	0	0	1	healthy plant	1		
Rehabilitation	46	m	46	35	40	0.5	0.0322	0	0	1	small plant	1		

Population	Plant Tag #	Sex	Height (cm)	Width (cm)	Depth (cm)	Alive Canopy	Alive Volume (m^3)	Flowering Score (0 to 3)	Fruiting Score (0 to 3)			Live	Dead	Young
Rehabilitation	47	m	47	68	60	0	0	0	0	1	**Dead plant,** some very old seed			
Rehabilitation	48	m	45	95	85	0.7	0.2543625	0	0	0		1		
Rehabilitation	49	f	50	98	90	0.95	0.41895	0	1	3		1		
Rehabilitation	50	m	50	127	115	0.4	0.2921	0	0	0		1		
Rehabilitation	51	m	30	65	40	0.75	0.0014625	0	0	0	Plant on northern edge of large Maireana pyramidata plant	1		
Rehabilitation	52	f	25	78	50	0.5	0.04875	0	0	0	very small fruits, young Maireana pyramidata within the Atriplex plant	1		
Rehabilitation	53	m	45	95	70	0.5	0.149625	0	0	0		1		
Rehabilitation	54	f	28	88	75	0.5	0.0924	0	0	2	very small fruits	1		
Rehabilitation	55	m	38	110	85	1	0.3553	0	0	0		1		
Rehabilitation	56	m	38	75	75	0.7	0.149625	0	0	0		1		
Rehabilitation	57	m	30	72	60	1	0.1296	0	0	0	on eastern side of a young Acacia ayersiana shrub 1.3m tall	1		
Rehabilitation	58	f	45	115	105	0.5	0.2716875	0	3	3	very small fruits	1		
Rehabilitation	59	m	35	130	100	0.3	0.1365	0	0	0	plant is live in the middle only	1		
Rehabilitation	60	f	10	115	110	0	0	0	0	3	**Dead Plant**		1	

Population	Plant Tag #	Sex	Height (cm)	Width (cm)	Depth (cm)	Alive Canopy	Alive Volume (m^3)	Flowering Score (0 to 3)	Fruiting Score (0 to 3)			Live	Dead	Young
Rehabilitation	61	f	28	140	135	0.15	0.07938	0	0	3	very small, weathered fruits	1		
Rehabilitation	62	m	28	90	75	0.85	0.16065	0	0	0		1		
Rehabilitation	63	?	19	13	10	1	0.00247	0	0	0	**Young plant, sex not known**	1		1
Rehabilitation	64	f	55	105	100	0.3	0.17325	0	1	3		1		
Rehabilitation	65	f	50	80	60	1	0.24	0	2	3		1		
Rehabilitation	66	f	25	140	95	0	0	0	0	3	**Dead Plant, very small, weathered fruits**			
Rehabilitation	67	m	30	85	65	0.9	0.149175	0	0	0	under a Maireana georgei	1		
Rehabilitation	68	f	20	80	35	0	0	0	0	2	may just be a pile of branches, not a live plant, has very old, weathered fruits			
Rehabilitation	69	f	57	108	108	0	0	0	2	3		1		
Rehabilitation	70	f	32	85	68	1	0.18496	0	2	0	**Young plant**	1		1
Rehabilitation	71	?	30	57	35	1	0.05985	0	0	0	**Young plant**	1		1
Rehabilitation	72	m	43	85	67	0.3	0.0734655	0	0	0		1		
Rehabilitation	73	m	55	115	95	0.5	0.3004375	0	0	0		1		
Rehabilitation	74	f	38	95	95	1	0.34295	0	3	3	very healthy plant but has tiny fruits	1		
Rehabilitation	75	m	30	73	68	0.7	0.104244	0	0	0		1		

