MINERAL RESOURCES

J5 and Bungalbin East Iron Ore Proposal
Response to Submissions – Attachment 5
Supplementary Flora and Vegetation Information

ATTACHMENT 5

SUPPLEMENTARY FLORA AND VEGETATION INFORMATION

TABLE A5-1: OUTCOME OF MONITORING PROGRAMS TO ASSESS INDIRECT IMPACTS

Location	Objective	Outcome
Barrow Island (Matsuki et al 2016)[1]	Assess impact of dust on health of native vegetation (2009-2012).	Health and condition of plants did not vary with distance from dust source (construction activity, access road).
Carina (Astron 2016)[2]	Assess health and condition of vegetation within 1 km of the proposal boundary (2013-2016).	No significant changes recorded in plant community composition, plant health, cover or dust loads.
Jack Hills (Turner 2013)[3]	Assess impact of dust on health and physiological function of native flora surrounding an iron ore mine (2011).	Stomatal conductance and plant condition reduced in two *Acacia* species. Other species were not affected.
Koolanooka (Maia 2015)[4]	Assess health and condition of vegetation adjacent to an open pit iron ore mine (2010-2015).	Plant health within 50 m of the mine was reduced but other measures, including plant numbers and canopy volume, were unaffected.
Windarling (Matsuki et al 2016)	Assess impact of dust on health of native vegetation (2003-2010, 2011-2014).	Health and condition of plants did not vary with distance from dust source (open pit).

[1] Matsuki, M., Gardener, M.R., Smith, A., Howard, R.K. and Gove, A. (2016) Impacts of dust on plant health, survivorship and plant communities in semi-arid environments. *Austral Ecology* **41**: 417-427

[2] Astron (2016). Carina Iron Ore Project – Flora and Vegetation Condition Monitoring, December 2016.

[3] Turner G.F. (2013). Vulnerability of Vegetation to Mining Dust at the Jack Hills, Western Australia. M.Sc. thesis, University of Western Australia.

[4] Maia Environmental Consultancy (2015). Sinosteel Midwest Corporation Ltd: Koolanooka Vegetation Monitoring Program, Spring 2015.

Figure A5-1: Relationship between direct and indirect disturbance for four taxa of high conservation significance.

