TECHNICAL REPORT 01

Biodiversity development assessment report

(Part 3 of 3)

NARROMINE TO NARRABRI ENVIRONMENTAL IMPACT STATEMENT

TECHNICAL REPORT

01

Biodiversity development assessment report

Appendix L Plot justifications and BAM input data

NARROMINE TO NARRABRI RESPONSE TO SUBMISSIONS

Appendix L – Plot justifications

PCT ID	Vegetation zone – condition	Plot ID	Subregion	Within CIZ	Plot use justification for plots outside CIZ or subregion
NSW South Western Slopes bioregion, Inland slopes subregion					
185	Dwyer's Red Gum - White Cypress Pine - Currawang shrubby woodland – Good	185_Bench	Inland Slopes		X1 benchmark data for woodland
185	Dwyer's Red Gum - White Cypress Pine - Currawang shrubby woodland – DNG	T2-BP3	Inland Slopes	Yes	
		T2-BP3-2	Inland Slopes	Yes	Plot replicated x2 to meet three plots
Darling Riverine Plains bioregion, Bogan-Macquarie subregion					
36	River Red Gum tall to very tall open forest/woodland wetland on rivers on floodplains mainly in the Darling Riverine Plains Bioregion – good	T1-25	Bogan-Macquarie	Yes	Plot replicated x2 at BCS request
49	Partly derived Windmill Grass - Copperburr alluvial plains shrubby grassland of the Darling Riverine Plains Bioregion and Brigalow Belt South bioregion – Good	T1-P22	Bogan-Macquarie	Yes	Plot replicated x2 at BCS request
					x1 benchmark
56	Poplar Box - Belah woodland on clay-loam soils on alluvial plains on north central NSW – Good				X1 benchmark
81	Western Grey Box - cypress pine shrub grass shrub tall woodland in the Brigalow Belt South Bioregion	T2-P37	Bogan-Macquarie	Yes	In CIZ culvert impact area
88	Pilliga Box - White Cypress Pine - Buloke shrubby woodland in the Brigalow Belt South bioregion – Good	T1-P20	Bogan-Macquarie	Yes	Plot replicated x2 at BCS request
		T1-P21	Bogan-Macquarie	Yes	
88	Pilliga Box - White Cypress Pine - Buloke shrubby woodland in the Brigalow Belt South bioregion – DNG				x1 benchmark data for derived native grassland

PCT ID	Vegetation zone – condition	Plot ID	Subregion	Within CIZ	Plot use justification for plots outside CIZ or subregion
248	Mixed box eucalypt woodland on low sandy-loam rises on alluvial plains in central western NSW – Good	BN1	Bogan-Macquarie	Yes	Plot replicated x1
		T2-P24	Bogan-Macquarie	No	40 metres to north. Same PCT and same crown reserve under same management
255	Mugga Ironbark - Buloke - Pilliga Box - White Cypress Pine shrubby woodland on sandstone in the Dubbo region, south-western Brigalow Belt South Bioregion – Good	T2-BP2	Bogan-Macquarie	Yes	Plot replicated to meet two plots. Existing quarry site very disturbed.
599	Blakely's Red Gum - Yellow Box grassy tall woodland on flats and hills in the Brigalow Belt South and Nandewar bioregions – Good	T2-P36	Bogan-Macquarie	No	10 metres to the east of alignment but patch to be cleared is connected to this plot.
		T2-P35	Bogan-Macquarie	No	140 metres to the east of alignment but patch to be cleared in the north is connected to this patch and same PCT in roadside
Darling Riverine Plains bioregion, Castlereagh-Barwon subregion					
27	Weeping Myall open woodland of the Darling Riverine Plains Bioregion and Brigalow Belt South Bioregion – Good	T2-SP2	Castlereagh-Barwon	Yes	
		BN2	Castlereagh-Barwon	No	18 metres to the west of CIZ part of same connected patch
49	Partly derived Windmill Grass - Copperburr alluvial plains shrubby grassland of the Darling Riverine Plains Bioregion and Brigalow Belt South bioregion – Good	BN3	Castlereagh-Barwon	Yes	
		BN4	Castlereagh-Barwon	Yes	
		T2-P18		No	1.4 kilometres to west of CIZ within Travelling Stock Reserve. Disjunct patch but consistent with other veg zone plots

PCT ID	Vegetation zone – condition	Plot ID	Subregion	Within CIZ	Plot use justification for plots outside CIZ or subregion
		BN5	Pilliga Outwash	Yes	77 metres west of subregion boundary with Castlereagh-Barwon. 970 metres west of Castlereagh-Barwon subregion boundary
		BN6	Pilliga Outwash	No	150 metres north of CIZ and 1200 metres north east of subregion boundary with Castlereagh-Barwon subregion
					x1 benchmark
56	Poplar Box - Belah woodland on clay-loam soils on alluvial plains on north central NSW – Good	T1-P13	Pilliga	Yes	1900 metres north east of Castlereagh -Barwon subregion boundary
		S2	Pilliga	Yes	880 metres west of subregion boundary
		T2-P21	Castlereagh-Barwon	No	60 metres to the east of CIZ
56	Poplar Box - Belah woodland on clay-loam soils on alluvial plains on north central NSW – DNG				x3 benchmark data for derived native grasslands
78	River Red Gum riparian tall woodland / open forest wetland in the Nandewar Bioregion and Brigalow Belt South Bioregion – Good	T2-P14	Castlereagh-Barwon	No	70 metres to west of CIZ. Same PCT and same patch under same management by same landowner
		T2-P15	Castlereagh-Barwon	Yes	
		T1-P9	Pilliga	No	30 metres to the south east. Part of same riparian corridor of Castlereagh River on same Crown land patch. 170 metres north of Castlereagh-Barwon subregion boundary.

PCT ID	Vegetation zone – condition	Plot ID	Subregion	Within CIZ	Plot use justification for plots outside CIZ or subregion
88	Pilliga Box - White Cypress Pine - Buloke shrubby woodland in the Brigalow Belt South bioregion – Good	T2-P16	Castlereagh-Barwon	No	20 metres to west of CIZ. Same PCT and same patch.
		T1-P10	Pilliga	No	20 metres to the south east of CIZ. Part of same patch rising out of Castlereagh River on same Crown land patch. 440 metres north of Castlereagh-Barwon subregion boundary.
		T1-P12	Pilliga	No	140 metres to the south east of CIZ. Patch not impacted. 1300 metres north of Castlereagh-Barwon subregion boundary.
		T1-P11	Pilliga	No	40 metre north west of CIZ
88	Pilliga Box - White Cypress Pine - Buloke shrubby woodland in the Brigalow Belt South bioregion – DNG				x2 benchmark data for derived native grasslands
145	Western Rosewood - Wilga - Wild Orange - Belah low woodland of the Brigalow Belt South Bioregion and eastern Darling Riverine Plains Bioregion – Good	T1-SP1		Yes	1000 metres east of Castlereagh-Barwon subregion boundary
		T1-SP4	Pilliga	Yes	1000 metres east of Castlereagh-Barwon subregion boundary
		T1-BP5		No	340 metres to the south-east of CIZ. Same patch as CIZ under the same management/landowner and in same paddock.1000 metres east of Castlereagh-Barwon subregion boundary
		T1-SP2	Pilliga	Yes	1100 metres east of Castlereagh Barwon subregion boundary

PCT ID	Vegetation zone – condition	Plot ID	Subregion	Within CIZ	Plot use justification for plots outside CIZ or subregion
206	Dirty Gum – White Cypress Pine – Buloke shrubby woodland in the Brigalow Belt South Bioregion – good	WP7	Pilliga	Yes	400 metres south of Castlereagh-Barwon subregion boundary
		WP8	Pilliga	Yes	510 metres south of Castlereagh-Barwon subregion boundary
					x1 benchmark
244	Poplar Box grassy woodland on alluvial clay-loams soils mainly in the temperate (hot summer) climate zone of central NSW (wheatbelt) – good	T2-P19	Pilliga	No	3.2 kilometres east of Castlereagh-Barwon subregion boundary. Plot replicated x2 at BCS request
					x1 benchmark
444	Silver-leaved Ironbark grassy tall woodland on clay-loam soils on plains in the Brigalow Belt South Bioregion – good	T2-P20	Pilliga	Yes	300 metres north east of Castlereagh-Barwon subregion boundary
Brigalow Belt South bioregion, Pilliga subregion					
27	Weeping Myall open woodland of the Darling Riverine Plains Bioregion and Brigalow Belt South Bioregion – Good	T2-SP2	Castlereagh-Barwon	Yes	1000 metres north of Pilliga subregion boundary
36	River Red Gum tall to very tall open forest/woodland wetland on rivers on floodplains mainly in the Darling Riverine Plains Bioregion – Good	T2-P30	Pilliga	No	80 metres to west of CIZ. Same PCT and same paddock under same management
		T2-P32	Pilliga	No	40 metres to north of CIZ. Same PCT and same paddock under same management
49	Partly derived Windmill Grass - Copperburr alluvial plains shrubby grassland of the Darling Riverine Plains Bioregion and Brigalow Belt South bioregion – Good	AN1	Pilliga	Yes	
		T2-MP-24	Pilliga	Yes	
		WP1	Pilliga	Yes	
		WP2	Pilliga	Yes	
		WP3	Pilliga	Yes	
55	Belah woodland on alluvial plains and low rises in the central NSW wheatbelt to Pilliga and Liverpool Plains regions – Good	WP6	Pilliga	Yes	

PCT ID	Vegetation zone – condition	Plot ID	Subregion	Within CIZ	Plot use justification for plots outside CIZ or subregion
56	Poplar Box - Belah woodland on clay-loam soils on alluvial plains on north central NSW – Good	S2	Pilliga	Yes	
		T2-P21	Pilliga	Yes	
		WP5	Pilliga	Yes	
78	River Red Gum riparian tall woodland / open forest wetland in the Nandewar Bioregion and Brigalow Belt South Bioregion – good	T1-P9	Pilliga	No	30 metres to the south east. Part of same riparian corridor of Castlereagh River on same Crown land patch.
		T2-P14	Castlereagh-Barwon	No	70 metres to west. Same PCT and same patch under same management by same landowner. 3.9 kilometres north of Pilliga subregion boundary
		T2-P15	Castlereagh-Barwon	Yes	3.9 kilometres north of Pilliga subregion boundary
88	Pilliga Box - White Cypress Pine - Buloke shrubby woodland in the Brigalow Belt South bioregion – Good	T2-P31	Pilliga		
		T1-P10	Pilliga		20 metres to the south east. Part of same patch rising out of Castlereagh River on same Crown land patch.
		T1-MP24	Pilliga	Yes	
		T1-MP13	Pilliga Outwash	Yes	
		T1-P16	Pilliga	No	20 metres to west. Same PCT and same patch. Different landowner and therefore different management to plot location across the fence
		T1-P17	Pilliga	No	40 metres to the east of CIZ in connected patch as preferred alignment CIZ under the same management/landowner.