Population	Plant Tag #	Sex	Height (cm)	Width (cm)	Depth (cm)	Alive Canopy	Alive Volume (m^3)	Flowering Score (0 to 3)	Fruiting Score (0 to 3)			Live	Dead	Young
Rehabilitation	76	m	39	70	45	0.8	0.09828	0	0	0	**Young plant**	1		1
Rehabilitation	77	f	48	195	165	0.9	1.38996	0	2	3		1		
Rehabilitation	78	m	25	110	85	0.85	0.1986875	0	0	0		1		
Rehabilitation	79	m	45	130	100	0.7	0.4095	0	0	0		1		
Rehabilitation	80	f	33	110	100	0.9	0.3267	0	3	3	fruits with short spines on bracts	1		
Rehabilitation	81	f	33	78	70	1	0.18018	0	3	3		1		
Rehabilitation	82	m	38	75	55	0.8	0.1254	0	0	0		1		
Rehabilitation	83	f	30	160	155	0.9	0.6696	0	3	3		1		
Rehabilitation	84	f	50	115	105	0.7	0.422625	0	3	3		1		
Rehabilitation	85	f	48	135	110	0.85	0.60588	0	3	3		1		
Rehabilitation	86	m	54	125	96	1	0.648	0	0	0		1		
Rehabilitation	87	m	50	85	80	0.9	0.306	0	0	0		1		
Rehabilitation	88	f	40	185	130	0.85	0.8177	0	2	3		1		
Rehabilitation	89	f	44	100	80	0.9	0.3168	0	2	3	small fruits with short spines on bracts	1		
Rehabilitation	90	m	55	130	125	0.6	0.53625	0	1	0		1		
Rehabilitation	91	f	52	125	108	0.8	0.5616	0	2	2	very weathered fruits	1		
Rehabilitation	92	f	15	75	70	0	0	0	0	3	**Dead Plant, very weathered fruits**			
Rehabilitation	93	f	35	100	85	0.3	0.08925	0	0	3	very small, weathered fruits	1		
Rehabilitation	94	m	57	135	130	0.95	0.9503325	0	0	0	very healthy plant	1		

Population	Plant Tag #	Sex	Height (cm)	Width (cm)	Depth (cm)	Alive Canopy	Alive Volume (m^3)	Flowering Score (0 to 3)	Fruiting Score (0 to 3)			Live	Dead	Young
Rehabilitation	95	m	57	140	130	0.6	0.62244	0	0	0		1		
Rehabilitation	96	f	50	118	110	0.9	0.5841	0	3	3		1		
Rehabilitation	97	f	55	170	150	0.8	1.122	0	3	3		1		
Rehabilitation	98	f	20	150	150	0	0	0	0	3	**Dead Plant**		1	
Rehabilitation	99	f	28	148	125	0.35	0.1813	0	0	2		1		
Rehabilitation	100	?	37	50	45	1	0.08325	0	0	0	**Young plant**	1		1
Rehabilitation	101	m	45	97	85	1	0.371025	0	0	0	healthy plant	1		
Rehabilitation	102	m	55	120	110	1	0.726	0	0	0	healthy plant	1		
Rehabilitation	103	f	62	185	167	0.8	1.532392	0	3	3		1		
Rehabilitation	104	f	56	182	159	0.8	1.2964224	0	2	3	Minute fruits, 3mm diameter, probably infertile, horns on bracts	1		
Rehabilitation	105	m	62	165	151	0.8	1.235784	0	1	0		1		
Rehabilitation	106	f	53	136	134	0.4	0.3863488	0	3	3		1		
Rehabilitation	107	f	42	150	123	0.55	0.426195	0	3	3	normal fruits size, 6 to 8mm diameter	1		
Rehabilitation	108	m	43	139	89	0.3	0.1595859	0	0	0		1		
Rehabilitation	109	f	54	154	118	0.7	0.6869016	0	3	3	very small fruits, 4mm diameter	1		
Baseline Assessment Quadrat														