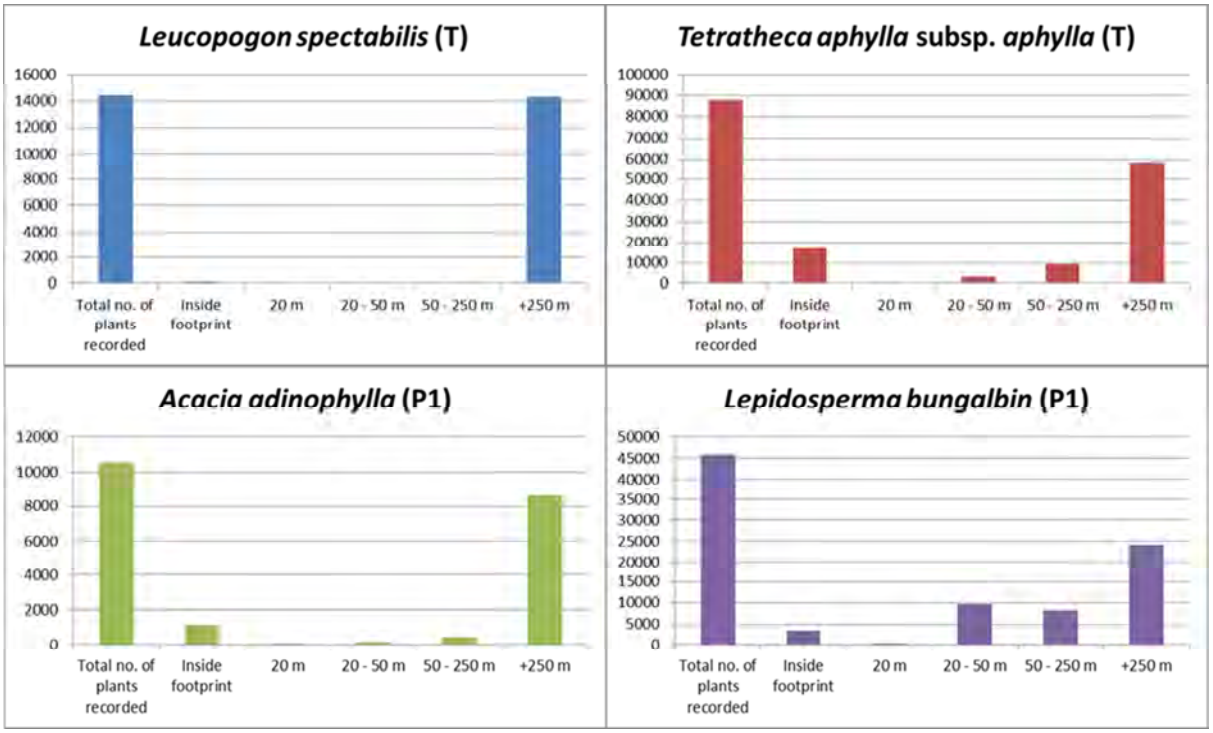


TABLE A5-2: ASSUMPTIONS USED TO CALCULATE POTENTIAL DIRECT AND INDIRECT IMPACTS ON CONSERVATION SIGNIFICANT FLORA

Location	Likely direct and indirect impacts	Assumption for EIA purposes
All areas of direct disturbance (including open pits, waste rock landforms stockpile areas, access roads).	All plants removed.	All plants removed.
Pits surrounds between pit edge and abandonment bund.	Direct disturbance of some plants for access tracks and abandonment bund construction; potential future direct impacts due to pit wall failure; indirect impacts from dust deposition or microclimate change.	All plants removed.
Abandonment bunds	All plants removed.	All plants removed.
20 m buffer outside abandonment bunds and all other areas of direct disturbance	No direct disturbance, potential for indirect impacts.	All plants removed.
All other areas outside of 20 m buffer	Some potential for indirect impacts, may be species-dependent.	No impacts.

TABLE A5-3: COMPARISON OF METHODS TO ASSESS INDIRECT IMPACTS – 20 M BUFFER (TOTAL LOSS) AGAINST 4.2 G/M^2/MONTH DUST DEPOSITION CONTOUR (5% LOSS).

Taxon	Code	No. of plants within 20 m buffer (100% loss)	No. of plants within dust deposition contour (5% loss)	Difference (4-3)
1	2	3	4	5
Leucopogon spectabilis (Ironstone Beard-heath)	T	0	3	3
Tetratheca aphylla subsp. *aphylla* (Bungalbin Tetratheca)	T	326	358	32
Acacia adinophylla	P1	108	42	-66
Acacia shapelleae	P1	0	0	0
Beyeria rostellata	P1	0	0	0
Lepidosperma bungalbin	P1	347	388	41
Grevillea georgeana	P3	4	23	19
Hibbertia lepidocalyx subsp. tuberculata	P3	338	194	-144
Lepidosperma ferricola	P3	10	226	216
Mirbelia ferricola	P3	11	16	5
Neurachne annularis	P3	107	1447	1340
Stenanthemum newbeyi	P3	595	182	-413
Banksia arborea	P4	123	49	-74
Eucalyptus formanii	P4	9	5	-4
Grevillea erectiloba	P4	5	1	-4

TABLE A5-4: SUMMARY OF POTENTIAL INDIRECT IMPACTS ON FOUR KEY TAXA

Taxon	Potential indirect impact	Assessment
Leucopogon spectabilis (T) - erect, narrow and sparingly branched shrub, to about 1 m high.	Foliar dust deposition	*L. spectabilis* has leaves that are spirally arranged and steeply antrorse (pointing upwards) (Hislop and Chapman 2007)[5]. This characteristic and the distance of the great majority of plants from areas of direct impact (see Figure A3-1) suggest that dust deposition is unlikely to occur to a significant degree.
	Fragmentation and changes to microhabitats	The removal of one sub-population of this taxon from within the footprint of the Bungalbin East pit will increase the distance between the northernmost sub-population and other sub-populations. However, this sub-population already occurs more than 1,500 m from other sub-populations. Due to the habitat preference of this taxon (shallow, red brown loam in rock crevices) and the distance of the majority of plants from the Bungalbin East pit (see Figure A3-1), impacts from changes to microhabitats are not anticipated.
	Ecosystem processes	There is no apparent reason why ecosystem processes such as pollination (likely by insects) and seed dispersal (birds) should not continue as the great majority of the population remains intact and away from mine operations (see Figure A3-1).
	Weeds	The habitat preference of this taxon (shallow, red brown loam in rock crevices) is unlikely to be affected by invasive weeds.

[5] Hislop, M. & Chapman, A.R. (2007). Three new and geographically restricted species of *Leucopogon* (Ericaceae: Styphelioideae: Styphelieae) from south-west Western Australia *Nuytsia* 17: 165–184.

