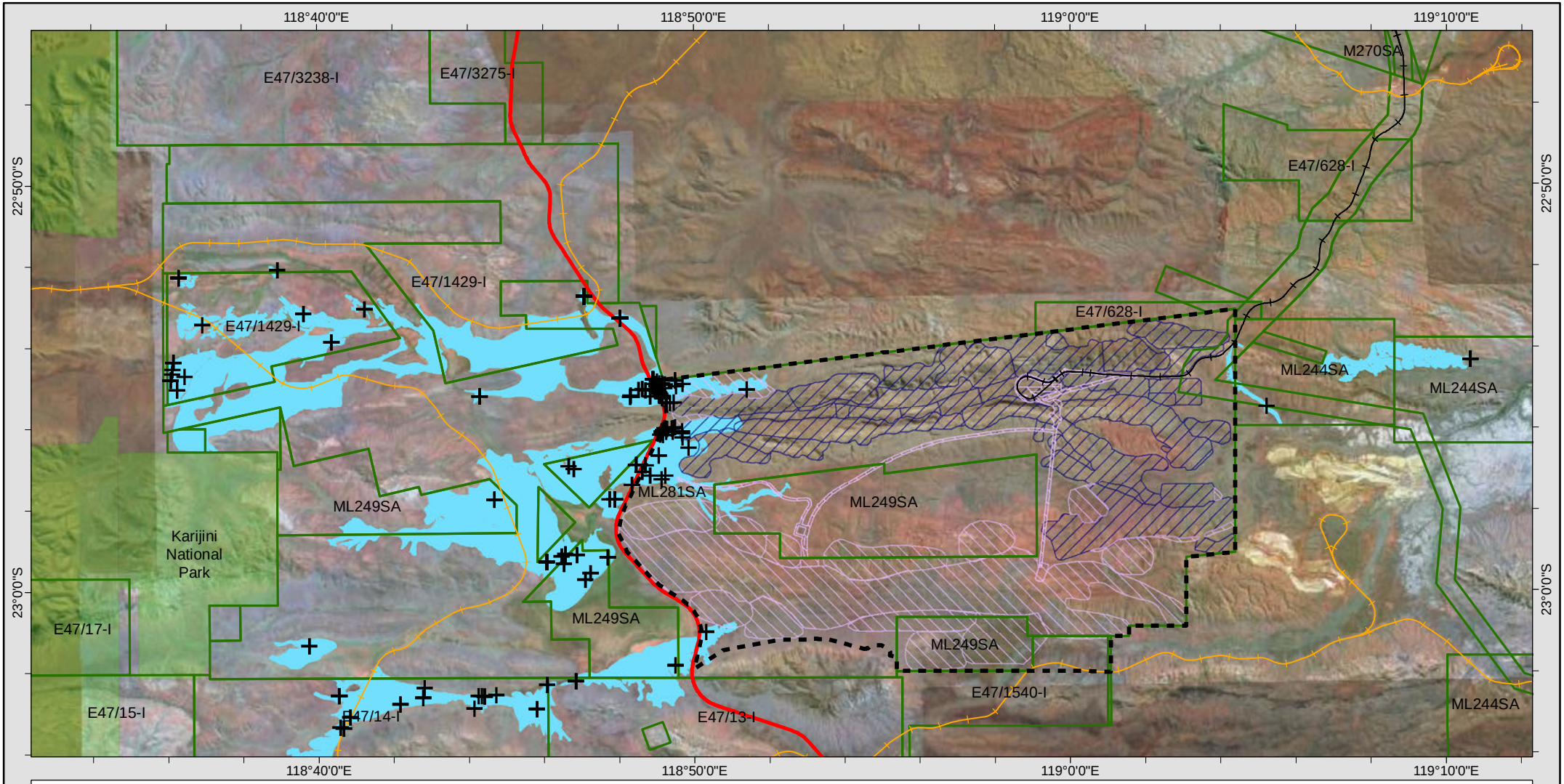


BHP BILLITON IRON ORE

MINING AREA C - SOUTHERN FLANK

Aristida jerichoensis var. subspinulifera locations and vegetation associations from which it has been recorded

Scale @ A4: 1:250,000	Prepared: M. LYTTLE	Project No: A780/064 REV A
Date: 26/07/2017	Checked: B. BARNETT	Figure: 2
Revision: Rev A	Reviewed: S. WILLIAMSON	

- Proposed Mining Area C Development Envelope
- Mining Area C EMP Rev 6 Impact Assessment Area
- Indicative Additional Impact Assessment Area
- BHP Billiton Tenements - Granted
- BHP Billiton Rail
- Rio Tinto Rail
- Great Northern Highway
- *Aristida jerichoensis var. subspinulifera*
- Vegetation Association

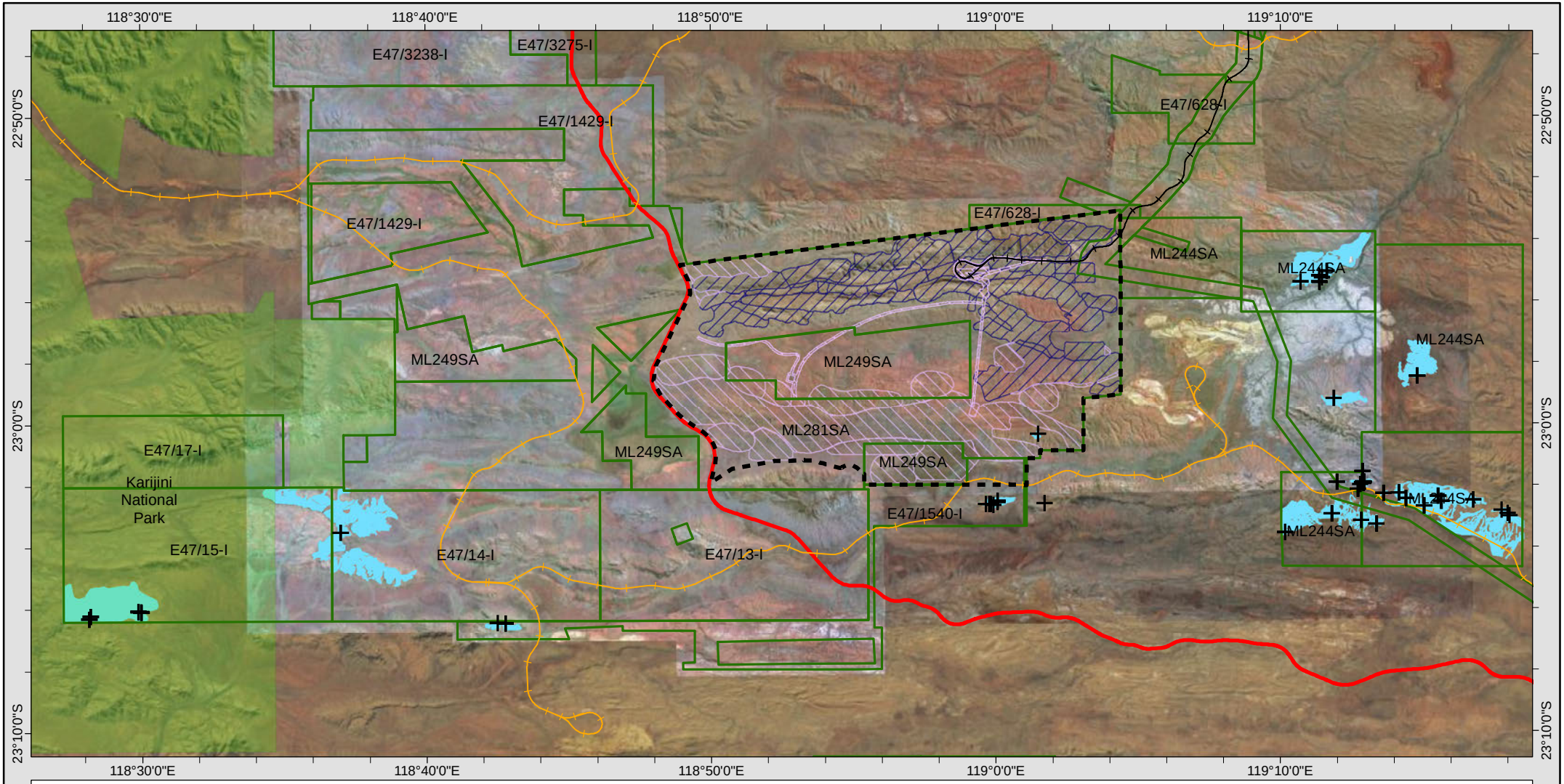
N

0 5 10

Kilometres

Coordinate System: Central Project Grid (CPG94)
Projection: Transverse Mercator
Datum: GDA 1994

Document Path: Y:\Jobs\A501_A1000\A780\3Project\A780_064_E_MAC_Southern_Flank_PER_A_Jericho_Fig2_RevA.mxd



BHP BILLITON IRON ORE

MINING AREA C - SOUTHERN FLANK

Grevillea saxicola locations and vegetation associations from which it has been recorded

Scale @ A4: 1:330,000	Prepared: M. LYTTLE	Project No: A780/067 REV A
Date: 26/07/2017	Checked: B. BARNETT	Figure: 5
Revision: Rev A	Reviewed: S. WILLIAMSON	

- Proposed Mining Area C Development Envelope
- Mining Area C EMP Rev 6 Impact Assessment Area
- Indicative Additional Impact Assessment Area
- BHP Billiton Tenements - Granted
- BHP Billiton Rail
- Rio Tinto Rail
- Great Northern Highway
- *Grevillea saxicola*
- Vegetation Association

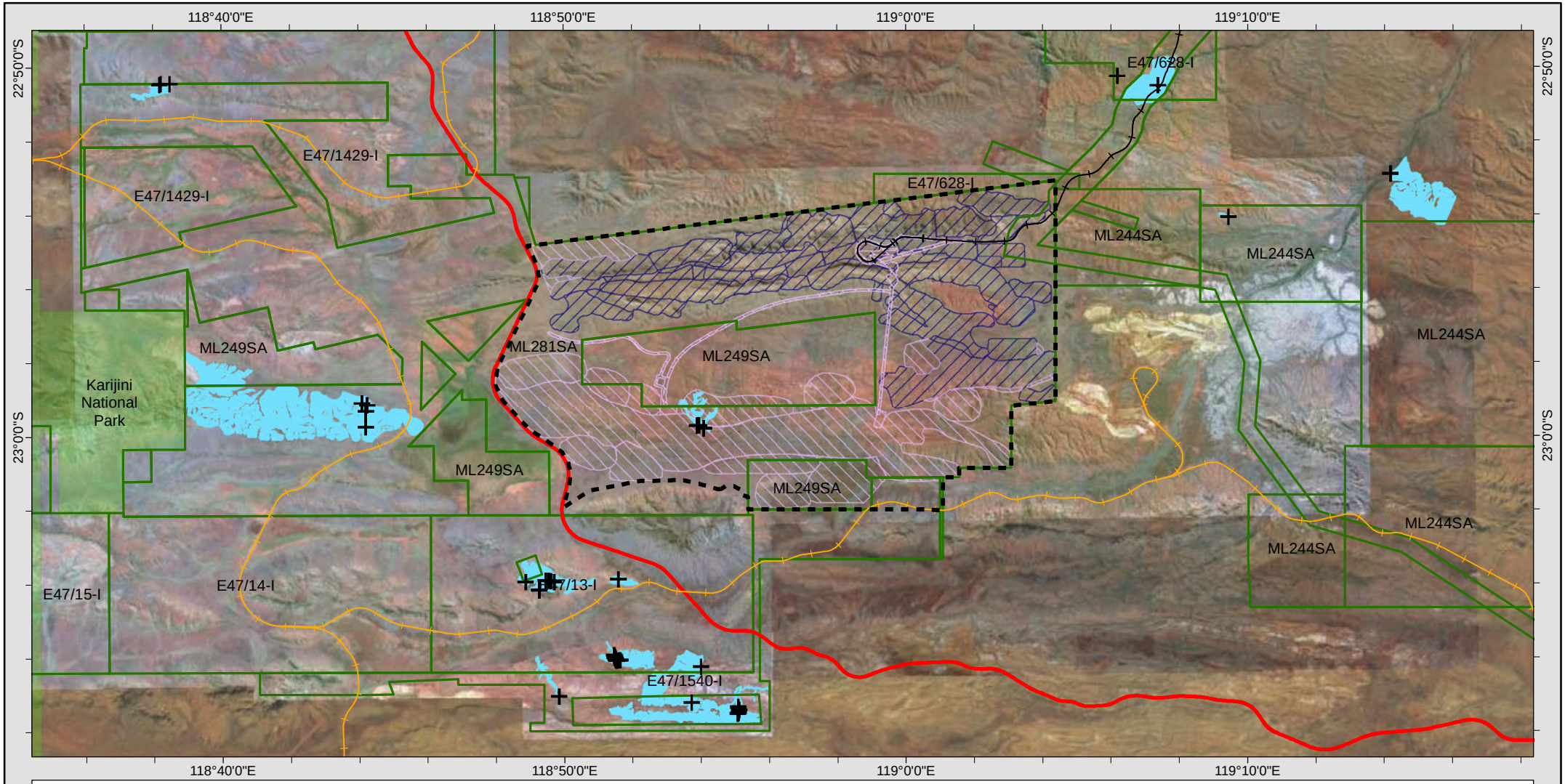
N

0 5 10

Kilometres

Coordinate System: Central Project Grid (CPG94)
Projection: Transverse Mercator
Datum: GDA 1994

Document Path: Y:\Jobs\A501_A1000\A780\3Project\A780_067_E_MAC_Southern_Flank_PER_G_Saxicola_Fig5_RevA.mxd



BHP BILLITON IRON ORE

MINING AREA C - SOUTHERN FLANK

Sida sp. Barlee Range (S. van Leeuwen 1642) locations and vegetation associations from which it has been recorded

Scale @ A4: 1:275,000	Prepared: M. LYTTLE	Project No: A780/071 REV A
Date: 27/07/2017	Checked: B. BARNETT	Figure: 9
Revision: Rev A	Reviewed: S. WILLIAMSON	

- Proposed Mining Area C Development Envelope
- Mining Area C EMP Rev 6 Impact Assessment Area
- Indicative Additional Impact Assessment Area
- BHP Billiton Tenements - Granted
- BHP Billiton Rail
- Rio Tinto Rail
- Great Northern Highway
- *Sida* sp. Barlee Range (S. van Leeuwen 1642)
- Vegetation Association

N

0 5 10

Kilometres

Coordinate System: Central Project Grid (CPG94)
Projection: Transverse Mercator
Datum: GDA 1994

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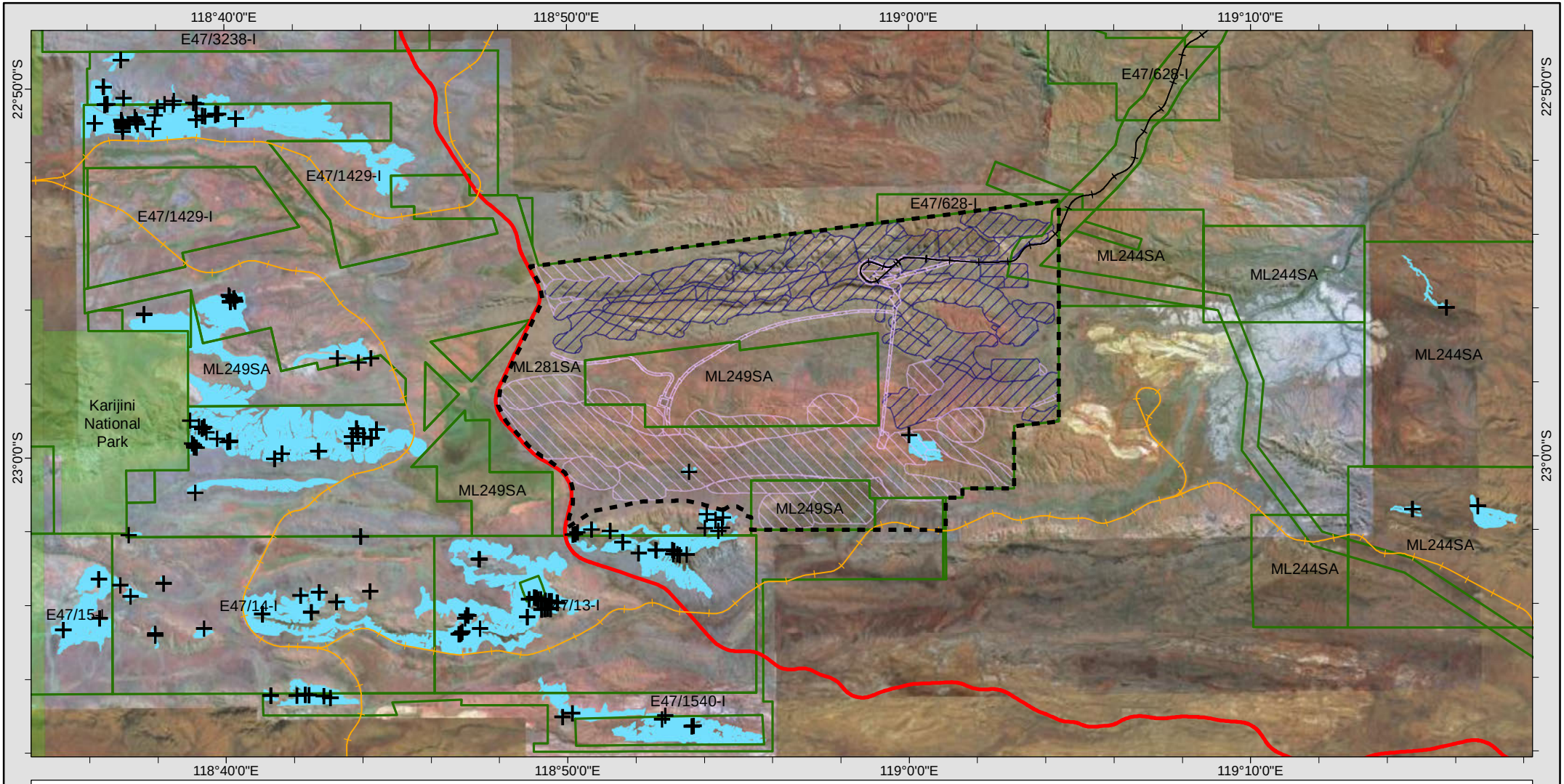

BHP BILLITON IRON ORE

MINING AREA C - SOUTHERN FLANK

Triodia sp. Mt Ella (M.E. Trudgen 12739) locations and vegetation associations from which it has been recorded

Scale @ A4: 1:275,000	Prepared: M. LYTTLE	Project No: A780/072 REV A
Date: 27/07/2017	Checked: B. BARNETT	Figure: 10
Revision: Rev A	Reviewed: S. WILLIAMSON	