Population	Plant Tag #	Sex	Height (cm)	Width (cm)	Depth (cm)	Alive Canopy	Alive Volume (m^3)	Flowering Score (0 to 3)	Fruiting Score (0 to 3)			Live	Dead	Young
Baseline, Western Resource Area	110	f	41	65	70	1	0.18655	0	2	0		1		
Baseline, Western Resource Area	111	f	58	120	97	0.97	0.6548664	0	2	2		1		
Baseline, Western Resource Area	112	f	38	52	52	1	0.102752	0	2	0		1		
Baseline, Western Resource Area	113	f	23	56	55	1	0.07084	0	2	0		1		
Baseline, Western Resource Area	114	?	34	39	45	1	0.05967	0	0	0	has another female plant on it's southern side	1		
Baseline, Western Resource Area	115	f	56	126	142	0.97	0.97189344	0	3	3	dead branch in the center of the plant, overall the plant carrying a lot of fruits	1		
Baseline, Western Resource Area	116	?	28	27	25	1	0.0189	0	0	0	**Young plant**	1		1

Population	Plant Tag #	Sex	Height (cm)	Width (cm)	Depth (cm)	Alive Canopy	Alive Volume (m^3)	Flowering Score (0 to 3)	Fruiting Score (0 to 3)			Live	Dead	Young
Baseline, Western Resource Area	117	f	25	39	37	1	0.036075	0	1	0		1		
Baseline, Western Resource Area	118	m	31	37	35	1	0.040145	0	0	0		1		
Baseline, Western Resource Area	119	?	22	19	15	1	0.00627	0	0	0	**Young plant**	1		1
Baseline, Western Resource Area	120	f	20	23	24	1	0.01104	0	1	0		1		
Baseline, Western Resource Area	121	f	27	25	39	1	0.026325	0	1	0		1		
Baseline, Western Resource Area	122	?	21	22	22	1	0.010164	0	0	0		1		
Baseline, Western Resource Area	123	f	26	33	37	1	0.031746	0	1	0		1		
Baseline, Western Resource Area	124	?	27	33	17	1	0.015147	0	0	0		1		

Population	Plant Tag #	Sex	Height (cm)	Width (cm)	Depth (cm)	Alive Canopy	Alive Volume (m^3)	Flowering Score (0 to 3)	Fruiting Score (0 to 3)			Live	Dead	Young
Baseline, Western Resource Area	125	?	19	12	13	1	0.002964	0	0	0		1		
Baseline, Western Resource Area	126	?	21	9	16	1	0.003024	0	0	0		1		
Baseline, Western Resource Area	127	f	29	50	37	1	0.05365	0	1	0		1		
Baseline, Western Resource Area	128	f	61	135	106	1	0.87291	0	3	3	lots of seed	1		
Baseline, Western Resource Area	129	?	20	20	16	1	0.0064	0	0	0		1		
Baseline, Western Resource Area	130	?	14	11	12	1	0.001848	0	0	0		1		
Baseline, Western Resource Area	131	?	24	23	15	1	0.00828	0	0	0		1		
Baseline, Western Resource Area	132	?	21	27	20	1	0.01134	0	1	0		1		

Population	Plant Tag #	Sex	Height (cm)	Width (cm)	Depth (cm)	Alive Canopy	Alive Volume (m^3)	Flowering Score (0 to 3)	Fruiting Score (0 to 3)			Live	Dead	Young
Baseline, Western Resource Area	133	f	27	35	44	1	0.04158	0	0	0		1		
Baseline, Western Resource Area	134	?	28	50	57	1	0.0798	0	0	0		1		
Baseline, Western Resource Area	135	?	30	33	24	1	0.02376	0	0	0		1		
Baseline, Western Resource Area	136	f	53	187	145	1	1.437095	0	3	3		1		
Baseline, Western Resource Area	137	m	34	77	69	1	0.180642	0	1	0		1		
Baseline, Western Resource Area	138	?	30	52	45	1	0.23556	0	0	0		1		
Baseline, Western Resource Area	139	f	39	81	69	1	0.303264	0	3	0		1		
Baseline, Western Resource Area	140	f	52	132	151	1	0.679536	0	3	3		1		