PCT ID	Vegetation zone – condition	Plot ID	Subregion	Within CIZ	Plot use justification for plots outside CIZ or subregion
		T2-P25	Pilliga	No	40 metres to the east of CIZ in connected patch as preferred alignment CIZ under the same management/landowner.
88	Pilliga Box - White Cypress Pine - Buloke shrubby woodland in the Brigalow Belt South bioregion – Low	T2-P34		Yes	
88	Pilliga Box - White Cypress Pine - Buloke shrubby woodland in the Brigalow Belt South bioregion – DNG				X2 benchmark data for derived native grasslands
		T1-P6	Pilliga Outwash	Yes	Five kilometres north west of Pilliga subregion boundary
		T2-P22	Pilliga	Yes	
141	Broombush - wattle very tall shrubland of the Pilliga to Goonoo regions, Brigalow Belt South Bioregion – Good	T1-MP11	Pilliga Outwash	Yes	100 metres south of Pilliga subregion boundary
		T1-MP13	Pilliga	Yes	
		T1-MP14	Pilliga	Yes	
		T1-MP19	Pilliga	Yes	
145	Western Rosewood - Wilga - Wild Orange - Belah low woodland of the Brigalow Belt South Bioregion and eastern Darling Riverine Plains Bioregion – Good	T1SP1	Pilliga	Yes	
		T2-SP4	Pilliga	Yes	
		T1SP2	Pilliga Outwash	Yes	1100 metres north of Pilliga subregion boundary
		T1BP5	Pilliga	No	340 metres to the south-east of CIZ within same vegetation zone patch to be impacted and under the same management/landowner.
		S1	Pilliga	Yes	

PCT ID	Vegetation zone – condition	Plot ID	Subregion	Within CIZ	Plot use justification for plots outside CIZ or subregion
202	Fuzzy Box woodland on colluvium and alluvial flats in the Brigalow Belt South and Nandewar bioregions (including Pilliga) – Good				x2 benchmark data
206	Dirty Gum - White Cypress Pine tall woodland of alluvial sand (sand monkeys) in the Darling Riverine Plains Bioregion and Brigalow Belt South Bioregion – good	WP7	Pilliga	Yes	
		WP8	Pilliga	Yes	
244	Poplar Box grassy woodland on alluvial clay-loams soils mainly in the temperate (hot summer) climate zone of central NSW (wheatbelt) – good	T2P19	Pilliga	No	10 metres to the west of CIZ.
		T2-MP25	Pilliga	Yes	
		T2-MP26	Pilliga	Yes	Plot replicated x2 at request of BCS.
		T2-P24	Pilliga Outwash	No	100 metres to the west of CIZ in same patch and creekline with same landowner and management. 4.9 kilometres north of Pilliga subregion boundary
255	Mugga Ironbark - Buloke - Pilliga Box - White Cypress Pine shrubby woodland on sandstone in the Dubbo region, south-western Brigalow Belt South Bioregion – Good	T2-BP2	Bogan Macquarie	Yes	12 kilometres south west of Pilliga subregion boundary on similar rocky hillslope as other borrow pit site in Pilliga subregion
		T2-BP5	Pilliga	Yes	
		T2-BP5-2	Pilliga	Yes	
256	Green Mallee tall mallee woodland on rises in the Pilliga - Goonoo regions, southern Brigalow Belt South Bioregion – Good	T1-MP25	Pilliga	Yes	

PCT ID	Vegetation zone – condition	Plot ID	Subregion	Within CIZ	Plot use justification for plots outside CIZ or subregion
394	Narrow-leaved Ironbark - White Cypress pine woodland on slopes and flats in the Coonabarabran - Pilliga Scrub regions – Good	T1-MP30	Pilliga		
		T1-MP31	Pilliga		
		T1-P14	Pilliga	No	20 metres to the east of CIZ in same patch to be impacted
		T1-MP18	Pilliga	Yes	
		T1-P15	Pilliga	No	20 metres east of CIZ
		T2-P23	Pilliga	No	60 metres east of CIZ
394	Narrow-leaved Ironbark - White Cypress pine woodland on slopes and flats in the Coonabarabran - Pilliga Scrub regions – Good, fire affected	T1-MP22	Pilliga	Yes	
		T1-MP23	Pilliga	No	60 metres to the east of CIZ in same patch to be impacted by preferred alignment
		T2-MP8	Pilliga	Yes	
394	Narrow-leaved Ironbark - White Cypress pine woodland on slopes and flats in the Coonabarabran - Pilliga Scrub regions – DNG				x3 benchmark derived native grassland
397	Poplar Box - White Cypress Pine shrub grass tall woodland of the Pilliga - Warialda region, Brigalow Belt South Bioregion – Good	T2-MP17	Pilliga Outwash	Yes	1300 metres west of Pilliga subregion boundary
		T1-MP33	Pilliga Outwash	Yes	1700 metres west of Pilliga subregion boundary
398	Narrow-leaved Ironbark - White Cypress Pine - Buloke tall open forest on lower slopes and flats in the Pilliga Scrub and surrounding forests in the central north Brigalow Belt South Bioregion – Good	T1-MP20	Pilliga	Yes	Two kilometres east of Pilliga subregion boundary
		T2-MP1	Pilliga	No	40 metres to north west of CIZ in same patch under same management as CIZ.

PCT ID	Vegetation zone – condition	Plot ID	Subregion	Within CIZ	Plot use justification for plots outside CIZ or subregion
		T2-MP2	Pilliga Outwash	No	15 metres to north west CIZ in same patch under same management as CIZ.
		T2-MP5	Pilliga	Yes	
		T1-MP10	Pilliga Outwash		640 metres north of Pilliga subregion boundary in Pilliga forests
		T2-MP14	Pilliga Outwash	Yes	2.2 kilometres east of Pilliga subregion boundary
		T1-MP9	Pilliga Outwash	Yes	Two kilometres north of Pilliga subregion boundary in Pilliga forests
399	Red gum - Rough-barked Apple +/- tea tree sandy creek woodland (wetland) in the Pilliga - Goonoo sandstone forests, Brigalow Belt South Bioregion – Good	T1-MP17	Pilliga	Yes	
		T1-MP21	Pilliga	Yes	
		T1-MP29	Pilliga	Yes	
		T2-MP3	Pilliga	Yes	
404	Red Ironbark - White Bloodwood +/- Burrows Wattle heathy woodland on sandy soil in the Pilliga forests – Good	T2-MP10	Pilliga	Yes	
		T2-MP6	Pilliga	Yes	
		T2-MP7	Pilliga	Yes	
		AN5	Pilliga	Yes	
406	White Bloodwood - Motherumbah - Red Ironbark shrubby sandstone hill woodland / open forest mainly in east Pilliga forests – Good	T1-MP15	Pilliga	No	70 metres to south east. Same PCT and same patch under same management
		T1-MP16	Pilliga	Yes	
409	Dirty (Baradine) Gum - White Bloodwood - White Cypress Pine – Motherumbah shrubby woodland on sandy soils in the Pilliga Scrub and surrounding region, Brigalow Belt South Bioregion	T1-MP28	Pilliga	Yes	

PCT ID	Vegetation zone – condition	Plot ID	Subregion	Within CIZ	Plot use justification for plots outside CIZ or subregion
414	White Mallee - Dwyer's Red Gum mallee heath on sands in the Goonoo - Pilliga region, Brigalow Belt South Bioregion – Good, fire affected	T1-MP26	Pilliga	Yes	
		T1-MP27	Pilliga	Yes	
		AN4	Pilliga	Yes	
469	White Cypress Pine - Narrow-leaved Ironbark - Buloke grassy open forest of the Dubbo region, southern Brigalow Belt South Bioregion – Good	T2-P33	Pilliga	Yes	In culvert easement
746	Brown Bloodwood - cypress - ironbark heathy woodland in the Pilliga region of the Brigalow Belt South Bioregion – good	T1-BP1	Pilliga	Yes	
		T1-BP2	Pilliga	Yes	
1384	White Cypress Pine - Bulloak - ironbark woodland of the Pilliga area of the Brigalow Belt South Bioregion – Good	T1-MP12	Pilliga	Yes	
		BN7	Pilliga	Yes	
		AN6	Pilliga	Yes	
Brigalow Belt South bioregion, Pilliga Outwash subregion					
35	Brigalow - Belah open forests / woodland on alluvial often gilgaied clay from Pilliga scrub to Gondiwindi, Brigalow Belt South bioregion – Good	T1-P5	Pilliga Outwash	No	350 metres north of CIZ in connected patch to impact zone
35	Brigalow - Belah open forests / woodland on alluvial often gilgaied clay from Pilliga scrub to Gondiwindi, Brigalow Belt South bioregion – DNG				x3 benchmark derived native grassland
49	Partly derived Windmill Grass - Copperburr alluvial plains shrubby grassland of the Darling Riverine Plains Bioregion and Brigalow Belt South bioregion – Good	T1-MP38	Pilliga Outwash	Yes	
		AN3	Pilliga Outwash	Yes	
		BN5	Pilliga Outwash	Yes	

PCT ID	Vegetation zone – condition	Plot ID	Subregion	Within CIZ	Plot use justification for plots outside CIZ or subregion
		BN6	Pilliga Outwash	Yes	
		AN2	Pilliga Outwash	Yes	
78	River Red Gum riparian tall woodland / open forest wetland in the Nandewar Bioregion and Brigalow Belt South Bioregion – Good	T1-P8	Pilliga Outwash	No	60 metres to west. Same PCT and same paddock under same management
		T2-P1	Liverpool Plains	Yes	1.6 kilometres north of Pilliga outwash subregion boundary
					x1 benchmark
78	River Red Gum riparian tall woodland / open forest wetland in the Nandewar Bioregion and Brigalow Belt South Bioregion – DNG				x1 benchmark derived native grassland
88	Pilliga Box - White Cypress Pine - Buloke shrubby woodland in the Brigalow Belt South bioregion – Good	T1-MP4	Pilliga Outwash	Yes	Plot replicated x2 at request of BCS
		T2-MP13	Pilliga Outwash	Yes	Plot replicated x2 at request of BCS
		T1-MP24	Pilliga	Yes	3.4 kilometres east of Pilliga Outwash subregion boundary
88	Pilliga Box - White Cypress Pine - Buloke shrubby woodland in the Brigalow Belt South bioregion – DNG				x4 benchmark derived native grassland
141	Broombush - wattle very tall shrubland of the Pilliga to Goonoo regions, Brigalow Belt South Bioregion – Good	T1-MP11	Pilliga Outwash	Yes	
145	Western Rosewood - Wilga - Wild Orange - Belah low woodland of the Brigalow Belt South Bioregion and eastern Darling Riverine Plains Bioregion – Good	T1BP5	Pilliga	No	340 metres to the south-east of CIZ within same vegetation zone patch to be impacted and under the same management/landowner. 7.3 kilometres south of Pilliga Outwash subregion boundary
		S1	Pilliga	Yes	16 kilometres south of Pilliga Outwash subregion boundary
		T1-SP1	Pilliga	Yes	7.4 kilometres south of Pilliga Outwash subregion boundary

PCT ID	Vegetation zone – condition	Plot ID	Subregion	Within CIZ	Plot use justification for plots outside CIZ or subregion
148	Dirty Gum - Buloke - White cypress pine - ironbark shrubby woodland of the deep sandy soils on the Liverpool Plains Region of the Brigalow Belt South Bioregion – Good	T2-P6	Pilliga Outwash	No	50 metres to north of CIZ. Same veg zone part of same patch to be impacted on local roadside.
		T2-P13	Pilliga Outwash	No	20 metres to west of CIZ. Same PCT and same connected patch under the same management/landowner.
		BN8	Pilliga Outwash	Yes	
		BN9	Pilliga Outwash	Yes	
		AN7	Pilliga Outwash	Yes	
148	Dirty Gum - Buloke - White cypress pine - ironbark shrubby woodland of the deep sandy soils on the Liverpool Plains Region of the Brigalow Belt South Bioregion – DNG	T2-P3	Pilliga Outwash	No	15 metres to east of CIZ. Same PCT and same patch under same management as CIZ.
		T2-P2	Pilliga Outwash	No	47 metres west of CIZ. Same PCT and same patch under same management as CIZ.
		T1-P6	Pilliga Outwash	No	750 metres to west of CIZ. Same patch and under same management as CIZ.
					x2 benchmark derived native grasslands
168	Derived Copperburr shrubland of the NSW northern inland alluvial floodplain – derived		Pilliga Outwash		x1 benchmark
394	Narrow-leaved Ironbark - White Cypress pine woodland on slopes and flats in the Coonabarabran - Pilliga Scrub regions – Good	T1-MP34	Pilliga Outwash	Yes	
		T1-MP42	Pilliga Outwash	Yes	
		T1-MP31	Pilliga	Yes	230 metres north of Pilliga Outwash subregion boundary
397	Poplar Box - White Cypress Pine shrub grass tall woodland of the Pilliga - Warialda region, Brigalow Belt South Bioregion – Good	T2-MP11	Pilliga Outwash	Yes	