- Proposed Mining Area C Development Envelope
- Mining Area C EMP Rev 6 Impact Assessment Area
- Indicative Additional Impact Assessment Area
- BHP Billiton Tenements - Granted
- BHP Billiton Rail
- Rio Tinto Rail
- Great Northern Highway
- *Triodia* sp. Mt Ella (M.E. Trudgen 12739)
- Vegetation Association

N

0 5 10

Kilometres

Coordinate System: Central Project Grid (CPG94)
Projection: Transverse Mercator
Datum: GDA 1994

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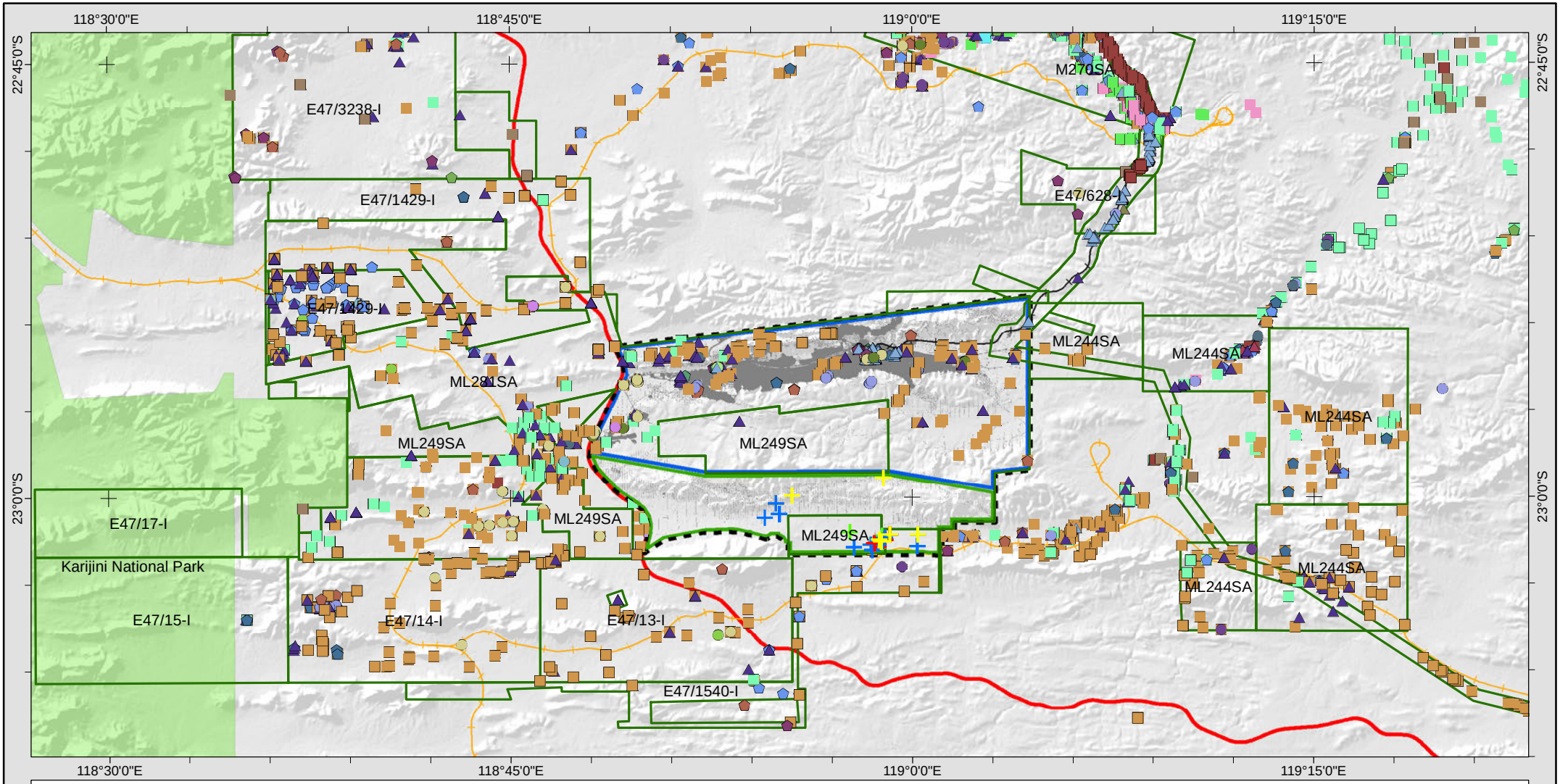

BHP BILLITON IRON ORE

MINING AREA C - SOUTHERN FLANK
Weed Affected Areas

Scale @ A4: 1:350,000	Prepared: M. LYTTLE	Project No: A780/073 REV A
Date: 2/08/2017	Checked: B. BARNETT	Figure : 11
Revision: Rev A	Reviewed: S. WILLIAMSON	

- Proposed Mining Area C Development Envelope
- Approved Mining Area C (Northern Flank) Development Envelope
- Additional Development Envelope
- BHPBIO Disturbance Footprint (Dec 2016)
- BHP Billiton Rail
- Rio Tinto Rail
- Great Northern Highway
- BHP Billiton Tenements - Granted
- National Park

Species Observations (Weeds) outside Additional Development Envelope

- Aerva javanica
- Alternanthera pungens
- Argemone ochroleuca
- Argemone ochroleuca subsp. ochroleuca
- Bidens bipinnata
- Brassica rapa
- Cenchrus ciliaris
- Cenchrus setiger
- Centaurea melitensis
- Chloris barbata
- Chloris virgata
- Citrullus colocynthis
- Citrullus lanatus
- Conyza bonariensis
- Cucumis myriocarpus
- Cynodon dactylon
- Datura leichhardtii
- Digitaria ciliaris
- Echinochloa colona
- Euphorbia hirta
- Flaveria trinervia
- Lactuca serriola
- Lactuca serriola forma serriola
- Lysimachia arvensis
- Malvastrum americanum
- Phoenix dactylifera
- Rostraria cristata
- Rumex vesicarius
- Setaria verticillata
- Sigesbeckia orientalis
- Sisymbrium orientale
- Solanum nigrum
- Sonchus asper
- Sonchus oleraceus
- Stylosanthes hamata
- Tribulus terrestris
- Tridax procumbens
- Vachellia farnesiana

Species Observations (Weeds) inside Additional Development Envelope

- Bidens bipinnata
- Cenchrus ciliaris
- Malvastrum americanum
- Setaria verticillata
- Vachellia farnesiana

N

0 2 4 6 8 10
Kilometres

Coordinate System: Central Project Grid (CPG94)
Projection: Transverse Mercator
Datum: GDA 1994

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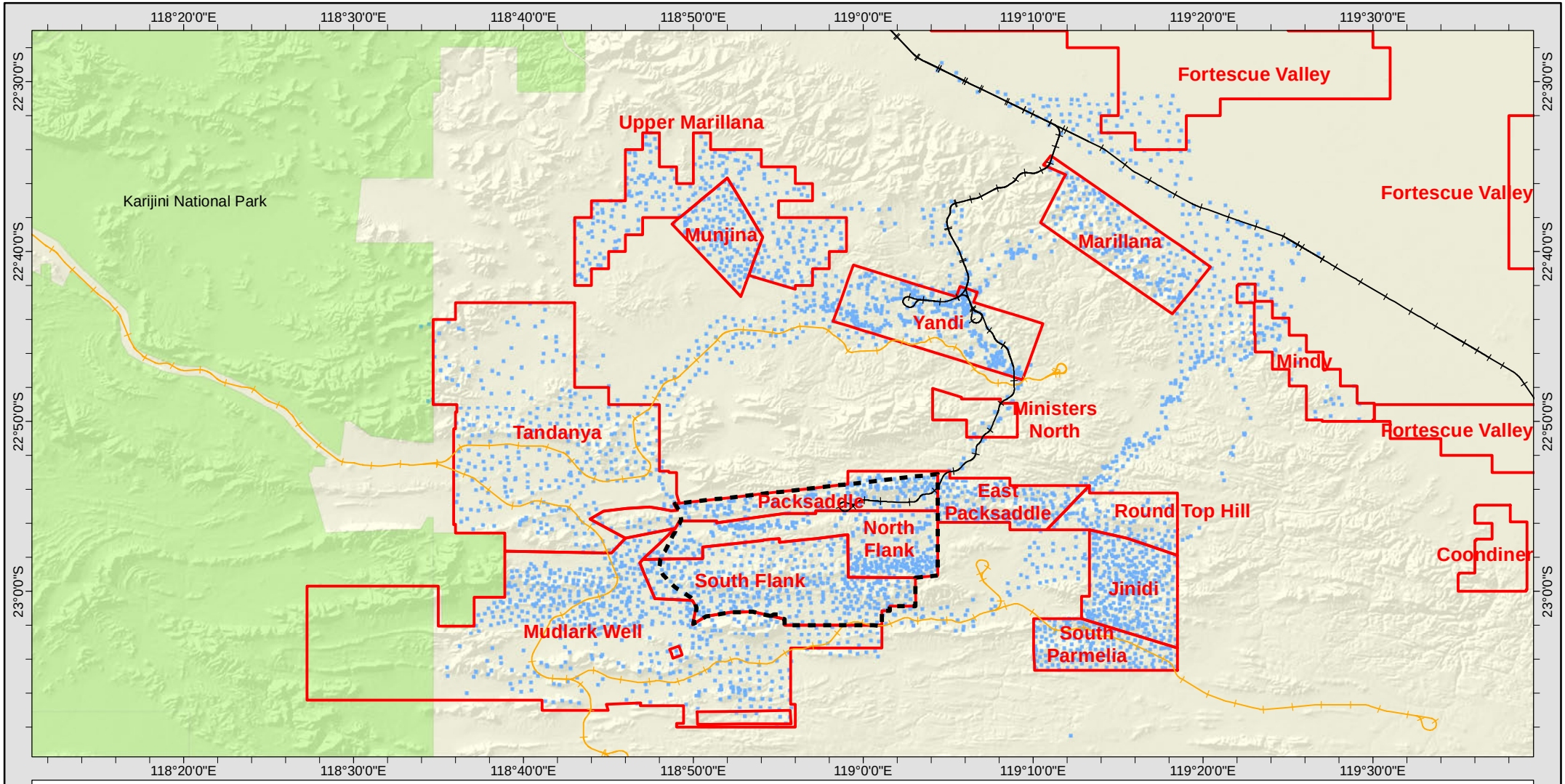


BHP BILLITON IRON ORE

MINING AREA C - SOUTHERN FLANK

Quadrat site location for Central Pilbara

Scale @ A4: 1:600,000	Prepared: M. LYTTLE	Project No: A780/074 REV A
Date: 9/08/2017	Checked: B. BARNETT	Figure: 12
Revision: Rev A	Reviewed: S. WILLIAMSON	

Proposed Mining Area C Development Envelope

Quadrat Sites

Projects

National Park

N

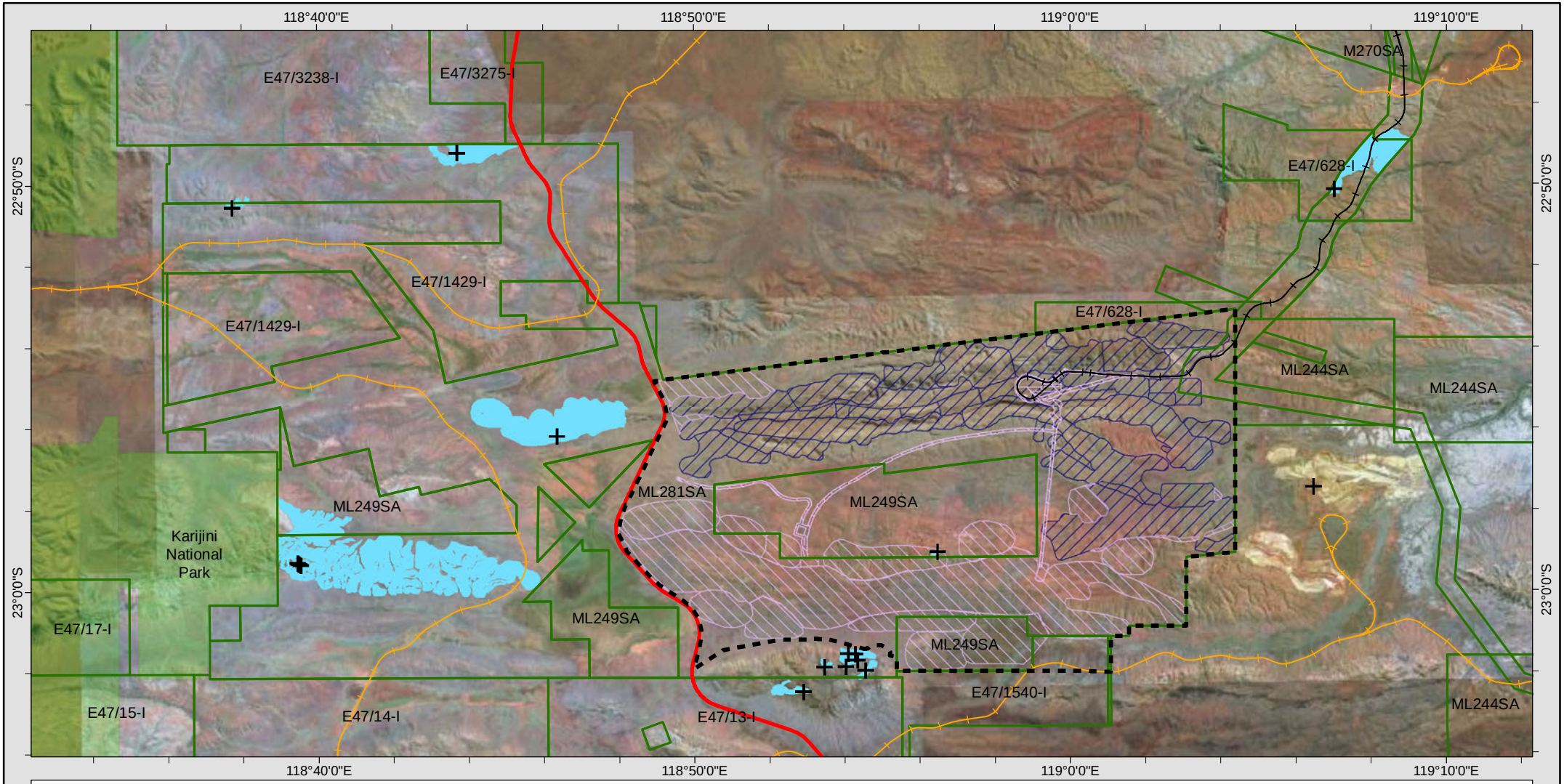
0 10 20

Kilometres

Coordinate System: GCS GDA 1994

Datum: GDA 1994

Document Path: Y:\Jobs\A501_A1000\A780\3Project\A780_074_E_MAC_Southern_Flank_PER_VegSites_Fig12_RevA.mxd



BHP BILLITON IRON ORE

MINING AREA C - SOUTHERN FLANK

Acacia bromilowiana locations and vegetation associations from which it has been recorded

Scale @ A4: 1:250,000	Prepared: M. LYTTLE	Project No: A780/063 REV A
Date: 26/07/2017	Checked: B. BARNETT	Figure: 1
Revision: Rev A	Reviewed: S. WILLIAMSON	

- Proposed Mining Area C Development Envelope
- Mining Area C EMP Rev 6 Impact Assessment Area
- Indicative Additional Impact Assessment Area
- BHP Billiton Tenements - Granted
- BHP Billiton Rail
- Rio Tinto Rail
- Great Northern Highway
- *Acacia bromilowiana*
- Vegetation Association