Population	Plant Tag #	Sex	Height (cm)	Width (cm)	Depth (cm)	Alive Canopy	Alive Volume (m^3)	Flowering Score (0 to 3)	Fruiting Score (0 to 3)			Live	Dead	Young
Baseline, Western Resource Area	141	m	61	113	96	1	0.448045	0	1	0		1		
Baseline, Western Resource Area	142	m	47	109	99	1	0.640375	0	1	0		1		
Baseline, Western Resource Area	143	m	40	57	65	1	0.23256	0	1	0		1		
Baseline, Western Resource Area	144	f	60	119	125	1	0.8211	0	3	2		1		
Baseline, Western Resource Area	145	f	55	108	102	1	0.4158	0	3	3		1		
Baseline, Western Resource Area	146	f	59	117	115	1	0.497016	0	3	2		1		
Baseline, Western Resource Area	147	m	42	88	70	1	0.25872	0	1	0		1		
Baseline, Western Resource Area	148	m	39	87	72	1	0.244296	0	1	0		1		

Population	Plant Tag #	Sex	Height (cm)	Width (cm)	Depth (cm)	Alive Canopy	Alive Volume (m^3)	Flowering Score (0 to 3)	Fruiting Score (0 to 3)			Live	Dead	Young
Baseline, Western Resource Area	149	m	24	61	62	1	0.090768	0	1	1	clump of plants, with at least 2 more plants within the clump	1		
Baseline, Western Resource Area	150	m	48	67	96	1	0.308736	0	1	1	clump of plants, with at least 2 more plants within the clump	1		
Baseline, Western Resource Area	151	m	39	75	64	1	0.1872	0	1	0	clump of plants, with at least 2 more plants within the clump	1		
Baseline, Western Resource Area	152	m	30	70	64	1	0.1344	0	1	0		1		
Baseline, Western Resource Area	153	?	14	20	20	1	0.0056	0	0	0	**Young plant**	1		1
Baseline, Western Resource Area	154	m	49	95	92	1	0.42826	0	1	1		1		
Baseline, Western Resource Area	155	f	34	54	61	1	0.111996	0	1	0		1		
Baseline, Western Resource Area	156	m	58	92	80	1	0.42688	0	1	0		1		

Population	Plant Tag #	Sex	Height (cm)	Width (cm)	Depth (cm)	Alive Canopy	Alive Volume (m^3)	Flowering Score (0 to 3)	Fruiting Score (0 to 3)			Live	Dead	Young
Baseline, Western Resource Area	157	f	39	97	107	1	0.404781	0	1	0		1		
Baseline, Western Resource Area	158	?	19	46	29	1	0.025346	0	0	0	**Young plant**	1		1
Baseline, Western Resource Area	159	f	41	102	97	1	0.405654	0	1	0		1		
Baseline, Western Resource Area	160	?	31	43	39	1	0.051987	0	0	0	**Young plant**	1		1
Baseline, Western Resource Area	161	?	32	42	35	1	0.04704	0	0	0	**Young plant**	1		1
Baseline, Western Resource Area	162	?	26	41	30	1	0.03198	0	0	0	**Young plant**	1		1
Baseline, Western Resource Area	163	f	63	155	126	1	1.23039	0	3	3		1		
Baseline, Western Resource Area	164	f	28	55	50	1	0.077	0	0	0		1		