PCT ID	Vegetation zone – condition	Plot ID	Subregion	Within CIZ	Plot use justification for plots outside CIZ or subregion
		T2-MP12	Pilliga Outwash	Yes	
		T2-MP17	Pilliga Outwash	Yes	
		T1-MP33	Pilliga Outwash	Yes	
		T1-MP39	Pilliga Outwash	Yes	
398	Narrow-leaved Ironbark - White Cypress Pine - Buloke tall open forest on lower slopes and flats in the Pilliga Scrub and surrounding forests in the central north Brigalow Belt South Bioregion – Good	T1-MP3	Pilliga Outwash	Yes	
		T1-MP7	Pilliga Outwash	Yes	
		T1-MP9	Pilliga Outwash	Yes	
		T1-MP10	Pilliga Outwash	Yes	
		T2-MP14	Pilliga Outwash	Yes	
		T1-MP35	Pilliga Outwash	Yes	
		T1-MP36	Pilliga Outwash	Yes	
		T2-MP19	Pilliga Outwash	Yes	
		T2-MP15	Pilliga Outwash	No	70 metres west of CIZ
		T2-MP-20	Pilliga Outwash	No	37 metres west of CIZ
		T1-MP6	Pilliga Outwash	Yes	
398	Narrow-leaved Ironbark - White Cypress Pine - Buloke tall open forest on lower slopes and flats in the Pilliga Scrub and surrounding forests in the central north Brigalow Belt South Bioregion (Moderate, shrubs removed)	T1-MP41	Pilliga Outwash	Yes	
		T1-MP40	Pilliga Outwash	No	140 metres north west of CIZ. Same PCT and same patch under same management as CIZ

PCT ID	Vegetation zone – condition	Plot ID	Subregion	Within CIZ	Plot use justification for plots outside CIZ or subregion
399	Red gum - Rough-barked Apple +/- tea tree sandy creek woodland (wetland) in the Pilliga - Goonoo sandstone forests, Brigalow Belt South Bioregion – Good	T2-P11	Pilliga	No	20 metres to west of CIZ. Same PCT and same patch under same management as CIZ.
		T1-MP32	Pilliga Outwash	Yes	
		T2-MP16	Pilliga Outwash	Yes	
		T2-MP3	Pilliga Outwash	Yes	3.8 kilometres south west of Pilliga Outwash subregion boundary
435	White Box – White Cypress Pine shrub grass hills woodland in the Brigalow Belt South bioregion and Nandewar bioregion – Good				x1 benchmark
435	White Box – White Cypress Pine shrub grass hills woodland in the Brigalow Belt South bioregion and Nandewar bioregion – DNG				X3 benchmark derived native grassland
473	Red gum - Rough-barked Apple - Narrow-leaved Ironbark - cypress pine grassy open forest on flats and drainage lines in the Goonoo and surrounding forests, southern Brigalow Belt South Bioregion – Good	T2-P8	Pilliga Outwash	Yes	
		T2-P7	Pilliga Outwash	No	70 metres to west of CIZ. Same PCT and same patch under same management as CIZ.
		T1-P4	Pilliga Outwash	No	890 metres to east of the CIZ. Patch is part of wider connected patch to be impacted to the south along the Newell Highway
473	Red gum - Rough-barked Apple - Narrow-leaved Ironbark - cypress pine grassy open forest on flats and drainage lines in the Goonoo and surrounding forests, southern Brigalow Belt South Bioregion – DNG	T2-P10	Pilliga Outwash	Yes	
589	White Box - White Cypress Pine - Silver-leaved Ironbark grassy woodland on mainly clay loam soils on hills mainly in the Nandewar Bioregion – Moderate, logged	T1-MP37	Pilliga Outwash	Yes	

PCT ID	Vegetation zone – condition	Plot ID	Subregion	Within CIZ	Plot use justification for plots outside CIZ or subregion
Brigalow Belt South bioregion, Liverpool Plains subregion					
78	River Red Gum riparian tall woodland / open forest wetland in the Nandewar Bioregion and Brigalow Belt South Bioregion – good	T2-P1	Liverpool Plains	Yes	
168	Derived Copperburr shrubland of the NSW northern inland alluvial floodplain – derived	T1-P1	Liverpool Plains	No	410 metres to the north west of CIZ in connected patch to CIZ under the same management/landowner.
					x2 benchmarks
Brigalow Belt South bioregion, Northern Basalts subregion					
49	Partly derived Windmill Grass - Copperburr alluvial plains shrubby grassland of the Darling Riverine Plains Bioregion and Brigalow Belt South bioregion – Good	Plot 11	Northern Basalts	No	700 metres to the west in same paddock under same management and landholder as CIZ.
		Plot 14	Northern Basalts	No	375 metres to the west in same paddock under same management and landholder as CIZ.
		Plot 20	Northern Basalts	No	530 metres to the west in same paddock under same management and landholder as CIZ.