N

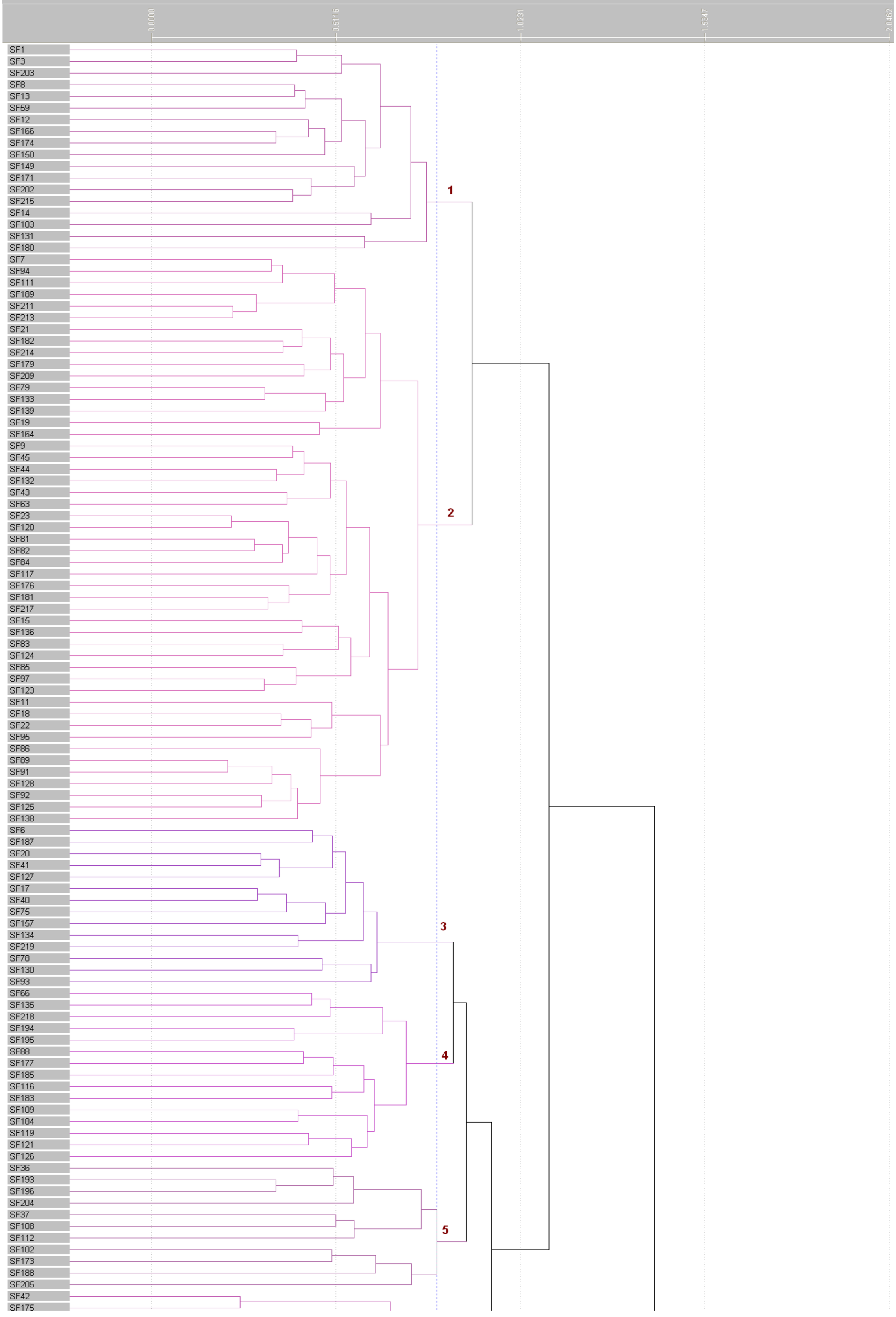
0 5 10

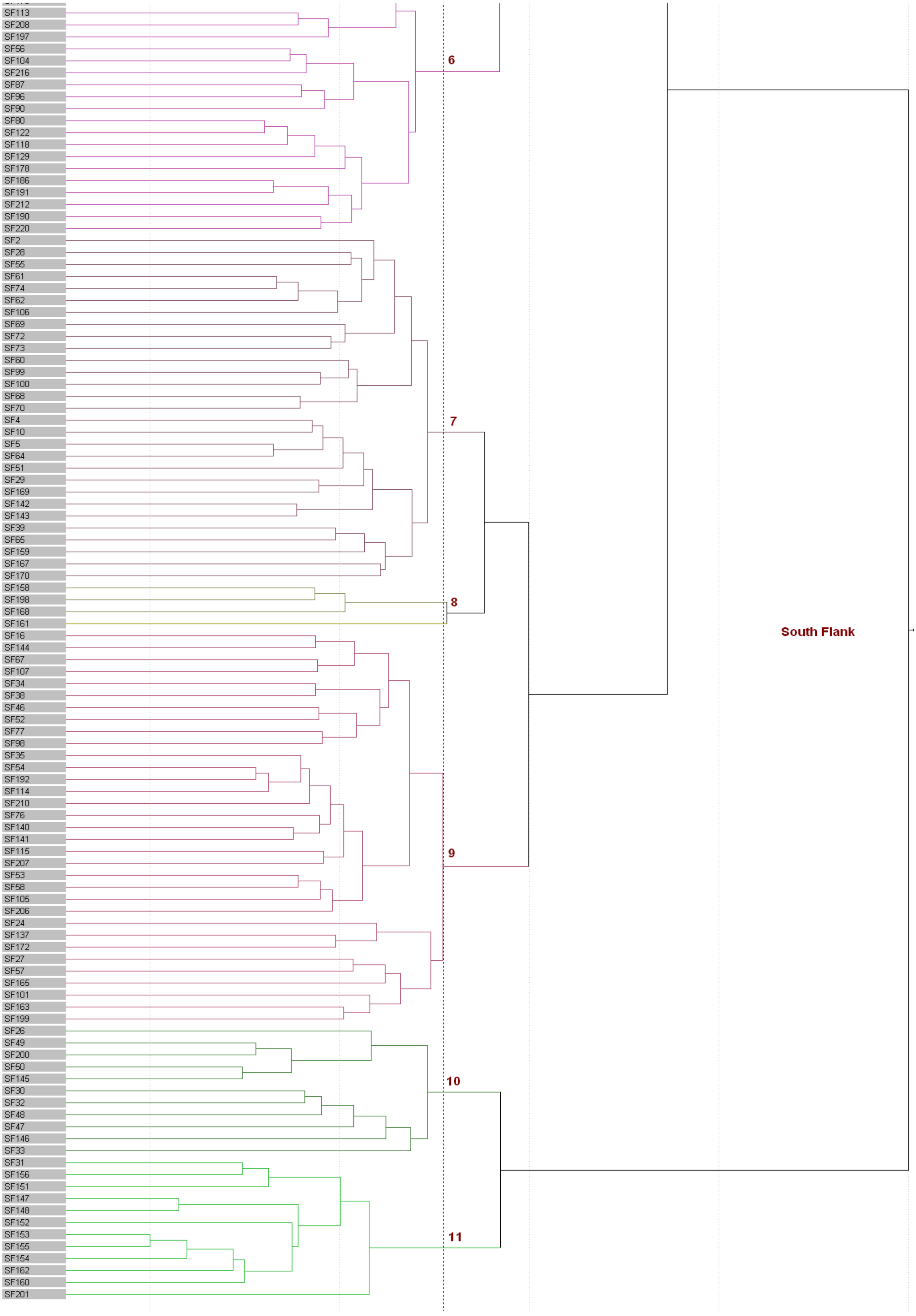
Kilometres

Coordinate System: Central Project Grid (CPG94)
Projection: Transverse Mercator
Datum: GDA 1994

Document Path: Y:\Jobs\A501_A1000\A780\3Project\A780_063_E_MAC_Southern_Flank_PER_AcaciaBromilowiana_Fig1_RevA.mxd

Row Fusion Dendrogram




SF113
SF208
SF197
SF56
SF104
SF216
SF87
SF96
SF90
SF80
SF122
SF118
SF129
SF178
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SF191
SF212
SF190
SF220
SF2
SF28
SF55
SF61
SF74
SF62
SF106
SF69
SF72
SF73
SF60
SF99
SF100
SF68
SF70
SF4
SF10
SF5
SF64
SF51
SF29
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SF58
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SF206
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SF27
SF57
SF165
SF101
SF163
SF199
SF26
SF49
SF200
SF50
SF145
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SF32
SF48
SF47
SF146
SF33
SF31
SF156
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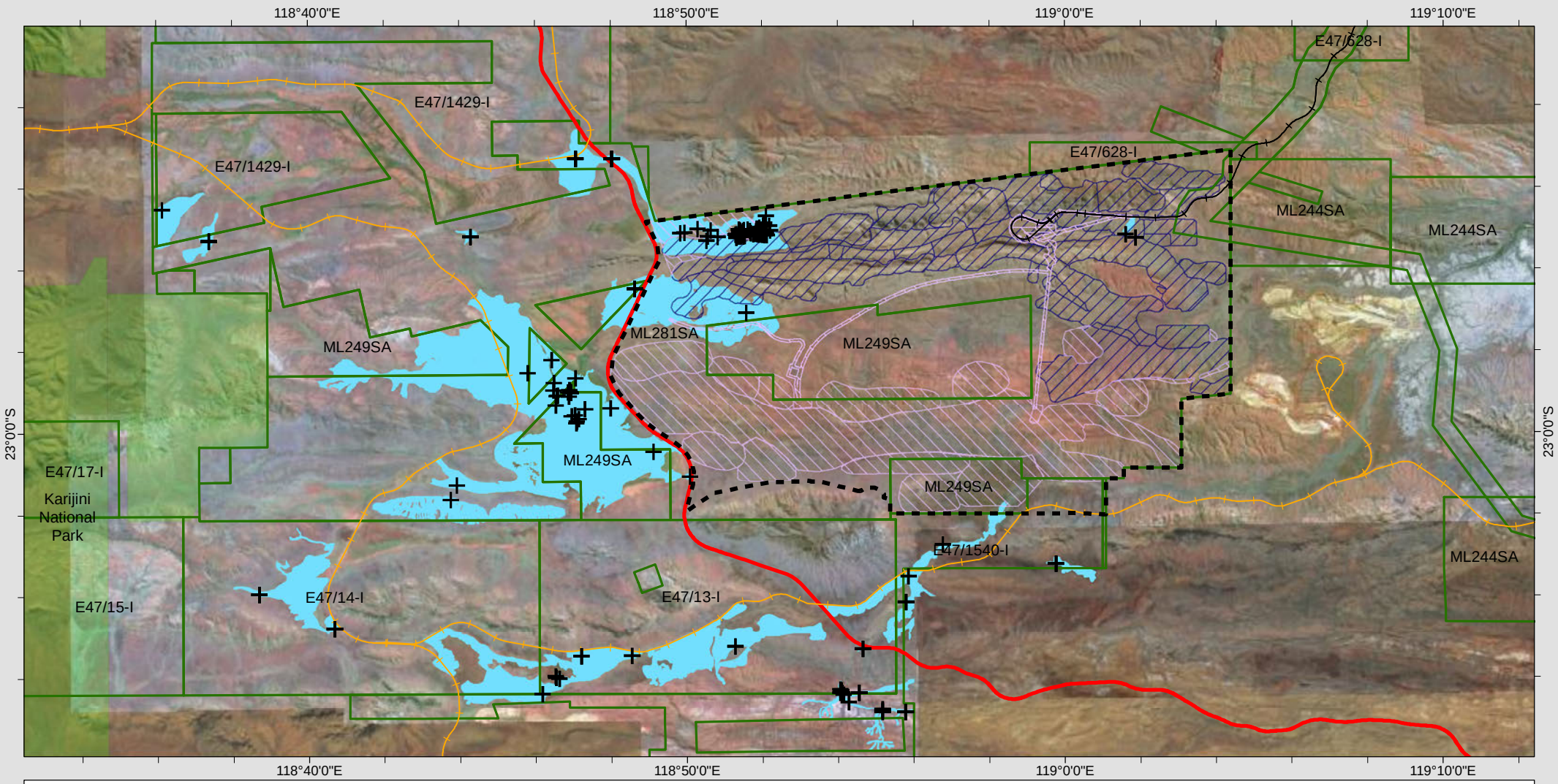
SF201
6
7
8
9
10
11
South Flank



BHP BILLITON IRON ORE

MINING AREA C - SOUTHERN FLANK

Aristida lazaridis locations and vegetation associations from which it has been recorded

Scale @ A4: 1:250,000	Prepared: M. LYTTLE	Project No: A780/065 REV A
Date: 26/07/2017	Checked: B. BARNETT	Figure: 3
Revision: Rev A	Reviewed: S. WILLIAMSON	

- Proposed Mining Area C Development Envelope
- Mining Area C EMP Rev 6 Impact Assessment Area
- Indicative Additional Impact Assessment Area
- BHP Billiton Tenements - Granted
- BHP Billiton Rail
- Rio Tinto Rail
- Great Northern Highway
- *Aristida lazaridis*
- Vegetation Association

N

0 5 10

Kilometres

Coordinate System: Central Project Grid (CPG94)
Projection: Transverse Mercator
Datum: GDA 1994

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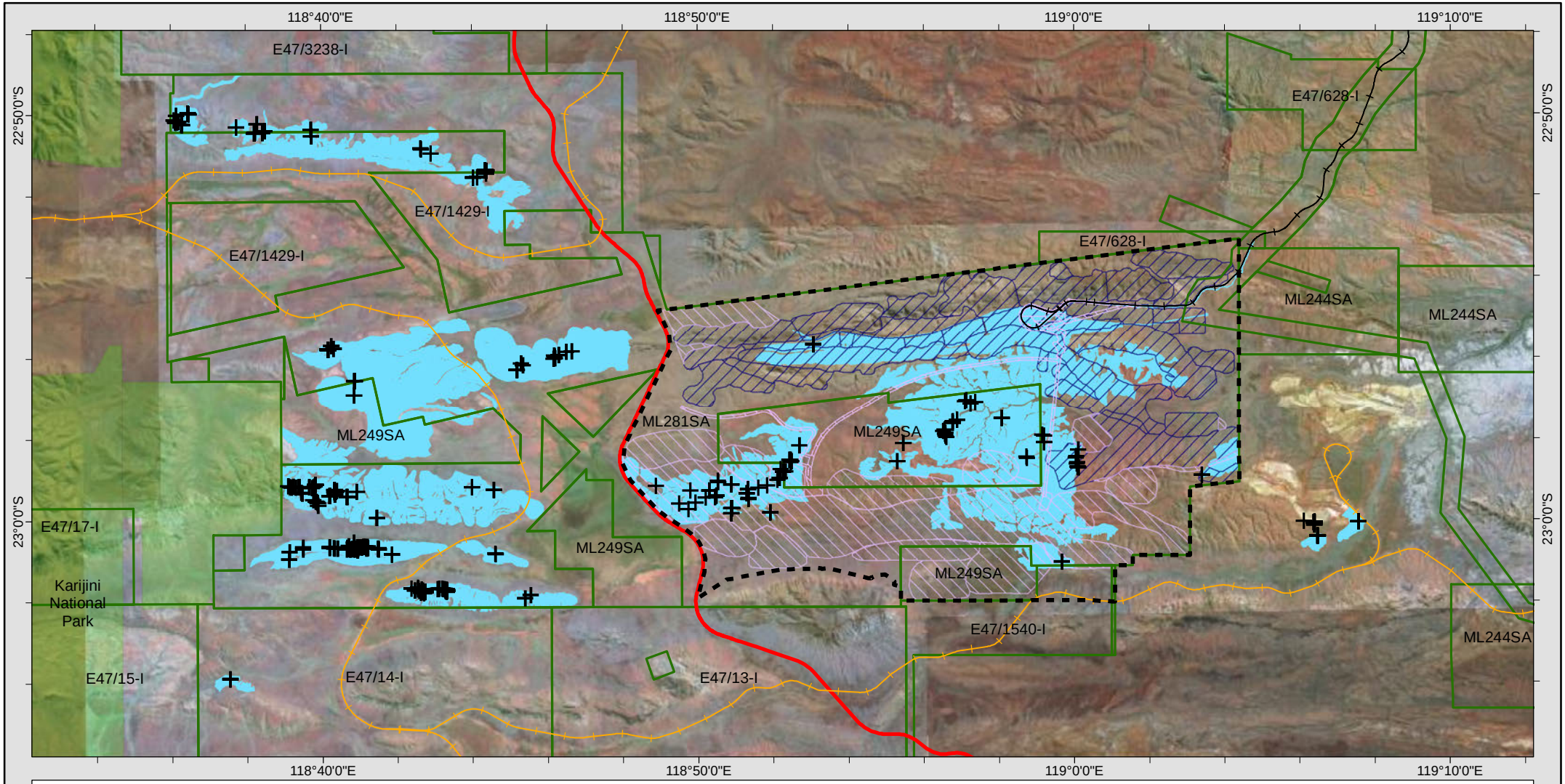

BHP BILLITON IRON ORE

MINING AREA C - SOUTHERN FLANK

Eremophila magnifica subsp. magnifica locations and vegetation associations from which it has been recorded

Scale @ A4: 1:250,000	Prepared: M. LYTTLE	Project No: A780/066 REV A
Date: 26/07/2017	Checked: B. BARNETT	Figure: 4
Revision: Rev A	Reviewed: S. WILLIAMSON	

- Proposed Mining Area C Development Envelope
- Mining Area C EMP Rev 6 Impact Assessment Area
- Indicative Additional Impact Assessment Area
- BHP Billiton Tenements - Granted
- BHP Billiton Rail
- Rio Tinto Rail
- Great Northern Highway
- *Eremophila magnifica subsp. magnifica*
- Vegetation Association

N

0 5 10

Kilometres

Coordinate System: Central Project Grid (CPG94)
Projection: Transverse Mercator
Datum: GDA 1994

Document Path: Y:\Jobs\A501_A1000\A780\3Project\A780_066_E_MAC_Southern_Flank_PER_E_Magnifica_Fig4_RevA.mxd

4th January 2011

Multivariate analyses of floristic quadrat data from BHPBIO's South Flank operations area.

Prepared for *Onshore Environmental*

By Russell Smith*, Ekologica Pty Ltd*
PO Box 207 Bunbury, WA, 6231

Summary

Ekologica was requested to carry out a multivariate analysis of floristic quadrat data from 220 sites at the "South Flank" area. The project area is part of the Area C mine site in the Pilbara.

After converting cover data to presence and removing five taxa which did not occur in any quadrats the data was classified using the program PATN (Belbin, 2003). Preliminary analysis of the data showed that quadrats SF25, SF71 and SF110 were significant outliers so these were removed from further analysis.

The flexible UPGMA classification strategy was used ($\beta = -0.1$), together with the Bray-Curtis site similarity measure with 12 groups being selected as the cutoff. In addition an ordination using multidimensional scaling (SSH) was carried out.

Following the initial classification into 12 groups the number of groups was reduced by one by combining a single-group quadrat (SF161) with a small group composed of quadrats SF158, SF168 and SF198 which was the closest to it on the dendrogram. This reduced the overall number of groups to 11.

Outputs from the classification included quadrat and quadrat group dendrograms and a table showing characteristic taxa (with a frequency > 60%) for the quadrat groups.

1. Project Background

Ekologica was requested to carry out a multivariate analysis of floristic quadrat data from 220 sites at the "South Flank" area. The project area is part of the Area C mine site in the Pilbara.

2. Objectives

Carry out a multivariate analysis of the floristic quadrat data provided for the Southern Flank project area that to form quadrat groups that will assist in the understanding of vegetation-habitat relationships within the project area.

3. Methods

The original 358 taxon by 220 quadrat matrix (supplied as "Sth Flank matrix FINAL 201210.xlsx") was modified by:

- Removing the following 8 taxa that did not occur within any of the quadrats:
    - *Acacia hamersleyensis*
    - *Acacia hamersleyensis* (broad)
    - *Cullen leucochaites*
    - *Dysphania rhadinostachya* subsp. *rhadinostachya*
    - *Goodenia cusackiana*
    - *Goodenia microptera*
    - *Heliotropium inexplicitum*
    - *Pluchea tetranthera*
- Converting cover data to presence,

Preliminary analysis of this modified dataset showed that quadrats SF25, SF71 and SF110 were significant outliers and it they were removed from the analysis at this stage. Removing the three taxa that only occurred in these quadrats resulted in a new 217 quadrat by 238 taxon dataset.

A two-way classification (Agglomerative Hierarchical Fusion) of the presence/absence quadrat data was carried out on the 248 taxon x 217 quadrat dataset using the program PATN (Belbin, 2003). The flexible UPGMA classification strategy was used (β = -0.1), together with the Bray-Curtis site similarity measure. The number of groups to be determined was set at 12.

The primary output of the classification was in the form of dendrograms and a two-way table of taxa and quadrats.

An concurrent ordination of the data was also carried out using multidimensional scaling (SSH).

The primary output of the ordination was in the form of scatterplots.

4. Results and Discussion

4.1. Classification of quadrats and species

The output number of groups was reduced by one by combining a single-group quadrat (SF161) with a small group composed of quadrats SF158, SF168 and SF198 which was the closest to it on the dendrogram. This reduced the overall number of groups to 11 (Fig. 1). The number of quadrats within groups ranged from four in Group 8 to forty eight in Group 2.