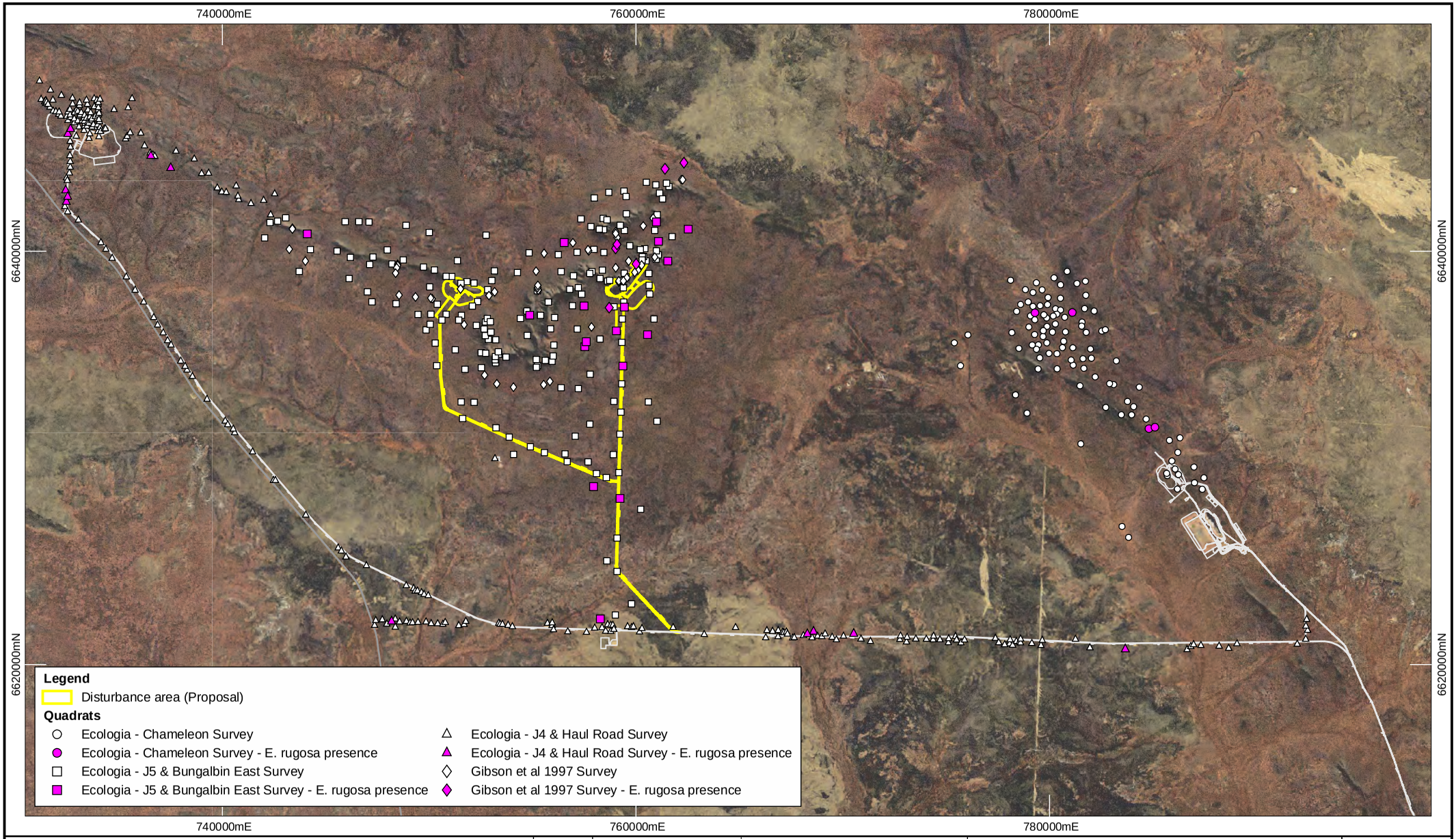
Taxon	Potential indirect impact	Assessment
Tetratheca aphylla subsp. *aphylla* (T) - caespitose shrub, to 0.6 m high.	Foliar dust deposition	*T. aphylla* subsp. *aphylla* has much reduced leaves and stems described as “rugose to+/−striate”, “densely covered in very slender acute tubercules, appearing hispid” (Butcher 2007)[6]. These characteristics may promote the accumulation of dust on the leaf surface.
	Fragmentation and changes to microhabitats	This taxon occurs more or less continuously along the HAR ridgeline. The footprint of proposed Bungalbin East pit will isolate some clumps of this taxon in the area of the pit but the distances involved are less than 500 m. The habitat preferences for this taxon (red-brown loam, sandy loam, banded ironstone, crevices in cliffs and outcrops, slopes, valleys, ridges) are varied but plants occurring in the immediate vicinity (~5 m) of the proposed mine and associated operations could experience increased exposure and therefore some microhabitat change.
	Ecosystem processes	Very substantial numbers of plants occur along the ridgeline outside of the proposed Bungalbin East pit. Ecosystem process, including wind pollination and dispersal of seeds by ants, should continue.
	Weeds	Weed incursion into the habitat of this taxon is unlikely but possible if weed hygiene is not maintained.