plot	pct	area	patchsize	conditionclass	zone	easting	northing	bearing	compTree	compShrub	compGrass	compForbs	compFerns	compOther	strucTree	strucShrub	strucGrass	strucForbs	strucFerns	strucOther	funLargeTrees	funHollowtrees	funLitterCover	funLenFallenLogs	funTreeStem5to9	funTreeStem10to19	funTreeStem20to29	funTreeStem30to49	funTreeStem50to79	funTreeRegen	funHighThreatExotic
T2-SP2	27	4.6	101	Good	55	659057	6524827	0	1	3	5	12	0	3	10	0.3	0.5	1.2	0	0.4	4	0	12	42	0	1	1	1	0	1	0.1
BN2	27	4.6	101	Good	55	659683	6528866.0	207	1	4	6	13	0	2	0.5	6.1	10.9	2.7	0.0	2.0	1	0	2.2	0.0	0	0	0	1	1	0	0.1
T2-SP2	27	1.9	101	Good	55	659057	6524827	0	1	3	5	12	0	3	10	0.3	0.5	1.2	0	0.4	4	0	12	42	0	1	1	1	0	1	0.1
35BchDNG1	35	5.9	101	DNG	55	111111	1111111	1	0	8	7	10	0	1	0	13	9	4	0	0	0	0	0	0	0	0	0	0	0	1	0
35BchDNG2	35	5.9	101	DNG	55	111111	1111111	1	0	8	7	10	0	1	0	13	9	4	0	0	0	0	0	0	0	0	0	0	0	1	0
35BchDNG3	35	5.9	101	DNG	55	111111	1111111	1	0	8	7	10	0	1	0	13	9	4	0	0	0	0	0	0	0	0	0	0	0	1	0
T1-P5	35	1.4	101	Good	55	762537	6637450	216	3	3	6	8	0	0	32	1.2	5.5	1	0	0	1	1	31	57	0	1	1	1	0	0	0.3
T1-P25A	36	2.8	101	Good	55	622160	6431885	311	2	0	4	1	0	0	31	0	0.5	0.1	0	0	6	2	85	12	0	0	0	1	1	1	0.2
T1-P25B	36	2.8	101	Good	55	622160	6431885	311	2	0	4	1	0	0	31	0	0.5	0.1	0	0	6	2	85	12	0	0	0	1	1	1	0.2
T2-P30	36	3	101	Good	55	630172	6461554	176	4	0	9	4	0	1	12.2	0	61.5	0.4	0	0.1	0	0	50	0	1	1	1	1	0	1	0
T2-P32	36	3	101	Good	55	630279	6461582	137	4	5	7	13	0	0	10	0.6	2.5	1.3	0	0	3	3	34	8	0	1	1	1	0	0	0
BN3	49	122.2	101	Good	55	659819	6529462.0	31	0	3	6	15	0	2	0.0	0.3	78.2	5.9	0.0	0.2	0	0	0.0	0.0	0	0	0	0	0	0	0.0
BN4	49	122.2	101	Good	55	660121	6531180.0	184	0	1	5	16	0	1	0.0	0.1	1.3	11.7	0.0	0.2	0	0	0.0	0.0	0	0	0	0	0	0	0.1
T2-P18	49	122.2	101	Good	55	666697	6546371	0	0	2	6	12	0	0	0	5.1	5.7	1.3	0	0	0	0	2.9	0	0	0	0	0	0	0	0.1
BN5	49	122.2	101	Good	55	680909	6579023.0	205	0	6	8	12	0	1	0.0	2.6	73.2	3.9	0.0	0.1	0	0	0.0	0.0	0	0	0	0	0	0	0.0
BN6	49	122.2	101	Good	55	681960	6579746.0	309	0	7	8	10	0	0	0.0	1.0	10.1	3.9	0.0	0.0	0	0	0.6	0.0	0	0	0	0	0	0	0.0
49Bch	49	122.2	101	Good	55	111111	1111111.0	1	1	5	9	11	0	1	0.0	6.0	94.0	5.0	0.0	0.0	0	0	30.0	0.0	0	0	0	0	0	0	0.0
T1-P22A	49	11.7	101	Good	55	615457	6425366	59	0	1	6	8	0	1	0	0.1	41.4	0.8	0	0.1	0	0	60	0	0	0	0	0	0	0	0.2
49Bench	49	11.7	101	Good	55	111111	1111111	1	1	5	9	11	0	1	0.0	6.0	94.0	5.0	0.0	0.0	0	0	30.0	0.0	0	0	0	0	0	0	0.0
T1-P22B	49	11.7	101	Good	55	615457	6425366	59	0	1	6	8	0	1	0	0.1	41.4	0.8	0	0.1	0	0	60	0	0	0	0	0	0	0	0.2
T1-MP38	49	98	101	Good	55	691530	6582685	238	0	3	4	5	0	1	0	0.3	2.4	0.5	0	0.1	0	0	12	0	0	0	0	0	0	0	0.1
AN3	49	98	101	Good	55	685947	6581291.0	100	0	3	9	11	0	0	0.0	0.8	32.1	31.0	0.0	0.0	0	0	22.2	0.0	1	0	0	0	0	0	0.0
BN5	49	98	101	Good	55	680909	6579023.0	205	0	6	8	12	0	1	0.0	2.6	73.2	3.9	0.0	0.1	0	0	0.0	0.0	0	0	0	0	0	0	0.0
BN6	49	98	101	Good	55	681960	6579746.0	309	0	7	8	10	0	0	0.0	1.0	10.1	3.9	0.0	0.0	0	0	0.6	0.0	0	0	0	0	0	0	0.0
AN2	49	98	101	Good	55	683788	6580537.0	335	0	2	7	11	0	1	0.0	0.3	50.6	2.0	0.0	0.1	0	0	34.0	0.0	0	0	0	0	0	0	0.4
AN1	49	91.1	101	Good	55	639495	6477731.0	200	0	3	7	9	0	1	0.0	0.4	8.8	45.1	0.0	0.1	0	0	20.0	0.0	0	0	0	0	0	0	0.2
T2-MP24	49	91.1	101	Good	55	626987	6452842	149	0	2	4	3	0	0	0	0.2	0.4	0.3	0	0	0	0	6.8	0	0	0	0	0	0	0	0.1
WP1	49	91.1	101	Good	55	640761	6489660	358	0	3	8	11	0	1	0	2.2	50.4	1.1	0	0.1	0	0	0	0	0	0	0	0	0	0	0
WP2	49	91.1	101	Good	55	640929	6490776	359	0	1	11	10	0	1	0	1	70.6	1	0	1	0	0	0	0	0	0	0	0	0	0	0
WP3	49	91.1	101	Good	55	641138	6492177	350	1	1	14	13	0	1	0.1	0.1	54	1.3	0	0.5	0	0	0	0	0	0	0	0	0	0	0.1
Plot 14	49	7.1	101	Good	55	768735	6646845	282	0	2	3	7	0	0	0	5.1	11.1	1.5	0	0	0	0	7	0	0	0	0	0	0	0	0
Plot 20	49	7.1	101	Good	55	768317	6646860	30	0	2	5	6	0	0	0	0.4	10.5	0.6	0	0	0	0	24	0	0	0	0	0	0	0	0
Plot 11	49	7.1	101	Good	55	767853	6646967	221	0	2	4	8	0	0	0	0.3	58	2.1	0	0	0	0	21	0	0	0	0	0	0	0	0
WP6	55	3.1	101	Good	55	641307	6492883	2	1	5	8	7	0	0	30	0.6	8.4	10.6	0	0	0	1	1.4	34	0	1	1	1	0	0	30.1
WP6A	55	3.1	101	Good	55	641307	6492883	2	1	5	8	7	0	0	30	0.6	8.4	10.6	0	0	0	1	1.4	34	0	1	1	1	0	0	30.1
Plot12	55	0.7	101	Good	55	767831	6646608	75	2	3	11	7	0	0	15	9	54.3	3	0	0	3	3	41	12	0	0	0	0	1	0	2
Plot12	55	0.2	101	Good	55	767831	6646608	75	2	3	11	7	0	0	15	9	54.3	3	0	0	3	3	41	12	0	0	0	0	1	0	2
56BchDNG	56	18.4	101	DNG	55	111111	1111111	1	0	6	8	10	1	2	0	6	41	6	0	0	0	0	0	0	0	0	0	0	0	1	0
56BchDNG	56	18.4	101	DNG	55	111111	1111111	1	0	6	8	10	1	2	0	6	41	6	0	0	0	0	0	0	0	0	0	0	0	1	0
56BchDNG	56	18.4	101	DNG	55	111111	1111111	1	0	6	8	10	1	2	0	6	41	6	0	0	0	0	0	0	0	0	0	0	0	1	0
T1-P13	56	12.8	25	Good	55	643629	6502913	211	3	4	8	14	0	0	25.5	0.4	1.6	3.3	0	0	3	1	77	23	0	0	1	1	1	0	0
S1	56	12.8	25	Good	55	675355	6563308	85	2	4	2	3	0	1	20.1	7.4	0.3	3.1	0	2	5	4	48	38	1	1	0	1	1	1	1.1
T2-P21	56	12.8	25	Good	55	641225	6492153	10	1	5	7	10	0	1	1	1	1.3	1.2	0	0.1	0	0	12	5	0	0	0	1	0	0	0.1
56Bench	56	0.6	101	Good	55	111111	1111111	1	4	6	8	10	1	2	38	6	41	6	0	0	3	3	60	45	1	1	1	1	1	1	0
S2	56	6.5	50	Good	55	675355	6563308	85	2	4	2	3	0	1	20.1	7.4	0.3	3.1	0	2	5	4	48	38	1	1	0	1	1	1	1.1
T2-P21	56	6.5	101	Good	55	641225	6492153	10	1	5	7	10	0	1	1	1	1.3	1.2	0	0.1	0	0	12	5	0	0	0	1	0	0	0.1
WP5	56	6.5	101	Good	55	641085	6491467	8	3	4	7	10	0	0	20.1	5.3	40.2	5.8	0	0	0	3	2.6	8	1	0	1	1	1	0	10
78BchDNG1	78	1.3	101	DNG	55	111111	1111111	1	0	3	7	8	1	1	0	0	63	7	0	0	0	0	0	0	0	0	0	0	0	1	0
T2-P14	78	8.7	101	Good	55	659642	6527650	110	2	1	4	7	0	2	20	0.1	10.3	0.8	0	0.2	2	2	39	8	1	1	1	0	0	0	0.6
T2-P15	78	8.7	101	Good	55	659648	6528044	160	1	0	2	5	1	1	3	0	40.2	0.8	0.1	0.1	2	1	42.2	22	0	0	0	0	1	0	0.3
T1-P9	78	8.7	101	Good	55	650395	6510353	331	1	0	5	6	0	0	15	0	25.5	0.6	0	0	5	3	85	42.5	0	0	1	1	1	0	0.1
T1-P8	78	10.8	101	Good	55	759793	6633923	136	4	2	13	17	0	2	45.2	0.2	14.4	1.7	0	0.2	3	0	62	38.5	1	1	1	1	1	1	0.2
78Bench1	78	10.8	101	Good	55	111111	1111111	1	3	3	7	8	1	1	64	0	63	7	0	0	4	4	40	39	1	1	1	1	1	1	0
T2-P1	78	10.8	101	Good	55	765840	6643315	90	1	3	4	7	0	0	10	0.5	20.3	0.9	0	0	4	0	46	29	0	0	0	1	1	0	5.2
T1-P9	78	8.5	101	Good	55	650395	6510353	331	1	0	5	6	0	0	15	0	25.5	0.6	0	0	5	3	85	42.5	0	0	1	1	1	0	0.1
T2-P14	78	8.5	101	Good	55	659642	6527650	110	2	1	4	7	0	2	20	0.1	10.3	0.8	0	0.2	2	2	39	8	1	1	1	0	0	0	0.6
T2-P15	78	8.5	101	Good	55	659648	6528044	160	1	0	2	5	1	1	3	0	40.2	0.8	0.1	0.1	2	1	42.2	22	0	0	0	0	1	0	0.3
T2-P1	78	1.4	101	Good	55	765840	6643315	90	1	3	4	7	0	0	10	0.5	20.3	0.9	0	0	4	0	46	29	0	0	0	1	1	0	5.2
T2-P37	81	0.9	28	Good	55	622263	6428516	160	3	3	8	14	0	0	17	0.3	10.9	1.3	0	0	4	3	50	8	1	1	1	1	1	1	0
88BchDNG1	88	3.1	101	DNG	55	111111	1111111	1	0	8	8	9	1	2	0	22	25	5	0	0	0	0	0	0	0	0	0	0	0	1	0
88BchDNG2	88	3.1	101	DNG	55	111111	1111111	1	0	8	8	9	1	2	0	22	25	5	0	0	0	0	0	0	0	0	0	0	0	1	0
88BchDNG1	88	0.5	101	DNG	55	111111	1111111	1	0	8	8	9	1	2	0	22	25	5	0	0	0	0	0	0	0	0	0	0	0	1	0
88BchDNG1	88	36.3	101	DNG	55	111111	1111111	1	0	8	8	9	1	2	0	22	25	5	0	0	0	0	0	0	0	0	0	0	0	1	0
88BchDNG2	88	36.3	101	DNG	55	111111	1111111	1	0	8	8	9	1	2	0	22	25	5	0	0	0	0	0	0	0	0	0	0	0	1	0
88BchDNG3	88	36.3	101	DNG	55	111111	1111111	1	0	8	8	9	1	2	0	22	25	5	0	0	0	0	0	0	0	0	0	0	0	1	0
88BchDNG4	88	36.3	101	DNG	55	111111	1111111	1	0	8	8	9	1	2	0	22	25	5	0	0	0	0	0	0	0	0	0	0	0	1	0
T1-P6	88	49.9	101	DNG	55	761172	6637537	67	0	1	11	5	0	0	0	0.1	26	0.5	0	0	0	0	0.8	0	0	0	0	0	0	0	0
T2-P22	88	49.9	101	DNG	55	640822	6489517	95	0	1	8	8	0	0	0	0.1	6.7	1.1	0	0	0	0	1	0	0	0	0	0	0	0	0.1
88BechDNG	88	49.9	101	DNG	55	111111	1111111	1	0	8	8	9	1	2	0	22	25	5	0	0	0	0	0	0	0	0	0	0	0	1	0
88BechDNG	88	49.9	101	DNG	55	111111	1111111	1	0	8	8	9	1	2	0	22	25	5	0	0	0	0	0	0	0	0	0	0	0	1	0
T2-P16	88	13.6	101	Good	55	659470	6526938	180	1	4	4	13	0	1	3	0.9	20.3	1.4	0	0.1	3	2	39	34	1	1	1	0	1	1	0.2
T1-P10	88	13.6	101	Good	55	650460	6510408	90	0	3	11	12	0	0	0	0.3	21.7	4.1	0	0	0	0	37	0	0	0	0	0	0	0	0.3
T1-P12	88	13.6	101	Good	55	651331	6510780	66	3	4	4	12	0	2	45	0.8	2.7	1.2	0	0.2	1	1	49.4	46	0	1	1	1	1	1	0.2