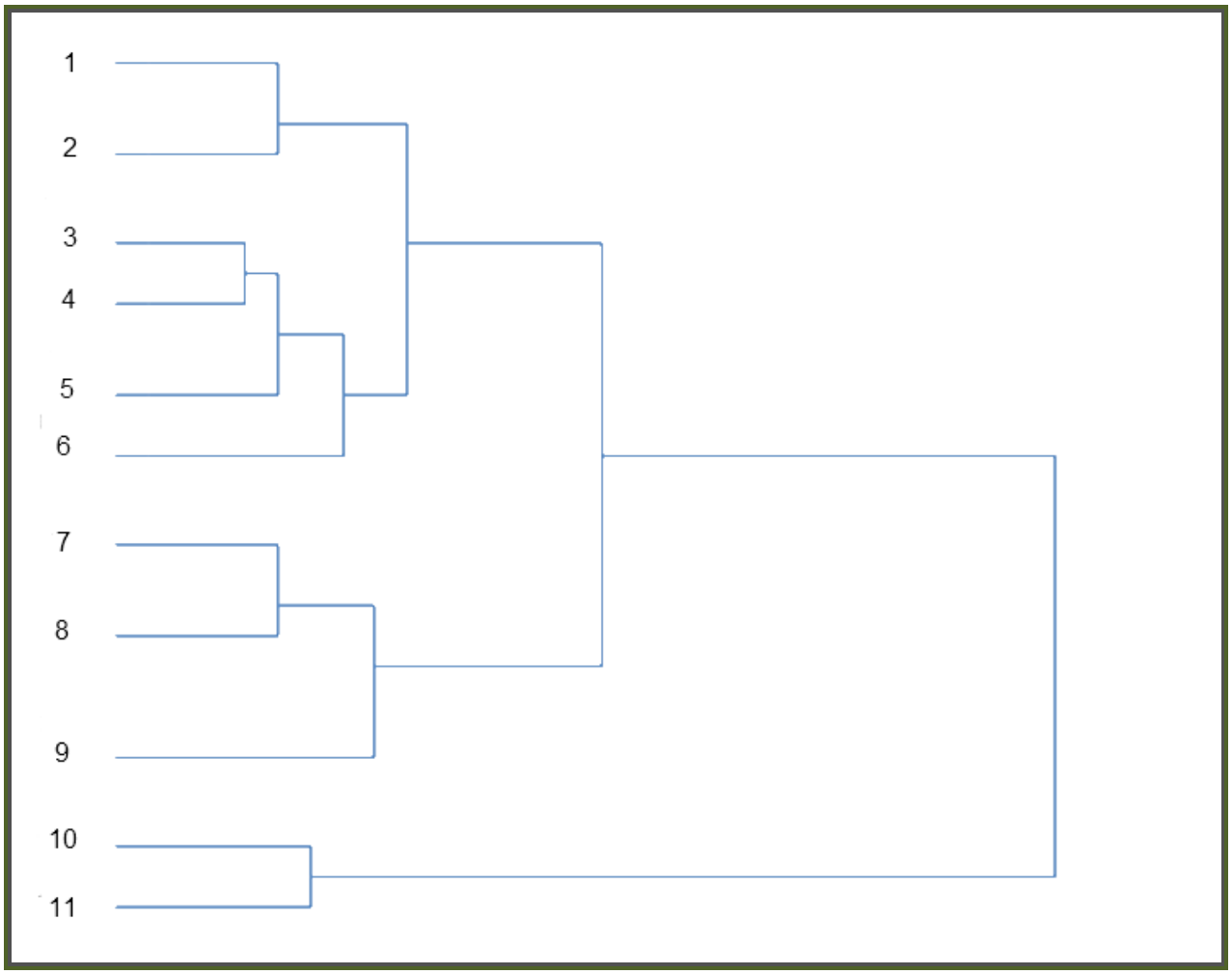

Figure 1. Dendrogram of floristic quadrat groups produced by the flexible UPGMA classification.

The two-way classification produced 16 floristic groups of taxa. The group composition table for the taxon groups is produced in the Appendix A spreadsheet ("Taxon Grp Comp"). A table which groups taxa by quadrat group is also produced in Appendix A ("Groups Matrix"). This table was used to produce a table showing the most characteristic species (i.e. taxa with a frequency > 60%) within each quadrat group (Table 1, also see Appendix A "Frequent Spp.").

Amongst the may observations that could be made about the distribution of taxa within quadrat groups are;

- The tree *Eucalyptus leucophloia* subsp. *leucophloia* is characteristic of quadrat groups 1 to 6 , but at low frequencies or absent from groups 7 to 11,
- *Eucalyptus victrix* is the characteristic tree of groups 10 and 11 and *Acacia pruinocarpa* the most frequent tree of groups 7, 8 and 9 (also *Eucalyptus gamophylla* in the latter group),
- *Corymbia hammersleyana* also has high or relatively high frequency in groups 1 to 6 but low frequency in groups 7 to 11 (it occurs at lower frequencies in group 1; 56%, and in group 5; 25%),
- Other species that tend to separate groups 1 to 6 from groups 7 to 11 are: *Acacia hamersleyensis, Eriachne mucronata* and *Triodia wiseana* (frequent in groups 1-6),
- Quadrat groups 1 to 9 are separated from Groups 10 and 11 at an early stage in the classification. Species such as *Acacia pruinocarpa* are absent from groups 10 and 11, while species such as *Eriachne benthamii*, *Eucalyptus victrix* and *Eulalia aurea* have high frequency in groups 10 and 11 but are at low frequencies (generally <25%) or are absent from the other quadrat groups.

	Quadrat Group										
Species	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
Acacia adoxa		65									
Acacia aneura var. A								100			67
Acacia aneura var. B	61										
Acacia aptaneura										73	
Acacia bivenosa									76		
Acacia hamersleyensis		67	86	80							
Acacia maitlandii	67					76					
Acacia marramamba	89										
Acacia monticola						67					
Acacia pruinocarpa	83		86				93	100	82		
Acacia pyrifolia var. pyrifolia		55				67					
Amyema fitzgeraldii											92
Aristida inaequiglumis							59	75			
Astrotricha hamptonii			64								
Capparis mitchelli			71								
Cheilanthes sieberi subsp. sieberi								75			
Codonocarpus cotinifolius	78	65		67			72		67		
Corchorus lasiocarpus subsp. parvus		67				76			61		
Corymbia ferriticola			71								
Corymbia hamersleyana		94	64	87		90					
Cymbopogon ambiguus			86	60	83						
Cymbopogon obtectus									67		
Digitaria ammophila								75		64	
Digitaria brownii							62				
Duperreya commixta			86				79		88		
Eremophila forrestii subsp. forrestii							62				
Eremophila jucunda subsp. pulcherrima	78		64								
Eremophila longifolia							66				
Eriachne benthamii										82	83
Eriachne mucronata			100	80	83	81					
Eucalyptus gamophylla									79		
Eucalyptus leucophloia subsp. leucophloia	94	92	86	93	92	67					
Eucalyptus victrix										82	100
Eulalia aurea										91	83
Gompholobium sp. Pilbara (N.F. Norris 908)		67									
Goodenia stobbsiana		80									
Gossypium robinsonii						95					
Grevillea wickhamii subsp. hispidula		73									
Hakea chordophylla		80									
Hakea lorea subsp. lorea								75			
Jasminum didymum subsp. lineare			64			71			67		
Keraudrenia veluntina subsp. elliptica C.F. Wilkins ms									67		
Muehlenbeckia florulenta											75
Paraneurachne muelleri							62		70		
Petalostylis labicheoides		61				62					
Psydrax latifolia			79								
Ptilotus obovatus var. obovatus			93		67	62	79				
Rulingia luteiflora	61										
Rulingia luteiflora						86					
Santalum lanceolatum			64			76					
Scaevola browniana subsp. browniana		67									
Senna glutinosa subsp. glutinosa				67	67						
Sida sp. Golden calyces glabrous (H.N.Foote 32)				73							
Solanum lasiophyllum	67						79		70		
Themeda triandra			79			62	59		61		
Triodia brizoides					75						
Triodia melvillei								75			
Triodia pungens	72		100	67	58	100	66		82		
Triodia sp. Shovelanna Hill (S. van Leeuwen 3835)									67		
Triodia wiseana	83	98		87		62					

Table 1. All species with a frequency of greater than 60% in each of the quadrat groups.

4.2. Ordination

A three-dimensional ordination diagram for the quadrat groups is shown in Fig. 2. Ordination scores for each quadrat are presented in Appendix A ("Ord Coords"). Quadrats in groups 10 and 11 tend to have low scores on axes 1 and 2. Quadrat groups 1, 2 and 3 have relatively high scores on axis 2.

The ordination diagram and scores may prove useful in the light of soil or geological data which would help explain the distribution of quadrat groups in ordination space.

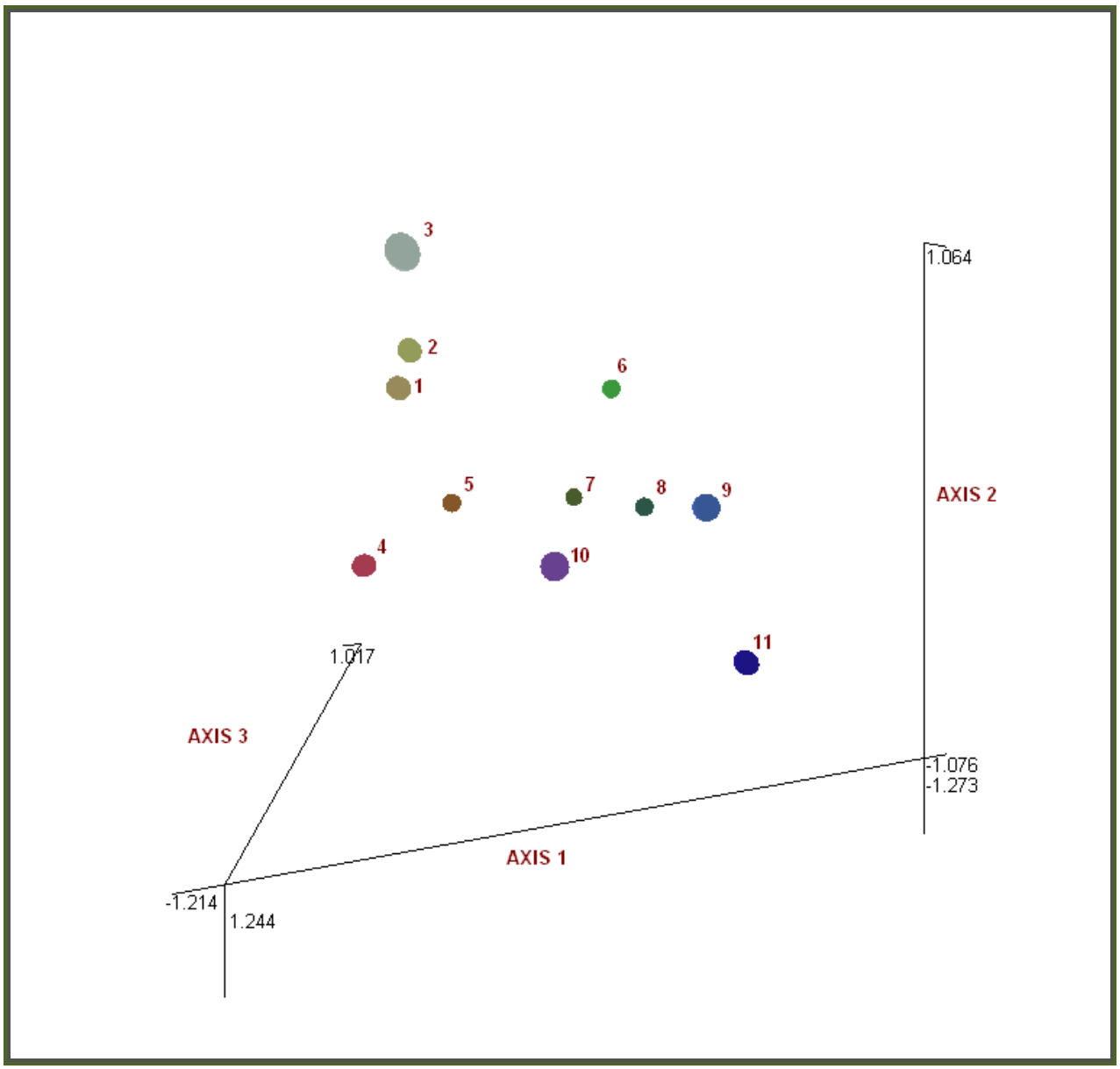

Figure 2. Ordination diagram of quadrat groups (larger symbols are closer to the observer along axis 3).

References

Belbin, Lee. (2003). PATN - A Revised User's Guide. Blatant Fabrications Pty Ltd.

McCune, B. and Metford, M.J. (1999). PC-ORD. Multivariate Analysis of Ecological Data, Version 4. MjM Software Design, Gleneden Beach, Oregon, USA.

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ABN 41 095 837 120

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PO Box 7122, Cloisters Square, Perth WA 6850

17th August 2017

EPA Comments Mining Area C South Flank PER

Please find our reply to comments recently received from the EPA in regard to flora and vegetation in the Mining Area C South Flank PER. A number of comments relate to the EPA's consideration of only the most recent baseline flora and vegetation surveys at Mining Area C and Surrounds (Onshore 2011) and South Flank (Onshore 2012) as stand alone documents, with no consideration for the eight other baseline surveys that form the total survey effort within the MAC Development Envelope.

There also appears to be confusion in the EPA's understanding of the methodology used to classify vegetation types within the baseline surveys, i.e. broad floristic formations, and their direct comparison with floristic types classified within the multivariate statistical analysis. Vegetation mapping utilises a classification methodology that includes structural attributes such as plant height, canopy cover, and identification of dominant life forms. The multivariate analysis is based purely on presence / absence of taxa.

BHP Billiton has sought professional advice from Mr Stephen van Leeuwen to provide comment of the two vegetation types identified as being poorly represented on the basis of representation within BHP Billiton Iron Ore's consolidated vegetation mapping database for Pilbara tenure. Mr van Leeuwen's comments reflect previous responses provided to the EPA on this matter, with one association being fire impacted, and the other association showing characteristically low species richness but refelective of long unburnt Mulga distributed between Wanna Mulla and Karijini.

If any further clarification is required by the EPA I am able to provide addiitonal spreadsheet data that was unable to be condensed into the current document.

Yours sincerely

Dr Darren Brearley
Director and Principal Botanist

EPA Comment: Are you able to provide any information to give confidence in the mapping classification of vegetation units?

Personnel

The field survey work including vegetation type mapping was undertaken by Dr Darren Brearley and Dr Jerome Bull, Principal Botanists employed with the boutique botanical consultancy Onshore Environmental Consultants PL. Dr Brearley and Dr Bull are highly experienced botanists and have been undertaking baseline survey work throughout the Pilbara since 2000. Their work undertaken on behalf of BHP Billiton Iron Ore has included the vast majority of BHP Billiton Iron Ore's Pilbara tenements extending between Port Hedland, Goldsworthy, Newman and Paraburdoo. They have also completed baseline surveys for other resource companies with Pilbara-based projects including Chevron (Wheatstone), Woodside (Pluto), Cameco (Kintyre) and Iron Ore Holdings (Buckland Hill). Most recently they were commissioned to consolidate vegetation mapping from over 80 project areas covering 430,000 hectares of BHP Billiton Iron Ore's Pilbara tenements as part of the Strategic Environmental Assessment.

Sampling Intensity

The Mining Area C and South Flank project areas represent some of the most intensively surveyed ground in the Pilbara. There are 772 quadrats[1] that have been assessed within the Mining Area C (MAC) Development Envelope (36,028 hectares), equating to one quadrat per 46.7 hectares (0.47 km^2). More than 1,000 additional quadrats have been assessed on the adjoining BHP Billiton Iron Ore project areas that include Tandanya and Mudlark (extending approximately 22 km to the west of the MAC Development Envelope) (Appendix 1).

Within the MAC Development Envelope there was initially 110 quadrats sampled at South Flank in 2008 by ENV Australia (2008), with a further 42 quadrats established as part of the South Flank NVCP Extension (ENV Australia 2010a, 2010b). Another 220 quadrats were sampled in 2010 (two season survey), with a targeted survey of the South Flank project area undertaken in 2011 (Onshore Environmental 2012). The eastern sector of the South Flank project area was surveyed as part of the R-Deposit Flora and Vegetation Assessment, which included establishment of 72 quadrats by ENV Australia (2007) and a further 95 quadrats by Onshore Environmental (2011a). In total, 372 quadrats occur within the Additional Development Envelope, noting that the baseline study areas extend outside the footprint of the Additional Development Envelope. Species accumulation curves confirm an adequate level of sampling was completed at South Flank (Appendix 2).

Baseline surveys at Mining Area C commenced in 1997 when 132 quadrats[2] were established around proposed mining operations at Area C (Ecologia 1998). In 2004 a further 54 quadrats were assessed at Packsaddle Range (Ecologia 2004a) and 35 quadrats were assessed across Deposits D, E and F (Ecologia 2004b). In 2007 there was an assessment of 72 quadrats at R-Deposit in the south-east (ENV Australia 2007), with a further 110 quadrats covering Area C and Surrounds (Onshore Environmental 2011a). Other baseline surveys that overlap the MAC Development Envelope include A, D, P1 and P3 Deposits (Woodman Environmental 2009) and the Jinayri to Area C Access Corridor (ENV Australia 2010c). As was the case for the Additional Development Envelope at South Flank, it is important to note

[1] 35 quadrats have been cleared to date as part of approved mining activities at Mining Area C.

[2] These quadrats were 100m by 100m in dimension, compared to the accepted standard of 50m by 50m used more recently in the Pilbara.

that boundaries for the baseline study areas extend outside the footprint of the MAC Development Envelope. Species accumulation curves confirm an adequate level of sampling was completed within the northern sector of the MAC Development Envelope (Appendix 2).

Methodology

The even spatial distribution of quadrats across the MAC Development Envelope (Appendix 1) required extensive ground truthing, with quadrats generally established less than 500 metres apart. This intensive sampling strategy provided the opportunity to accurately record changes in vegetation structure and composition evident on high resolution aerial photography in the field, resulting in accurate fine scale vegetation association mapping.

Vegetation mapping utilised high-resolution aerial photography of the entire MAC Development Envelope at a scale of 1:20,000. Description of vegetation structure follows the height, life form and density classes of Specht (1970) as modified by Aplin (1979) and Trudgen (2009), which is equivalent to the National Vegetation Information System (NVIS) Level V - Association (ESCAVI 2003), i.e. dominant growth form, height, cover and species (three species) for the three traditional strata (upper, mid and ground).

Multivariate statistical analysis of quadrat data was completed for all previous baseline surveys completed within the MAC Development Envelope. The analyses were completed using presence / absence of taxa, and for Area C and Surrounds (Onshore Environmental 2011a) a second analysis was also completed using transformed percentage cover data. The floristic outputs were used as a reference when grouping quadrats for preliminary vegetation association mapping. However, there were obvious discrepancies in a number of the floristic groups when compared to field vegetation type classification. These discrepancies resulted from the multivariate analysis not accounting for vegetation structural attributes or variation in canopy cover for taxa recorded within each quadrat. The floristic groups were also heavily influenced by spatial distribution of the quadrats and high sampling intensity, i.e. higher levels of similarity appeared where quadrats were situated closer together due to overlap over non-characteristic taxa between vegetation types.