Population	Plant Tag #	Sex	Height (cm)	Width (cm)	Depth (cm)	Alive Canopy	Alive Volume (m^3)	Flowering Score (0 to 3)	Fruiting Score (0 to 3)			Live	Dead	Young
Baseline, Western Resource Area	165	f	37	46	47	1	0.079994	0	2	2		1		
Baseline, Western Resource Area	166	?	39	47	45	1	0.082485	0	1	0		1		
Baseline, Western Resource Area	167	?	29	43	49	1	0.061103	0	0	0		1		
Baseline, Western Resource Area	168	?	20	30	47	1	0.0282	0	0	0		1		
Baseline, Western Resource Area	169	?	28	38	49	1	0.052136	0	0	0		1		
Baseline, Western Resource Area	170	?	28	39	56	1	0.061152	0	0	0		1		
Baseline, Western Resource Area	171	f	40	38	53	1	0.08056	0	2	0		1		
Baseline, Western Resource Area	172	?	18	29	20	1	0.01044	0	0	0		1		

Population	Plant Tag #	Sex	Height (cm)	Width (cm)	Depth (cm)	Alive Canopy	Alive Volume (m^3)	Flowering Score (0 to 3)	Fruiting Score (0 to 3)			Live	Dead	Young
Baseline, Western Resource Area	173	f	33	44	30	1	0.04356	0	1	0		1		
Baseline, Western Resource Area	174	f	30	45	38	1	0.0513	0	2	0		1		
Baseline, Western Resource Area	175	?	29	10	16	1	0.00464	0	0	0		1		
Baseline, Western Resource Area	176	f	36	43	59	1	0.091332	0	1	0		1		
Baseline, Western Resource Area	177	?	22	33	36	0.5	0.013068	0	0	0	Plant looks like it was stepped on with broken stems, small plant	1		
Baseline, Western Resource Area	178	f	32	54	37	1	0.063936	0	3	0		1		
Baseline, Western Resource Area	179	m	51	99	86	1	0.434214	0	1	1		1		
Baseline, Western Resource Area	180	m	47	81	92	1	0.350244	0	1	0	growing along side a large female plant on it's southern side	1		

Population	Plant Tag #	Sex	Height (cm)	Width (cm)	Depth (cm)	Alive Canopy	Alive Volume (m^3)	Flowering Score (0 to 3)	Fruiting Score (0 to 3)			Live	Dead	Young
Baseline, Western Resource Area	181	m	44	130	138	1	0.78936	0	1	0		1		