T1-P11	88	13.6	101	Good	55	650348	6510472	62	2	5	5	10	0	1	25	10.4	1.9	1	0	0.1	1	1	18.2	11	1	1	1	0	0	1	0
T1-P20a	88	19	101	Good	55	614002	6425724	1	2	2	8	14	1	2	21	0.2	9.7	1.4	0.1	0.2	2	2	36	5	0	0	1	1	0	0	0
T1-P20b	88	19	101	Good	55	614002	6425724	1	2	2	8	14	1	2	21	0.2	9.7	1.4	0.1	0.2	2	2	36	5	0	0	1	1	0	0	0
T1-P21	88	19	50	Good	55	615457	6425366	5	0	2	5	6	1	0	0	0.3	2.4	0.6	0.1	0	3	1	19	9	0	0	0	0	1	0	0.1
T1-MP4A	88	72.6	101	Good	55	750244	6624091	214	4	2	5	2	1	0	57	0.2	0.7	0.2	0.1	0	1	0	46	80	1	1	1	1	1	1	0
T2-MP13A	88	72.6	101	Good	55	701244	6592182	260	4	3	4	2	0	0	25.3	0.7	0.4	0.2	0	0	1	3	69	139	0	1	1	1	1	0	0.1
T1-MP24	88	72.6	101	Good	55	750244	6624091	214	4	2	5	2	1	0	57	0.2	0.7	0.2	0.1	0	1	0	46	80	1	1	1	1	1	1	0
T2-MP13B	88	72.6	101	Good	55	701244	6592182	260	4	3	4	2	0	0	25.3	0.7	0.4	0.2	0	0	1	3	69	139	0	1	1	1	1	0	0.1
T1-MP4B	88	72.6	101	Good	55	750244	6624091	214	4	2	5	2	1	0	57	0.2	0.7	0.2	0.1	0	1	0	46	80	1	1	1	1	1	1	0
T2-P31	88	205.4	101	Good	55	630058	6461424	129	1	5	9	8	1	1	6	0.8	2.9	0.9	0.2	0.1	0	0	22	6	1	1	0	1	0	1	0
T1-P10	88	205.4	101	Good	55	650460	6510408	90	0	3	11	12	0	0	0	0.3	21.7	4.1	0	0	0	0	37	0	0	0	0	0	0	0	0.3
T1-MP24	88	205.4	101	Good	55	709453	6602623	92	3	3	3	3	1	0	33.1	50.2	0.3	0.4	0.1	0	1	0	30	26	1	1	1	1	1	1	0.1
T2-MP13	88	205.4	101	Good	55	701244	6592182	260	4	3	4	2	0	0	25.3	0.7	0.4	0.2	0	0	1	3	69	139	0	1	1	1	1	0	0.1
T1-P16	88	205.4	101	Good	55	640339	6483891	261	3	7	7	9	0	1	20.1	1.4	0.7	0.9	0	0.1	1	0	35	13	1	1	1	1	1	1	0
T1-P17	88	205.4	101	Good	55	640367	6482407	6	3	5	7	3	0	0	11	5.7	0.7	0.3	0	0	0	0	54	7	1	1	1	1	0	1	0
T2-P25	88	205.4	101	Good	55	640528	6483386	180	2	1	6	1	1	0	8.2	0.1	0.7	0.1	0.1	0	0	0	47	2	1	1	1	0	0	1	0
T2-P34	88	1.7	2	Low	55	623541	6439434	51	2	6	4	4	0	1	16	10.7	0.5	0.4	0	5	1	1	72	11	1	1	1	0	0	1	0
T1-MP11	141	1.9	101	Good	55	736345	6616491	126	1	6	2	0	0	1	3	82.6	0.6	0	0	0.1	1	0	26	2	1	1	1	1	1	1	0
T1-MP13	141	29	101	Good	55	731689	6612411	241	2	7	3	1	0	1	7	75.7	3.4	0.2	0	0.1	0	0	22	3	1	1	0	1	0	1	0
T1-MP14	141	29	101	Good	55	731011	6611838	315	1	8	2	1	0	1	2	82.2	10.1	0.5	0	0.3	0	0	13	11	1	1	1	1	0	1	0
T1-MP19	141	29	101	Good	55	717347	6605465	64	1	8	2	0	1	0	0.1	59.1	80.1	0	0.1	0	0	0	30	3	0	0	0	1	0	1	0
T1-MP19	141	29	101	Good	55	717347	6605465	64	1	8	2	0	1	0	0.1	59.1	80.1	0	0.1	0	0	0	30	3	0	0	0	1	0	1	0
T1-SP1	145	15.8	101	Good	55	674395	6565366	220	1	5	1	3	0	0	10	0.7	0.1	0.7	0	0	2	2	16	9	0	1	1	1	0	0	0
T1-SP4	145	15.8	101	Good	55	672447	6556374	265	4	2	0	2	0	1	4.5	0.2	0	0.2	0	0.1	2	1	13.4	7	0	0	1	1	0	1	0
T1-BP5	145	15.8	101	Good	55	674966	6564841	96	2	6	0	3	0	2	4	7.8	0	0.8	0	0.4	2	0	8	8	0	1	1	1	0	0	0
T1-SP2	145	15.8	101	Good	55	659066	6524989	62	1	3	0	2	0	0	5	1.1	0	0.3	0	0	1	1	3.2	6	0	0	1	1	0	0	0
T1-SP1	145	5.8	101	Good	55	674395	6565366	220	1	5	1	3	0	0	10	0.7	0.1	0.7	0	0	2	2	16	9	0	1	1	1	0	0	0
T1-BP5	145	5.8	101	Good	55	674966	6564841	96	2	6	0	3	0	2	4	7.8	0	0.8	0	0.4	2	0	8	8	0	1	1	1	0	0	0
Singles 1	145	5.8	101	Good	55	674400	6565362	4	2	6	0	3	0	0	10	8.2	0	0.3	0	0	1	3	7	6	1	1	1	1	0	1	0.5
T1-SP2	145	49.3	101	Good	55	659066	6524989	62	1	3	0	2	0	0	5	1.1	0	0.3	0	0	1	1	3.2	6	0	0	1	1	0	0	0
S1	145	49.3	101	Good	55	674400	6565362	4	2	6	0	3	0	0	10	8.2	0	0.3	0	0	1	3	7	6	1	1	1	1	0	1	0.5
T1-BP5	145	49.3	101	Good	55	674966	6564841	96	2	6	0	3	0	2	4	7.8	0	0.8	0	0.4	2	0	8	8	0	1	1	1	0	0	0
T1-SP1	145	49.3	101	Good	55	674395	6565366	220	1	5	1	3	0	0	10	0.7	0.1	0.7	0	0	2	2	16	9	0	1	1	1	0	0	0
T1-SP4	145	49.3	101	Good	55	672447	6556374	265	4	2	0	2	0	1	4.5	0.2	0	0.2	0	0.1	2	1	13.4	7	0	0	1	1	0	1	0
T2-P3	148	95.4	101	DNG	55	762363	6638717	88	0	2	9	15	0	0	0	0.8	5.9	2.5	0	0	0	0	85	0	0	0	0	0	0	0	0.1
T2-P2	148	95.4	101	DNG	55	762150	6638148.0	290	0	1	6	11	0	0	0.0	0.3	46.9	1.1	0.0	0.0	0	0	78.0	0.0	0	0	0	0	0	0	0.0
T1-P6	148	95.4	101	DNG	55	761172	6637537	67	0	1	11	5	0	0	0	0.1	26	0.5	0	0	0	0	0.8	0	0	0	0	0	0	0	0
148BchDNG1	148	95.4	101	DNG	55	111111	1111111	1	0	8	8	9	1	2	0	22	25	5	0	0	0	0	0	0	0	0	0	0	0	1	0
148BchDNG2	148	95.4	101	DNG	55	111111	1111111	1	0	8	8	9	1	2	0	22	25	5	0	0	0	0	0	0	0	0	0	0	0	1	0
T2-P6	148	46.2	101	Good	55	762014	6637817	250	2	1	6	5	0	0	13	0.1	1	0.4	0.1	0	1	0	59.6	78	1	1	1	1	1	1	0
T2-P13	148	46.2	101	Good	55	758223	6631327	285	3	0	5	0	0	0	11	0	51.4	0	0	0	1	0	23	12	1	1	1	1	1	0	0
BN8	148	46.2	101	Good	55	756850	6629278.0	221	3	7	8	14	1	1	0.8	1.4	9.2	23.7	0.1	0.3	1	2	35.0	141.0	1	1	1	1	1	1	0.0
BN9	148	46.2	101	Good	55	756865	6629368.0	19	3	3	14	9	1	1	1.4	16.2	28.2	1.3	2.0	0.1	3	0	12.6	110.0	1	1	1	1	1	1	0.0
AN7	148	46.2	101	Good	55	756485	6629411.0	241	2	2	13	14	1	2	0.3	0.2	14.1	22.2	0.3	0.6	3	0	38.0	16.0	1	1	1	1	1	1	0.0
T1-P1	168	7.1	4	Derived	55	764998	6643436	275	0	7	6	6	0	0	0	15.6	7.5	0.9	0	0	0	0	2.4	0	0	0	0	0	0	0	0.1
168-BenchA	168	7.1	4	Derived	55	111111	1111111	0	1	8	5	6	0	0	0	65	3	5	0	0	0	0	30	0	0	0	0	0	0	0	0
168-BenchB	168	7.1	4	Derived	55	111111	1111111	0	1	8	5	6	0	0	0	65	3	5	0	0	0	0	30	0	0	0	0	0	0	0	0
168-BenchB	168	0.2	4	Good	55	111111	1111111	0	1	8	5	6	0	0	0	65	3	5	0	0	0	0	30	0	0	0	0	0	0	0	0
T2-BP3	185	12.1	15	DNG	55	621788	6409615	272	1	2	3	5	1	0	0.1	10.1	20.2	0.5	0.1	0	0	0	16	5	0	0	0	0	0	0	0
T2-BP3-2	185	12.1	15	DNG	55	621416	6409718	186	0	1	6	6	1	0	0	0.1	21.9	0.6	0.1	0	0.1	0	4	0	0	0	0	0	0	0	0.1
T2-BP3-2	185	12.1	15	DNG	55	621416	6409718	186	0	1	6	6	1	0	0	0.1	21.9	0.6	0.1	0	0.1	0	4	0	0	0	0	0	0	0	0.1
185_Bench	185	1.4	15	Good	55	111111	1111111	1	4	8	6	9	1	2	43	9	12	5	1	0	5	1	70	45	1	1	1	1	1	1	0
202-BenchA	202	3.6	101	Good	55	111111	1111111	0	3	4	9	12	1	2	18	2	42	6	0	1	2	1	30	41	1	1	1	1	1	1	0
202-BenchB	202	3.6	101	Good	55	111111	1111111	0	3	4	9	12	1	2	18	2	42	6	0	1	2	1	30	41	1	1	1	1	1	1	0
WP7	206	5.2	101	Good	55	641412	6494027	15	3	0	6	13	1	0	5.2	0	5.4	28	1	0	0	0	4.4	6	1	1	1	1	0	1	0
WP8	206	5.2	101	Good	55	641467	6493936	185	2	1	7	16	1	1	45	0.1	5.9	33.2	0.5	0.1	0	1	1	21	1	1	1	1	1	1	0.1
206Bch	206	5.2	101	Good	55	111111	1111111	1	5	5	7	11	0	3	68	7	88	10	0	1	4	4	50	38	1	1	1	1	1	1	0
WP7	206	4.9	101	Good	55	641412	6494027	15	3	0	6	13	1	0	5.2	0	5.4	28	1	0	0	0	4.4	6	1	1	1	1	0	1	0
WP8	206	4.9	101	Good	55	641467	6493936	185	2	1	7	16	1	1	45	0.1	5.9	33.2	0.5	0.1	0	1	1	21	1	1	1	1	1	1	0.1
T2-P19A	244	19.7	50	Good	55	667463	6543464	170	3	1	4	3	0	0	14	0.1	2.2	0.3	0	0	2	2	59	25	1	1	1	1	1	1	0
T2-P19B	244	19.7	50	Good	55	667463	6543464	170	3	1	4	3	0	0	14	0.1	2.2	0.3	0	0	2	2	59	25	1	1	1	1	1	1	0
244Bch	244	19.7	101	Good	55	111111	1111111	1	4	6	8	10	1	2	38	6	41	6	0	0	3	3	60	45	1	1	1	1	1	1	0
T2-MP25	244	24.2	50	Good	55	627125	6453245	236	3	3	7	2	0	1	15.1	1.2	0.7	0.2	0	0.1	1	1	16	53	1	1	1	1	1	1	0.1
T2-MP26A	244	24.2	50	Good	55	627070	6453801	162	1	1	3	0	1	0	20	1	2.2	0	0.1	0	0	0	34	24	1	1	1	0	0	1	0
T2-MP26B	244	24.2	50	Good	55	627070	6453801	162	1	1	3	0	1	0	20	1	2.2	0	0.1	0	0	0	34	24	1	1	1	0	0	1	0
T2-P19	244	24.2	50	Good	55	667463	6543464	170	3	1	4	3	0	0	14	0.1	2.2	0.3	0	0	2	2	59	25	1	1	1	1	1	1	0
BN1a	248	16.3	101	Good	55	622174	6431295	64	2	5	5	10	0	1	0.2	20.1	3.0	5.6	0.0	0.3	4	3	11.2	41.0	0	0	0	1	1	0	0.1
T1-P24	248	16.3	101	Good	55	622612	6431283	277	2	2	8	12	0	0	10	1.1	7	1.4	0	0	2	1	42	13	0	0	0	0	0	1	0
BN1	248	16.3	101	Good	55	622174	6431295	64	2	5	5	10	0	1	0.2	20.1	3.0	5.6	0.0	0.3	4	3	11.2	41.0	0	0	0	1	1	0	0.1
T2-BP2	255	4.3	101	Good	55	616674	6421450	148	2	2	5	0	0	0	35	0.2	5	0	0	0	4	1	59	64	1	1	1	1	1	0	0
T2-BP2A	255	4.3	101	Good	55	616674	6421450	148	2	2	5	0	0	0	35	0.2	5	0	0	0	4	1	59	64	1	1	1	1	1	0	0
T2-BP2	255	7.9	101	Good	55	616674	6421450	148	2	2	5	0	0	0	35	0.2	5	0	0	0	4	1	59	64	1	1	1	1	1	0	0
T2-BP5	255	7.9	101	Good	55	623604	6434914	92	3	5	1	0	0	0	30.5	5.4	0.1	0	0	0	0	1	56	105	1	1	1	1	1	0	0
T2-BP5-2	255	7.9	101	Good	55	623574	6435151	133	2	3	1	0	0	0	20.5	1.2	0.1	0	0	0	3	1	64	52	1	1	1	1	1	1	0
T1-MP25	256	0.3	101	Good	55	708253	6602211	334	1	3	3	1	0	2	35	2.6	0.3	0.1	0	0.5	0	0	70	200	1	1	1	1	0	1	0