As the name suggests, the “floristic community type” output from multivariate statistical analysis is defined purely by the floristic composition. It does not account for vegetation structural attributes, it has no absolute scale (EPA 2016), and the distribution of floristic community types cannot be mapped. Multivariate analysis is an effective tool used to determine similarity of quadrat data with that from a known significant vegetation community (i.e. Threatened or Priority Ecological Community). However, the above limitations in the data need to be acknowledged when converting outputs to spatial vegetation type mapping.

EPA Comment: Can you demonstrate that your ability to provide evidence regarding the floristic relationships and broader occurrence of vegetation units likely to be subject to high levels of clearing under the Mining Area C Southern Flank proposal has not been affected?

Background

In 2014 BHP Billiton Iron Ore collated all previous vegetation mapping across its Pilbara tenure into a single collated vegetation association map (with one legend); the mapping covers approximately 5 percent of the Pilbara by area. The consolidated database was utilised in the most recent flora and vegetation management plan to provide guidance in determining significance of vegetation types within the MAC Development Envelope. Two vegetation types were determined to have greater than 30 percent of their extent within the Mining Area C Development Envelope which triggered the requirement for further investigation.

The two vegetation associations in question are:

- **MGW** Low Woodland of *Acacia aptaneura* and *Acacia pruinocarpa* over Shrubland of *Eremophila jucunda* subsp. *pulcherrima*, *Acacia marramamba* and *Codonocarpus cotinifolius* over Open Hummock Grassland of *Triodia wiseana* and *Triodia pungens* on red brown loam on hill slopes (HS AaApr ErjpAmarCocf TwTp; Mulga and Gidgee Woodland; equivalent to type 14a at South Flank [Onshore Environmental 2012]); and
- **WBMF** Low Open Forest of *Acacia catenulata* subsp. *occidentalis* and *Acacia aptaneura* over Very Open Tussock Grassland of *Aristida obscura*, *Digitaria ammophila* and *Chrysopogon fallax* on red brown clay loam on lower stony plains (SP AcaoAa ArobDiaChf; Western Bendee and Mulga Forest; equivalent to type 3b at South Flank [Onshore Environmental 2012]).

The Mulga and Gidgee Woodland (MGW) association had been recently burnt prior to the most recent baseline survey at South Flank in 2010 (Onshore Environmental 2012), and the Western Bendee and Mulga Forest (WBMF) association had a very open understorey in part caused by grazing and low rainfall prior to the assessment period. The WBMF association was closely aligned to the other two Mulga Low Forest vegetation types mapped at South Flank (3a and 3c) (Onshore Environmental 2012).

Multivariate Analysis of Floristic Data

The aim of the multivariate analysis was to determine how closely aligned floristically, quadrats within the MGW and WBMF vegetation associations were with other quadrats established both within and adjacent to the MAC Development Envelope.

A matrix of quadrats (1,504) by taxa (683) of floristic quadrat data from baseline surveys completed within the MAC Development Envelope and surrounding tenements was entered into an excel spreadsheet in readiness for multivariate analysis. The multivariate analysis was carried out using the PATN software (Belbin 2003). A two-way classification (Agglomerative Hierarchical Fusion) of the presence/absence quadrat data was carried out on the 683-taxon by 1,504-quadrat dataset. The large size of the dataset presented some difficulties in carrying out the analysis. For this reason a concurrent ordination was not attempted with the classification. Quadrats identified as belonging to the “Mulga and Gidgee Woodland” association were appended with “_MGW”, and those in the “Western Bendee and Mulga Forest” association were appended with “_WBMF” (e.g. “SFE094_WBMF”). This assisted in finding the quadrats in the very large dendrogram produced by the analysis. A flexible UPGMA

classification strategy was used (β = -0.1) for the comparison of floristic quadrats, together with the Bray-Curtis site similarity measure. The number of quadrat groups to be determined was set at 39. A concurrent classification of taxon groups was conducted using non-hierarchical clustering (Bray-Curtis similarity measure). The primary output of the classification was in the form of a dendrogram showing quadrat groups and a two-way table of taxa and quadrats. A table showing similarities between quadrats (Bray-Curtis similarity measure) was also produced.

The output determined that 11 of the 15 MGW quadrats formed part of the same floristic group (No. 32) which supported a total of 28 quadrats. In comparison, the three WBMF quadrats were classified into separate groups[3] (No. 1, 25 and 30, see Appendix 3). One clear trend evident from the analysis was the tendency for quadrats from the same study area to cluster more closely (Appendix 3); this is not unusual and typically reflects the high sampling intensity and close spatial distribution of the quadrats resulting in high levels of species overlap between adjacent vegetation types.

Professional Opinion

A professional opinion on the conservation significance of the MGW and WBMF vegetation types was sought by BHP Billiton Iron Ore from Mr Stephen van Leeuwen, Assistant Director of Science and Conservation Division with the Department of Biodiversity, Conservation and Attractions. Mr van Leeuwen has expertise in the areas of arid zone ecology, botanical survey, mulga woodland ecology, plant species distributions, and vegetation mapping. He is very familiar with flora and vegetation of the Pilbara and has undertaken a significant amount of work in the Mining Area C and Southern Flank region.

Mr van Leeuwen commented by email to BHP Billiton Iron Ore on the 7th August 2017 that the Mulga and Gidgee Woodland (MGW) doesn't appear to be anything special and is probably an artefact of the floristic analysis and fire history (thus presence of Codonocarpus) more than anything else. This is a typical fire degraded mulga community off lower BIF ridges in the Newman to Karijini area. It is very similar to some of the site data within the 5eca community (found on Brockman iron formation) mapped for the West Angelas project (Trudgen 1998).

The Western Bendee and Mulga Forest (WBMF) vegetation community is an important community and is of high conservation value principally because of its long-unburnt status. Typically floristically depauperate compared to other Mulga communities and supports an understorey dominated by ephemerals and *Chrysopogon* / *Themeda* - soft grasses with scatted soft spinifex - *Triodia pungens* or *Triodia melvillei.* From Mr van Leeuwen's knowledge this community is present on the western side of the Great Northern Highway and extends west and south of Coondewanna Flats down to West Angelas and to the east across to Wanna Munna, usually occurring on heavy soil low in the landscape, but not on alluvial flats or gilgai. In respect to other work the best match are vegetation types 6abd23 or 6abd211 which was mapped as seven and two occurrence respectively at West Angelas (Trudgen 1998).

Comparison of the two vegetation types with mapping captured at the Hope Downs 4 project (Mattiske Consulting 2008) is difficult, as that mapping is simply too course to be of any use (as DEC advised at the time). However, the WBMF community at South Flank would best fit in the M1 community at Hope Downs 4, and the MGW community at South Flank would best fit in the S1 community at Hope Downs 4.

[3] Reducing the number of quadrat groups produced by the analysis to 34 did not change the output.

EPA Comment: South Flank Study Area Level 2 Flora and Vegetation Survey (Onshore 2012)

i. Of the 34 vegetation units described in the report, seven were represented by one or fewer quadrats, where Guidance Statement 51 requires a minimum of two quadrats per unit.

The study area for the South Flank Level 2 Flora and Vegetation Survey (Onshore Environmental 2012) was a different shape to that defined as the MAC Development Envelope and only covered a portion of the Additional Impact Assessment Area at South Flank. As such, not all vegetation associations mapped within the South Flank study area (Onshore Environmental 2012) occur within the footprint of the MAC Development Envelope. Additionally, the total sampling effort completed within the MAC Development Envelope includes a significant number of additional quadrats assessed as part of overlapping study areas such as Area C South Flank Deposit Flora and Vegetation Assessment (ENV Australia 2008), South Flank NVCP Extension (ENV Australia 2010a), Tandanya (Onshore Environmental 2013a) and Mudlark (Onshore Environmental 2013b). These additional quadrats must be considered when determining the adequacy of sampling within vegetation types mapped.

Four of the seven vegetation associations identified by the EPA as being under-sampled (i.e. less than two quadrats) within the South Flank survey (Onshore Environmental 2012) were not represented within the MAC Development Envelope (Table 1). Two of the three remaining vegetation associations were each sampled by two quadrats within the MAC Development Envelope when the total survey effort was considered (vegetation associations 1b and 12a, see Table 1). The final vegetation association (13i TaTw El Es) was under sampled within the MAC Development Envelope recorded by one releve site (Table 1). Vegetation type 13i TaTw El Es over a relatively small area within the MAC Development Envelope (20 ha) but has been extensively sampled on adjacent tenements (Figure 1). It is known to be widespread locally and the area represented within the MAC Development Envelope was extensively covered during the targeted survey in June 2011 (Onshore Environmental 2012).

Table 1 Seven of 34 vegetation types described and mapped within the South Flank Level 2 Flora and Vegetation Survey (Onshore Environmental 2012) that were subsequently identified by the EPA as being represented by one or fewer quadrats.

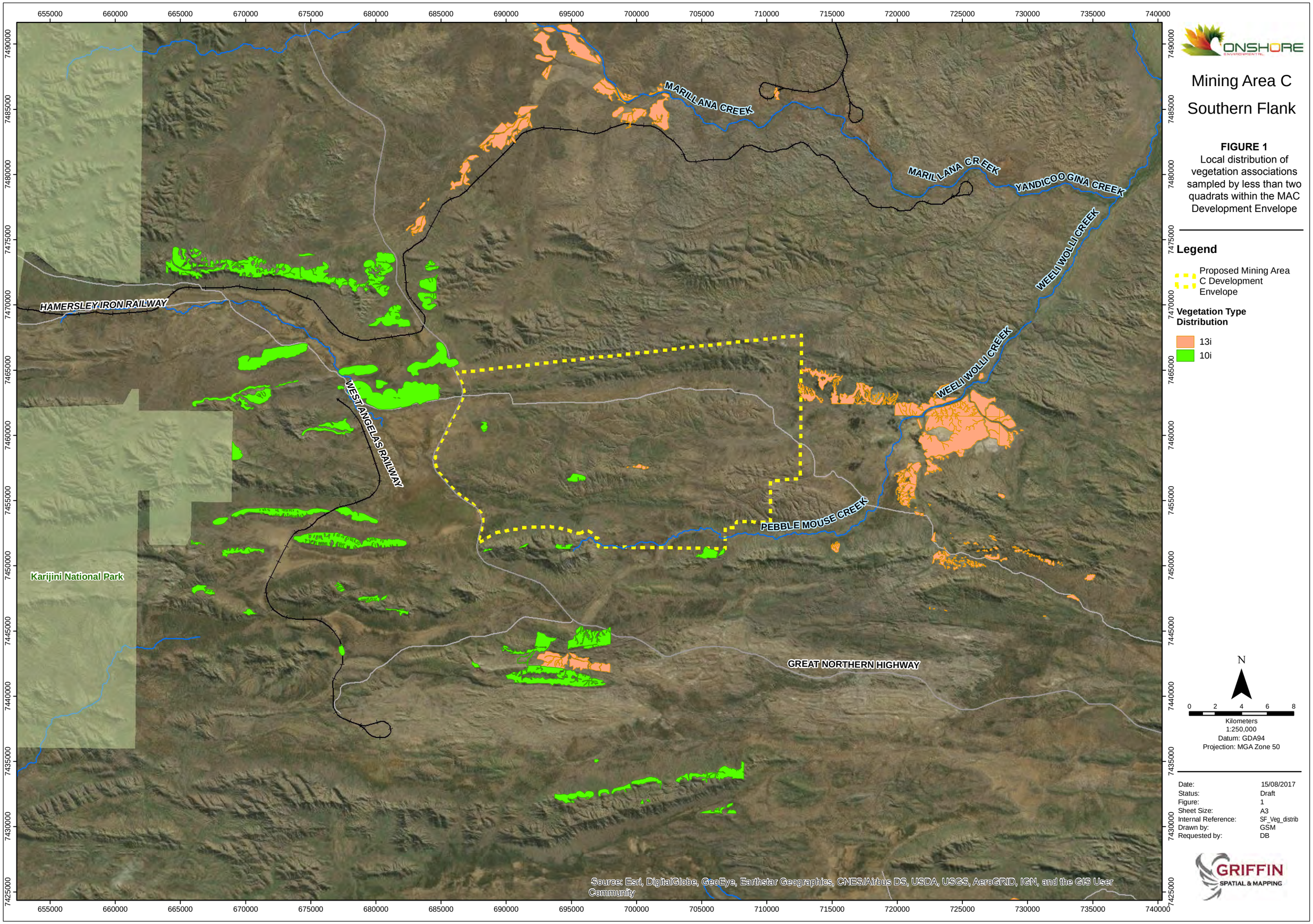
Vegetation Code	Represented within MAC Development Envelope	Quadrats	Area (ha) within MAC Development Envelope	Comment
1b EvEc Tl Ap	Yes	SF71, M33[4]	30.9 ha	There are two quadrats represented within the MAC Development Envelope that have sampled the 'EvEc Tl Ap' unit, SF71 from the South Flank survey (Onshore 2012) and M33 from the overlapping Mudlark survey (Onshore 2013b). The vegetation is characterised by *Eucalyptus camaldulensis* and *Eucalyptus victrix* trees along major incised drainage lines with hummock/tussock grasses and open shrublands.

[4] Quadrat M33 was assessed as part of the overlapping Mudlark baseline survey (Onshore 2013c) and occurs within the MAC Development Envelope.

Vegetation Code	Represented within MAC Development Envelope	Quadrats	Area (ha) within MAC Development Envelope	Comment
12a EfrEjAma Tp AaAp	Yes	SF203, SFE96[5]	48.9 ha	There are two quadrats represented within the MAC Development Envelope that have sampled the 'EfrEjAma Tp AaAp' unit, SFE96 from the original South Flank baseline survey (ENV 2008) and SF203 from the most recent survey (Onshore 2012). The vegetation is characterised by low trees of *Acacia aneura* over a variety of *Eremophila* species including *E. fraseri* and *E. forrestii* subsp. *forrestii,* and the dominant hummock grass *Triodia pungens.* The unit occurs on pisolitic ironstone hill crests.
13i TaTw El Es	Yes	No (one releve site)	20.04	Represented by one releve site within the South Flank baseline survey (Onshore 2012), noting that the vegetation unit occurs over 20 ha within the MAC Development Envelope. The vegetation is characterised by *Eucalyptus socialis* mallee over *Triodia angusta* and occupies low stony rises of calcrete. It is well represented locally and has been extensively mapped and adequately sampled on adjacent tenements (Figure 1).
15b Eb Ev	No	No	0.00	Represented by Quadrat SF200 within the South Flank baseline survey (Onshore 2012), but this quadrat is outside the MAC Development Envelope (west side of Great Northern Highway). The vegetation is characterised by scattered *Eucalyptus victrix* and *Hakea lorea* subsp. *lorea* trees in the absence of *Duma florulenta* (Lignum). This unit could be incorporated into one of the Lake Robinson vegetation types.
14b TwTlTe TtEm ElCf	No	No	0.00	Represented by Quadrat SF204 within the South Flank baseline survey (Onshore 2012), but this quadrat is outside the MAC Development Envelope (outside the southern boundary). The vegetation is characterised by a variety of *Triodia* spp and cliff line vegetation; occurring in a large open valley on the northern slopes of Mount Robinson.

[5] Quadrat SFE96 was assessed as part of the original South Flank baseline survey (ENV 2008) and occurs within the MAC Development Envelope.

Vegetation Code	Represented within MAC Development Envelope	Quadrats	Area (ha) within MAC Development Envelope	Comment
13h TwTb ChEk DmSb	No	No	0.00	Represented by Quadrat SF110 within the South Flank baseline survey (Onshore 2012), but this quadrat is outside the southern boundary of the MAC Development Envelope. The vegetation is characterised by *Corymbia hamersleyana* occurring in mallee form alongside *Eucalyptus kingsmillii,* but in the absence of *Eucalyptus leucophloia.* The Priority 3 flora taxon *Dampiera metallorum* occurs as a common understorey component with a suite of *Triodia* spp. The vegetation type occupies the highest hill crests of Mount Robinson (AHD >1050 m).
15c EbEa Ev	No	No	0.00	Represented by a releve site within the South Flank baseline survey (Onshore 2012), but this releve is outside the western boundary of the MAC Development Envelope. The vegetation is characterised by *Eucalyptus victrix* trees over tussock grasslands but in the absence of *Duma florulenta.* It forms part of the Coondewanna Flats and has been sampled as part of the Tandanya (Onshore 2013a) and Coondewanna Flats (2013c) baseline surveys.



Mining Area C Southern Flank

FIGURE 1
Local distribution of vegetation associations sampled by less than two quadrats within the MAC Development Envelope

Legend

- Proposed Mining Area C Development Envelope

Vegetation Type Distribution

- 13i
- 10i

N

0 2 4 6 8

Kilometers
1:250,000
Datum: GDA94
Projection: MGA Zone 50

Date:	15/08/2017
Status:	Draft
Figure:	1
Sheet Size:	A3
Internal Reference:	SF_Veg_distrib
Drawn by:	GSM
Requested by:	DB

ii. The 2010 vegetation surveys were inadequate due to poor seasonal conditions. In addition to establishing new quadrats to address insufficient sampling effort, some or all of the 2010 quadrats should have been revisited the following year to ensure a more comprehensive vegetation analysis could be undertaken.

Seasonal Conditions

We disagree with the EPA comment that vegetation surveys were inadequate due to poor seasonal conditions. The EPA comment appears to be directed towards the most recent baseline survey completed at South Flank in 2010 and 2011 (Onshore Environmental 2012). As detailed in previous comments above, there are five baseline surveys that contribute to survey effort within the Additional Development Envelope:

- South Flank Level 2 Flora and Vegetation Survey (Onshore Environmental 2012);
- South Flank NVCP Extension Flora, Vegetation and Fauna Assessment (ENV Australia 2010a);
- Area C South Flank Deposit Flora and Vegetation Assessment (ENV Australia 2008);
- Area C R-Deposit Flora and Vegetation Assessment (ENV Australia 2007); and
- Mining Area C Biological Survey (Ecologia 1998).

The five baseline surveys occur over six years and include periods of excellent seasonal condition. Regardless, the original EPA comment regarding seasonal conditions for each of the three surveys completed at South Flank by Onshore Environmental (2012) has been addressed below.

The first season survey was completed between the 22nd March and 24th May 2010. There was 95.2mm of summer rainfall recorded over the four months preceding the first season field survey, that included heaviest monthly falls during December 2009 (42.2mm) and February 2010 (42.0mm). Seasonal conditions were rated as *fair.*

The second season survey that included re-assessment of the 220 quadrats was completed between the 16th and 29th September 2010. There was 71.0mm of rainfall recorded during the four months preceding the second season field survey that included the heaviest monthly fall of 54.7mm during September 2010. The resultant seasonal conditions were rated as *poor.*

Due to the *poor* seasonal conditions experienced during the second season field survey, a follow-up targeted survey was undertaken by four botanists from the 22nd to the 27th June 2011. The targeted survey aimed to record annual and ephemeral life forms that may not have been present during the survey work completed in 2010. The targeted survey followed exceptional summer rainfall that included 128.3mm in January, 95.6mm in February, 50.4mm in March, and a combined total of 42.7mm for the three months from April to June 2011. This resulted in *very good* seasonal conditions.