[6] Butcher R (2007). New taxa of leafless *Tetratheca* (Elaeocarpaceae, formerly Tremandraceae) from Western Australia. *Australian Systematic Botany* 20, 139–160.

Taxon	Potential indirect impact	Assessment
Lepidosperma bungalbin (P1) - tufted rhizomatous, perennial, herb (sedge), leaves 0.23-0.64 m high, culms and leaves distichous.	Foliar dust deposition	Barrett (2007)[7] noted the leaves and culms of this taxon are "finely ribbed (faces appearing corrugated/ undulate)", a characteristic that may promote the accumulation of dust on the leaf surface. Significant numbers of plants occur within 50 m of the northern and western edges of the Bungalbin East pit.
	Fragmentation and changes to microhabitats	Some fragmentation will occur within one sub-population centred around the footprint for the Bunaglbin East pit. The overall population is naturally fragmented due to its habitat preference which occurs discontinuously along the Helena Aurora Range. The habitat preference of this taxon (steep mid-slopes on red loam soils with banded ironstone rock and gravel) suggests the taxon is adapted to exposed conditions.
	Ecosystem processes	Very substantial numbers of plants occur along the ridgeline outside of the proposed Bungalbin East pit. Ecosystem process, including wind pollination and dispersal of seeds by ants and birds, should continue.
	Weeds	Weed incursion into the habitat of this taxon is possible if weed hygiene is not maintained.

[7] Barrett, R.L. (2007). New species of *Lepidosperma* (Cyperaceae) associated with banded ironstone in southern Western Australia. *Nuytsia* 17: 37–60.

Taxon	Potential indirect impact	Assessment
Acacia adinophylla (P1) - prostrate or erect tangled shrub, 0.15-1.6 m high, to 3 m wide.	Foliar dust deposition	*A. adinophylla* is a prostrate or erect tangled shrub, 0.15-1.6 m high, to 3 m wide. Its' form gives it some potential, under dusty conditions, to accumulate dust on its reduced leaves.
	Fragmentation and changes to microhabitats	Though restricted to the HAR, *A. adinophylla* is locally widespread. Removal of plants for the Bungalbin East pit and waste rock landform will lead to some fragmentation of plants at the edge of its current known distribution (notably southeast of the proposed waste rock landform). The habitat preferences for this taxon (stony loamy or sandy soils, clay. Ironstone ridges, undulating plains) are varied but plants occurring in the immediate vicinity (~5 m) of the proposed mine and associated operations could experience increased exposure and therefore some microhabitat change.
	Ecosystem processes	This taxon is likely to be pollinated by non-specialised insect pollinators with seed dispersal likely to occur by ants. These activities should continue within the locally extensive areas where *A. adinophylla* occurs.
	Weeds	Weed incursion into the habitat of this taxon is possible if weed hygiene is not maintained.



Source: Infrastructure supplied by Mineral Resources (Dec 2016)
Quadrats supplied by Ecologia (2015)
Imagery: U.S. Geological Survey (2016)

0 2 5km
Scale 1:250,000
MGA94 (Zone 50)
CAD Ref: g2313_J5_BE_PER_Resp_001
Date: Feb 2017 | Rev: A | A4

Author: Mineral Resources
Drawn: CAD Resources ~ www.cadresources.com.au
Tel: (08) 9246 3242 ~ Fax (08) 9246 3202

LOCATION OF QUADRATS WITH KNOWN PRESENCES OF *EREMOPHILA RUGOSA*

Figure: 1

TABLE A5-5: EXAMPLES OF RE-ESTABLISHMENT OF CONSERVATION SIGNIFICANT FLORA ON BIF RANGES

Taxon	Code	Methods used	Ref.
Lepidosperma gibsonii	T	Translocation of separated clumps (with 70% survival after nine months), recruitment from soil seed bank appears to require fire.	Iron Hill PER
Darwinia masonii	T	Soil seed bank, vegetative propagation of cuttings as translocatees, translocation of juvenile plants. Success rate not known.	Iron Hill PER
Tetratheca paynterae subsp *paynterae*	T	Very limited success of recruitment on establishing plants in cracks and fissures related to mined landscapes; no information on relocation in the wild.	BGPA pers. comm.
Ricinocarpos brevis	T	Translocation. Plants translocated in April 2015 had high survival rates (> 80%) after their first summer. Good success on rehabilitation focussing on waste rock dumps, both with and without irrigation.	BGPA annual report 2015/16
Acacia woodmaniorum	T	Natural recruitment observed on cleared drill pad areas (in close proximity to natural population.)	Woodman Environmental pers. comm.