plot	pct	area	patchsize	conditionclass	zone	easting	northing	bearing	compTree	compShrub	compGrass	compForbs	compFerns	compOther	strucTree	strucShrub	strucGrass	strucForbs	strucFerns	strucOther	funLargeTrees	funHollowtrees	funLitterCover	funLenFallenLogs	funTreeStem5to9	funTreeStem10to19	funTreeStem20to29	funTreeStem30to49	funTreeStem50to79	funTreeRegen	funHighThreatExotic
394BencDNG	394	15.4	101	DNG	55	111111	1111111	1	0	8	9	12	1	3	0	22	30	7	1	2	0	0	0	0	0	0	0	0	0	1	0
394BencDNG	394	15.4	101	DNG	55	111111	1111111	1	0	8	9	12	1	3	0	22	30	7	1	2	0	0	0	0	0	0	0	0	0	1	0
394BencDNG	394	15.4	101	DNG	55	111111	1111111	1	0	8	9	12	1	3	0	22	30	7	1	2	0	0	0	0	0	0	0	0	0	1	0
T1-MP34	394	19	101	Good	55	700981	6591107	170	3	3	8	1	1	1	59	5.2	1	0.5	0.1	0.5	1	1	66	56	1	1	1	1	1	1	0
T1-MP42	394	19	101	Good	55	695893	6582704	137	2	4	4	0	0	0	52	0.7	0.4	0	0	0	0	0	66	88	1	1	1	1	0	1	0.1
T1-MP31	394	19	101	Good	55	703577	6597466	94	4	5	5	1	1	0	30.5	17.7	0.5	1.1	0.1	0	2	0	54	53	1	1	1	1	1	1	0
T1-MP30	394	35.6	101	Good	55	704436	6598802	229	4	3	3	6	1	1	40.3	5.2	0.3	0.7	0.1	0.1	0	0	56	32	1	1	1	1	0	1	0.1
T1-MP31	394	35.6	101	Good	55	703577	6597466	94	4	5	5	1	1	0	30.5	17.7	0.5	1.1	0.1	0	2	0	54	53	1	1	1	1	1	1	0
T1-P14	394	35.6	101	Good	55	640889	6485803	176	3	1	5	1	1	0	55.1	0.1	0.5	0.1	0.1	0	1	1	39	61	1	1	1	1	1	1	0
T1-MP18	394	35.6	101	Good	55	718007	6605737	162	2	6	3	3	1	1	16	28.4	1	0.3	0.1	0.1	1	0	56	9	1	1	1	1	1	1	0
T2-P23	394	35.6	101	Good	55	641008	6486314	210	2	1	6	0	1	0	3.3	0.1	1.5	0	0.1	0	0	0	18	62	1	1	1	1	0	1	0
T1-P15	394	35.6	101	Good	55	640857	6485661	171	3	1	6	2	1	0	25	0.1	0.6	0.2	0.1	0	1	0	56	33	1	1	1	1	1	1	0
T1-MP22	394	11.1	101	Good_fire_affected	55	714161	6604257	232	1	5	0	0	1	0	3	95.2	0	0	0.2	0	1	0	19	1	1	1	1	1	1	0	0
T1-MP23	394	11.1	101	Good_fire_affected	55	713478	6604002	280	2	2	2	2	1	0	1.3	93.2	0.2	0.2	0.1	0	1	0	42	12	1	1	1	0	1	0	0
T2-MP8	394	11.1	101	Good_fire_affected	55	712557	6603654	287	1	4	0	0	1	0	10	57.5	0	0	0.1	0	0	0	94	73	1	1	1	1	0	1	0
T2-MP11	397	14.7	101	Good	55	702014	6595343	178	5	2	5	3	2	1	26.2	0.2	0.6	0.3	0.2	0.1	0	0	74	164	1	1	1	1	0	1	0.1
T2-MP12	397	14.7	101	Good	55	701964	6594985	265	5	2	6	2	0	0	45.4	0.2	0.6	0.2	0	0	0	0	85	236	1	1	1	1	0	1	0.1
T2-MP17	397	14.7	101	Good	55	702233	6595526	244	3	1	4	0	0	0	30.1	0.1	0.4	0	0	0	0	0	66	159	1	1	1	1	0	1	0.1
T1-MP33	397	14.7	101	Good	55	701960	6594843	209	2	1	4	2	0	2	60	1	0.8	0.2	0	0.2	1	0	66	110	1	1	1	1	1	1	0
T1-MP39	397	14.7	101	Good	55	692321	6582506	108	2	1	4	2	0	0	40	0.1	0.4	0.2	0	0	6	6	78	194	0	1	1	1	1	1	0
T2-MP17	397	3.1	101	Good	55	702233	6595526	244	3	1	4	0	0	0	30.1	0.1	0.4	0	0	0	0	0	66	159	1	1	1	1	0	1	0.1
T1-MP33	397	3.1	101	Good	55	701960	6594843	209	2	1	4	2	0	2	60	1	0.8	0.2	0	0.2	1	0	66	110	1	1	1	1	1	1	0
T1-MP3	398	170.9	101	Good	55	745303	6621725	359	4	4	3	1	1	0	59	0.5	0.4	0.1	0.1	0	1	0	52	68	1	1	1	1	1	1	0
T1-MP7	398	170.9	101	Good	55	741979	6620091	44	3	2	4	1	1	0	39	0.4	1.1	0.1	0.1	0	0	0	70	150	1	1	1	1	0	1	0
T1-MP9	398	170.9	101	Good	55	737656	6617784	357	3	5	5	3	1	0	33	11.5	0.7	0.3	0.1	0	5	4	72	21	1	1	1	1	1	1	0
T1-MP10	398	170.9	101	Good	55	736800	6616957	255	2	9	3	0	1	1	1.5	89.4	1.2	0	0.1	0.5	2	0	21	8	1	1	1	1	1	1	0.5
T2-MP14	398	170.9	101	Good	55	701504	6593225	265	3	3	5	2	0	0	40	0.7	0.5	0.2	0	0	0	0	77	139	1	1	1	1	0	1	0.1
T1-MP35	398	170.9	101	Good	55	700762	6590417	281	3	4	5	0	1	0	35.1	8.4	4.2	0	0.1	0	1	1	55	72	1	1	1	1	1	1	0
T1-MP36	398	170.9	101	Good	55	699943	6587936	272	3	8	4	1	0	1	31	8.5	0.4	0.1	0	0.1	0	0	34	50	1	1	1	1	0	1	0
T2-MP20	398	170.9	101	Good	55	701152	6592056	312	3	2	4	1	0	0	40.1	0.3	0.4	0.1	0	0	0	0	57	178	1	1	1	1	0	1	0.1
T2-MP19	398	170.9	101	Good	55	699589	6586793	163	3	7	3	1	0	0	35	0.7	0.3	0.1	0	0	0	0	91	112	1	1	1	1	0	1	0
T2-MP15	398	170.9	101	Good	55	699550	6586958	93	3	8	4	1	0	0	35.2	1.2	40.3	0.1	0	0	1	2	45	80	1	1	1	1	1	1	0
T1-MP6	398	170.9	101	Good	55	746630	6622441	46	3	4	3	2	1	0	25	11.4	4.1	0.2	0.1	0	0	0	62	110	1	1	1	1	0	1	0
T1-MP20	398	203	101	Good	55	715877	6604892	158	2	12	3	1	1	1	31	48	0.4	0.3	0.1	0.1	1	0	37	21	1	1	1	1	1	1	0
T2-MP1	398	203	101	Good	55	728045	6610909	54	5	6	4	1	1	0	28.1	3.6	0.4	0.2	0.1	0	0	1	51	82	1	1	1	1	0	1	0
T2-MP2	398	203	101	Good	55	730245	6611560	349	5	4	5	1	1	2	31.1	10.3	0.5	0.1	0.1	0.4	1	2	64	67	1	1	1	1	1	1	0
T2-MP5	398	203	101	Good	55	725571	6609735	330	3	9	4	1	0	0	31	1	0.4	0.1	0	0	0	0	84	56	1	1	1	1	0	1	0
T1-MP10	398	203	101	Good	55	736800	6616957	255	2	9	3	0	1	1	1.5	89.4	1.2	0	0.1	0.5	2	0	21	8	1	1	1	1	1	1	0.5
T2-MP14	398	203	101	Good	55	701504	6593225	265	3	3	5	2	0	0	40	0.7	0.5	0.2	0	0	0	0	77	139	1	1	1	1	0	1	0.1
T1-MP9	398	203	101	Good	55	737656	6617784	357	3	5	5	3	1	0	33	11.5	0.7	0.3	0.1	0	5	4	72	21	1	1	1	1	1	1	0
T1-MP41	398	8.4	101	Mod_shrubs_removed	55	698347	6584420	266	2	4	4	3	0	0	40.1	0.4	0.5	0.3	0	0	2	3	48	13	0	1	1	1	1	1	0
T1-MP40	398	8.4	101	Mod_shrubs_removed	55	698531	6584867	186	3	3	4	1	0	1	36.5	3.3	1	0.1	0	0.1	0	0	59	24	1	1	1	1	0	1	0
T1-MP41A	398	8.4	101	Mod_shrubs_removed	55	698347	6584420	266	2	4	4	3	0	0	40.1	0.4	0.5	0.3	0	0	2	3	48	13	0	1	1	1	1	1	0
T2-P11	399	31.9	101	Good	55	757142	6629870	340	3	8	1	3	0	0	12.2	1.9	0.3	0.3	0	0	1	1	43	59	1	1	1	0	0	1	0
T1-MP32	399	31.9	101	Good	55	702819	6596182	134	2	7	3	2	0	1	32	6.2	0.5	0.2	0	0.1	1	1	56	16	1	1	1	1	1	1	0.1
T2-MP16	399	31.9	101	Good	55	702302	6595700	120	2	3	5	3	0	3	25.2	40.1	2.3	0.3	0	1.2	1	3	48	33	1	1	1	1	0	1	0.1
T2-MP3	399	31.9	101	Good	55	733338	6613704	345	4	5	5	1	0	1	26.2	15.3	5.9	0.1	0	0.1	1	0	67	129	1	1	1	1	1	1	0
T1-MP17	399	22.9	101	Good	55	718659	6606032	131	3	3	4	1	0	0	31.1	1	15.2	0.1	0	0	8	7	12	32	1	1	1	1	1	1	0
T1-MP21	399	22.9	101	Good	55	715071	6604630	300	5	10	2	3	1	0	19.6	7.8	0.3	0.4	0.1	0	2	2	41	19	1	1	1	1	1	1	0
T1-MP29	399	22.9	101	Good	55	705690	6600063	104	2	3	4	3	1	1	23	17.5	16.2	0.3	0.1	0.1	2	1	15	41	1	1	1	1	1	1	0.1
T2-MP3	399	22.9	101	Good	55	733338	6613704	345	4	5	5	1	0	1	26.2	15.3	5.9	0.1	0	0.1	1	0	67	129	1	1	1	1	1	1	0
T2-MP10	404	25.1	101	Good	55	711180	6603121	68	4	7	0	0	0	0	31.1	2.6	0	0	0	0	0	0	66	51	1	1	1	1	0	1	0
T2-MP6	404	25.1	101	Good	55	725401	6609595	158	4	5	0	0	0	1	26.1	0.9	0	0	0	0.1	1	3	53	25	1	1	1	0	1	1	0
T2-MP7	404	25.1	101	Good	55	725351	6609691	350	2	9	3	0	0	1	55	0.9	0.3	0	0	0.1	0	1	56	32	1	1	1	1	0	1	0
AN5	404	25.1	101	Good	55	711185	6603137.0	243	3	6	1	2	0	0	88.0	16.3	0.2	5.0	0.0	0.0	0	0	41.8	87.0	1	1	1	1	1	1	0.0
T1-MP15	406	2.4	101	Good	55	720456	6607062	53	3	5	2	1	0	0	61	5.1	0.3	0.1	0	0	1	0	18	38	1	1	1	1	1	1	0
T1-MP16	406	2.4	101	Good	55	720349	6607125	210	5	3	1	1	1	0	48.1	60.5	0.1	0.1	0.1	0	5	2	76	12	1	1	0	1	1	1	0
T1-MP28	409	0.8	101	Good	55	706928	6601545	172	3	5	4	1	0	0	19	13.5	0.6	0.1	0	0	1	1	58	68	1	1	1	1	1	1	0
T1-MP26	414	7.3	101	Good_fire_affected	55	707548	6601887	248	1	11	1	0	1	2	0.5	38	0.1	0	0.1	0.7	0	0	35	2	1	1	0	0	0	1	0
T1-MP27	414	7.3	101	Good_fire_affected	55	707474	6601844	255	3	10	1	1	0	0	2.2	58.1	0.1	0.2	0	1	0	0	19	8	1	0	0	0	0	0	0
AN4	414	7.3	101	Good_fire_affected	55	707426	6601890.0	38	2	9	3	11	0	1	0.2	13.5	2.2	77.0	0.0	0.5	0	0	22	2	1	0	0	0	0	0	0
435BchDNG1	435	5.1	101	DNG	55	111111	1111111	1	0	8	9	12	1	3	0	22	30	7	1	2	0	0	0	0	0	0	0	0	0	1	0
435BchDNG2	435	5.1	101	DNG	55	111111	1111111	1	0	8	9	12	1	3	0	22	30	7	1	2	0	0	0	0	0	0	0	0	0	1	0
435BchDNG3	435	5.1	101	DNG	55	111111	1111111	1	0	8	9	12	1	3	0	22	30	7	1	2	0	0	0	0	0	0	0	0	0	1	0
435Bench	435	0.3	101	Good	55	111111	1111111	1	5	8	9	12	1	3	60	22	30	7	1	2	3	1	60	62	1	1	1	1	1	1	0
T2-P20	444	1.7	50	Good	55	665076	6539557	270	4	0	11	8	0	2	15.9	0	15	1.1	0	0.2	6	1	39	36	1	0	0	1	1	1	0.1
T2-P33	469	1	101	Good	55	637443	6467037.0	193	3	3	4	4	0	1	19.0	1.9	1.3	0.4	0.0	0.1	2	0	54	31	1	1	1	1	1	1	0.1
T2-P10	473	0.9	101	DNG	55	755490	6627449	290	0	1	7	10	0	1	0	0.1	6.4	1	0	0.1	0	0	8	3	0	1	0	0	0	0	0.1
T2-P8	473	19.2	101	Good	55	756227	6628551	80	4	5	7	6	1	0	12.5	2.4	28.6	3.6	0.3	0	1	1	34	45	1	1	1	1	0	1	0.3
T2-P7	473	19.2	101	Good	55	755916	6628401	350	4	2	9	7	0	2	37.1	0.3	1	0.7	0	0.2	3	2	34	18	1	1	1	1	1	1	0.1
T1-P4	473	19.2	101	Good	55	763126	6638011	270	3	2	4	2	0	0	22	0.2	0.3	0.3	0	0.1	3	2	55	31	1	1	1	0	1	1	0.1
T1-MP37	589	1	101	Mod_logged	55	690486	6582956	90	2	1	5	5	0	0	35	0.1	0.8	0.5	0	0	1	1	61	157	1	1	1	1	1	1	0
T2-P36	599	3	50	Good	55	622082	6427525	165	2	2	6	13	0	3	22	1.1	5.8	1.8	0	0.3	2	2	61	19	0	0	1	1	1	0	0.3
T2-P35	599	3	50	Good	55	621961	6426820	165	2	4	11	16	0	2	24	1.6	3.9	1.7	0	0.4	7	7	39	12	1	1	0	1	1	0	0.4
T1-BP1	746	2.1	101	Good	55	764934	6632370	0	5	1	6	2	1	2	26	0.1	3.5	0.2	0.1	0.5	1	0	61.4	21	0	1	1	1	1	1	0
T1-BP2	746	2.1	101	Good	55	764950	6632523	0	5	1	5	2	1	3	19.1	0.1	5.8	0.2	0.1	0.4	2	0	69	122	1	1	1	1	1	1	0
T1-MP12	1384	8.8	101	Good	55	732599	6613219	304	4	4	2	3	1	0	42	2.6	2.1	0.3	0.1	0	1	0	84	45	1	1	1	1	1	1	0
BN7	1384	8.8	101	Good	55	732614	6613196.0	249	4	6	9	12	1	3	0.4	11.2	1.4	46.6	10.0	1.0	4	0	73.0	99.0	1	1	1	1	1	1	0.0
AN6	1384	8.8	101	Good	55	732115	6612770.0	49	4	7	10	7	1	0	20.1	8.9	48.9	10.4	0.1	0.0	2	0	33.0	15.0	1	1	1	1	1	1	0.0