Sampling Effort

We disagree with the EPA comment regarding “insufficient sampling effort”.

As part of the South Flank Level 2 Flora and Vegetation Survey (Onshore Environmental 2012) a total of 220 quadrats were assessed on two occasions during 2010, with a further targeted survey of the study area undertaken in mid-2011. It is noted that 168 of the 220 quadrats occur within the MAC Development Envelope being assessed as part of the PER. However, an additional 111 quadrats originating from four separate baseline surveys overlap the same

South Flank study area surveyed by Onshore Environmental (2012) and fall within the MAC Development Envelope. These surveys include:

- South Flank NVCP Extension Flora, Vegetation and Fauna Assessment (ENV Australia 2010a);
- Area C South Flank Deposit Flora and Vegetation Assessment (ENV Australia 2008);
- Area C R-Deposit Flora and Vegetation Assessment (ENV Australia 2007); and
- Mining Area C Biological Survey (Ecologia 1998).

In total there are 279 quadrats that occur within the South Flank study area and also intersect the MAC Development Envelope. This represents a very intensive sampling effort completed over six separate years and variable seasonal conditions.

iii. There is poor alignment between the results of the floristic analysis and the vegetation units. The floristic analysis separated the quadrats into 11 floristic groupings however 16 floristic groupings were used to describe 34 vegetation units.

Vegetation association mapping at South Flank was completed by two highly experienced Principal Botanists with regard for vegetation structure, species composition, and dominant plant taxa determined by percentage foliage cover (Attachment 2). Description of vegetation follows the height, life form and density classes of Specht (1970) as modified by Aplin (1979) and Trudgen (2009), which is equivalent to the NVIS Level V - Association (ESCAVI 2003), i.e. dominant growth form, height, cover and species (three species) for the three traditional strata (upper, mid and ground). This methodology is required by BHP Billiton Iron Ore across biological surveys on Pilbara tenure to ensure consistency of mapping between project areas. Importantly, the classification of vegetation into the 16 groupings[6] referred to in the EPA comment was based on 'broad floristic formation' which describes the dominant growth form, cover and height as well as the dominant land cover genus for the dominant stratum (ESCAVI 2003). It is therefore not surprising that there is poor alignment between the 16 broad floristic formations and 11 floristic groupings classified by the multivariate analysis. The multivariate analysis was performed on the species by site matrix from South Flank using presence / absence data with no consideration for vegetation structure, plant height or ground cover.

The Principal Botanists at Onshore Environmental rarely find that floristic groupings closely match fine scale vegetation association mapping units. The level of fit can be increased by making assumptions and manipulating the raw data within multivariate analyses, but this is a practise that is often used to 'push' floristic groupings to better align with vegetation association mapping (not vice versa).

Multivariate analysis is a useful tool where data is available for known significant communities such as TECs and PECs. However, quadrat data is rarely publically available for these communities as confirmed by recent requests to the Communities Branch.

[6] These were not 16 floristic groupings as referred to in the EPA comment

EPA Comment: Area C and Surrounds Study Area Level 2 Flora and Vegetation Survey (Onshore 2011)

i. Of the 37 vegetation units described in the report, eight were represented by one quadrat, where Guidance Statement 51 requires a minimum of two quadrats per unit.

We disagree with the EPA comment regarding "insufficient sampling effort".

The study area for the Area C and Surrounds Level 2 Flora and Vegetation Survey (Onshore Environmental 2011) was a different shape to that defined as the MAC Development Envelope, extending significantly further to both the east and west. As such, not all quadrats and vegetation associations represented within the Area C and Surrounds study area occur within the footprint of the MAC Development Envelope. Only 40 of the 110 quadrats from the Area C and Surrounds survey (Onshore Environmental 2011) occur within the MAC Development Envelope (Table 2, Appendix 1).

The Area C and Surrounds baseline survey (Onshore Environmental 2011) only represents a portion of the sampling effort around Mining Area C and within the northern half of the MAC Development Envelope. There are an additional 454 quadrats originating from eight other baseline surveys that intersect the same area (Table 2, Appendix 1) and require consideration when determining the adequacy of sampling effort; we do not believe this is the case for the above EPA comment.

Table 2 Total survey effort within the portion of Area C and Surrounds study area that intersects with the MAC Development Envelope.

Report	Code	Total No. Quadrats	No. Quadrats Intersecting Area C & Surrounds Study Area
Area C: Deposits D, E and F Biological Survey (Ecologia 2004b)	E	35	35
Packsaddle Range Biological Survey (Ecologia 2004a)	PS	54	48
Area C R-Deposit Flora and Vegetation Assessment (ENV 2007)	R	72	70
Area C South Flank Deposit Flora and Vegetation Assessment (ENV 2008)	SFE	110	29
Area C Mining Operations Environmental Management Plan (Revision 4) A, D, P1 and P3 Deposits Flora and Vegetation Assessment (Woodman 2009)	WEC	62	56
South Flank NVCP Extension Flora, Vegetation and Fauna Assessment (ENV 2010)	SW	30	18
Area C and Surrounds Flora and Vegetation Survey (Onshore 2011)	PSE	110	40
	OR	95	93
	W	17	17
South Flank Level 2 Flora and Vegetation Survey (Onshore 2012)	SF	220	2
Mining Area C Biological Survey (Ecologia 1998)	ACE	132	86
Total		949	494

The EPA identified eight vegetation associations within the Area C and Surrounds Level 2 Flora and Vegetation Survey (Onshore 2011) as being under-sampled (i.e. less than two quadrats). Further analysis has identified a ninth vegetation association (Table 3). However, five of the nine vegetation associations mapped within the Area C and Surrounds survey are not represented within the MAC Development Envelope (Table 3). Two vegetation types (10b, 11e) were found to have been sampled by three and five quadrats respectively within the within the MAC Development Envelope when the total survey effort was considered, and hence are not considered to be under-sampled (Table 3). Vegetation types 10i and 10l are under-sampled within the MAC Development Envelope, but occur extensively on the surrounding tenements where they have been adequately sampled (Table 3, Appendix 1). Vegetation type 10l extends immediately eastwards from the MAC Development Envelope and supports eight quadrats.

Table 3 Nine of 37 vegetation types described and mapped within the Area C and Surrounds Level 2 Flora and Vegetation Survey (Onshore 2011) that were represented by one quadrat.

Vegetation Code	Represented within MAC Development Envelope	Quadrats	Comment
1a	No	No	Represented by Quadrat WEC14a within the Area C and Surrounds baseline survey (Onshore 2011), but this quadrat and the associated map unit is outside the MAC Development Envelope occurring along Weeli Wolli Creek further to the east.
3c	No	No	Represented by Quadrat PS92 within the Area C and Surrounds baseline survey (Onshore 2011), but this quadrat and the associated map unit is outside the MAC Development Envelope (Weeli Wolli Creek).
7b	No	No	Represented by Quadrat WEC14b within the Area C and Surrounds baseline survey (Onshore 2011), but this quadrat and the associated map unit is outside the MAC Development Envelope (WW).
10b	Yes	ACE45, E1, E6	There are three quadrats represented within the MAC Development Envelope that have sampled the 10b unit; ACE45 from the original Mining Area C survey (Ecologia 1998), E1 and E6 from the Deposits D, E and F survey (Ecologia 2004b).
10i	Yes	No[7]	Represented by two releve sites within the Area C and Surrounds baseline survey (Onshore 2011), but these sites and the map unit are well represented outside the MAC Development Envelope (Figure 1).
10j	No	No	Represented by two releve sites within the Area C and Surrounds baseline survey (Onshore 2011), but these sites and the map unit are outside the MAC Development Envelope (east).

[7] The Quadrat WEC07 is situated just outside the eastern boundary of the MAC Development Envelope, with additional quadrats sampling this unit further east towards Weeli Wolli Creek.

Vegetation Code	Represented within MAC Development Envelope	Quadrats	Comment
10l	Yes[8]	No[9]	This vegetation type was mapped during the Jinayri to Area C Access Corridor Flora and Vegetation Assessment (ENV 2010). Approximately 95% of the map unit occurs outside the eastern boundary of the MAC Development Envelope and supports the following quadrats (IP18, IP19, IP22, IP33, IP38, IP40, WY46, WY88). The small portion of vegetation type 10l that overlaps the eastern extent of the MAC Development Envelope does not support any quadrats.
10m	No	No	Mapped by Woodman Environmental (2009) outside the MAC Development Envelope (east).
11e	Yes	ACE7, ACE65, ACE94, PS43, WEC47	There are five quadrats represented within the MAC Development Envelope that have sampled the 11e vegetation unit.

ii. There is poor alignment between the results of the floristic analysis and the vegetation units. The floristic analysis separated the quadrats into 13-15 floristic groupings however 11 floristic groupings were used to describe 37 vegetation units.

Vegetation association mapping at Mining Area C was completed by two highly experienced Principal Botanists with regard for vegetation structure, species composition, and dominant plant taxa determined by percentage foliage cover (Attachment 2). Description of vegetation follows the height, life form and density classes of Specht (1970) as modified by Aplin (1979) and Trudgen (2009), which is equivalent to the NVIS Level V - Association (ESCAVI 2003), i.e. dominant growth form, height, cover and species (three species) for the three traditional strata (upper, mid and ground). This methodology is required by BHP Billiton Iron Ore across biological surveys on Pilbara tenure to ensure consistency of mapping between project areas. Importantly, the classification of vegetation into the 11 groupings[10] referred to in the EPA comment was based on 'broad floristic formation' which describes the dominant growth form, cover and height as well as the dominant land cover genus for the dominant stratum (ESCAVI 2003). It is therefore not surprising that there is poor alignment between the 11 broad floristic formations and 13-15 floristic groupings classified by the multivariate analysis. The multivariate analysis was performed on the species by site matrix from Mining Area C and Surrounds using presence / absence data with no consideration for vegetation structure, plant height or ground cover.

The Principal Botanists at Onshore Environmental rarely find that floristic groupings closely match fine scale vegetation association mapping units. The level of fit can be increased by making assumptions and manipulating the raw data within multivariate analyses, but this is a practise that is often used to 'push' floristic groupings to better align with vegetation association mapping (not vice versa).

[8] It is noted that >95% of the extent of vegetation type 10l is outside the MAC Development Envelope.
[9] There are eight quadrats established within this vegetation type nearby (but outside) the MAC Development Envelope.
[10] These were not 11 floristic groupings as referred to in the EPA comment

Multivariate analysis is a useful tool where data is available for known significant communities such as TECs and PECs. However, quadrat data is rarely publically available for these communities as confirmed by recent requests to the Communities Branch.

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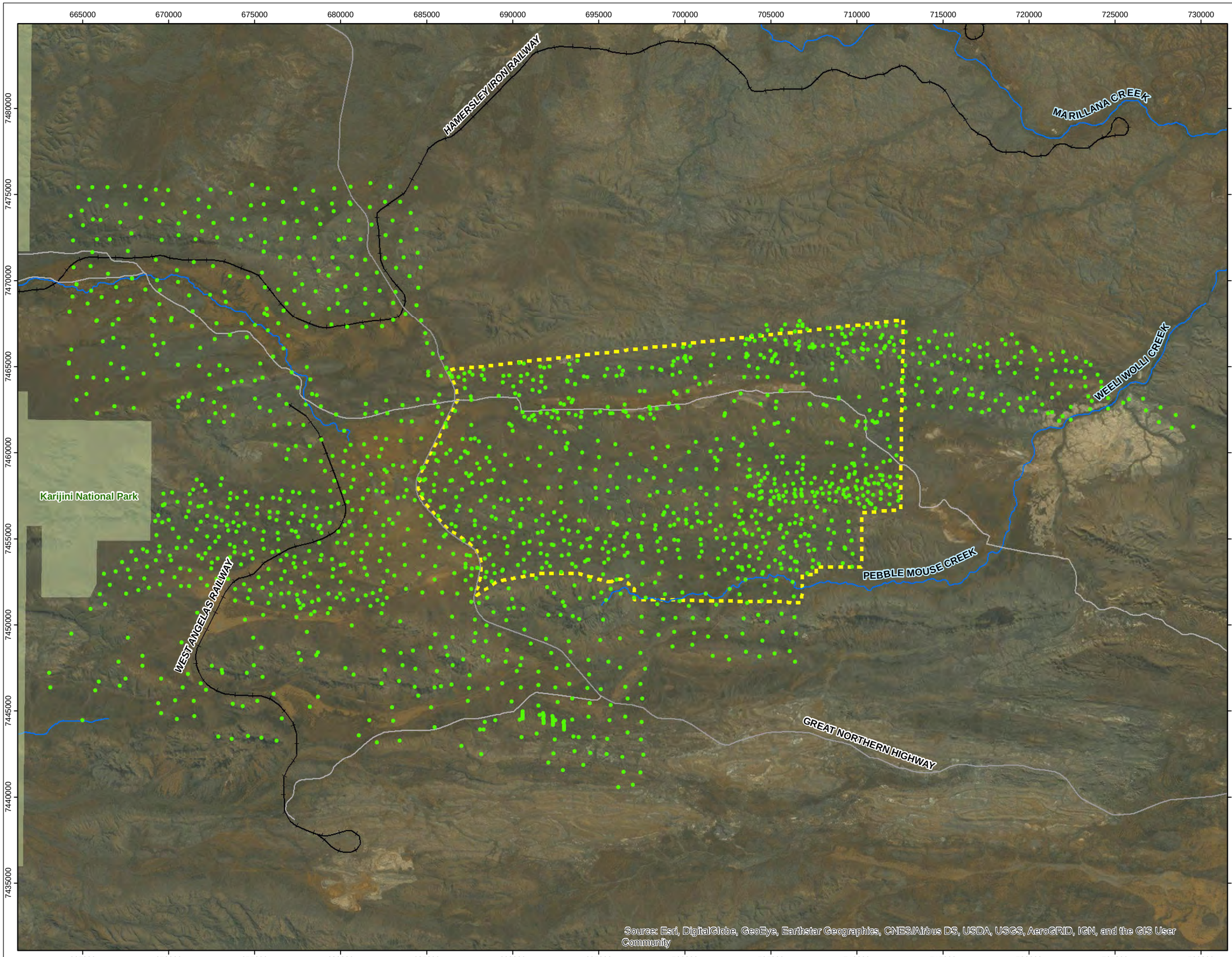
APPENDIX 1

Location of quadrats within the MAC Development Envelope and on adjoining tenements



ONSHORE ENVIRONMENTAL

BHPBIO

Mining Area C

Southern Flank

Location of quadrats within the MAC Development Envelope and on adjoining tenements

Legend

- Proposed Mining Area C Development Envelope
- Sample Locations

N

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Kilometers
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Datum: GDA94
Projection: MGA Zone 50

Date:	15/08/2017
Status:	Draft
Figure:	1
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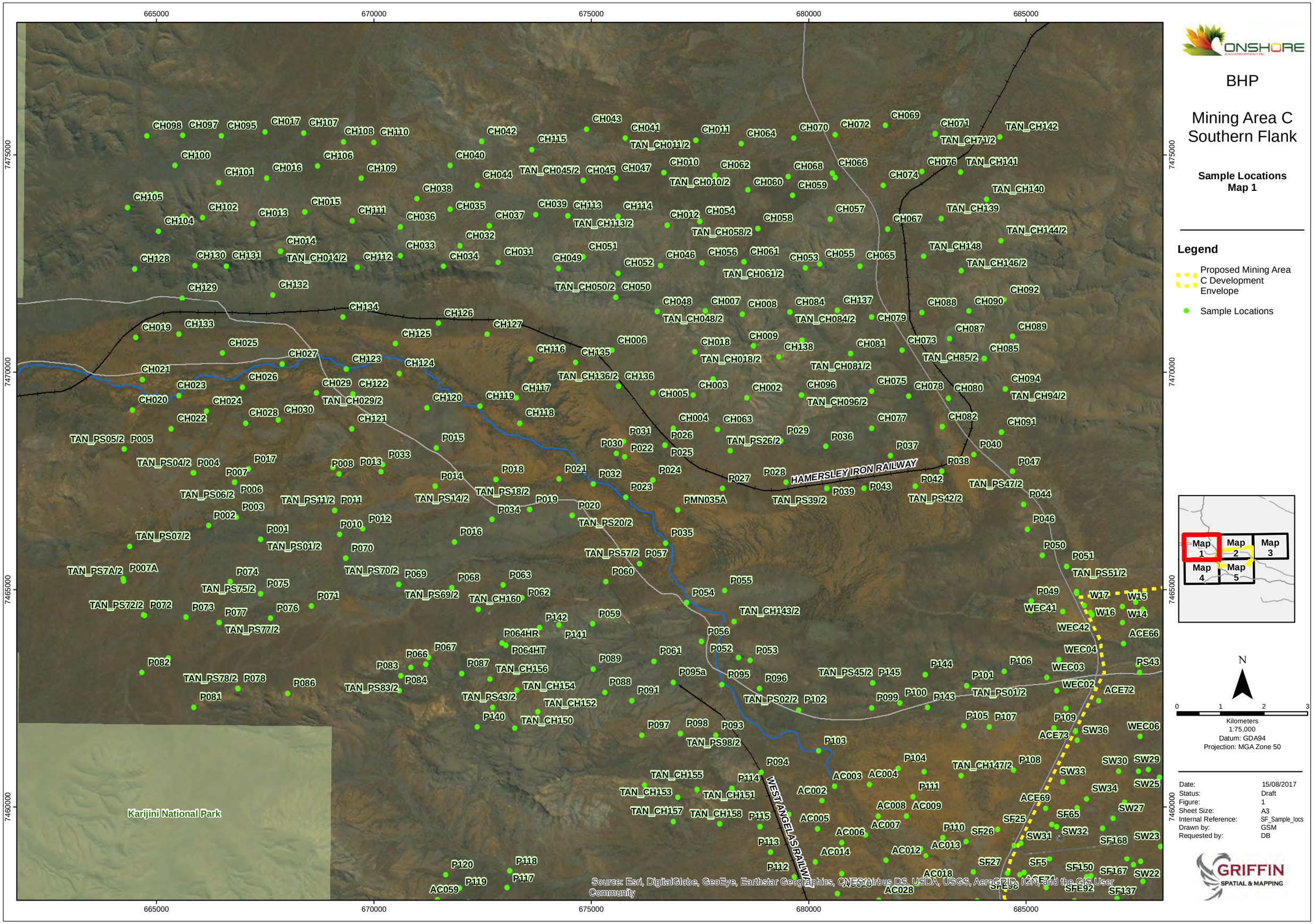
Drawn by:	GSM
Requested by:	DB

GRIFFIN SPATIAL & MAPPING



ONSHORE ENVIRONMENTAL

BHP

Mining Area C Southern Flank

Sample Locations Map 1

Legend

- Proposed Mining Area C Development Envelope
- Sample Locations

N

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Kilometers
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Projection: MGA Zone 50