Appendix 3. Soil Analysis Data

		SWA ID	14-0407-001	14-0407-002	14-0407-003	14-0407-004	14-0407-005	14-0407-006	14-0407-007	14-0407-008	14-0407-009	14-0407-010	14-0407-011	14-0407-012	14-0407-013	14-0407-014	14-0407-015
		Client ID	39051	39052	39053	39054	39055	39056	39057	39058	39059	39060	39061	39062	39063	39064	39065
		Description	0 to 10cm	10 to 20cm	20 to 40cm	bulk	bulk	0 to 10cm	10 to 20cm	20 to 50cm	bulk	bulk	0 to 7cm	7 to 20cm	20 to 40cm	bulk	bulk
		pH	8	7.24	7.21	8.33		8 83	8.59	8.37	8.38		8.19	8.35	8.43	8.32	
		EC mS/m	14.14	5.22	4	7.94		97.4	332	494	380		240.6	212.1	243.2	228.4	
Mehlich Suite	LOR																
Al	1	mg/kg				260					>550					540	>550
B	0.1	mg/kg				1.6					50					18	16
Ca	10	mg/kg				650					5500					5500	5500
Cd	0.01	mg/kg				<0.01					<0.01					<0.01	<0.01
Co	0.01	mg/kg				0.37					0.07					0.09	0.09
Cu	0.1	mg/kg				0.4					0.2					0.1	0.2
Fe	1	mg/kg				30					61					62	70
K	1	mg/kg				150					550					140	190
Mg	10	mg/kg				360					>1000					>1000	>1000
Mn	0.05	mg/kg				8.1					6.8					7.2	9.3
Mo	0.01	mg/kg				<0.01					0.03					<0.01	<0.01
Na	1	mg/kg				63					>1000					150	150
Ni	0.1	mg/kg				0.2					0.2					0.3	0.3
P	1	mg/kg				2					8					6	7
S	1	mg/kg				24					250					250	250
Zn	0.1	mg/kg				0.2					0.2					0.3	0.3
As	0.1	mg/kg				<0.1					0.6					0.4	0.4
Pb	0.1	mg/kg				0.5					1.2					1	1
Se	0.1	mg/kg				<0.1					0.1					<0.1	<0.1
Exchangeable Calcium	0.1	meq/100g				2.8					48.6					189	
Exchangeable Magnesium	0.1	meq/100g				1.9					14.2					4.1	
Exchangeable Potassium	0.1	meq/100g				0.5					3.6					0.4	
Exchangeable Sodium	0.1	meq/100g				0.4					20.4					1	
Cation Exchange Capacity	0.1	meq/100g				5.6					86.9					195	
Total Metals ICP-AES																	
Aluminium	50	mg/kg				3380	3680				20600					8620	
Antimony	5	mg/kg				<5	<5				<5					<5	
Barium	10	mg/kg				<10	20				30					20	
Boron	50	mg/kg				<50	<50				140					60	
Cobalt	2	mg/kg				<2	4				4					<2	
Iron	50	mg/kg				14700	15900				14300					5650	
Manganese	5	mg/kg				40	75				176					72	
Molybdenum	2	mg/kg				<2	<2				<2					<2	
Selenium	5	mg/kg				<5	<5				<5					<5	
Silver	2	mg/kg				<2	<2				<2					<2	
Strontium	2	mg/kg				9	10				110					2440	
Tin	5	mg/kg				<5	<5				<5					<5	
Vanadium	5	mg/kg				40	43				146					38	
Arsenic	5	mg/kg				<5	<5				8					<5	
Cadmium	1	mg/kg				<1	<1				<1					<1	
Chromium	2	mg/kg				44	47				38					14	
Copper	5	mg/kg				6	6				11					<5	
Lead	5	mg/kg				<5	5				6					<5	
Nickel	2	mg/kg				3	4				9					3	
Zinc	5	mg/kg				<5	<5				23					9	
Total Metals ICP-MS																	
Thorium	0.1	mg/kg				5.1	5.4				5.6					1.9	
Uranium	0.1	mg/kg				20.6	25				190					54.3	
Ammonia as N	20	mg/kg				<20					<20					<20	<20
Nitrite as N (Sol.)	0.1	mg/kg				<0.1					<0.1					<0.1	0.1
Nitrate as N (Sol.)	0.1	mg/kg				0.5					70.5					1.3	1.9
Nitrite + Nitrate as N (Sol.)	0.1	mg/kg				0.5					70.5					1.3	2
Total Organic Carbon	0.5	%				<0.5					<0.5					<0.5	<0.5
Moisture content	0.1	%	1.6	2.6	3.2	1.9		7.1	14.9	20.5	14.4		12.4	24.4	22.9	24.6	
Sand	0.1	%				90 3	89.4				50.9					80.1	
Silt	0.1	%				1.1	1 3				14					10.7	
Clay	0.1	%				8.6	9 3				35.1					9.2	
Texture						Sandy loam	Sandy loam				Clay					Loamy Sand	
Water Retention (v/v)																	
0 kPa	0.1	%				26.1					75.3	78 5				76.5	
10 kPa	0.1	%				15.1					62.1	59 9				72.9	
33 kPa	0.1	%				7.3					60.4	55.7				54.9	
100 kPa	0.1	%				5.3					55.1	51 2				37.2	
1500 kPa	0.1	%				4.1					49	40.6				30.8	
Plant Available Water																	
10 - 1500 kPa	0.1	%				11 0					13.1	19 3				42.1	
33 - 1500 kPa	0.1	%				3.2					11.4	15.1				24.1	

Western Botanical

P (08) 9270 0999
F (08) 6278 4988

E info@westernbotanical.com.au
www.westernbotanical.com.au