TECHNICAL REPORT 01

Biodiversity development assessment report

Appendix M EPBC Act assessments of significance

NARROMINE TO NARRABRI RESPONSE TO SUBMISSIONS

Koala (*Phascolarctos cinereus*) – endangered species

Distribution

The Koala (*Phascolarctos cinereus*) occurs in a range of forest and woodland communities throughout NSW.

Habitat requirements

Habitat occupied by the Koala is associated with vegetation containing nutritionally desirous Myrtaceous species (ie preferred feed tree species) capable of maintaining a positive nitrogen balance of slightly above one percent. In this respect higher value foraging habitat is often associated with vegetation on fertile soils and reliable access to water resources for drought affected regions. Up to 120 feed tree species are known to provide suitable foliage for the Koala although the Koala is known to exhibit regional, local and seasonal preferences (TSSC, 2012).

The size of an individual Koala's home range varies in accordance with two main factors these being the abundance of preferentially utilised food trees, and gender (ie males have larger home ranges than females). Stable populations are characterised by a well-structured network of overlapping adult Koala home ranges. Landscapes exceeding 60-70 percent native vegetation cover also appear to be linked with population stability, with 150 hectares being the minimum habitat patch area supporting non-declining populations (McAlpine et al. 2006).

Males and females disperse from natal home ranges. Dispersal generally occurs between June and December, with the dispersal of males commencing in July and August and that of females commencing between September and November. Dispersal is likely to be a social behaviour and mating systems of Koala populations provide mechanisms for young Koalas to disperse (Dique et al. 2003).

Habitat in the study area

One Koala was recorded during thermal drone surveys, and scats were recorded at two locations in the Pilliga, Etoo Creek and Coolangala Creek, and at a location north-west of Gilgandra.

The Pilliga Area of Regional Koala Significance (ARKS) covers much of the alignment in the Pilliga area. It is mapped west from where Yarraman Road meets Pilliga Forest Way to the Baradine area, and also a small area near the Newell Highway. The majority of the ARKS is mapped as being of low functional habitat and low resilience. Most of the ARKS is mapped as having very high threat of impacts from wildfire, heat stress and climate change, high impact from dog attack, and moderate threat from fragmentation and vehicle strike (OEH 2019).

Surveys of the Pilliga forests in the 1990s suggested that the forests were carrying the largest population of Koalas west of the Great Dividing Range in NSW, with the numbers estimated at approximately 15,000. Koalas were most common in the western half of the central Pilliga, fairly common in West Pilliga, and least common in the eastern and southern Pilliga (Kavanagh and Barrott 2001). A combined series of more recent repeat surveys for Koalas within the Pilliga forests showed a decline of over 80 percent in both the distribution and activity of Koalas within the forests (Lunney et al. 2017). Although Koalas remain within the forests, they were found in the later surveys to be restricted to moister areas adjacent to creek lines (Kavanagh and Barrott 2001).

Logistic regression analysis found that Koalas appear to persist better in areas of the Pilliga that are closer to mapped drainage lines with deep soils and high water-holding capacity. Sites with these characteristics tend to occur in the western part of the study area (Lunney et al 2017).

The recent decline of Koalas in the Pilliga is not likely to have been the result of a single short-lived catastrophic event (eg a single heatwave) reducing numbers, but is more likely to have been the result of ongoing disturbance (eg a prolonged drought), or a series of adverse events (eg a series of heatwaves or large-scale fires) (Lunney et al 2017).

An assessment of generational persistence by Phillips (2021) identified 260.4 hectares of occupied habitat in the proposal site (predominantly located within the Pilliga forests) which has been mapped as the species polygon for the Koala.

Patchy and isolated records occur elsewhere in the Narromine and Dubbo districts, with a roadside record south of Narromine (EES 2019a).

Table M1: Assessment of significance for the Koala

Criteria	Discussion
According to the DotE (2013) 'significant impact criteria', an action is likely to have a significant impact on an endangered species if there is a real chance or possibility that it will:	
Lead to a long-term decrease in the size of a population of a species	One Koala was recorded during thermal drone surveys, and scats were recorded at two locations in the Pilliga, Etoo Creek and Coolangala Creek. Scats were also recorded at a location north-west of Gilgandra. The proposal will remove 260.4 hectares of occupied Koala habitat, comprising 257.5 ha from the Pilliga and 2.9 ha from north-west of Gilgandra. Clearing in the Pilliga will occur as a new 73 kilometre gap ranging between 40 to over 25 metres wide, with about 24 percent of the in the range between 50-60 metres wide, and averaging 89 metres wide. For parts of this length, the clearing occurs alongside Pilliga Forest Way, and would thus substantially widen the existing gap (which is currently about five metres wide), or would create two parallel gaps with small linear strip of vegetation in between. Elsewhere in the proposal site, clearing will further fragment small isolated and linear patches of potential Koala habitat. The Pilliga Koala population has undergone recent population declines as a result of logging, wildfires, drought and increased heart. Koalas now tend to occur along drainage lines with deep soils and high water-holding capacity. Sites with these characteristics tend to occur in the western part of the study area (Lunney et al 2017). The proposal would remove 260.4 hectares of habitat identified as having generational persistence, which includes these drainage lines in the south-west of the Pilliga, as well as areas in the north-east (see expert report). The direct impacts on the Pilliga population as a result of the proposal would likely occur over a long-term duration and be difficult to predict or directly attribute to the proposal given the recent decline of the population and other ongoing threats. Large areas of potential habitat currently remain in the Pilliga Forests and would continue to provide habitat for the population. Logging is not undertaken along major watercourses in the Pilliga, protecting many of these areas from clearing. An old scat was recorded at a site north-west of Gilgandra during surveys by the expert. No other evidence of Koalas was recorded between Narromine and Baradine. No Areas of Regional Koala Significance are mapped in the area and no generational persistence was identified in this area (see the expert report). Operation of the rail line would affect movement of Koalas and create a risk of mortality from train strike. Many of the creeks would be crossed by bridges, and Koalas would be able to pass safely under the rail line at these locations. Dedicated underpasses are proposed in areas of generational persistence of the Koala in the Pilliga forests. In addition, minor drainage lines would be crossed by mostly multicell culverts. Many

Criteria	Discussion
	of these are of a suitable size for Koalas to utilise to cross under the rail line. Based on the above points, the proposal may result in long-term decreases in the Koala population of the Pilliga as the proposal would exacerbate existing threats. This species has already undergone substantial reductions in population size, and the clearing of 260.4 hectares of woodland and forest habitat from an area of generational persistence in the Pilliga would remove a large area of potential habitat for this population.
Reduce the area of occupancy of an important population	The Pilliga forests cover an area of about 535,000 hectares, and comprise the single largest remaining tract of native forest and woodland in NSW west of the Great Dividing Range (Predavec 2016). The population within the Pilliga has declined dramatically since the 1990s. The proposal would remove 260.4 hectares from within the Pilliga forests that is within areas of generational persistence for this species. Clearing may fragment or reduce home ranges, and the gap created may impact movement and dispersal of individuals in these areas. As such, there is potential for the proposal to reduce the area of occupancy of the important population.
Fragment an existing population into two or more populations	This clearing will occur as a new 73 kilometre gap ranging between 40 to over 25 metres wide, with about 24 percent of the in the range between 50-60 metres wide, and averaging 89 metres wide. For parts of this length increase the existing gap smaller gap associated with Pilliga Forest Way or create a parallel gap nearby. Operation of the rail line would affect movement of Koalas and create a risk of injury and mortality from train strike. The disruption of home-ranging patterns as a result of habitat fragmentation and degradation, the loss of home-range trees and creation of barriers to movement may result in the disintegration of social structure, potentially contributing to the decline of the population (Phillips 2000). Genetic research has identified major roads as a barrier to gene flow for Koalas (Lee et al 2009; 2010). A new rail line through the Pilliga forests would create a partial barrier to movement, and may affect home ranges of individual Koalas. Elsewhere along the alignment, the proposal may fragment habitat links for Koalas seeking to access habitats either side of the rail line, although there is only limited evidence of the species outside the Pilliga (see Appendix N). Koalas may attempt to cross the rail tracks, and are at risk of rail strike, although rail traffic initially will be low, and the risk of mortality is also relatively low, although this will increase as train traffic increases over time. Koalas would currently be at some risk of vehicle strike in the Pilliga, although given the low levels of vehicle traffic at night, this risk is likely to also be low. There is likely to be ongoing mortality of Koalas as a result of the proposal, however the Koala occurs at low densities which may minimise the impact. Impacts on gene flow may be mitigated by the presence of a variety of underpasses. Many of the creeks would be crossed by bridges, and Koalas would be able to pass safely under the rail line. In total, 23 bridges creating 2.39 kilometres of underpasses would be constructed in the Pilliga. The average bridge length is 104 metres, with bridges ranging from 30 metres in length to 345 metres in length (Etoo Creek). Dedicated Koala underpasses are proposed for at least 17 locations in the mapped area of generational persistence in the Pilliga forests, and Koalas may use other dedicated culverts elsewhere in the Pilliga. In addition, minor drainage lines would be crossed by mostly multicell culverts. Many of these are of a suitable size for Koalas to utilise to cross under the rail line. Based on the above points, the proposal has the potential to fragment the population, although the ability of Koalas to cross the rail line and