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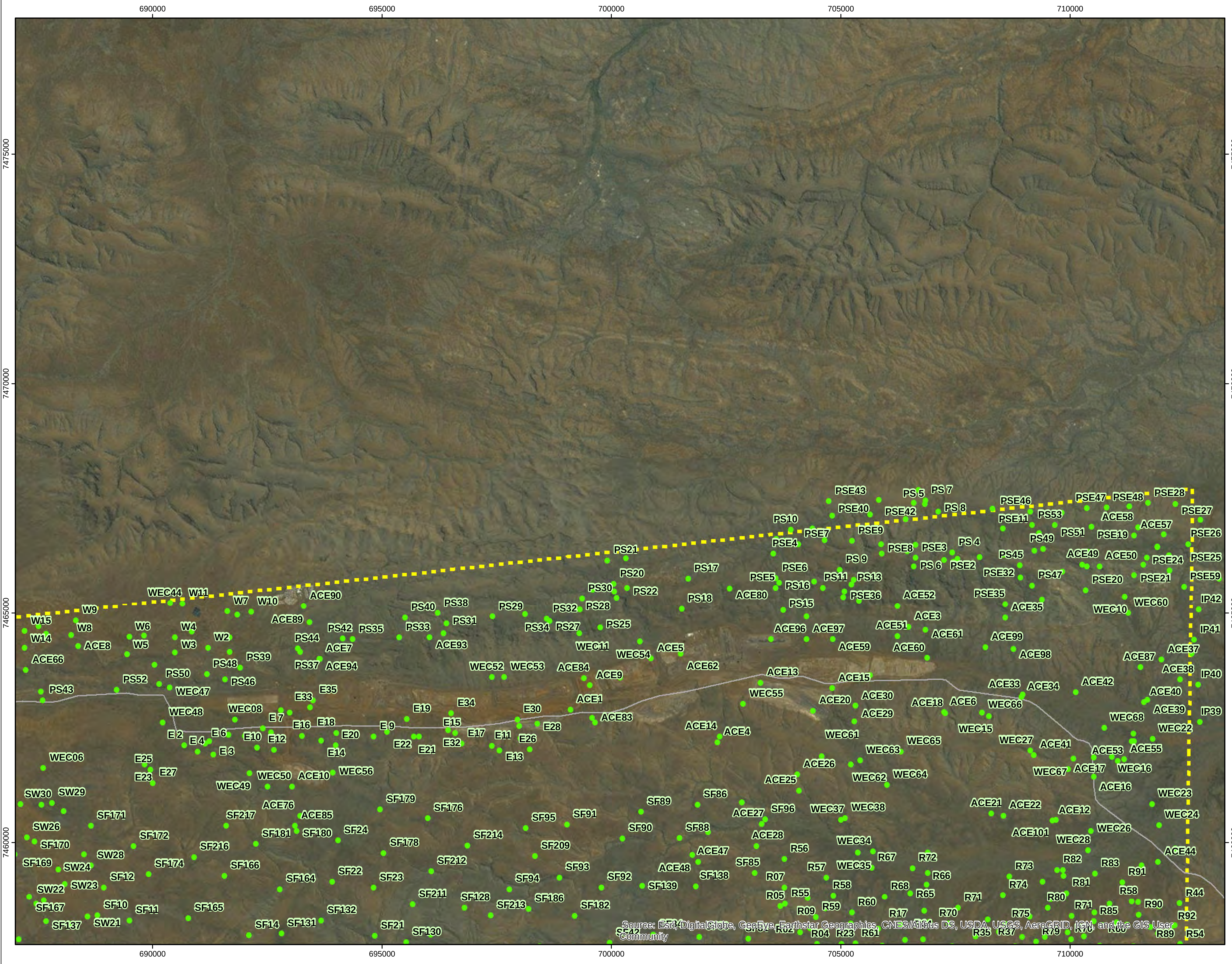
GRIFFIN SPATIAL & MAPPING



ONSHORE ENVIRONMENTAL

BHP

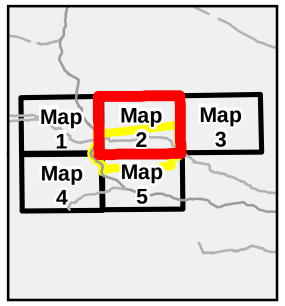
Mining Area C Southern Flank

Sample Locations
Map 2

Legend

Proposed Mining Area C Development Envelope

Sample Locations



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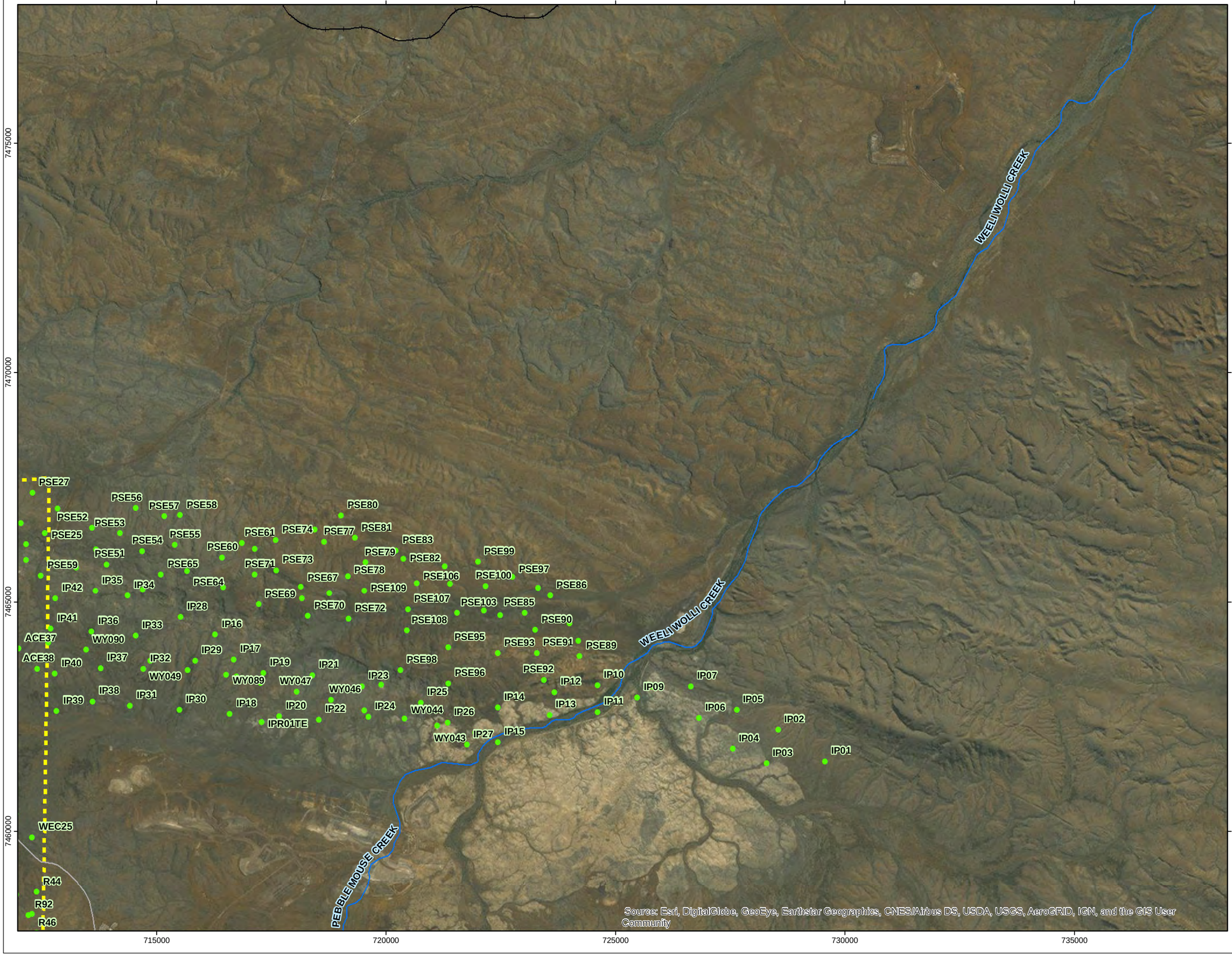


ONSHORE ENVIRONMENTAL

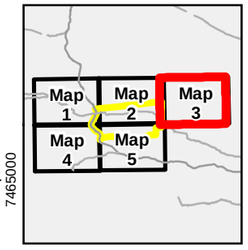
BHP

Mining Area C Southern Flank

Sample Locations Map 3

Legend

- Proposed Mining Area C Development Envelope
- Sample Locations



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GRIFFIN SPATIAL & MAPPING

ONSHORE ENVIRONMENTAL

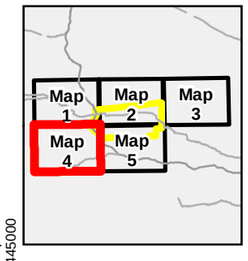
BHP

Mining Area C Southern Flank

Sample Locations Map 4

Legend

- Proposed Mining Area C Development Envelope
- Sample Locations



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GRIFFIN SPATIAL & MAPPING

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7455000 7450000 7445000 7440000

SW22 SF10 SF11 SF165 SF132 SF211 SF213 SF186 SF182 R55 R59 R60 R17 R70 R71 R75 R80 R85 R90 R92
SF137 SW21 SF14 SF131 SF21 SF130 SF128 R05 R64
SF9 SF185 SF183 SF42 SF84 SF80 SF81 R54 R61 R69 R40 R79 R71 R86 R88 R89 R93
SFE91 SF8 SF15 SF20 SF175 R06 R49 R63 R52 R78
SF18 SF19 SF127 R50 R30 R62 R34 R76 R77 R68 R87 R55 R56
SF218 SFE79 SF157 SF13 SF126 SF41 SF43 SF79 SF82 R08 R10 R24 R51 R32
SF135 SFE78 SF40 SFE05 SFE07 SFE09 SF77 R47 R45 R46 R53 R8 R64 R66 R51 R50
SF219 SF6 SF7 SF133 SF16 SF120 SF121 SF189 SF187 SFE03 SF44 R13 R12 R9
SF66 SFE74 SF134 SFE66 SF119 SF123 SF124 SF83 SF78 R14 R7 R4
SF17 SF190 SFE105 SF188 SFE06 SF125 SFE45 SF76 R48 R23 R15 R10 R6
SFE67 SFE54 R3
SF142 SF67 SF116 SF117 SF118 SF220 SF59 SF45 SF63 R27 R22 R16 R20 SWF06 R5
SF143 SF107 SFE71 SF56 SF122 SF97 R38 SFE25 R2
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SF30 SF53 SFE62 SF98 SF60 SF61 SF62 R36 R30 R39 SWF01 SFE33
SF64 SF51 SF55 SFE43 SF58 SF104 R40 R44
SW14 SF33 SW08 SW09 SW10 SW16 R34 R35 R29 R31 R41 R42 R43 SFE34
SW06 SF34 SW07 SF54 SFE32
SF113 SF103 SF99 SF74 SF72 SFE18A SFE28
SW15 SF197 R33 M75 M31
SF38 SF115 SF210 SF192 M33
SF28 SF35 SF112 SF207 M37 PEBBLE MOUSE CREEK
SF108 SF193 SF71
SF109 SF102 SF100 SF73 M29
SF37 SF36 SF111 SF195 SF205 SF206 SF208 SF70 M35
SF173 SF110 SF204 M68 M32 M34
M76 M58 M77 M70
SF163 M7 M9
M2 M3 M72 M74 M78 M80 M85 M60 M66 M45 M41 M39 M73 M28 M40
M4 M1 M30 M38
M3
M10
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M20 M59 M55
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M129 M92 M84 M96 M87 M89 M27 M51
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M2 M126
M166 M124
M8
M4 M5 M100 M108
M33 M32 M7 M9 M102 M110
M3 M16 M19
M6 M23
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M18 M22
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M169 M165
M167 M107 M101
M105 M103

GREAT NORTHERN HIGHWAY

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

ONSHORE ENVIRONMENTAL

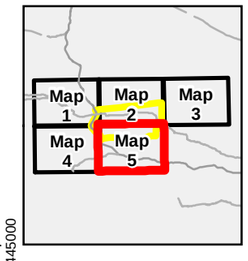
BHP

Mining Area C Southern Flank

Sample Locations Map 5

Legend

- Proposed Mining Area C Development Envelope
- Sample Locations



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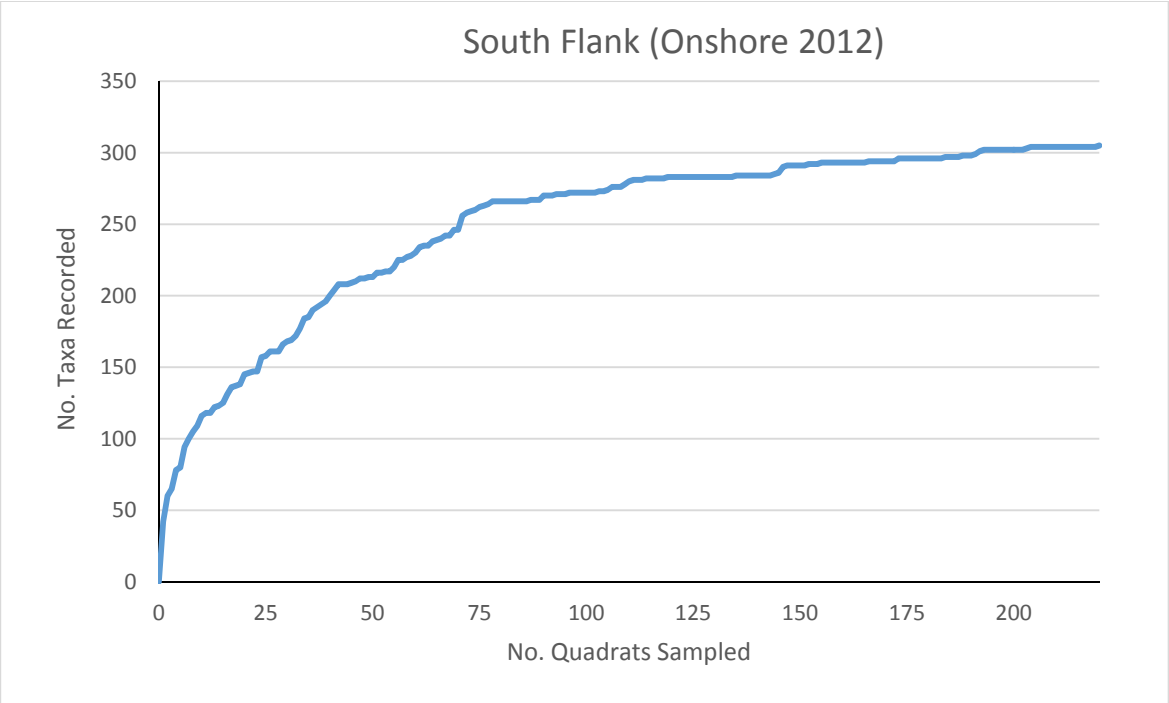
GRIFFIN SPATIAL & MAPPING

APPENDIX 2

Species accumulation curves for baseline survey work completed at South Flank and Mining Area C


South Flank (Onshore 2012)
No. Taxa Recorded
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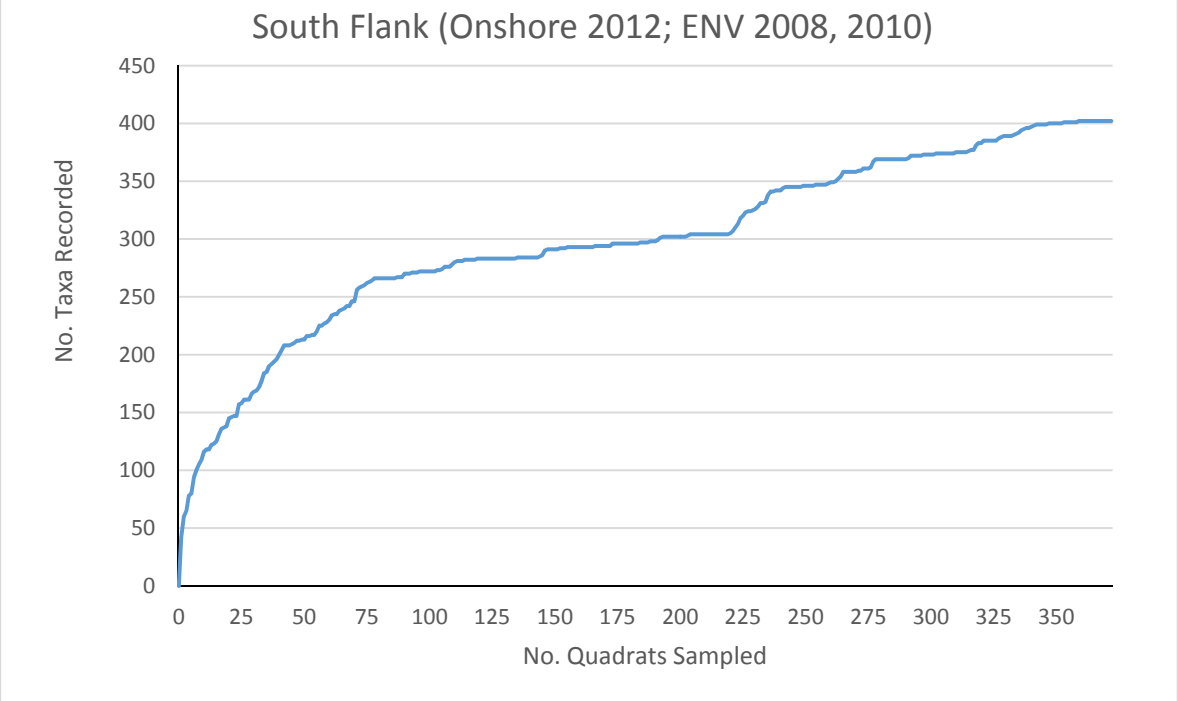
300
250
200
150
100
50
0
0
25
50
75
100
125
150
175
200
No. Quadrats Sampled


South Flank (Onshore 2012; ENV 2008, 2010)
No. Taxa Recorded
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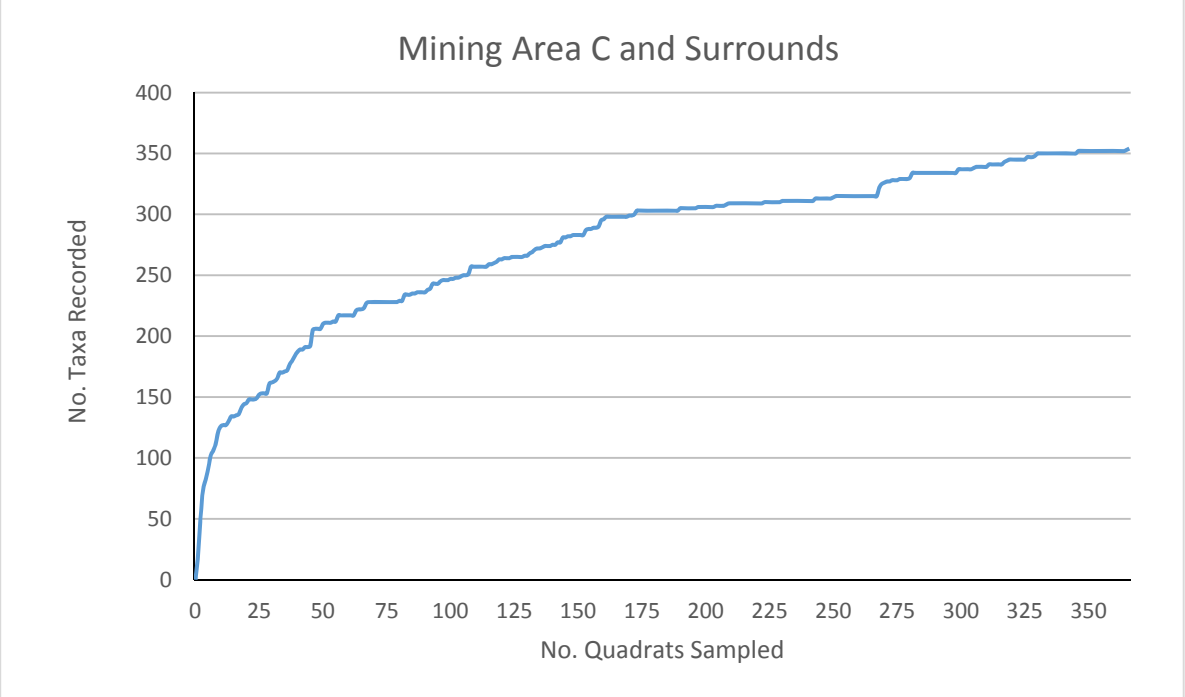
400
350
300
250
200
150
100
50
0
0
25
50
75
100
125
150
175
200
225
250
275
300
325
350
No. Quadrats Sampled

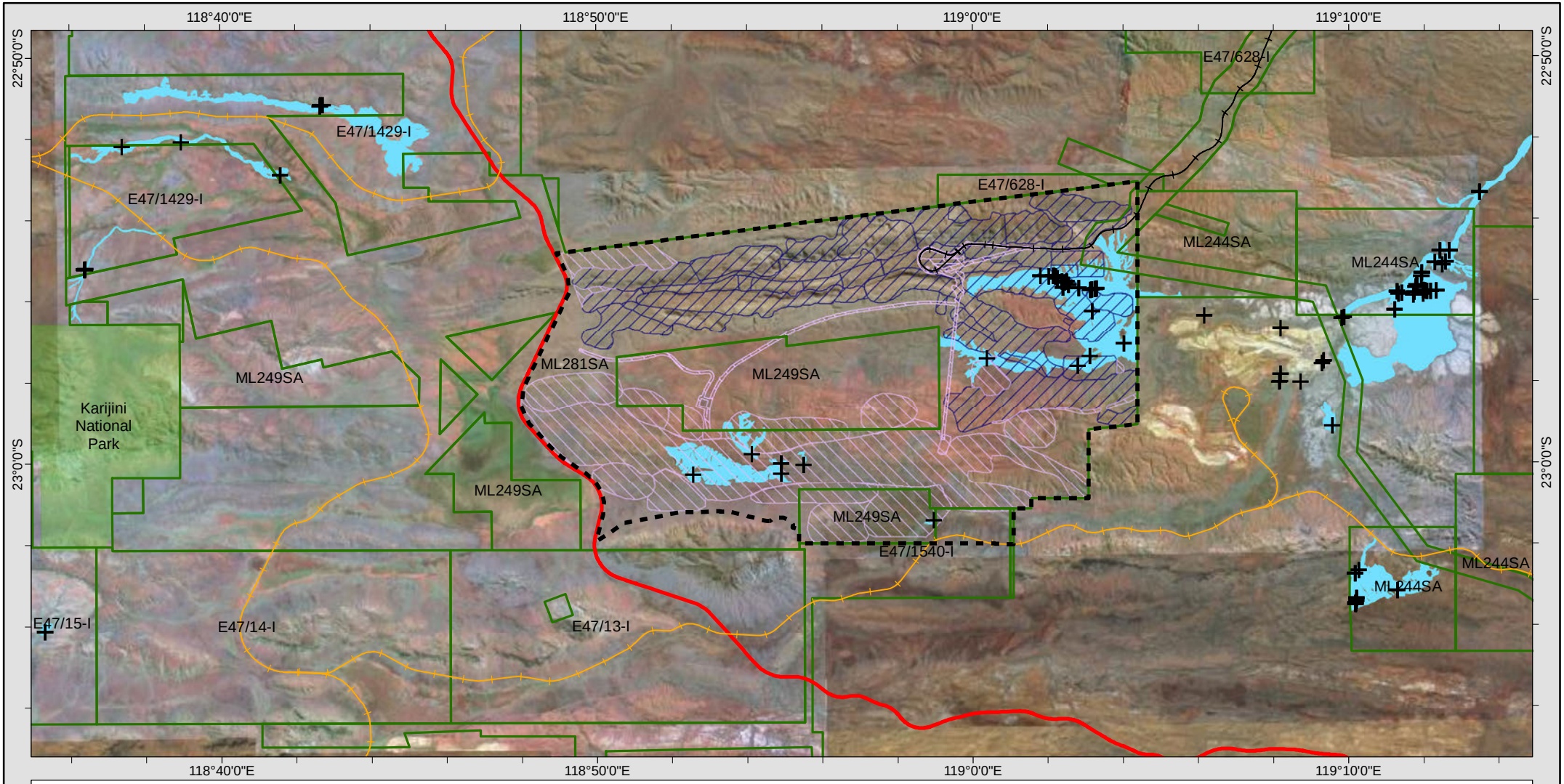

Mining Area C and Surrounds
No. Taxa Recorded
400
350
300
250
200
150
100
50
0
0
25
50
75
100
125
150
175
200
225
250
275
300
325
350
No. Quadrats Sampled

APPENDIX 3

Dendrogram (from multivariate analysis)

Summary of baseline surveys included in the multivariate analysis (total of 1,504 quadrats). Note: Codes match dendrogram output.

Report	Study Area	Code	No. Quadrats
Area C: Deposits D, E and F Biological Survey (Ecologia 2004b)	DEF Deposit (MAC)	E	35
Packsaddle Range Biological Survey (Ecologia 2004a)	Packsaddle Range	PS	54
Area C R-Deposit Flora and Vegetation Assessment (ENV 2007)	Area C R-Deposit	R	72
Area C South Flank Deposit Flora and Vegetation Assessment (ENV 2008)	South Flank	SFE	110
Area C Mining Operations Environmental Management Plan (Revision 4) A, D, P1 and P3 Deposits Flora and Vegetation Assessment (Woodman 2009)	Area C	WEC	62
Flora and Vegetation Survey and Fauna Assessment R-Deposit (South Flank West) (Onshore 2010)	South Flank	SFW	12
South Flank NVCP Extension Flora, Vegetation and Fauna Assessment (ENV 2010)	South Flank	SW	30
Area C West NVCP Flora, Vegetation and Fauna Assessment (ENV 2010)	Area C West	AC	126
	Boundary Ridge	BR	40
	Parallel Ridge	PR	28
	Fork South	FS	54
Packsaddle West Vegetation and Flora Survey and Fauna Assessment (Astron 2010)	Area C West	P	123
Jinayri to Area C Access Corridor Flora and Vegetation Assessment (ENV 2010)	Area C East	IP	42
	Area C East	WY	12
Area C and Surrounds Flora and Vegetation Survey (Onshore 2011)	Area C	PSE	110
	R-Deposit	OR	95
	Northern Extension	W	17
Camp Hill Level 2 Flora and Vegetation Survey Level 1 Fauna Assessment (Onshore 2011)	Camp Hill	CH	138
South Flank Level 2 Flora and Vegetation Survey (Onshore 2012)	South Flank	SF	220
Tandanya Level 2 Flora and Vegetation Survey (Onshore 2013)	Area C West	TAN_AC	8
	Boundary Ridge	TAN_BR	3
	Parallel Ridge	TAN_PR	5
	Fork South	TAN_FS	5
	Camp Hill	TAN_CH	55
	Packsaddle West	TAN_P	48



BHP BILLITON IRON ORE

MINING AREA C - SOUTHERN FLANK

Rostellularia adscendens var. latifolia

locations and vegetation associations from which it has been recorded

Scale @ A4: 1:250,000	Prepared: M. LYTTLE	Project No: A780/070 REV A
Date: 27/07/2017	Checked: B. BARNETT	Figure: 8
Revision: Rev A	Reviewed: S. WILLIAMSON	

- Proposed Mining Area C Development Envelope
- Mining Area C EMP Rev 6 Impact Assessment Area
- Indicative Additional Impact Assessment Area
- BHP Billiton Tenements - Granted
- BHP Billiton Rail
- Rio Tinto Rail
- Great Northern Highway
- *Rostellularia adscendens var. latifolia*
- Vegetation Association

N

0 5 10

Kilometres

Coordinate System: Central Project Grid (CPG94)
Projection: Transverse Mercator
Datum: GDA 1994

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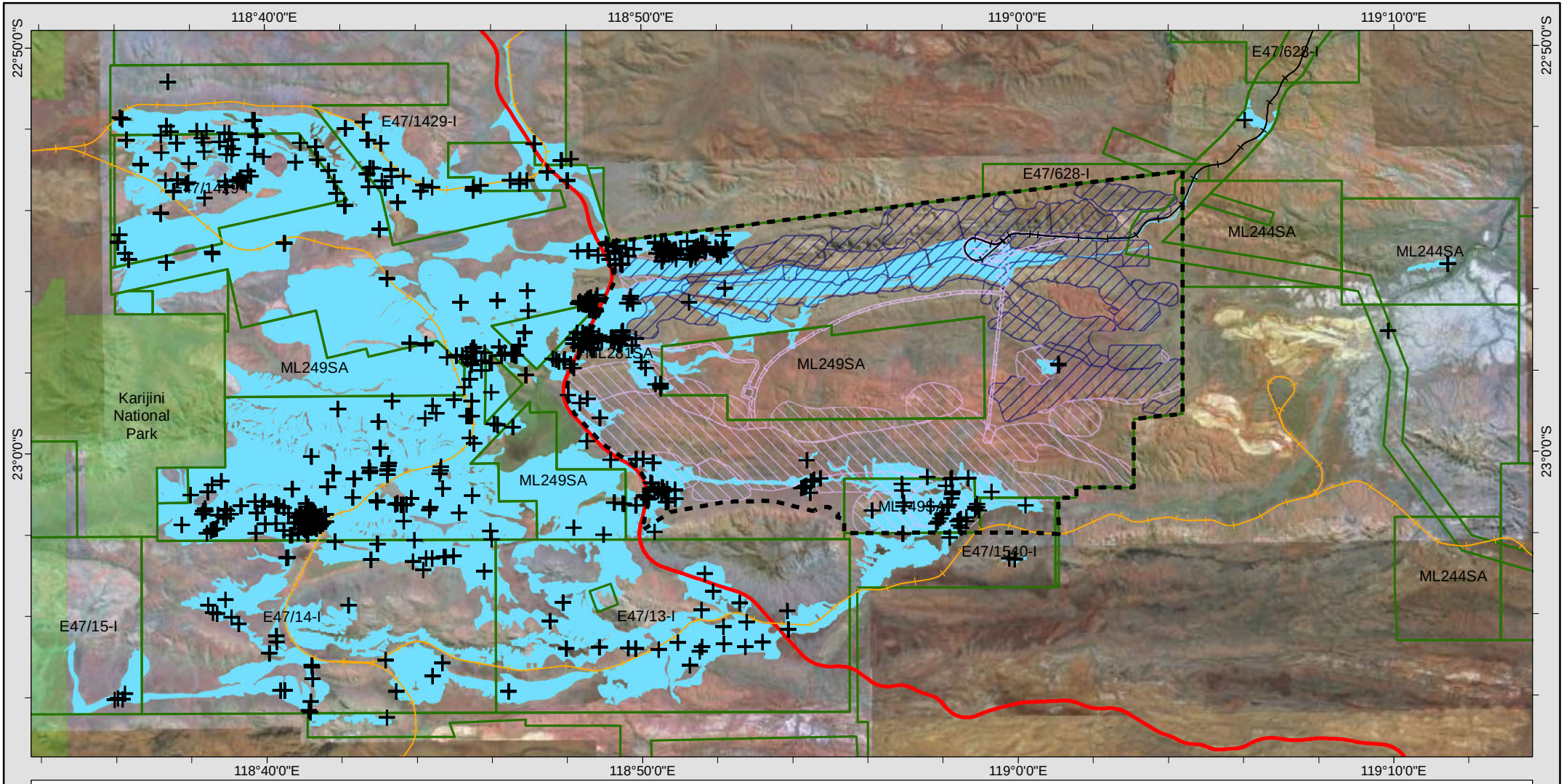

BHP BILLITON IRON ORE

MINING AREA C - SOUTHERN FLANK

Rhagodia sp. Hamersley (M. Trudgen 17794) locations and vegetation associations from which it has been recorded

Scale @ A4: 1:250,000	Prepared: M. LYTTLE	Project No: A780/069 REV A
Date: 27/07/2017	Checked: B. BARNETT	Figure: 7
Revision: Rev A	Reviewed: S. WILLIAMSON	

- Proposed Mining Area C Development Envelope
- Mining Area C EMP Rev 6 Impact Assessment Area
- Indicative Additional Impact Assessment Area
- BHP Billiton Tenements - Granted
- BHP Billiton Rail
- Rio Tinto Rail
- Great Northern Highway
- *Rhagodia* sp. Hamersley (M. Trudgen 17794)
- Vegetation Association

N

0 5 10

Kilometres

Coordinate System: Central Project Grid (CPG94)
Projection: Transverse Mercator
Datum: GDA 1994

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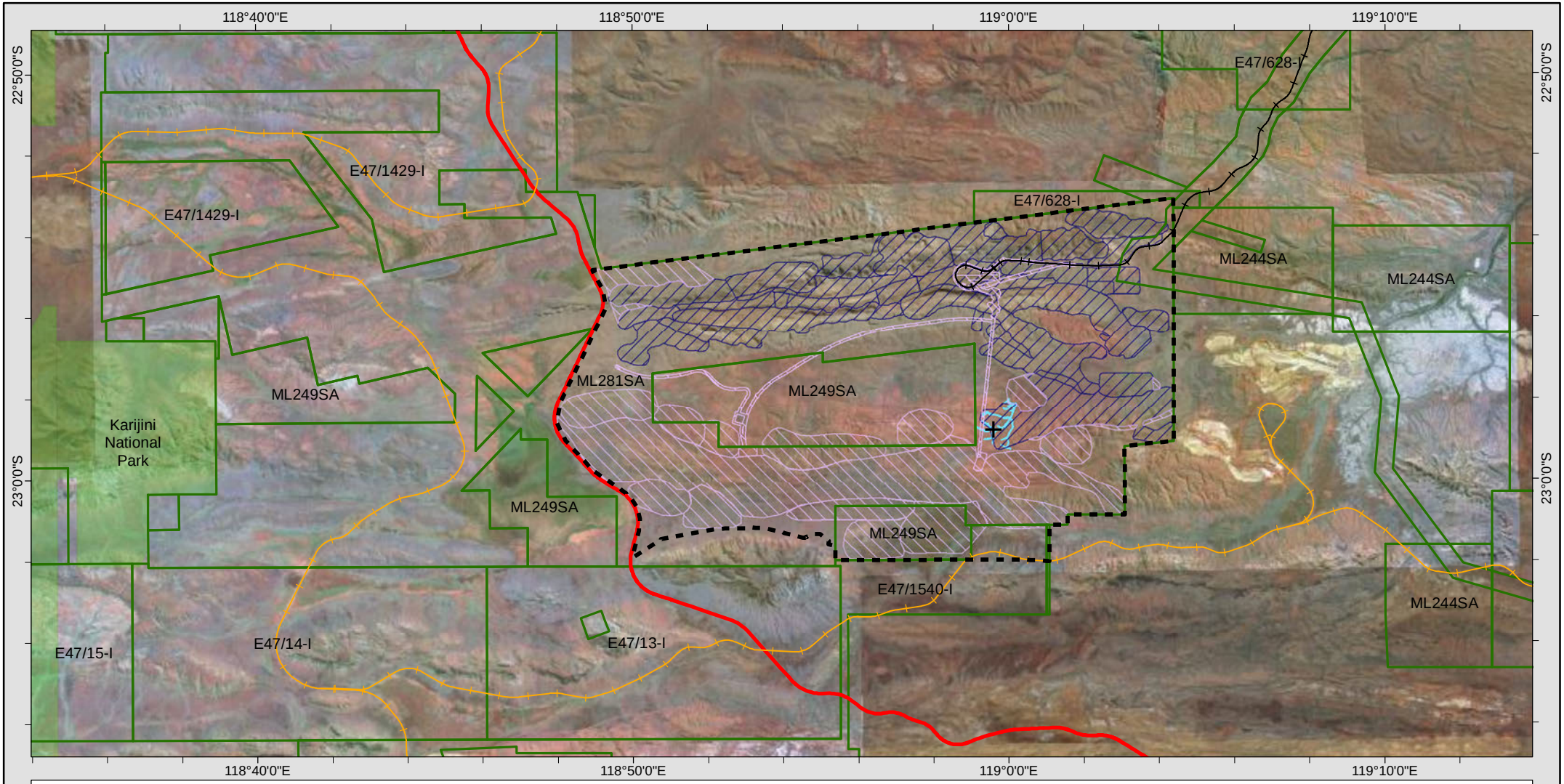

BHP BILLITON IRON ORE

MINING AREA C - SOUTHERN FLANK

Nicotiana umbratica locations and vegetation associations from which it has been recorded

Scale @ A4: 1:250,000	Prepared: M. LYTTLE	Project No: A780/068 REV A
Date: 26/07/2017	Checked: B. BARNETT	Figure: 6
Revision: Rev A	Reviewed: S. WILLIAMSON	

- Proposed Mining Area C Development Envelope
- Mining Area C EMP Rev 6 Impact Assessment Area
- Indicative Additional Impact Assessment Area
- BHP Billiton Tenements - Granted
- BHP Billiton Rail
- Rio Tinto Rail
- Great Northern Highway
- *Nicotiana umbratica*
- Vegetation Association

N

0 5 10

Kilometres

Coordinate System: Central Project Grid (CPG94)
Projection: Transverse Mercator
Datum: GDA 1994

Document Path: Y:\Jobs\A501_A1000\A780\3Project\A780_068_E_MAC_Southern_Flank_PER_N_Umbratica_Fig6_RevA.mxd