Criteria	Discussion
	use underpasses created by bridges and dedicated culverts would allow continued gene flow across the proposal.
Adversely affect habitat critical to the survival of a species	Habitat in the Pilliga is considered critical to the survival of the Koala. This is due to the existence of recent records, vegetation with two or more feed trees present, presence of a large areas of contiguous habitat, and habitat present is likely to be important for achieving the interim recovery objectives (DotE 2014). The proposal would remove 260.4 hectares from within the Pilliga forests that is within areas of generational persistence for this species, and create a barrier that has the potential to reduce gene flow across the proposal site.
Disrupt the breeding cycle of a population	Koalas live in breeding aggregations, generally comprising a dominant male, a small number of mature females, as well as juveniles of various ages (Phillips 1997). The home range of koalas varies depending on the quality of the habitat and the number of available food trees. In the Pilliga State Forest of central-western NSW, the average home range is 10–15 hectares (DECC 2008). The home range of the dominant male generally overlaps extensively with the home ranges of several females (DECC 2008). Adult koalas generally exhibit long-term fidelity to their individual home range areas (Mitchell 1990). Males and females disperse from natal home ranges, with dispersal of males commencing in July and August and that of females commencing between September and November (Dique et al. 2003). Koalas are known to adjust home ranges in response to road construction (AMBS 2011) and move away from noise associated with music festival (Phillips 2016), and this is likely to also occur during rail construction. Clearing would likely affect a single breeding cycle of Koalas along the alignment if Koalas are using the proposal site for breeding. Removal of habitat would permanently affect breeding habitat in the proposal site, however large areas of habitat are present in adjacent areas. Dispersal events would be affected throughout operation, as the rail line would create a semi-permeable barrier to movement, but train noise may also affect movement and dispersal in the long-term. Impacts on movement may be mitigated by the presence of a variety of underpasses, including bridges and culverts. Bridges in particular would provide safe crossing opportunities as they cover a wide expanse. Culverts are spread throughout the alignment in the Pilliga, and a high proportion of these are of a suitable size for Koalas to utilise to cross under the rail line. Based on the above information, the proposal may impact breeding of individual Koalas that occur near the proposal site, and could impact the local population due to barrier effects of the proposal.
Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	The proposal would remove 260.4 hectares of known habitat, comprising 257.5 hectares from the Pilliga and 2.9 hectares from north-west of Gilgandra. This clearing will occur as a new linear ranging between 40 - over 200 metres wide through the forest. For parts of this length, the clearing occurs alongside or near Pilliga Forest Way, and would thus widen the existing gap by another five metres, or create a second gap in close proximity to this existing gap. In the north-east of the Pilliga forests, the proposal is not located parallel to roads. Elsewhere in the proposal site, clearing will further fragment small isolated and linear patches of potential Koala habitat. This large area of clearing and fragmentation would further reduce the availability of habitat, particularly in the Pilliga, and may further add to the decline of the species.

Criteria	Discussion
Result in invasive species that are harmful to a vulnerable species becoming established in the endangered species' habitat	Introduction of weeds is of particular concern in the Pilliga forests as they can reduce quality of vegetation and thus impact fauna and flora habitats. Weeds such as the Tiger Pear, which is currently common in the Pilliga, may pose an infection risk to Koalas, and further spread of this weed through the alignment would further impact habitat for the Koala. Predator species have been shown to prefer moving down linear clearings, and therefore, clearings could increase predation risk for other species (Dawson et al 2017). The creation of a 73 kilometres linear gap through the Pilliga may increase the risk of fox predation on Koalas. There is little risk of establishment of predators elsewhere in the alignment as a result of the proposal.
Introduce disease that may cause the species to decline	The decline in Koala numbers in the Pilliga and Gunnedah areas post 2006 coincided with a significant heatwave experienced in the region in 2009. This extreme weather event saw above average temperatures in the region, and importantly the high temperatures occurred over strings of successive days rather than simply isolated days. The weather event saw an estimated 25 percent of the Koala population of the Gunnedah region die and an increase in the expression of symptoms of Chlamydia infection (Lunney et al., 2012). While the proposal is unlikely to introduce disease, further threats including clearing of habitat and impacts on movement may further affect Koala resilience. This could similarly lead to an increase in expression of symptoms of Chlamydia infection, further impacting the health of the remaining population.
Interfere substantially with the recovery of the species	Loss, fragmentation and degradation of habitat are the most important threats to Koalas throughout their range. The disruption of home-ranging patterns as a result of habitat fragmentation and degradation, the loss of home-range trees and creation of barriers to movement may result in the disintegration of social structure, potentially contributing to the decline of the population (Phillips 2000). The proposal will remove 260.4 hectares of occupied Koala habitat from within the Pilliga forests, which is regionally significant habitat for the species. The construction and operation of the rail line will fragment habitat and create a barrier to movement. Some Koalas would likely cross the tracks or use bridges and culverts to cross under the rail line, and thus gene flow across the proposal site is likely to continue. Despite, this, there is likely to be impacts on dispersing individuals, and some individuals may have their home range fragmented. Given the large area of regionally significant habitat that would be removed, the proposal may interfere with the recovery of the Koala.
Conclusion	The proposal is likely to have a significant impact on the Koala given: • 260.4 hectares of occupied would be removed, comprising 257.5 hectares from within the Pilliga forest, which is regionally significant for the species and an area where the species is in decline due to fire and drought, and 2.9 hectares from north-west of Gilgandra. • The proposal would further fragment habitat through widening of gaps in vegetation elsewhere along the alignment • The proposal would create a barrier to movement, although there would be opportunities for Koalas to cross safely under the rail line along riparian areas via bridges and culverts • Koalas would be at risk of mortality through train strike, although this would be mitigated by the presence of bridges and culverts.

Pilliga Mouse (*Pseudomys pilligaensis*) – vulnerable species

Distribution

The Pilliga Mouse is restricted to the Pilliga forests and Timallallie National Park. There is one record from the Warrumbungles National Park (EES 2019a).

Habitat requirements

Within the Pilliga region this species is largely restricted to low-nutrient deep sand soils which are recognised as supporting a distinctive vegetation type referred to as the Pilliga Scrub (EES 2019b). It appears to prefer areas with sparse ground cover (EES 2019b). It is nocturnal, seeking refuge in burrows (EES 2019b).

The Pilliga Mouse is found in greatest abundance in recently burnt moist gullies, areas dominated by Broombush (*Melaleuca uncinata*) and areas containing an understorey of *Acacia burrowii* with a *Corymbia trachyphloia* overstorey. Consistent features of the latter two habitats were: a relatively high plant species richness; a moderate to high low-shrub cover; site moisture retention; and groundcover of plants, litter and fungi. Areas with high rates of capture have extensive low grasses and sedges, with little shrub cover and large areas of ash-covered ground (Fox & Briscoe 1980; NSW DECC 2005ad; Tokushima et al. 2008).

Studies suggest that its population erupts when environmental conditions are favourable before suddenly declining (Tokushima et al. 2008).

Habitat in the study area

Broadly suitable foraging habitat occurs throughout the Pilliga forests (Paull et al 2014), but the species distribution is influenced by site specific factors, including local floristic variation, and different disturbance and fire histories across the forest.

The potential distribution of 'important habitat' for the Pilliga Mouse was mapped by Paull et al (2014) based on floristic and structural preferences and presented as a predictive map. Much of this habitat is located to the south-east of the proposal site in the Pilliga, with some to the north-west. Much of the alignment appears to pass through gaps in important habitat, however the proposal would impact some areas mapped by Paull et al (2014).

The proposal will remove a total of 647.1 hectares of woodland and shrubland from within the Pilliga forests, which is potential habitat for the Pilliga Mouse, including 29 hectares of PCT 141, a preferred breeding habitat, and 466.7 hectares of PCTs that contain *Acacia burrowii* and *Corymbia trachyphloia*, also identified as habitat for this species.

Table M2: Assessment of significance for the Pilliga Mouse

Criteria	Discussion
According to the DotE (2013) 'significant impact criteria', an action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that it will:	An 'important population' is a population that is necessary for a species' long-term survival and recovery. The Pilliga Mouse population is considered an 'important population' as the species only occurs in the Pilliga area.
Lead to a long-term decrease in the size of an important population of a species	Broadly suitable habitat occurs throughout the Pilliga forests, but the species distribution is influenced by site specific factors, including local floristic variation, and different disturbance and fire histories across the forest (Paull et al 2014). Some patches of PCT 141 Broombush (*Melaleuca uncinata*) have been found to sustain breeding animals and all-year occupancy, however some patches do not, and this is likely due to fire history, with young (1.5-3) year regrowth and old regrowth (>25 years) selected preferentially by the species (Paull et al 2014). The proposal will remove a total of 647.1 hectares of woodland and shrubland from within the Pilliga forests, which is potential habitat for the Pilliga Mouse, including 30 hectares of PCT 141, a preferred breeding habitat, and 466.7 hectares of PCTs that contain *Acacia burrowii* and *Corymbia trachyphloia*, also identified as habitat for this species. This clearing will occur as a new 73 kilometres linear gap through the forest. For parts of this length, the clearing occurs alongside or near Pilliga Forest Way, and would thus further widen the existing gap, or create two parallel gaps with small patches of vegetation in between. The potential distribution of 'important habitat' for the Pilliga Mouse was mapped by Paull et al (2014) based on floristic and structural preferences of the Pilliga Mouse and was presented as a predictive map. Much of this habitat is located to the south-east of the proposal site in the Pilliga, with some to the north-west. Much of the alignment appears to pass through gaps in important habitat, however the proposal would impact some areas mapped by Paull et al (2014). The Pilliga Mouse is terrestrial and lives in burrows and is at high risk of injury and mortality during construction. The proposal will result in the clearing of a large area of potential habitat in the Pilliga, and would create a gap that may impact movement of individuals, and thus may impact gene flow between areas of important habitat. The proposal has the potential to lead to a long-term decrease in the size of the important population.
Reduce the area of occupancy of an important population	The extent of possible habitat for the Pilliga Mouse covers some 106,800 hectares in the Pilliga State Forest and State Conservation Areas at any one time, although not all of this area would actually be suitable as important habitat due to local floristic variation and different disturbance and fire histories across the forest (Paull et al 2014). Milledge (2011) showed that within a broad area identified as possible habitat only 20 percent on average was suitable for the Pilliga Mouse. The proposal will remove a total of 647.1 hectares of woodland and forest from within the Pilliga forests, and 31 hectares of PCT 141, which has been shown to support breeding and provides year-round occupancy. This clearing will occur as a new 73 kilometres x 40 to over 250 metres wide linear gap through the forest, and would exacerbate existing clearings such as Pilliga Forest Way. The proposal is likely to reduce the area of occupancy given the large amount of vegetation clearing within potential and known habitat.

Criteria	Discussion
Fragment an existing important population into two or more populations	The proposal will clear a new 73 kilometre gap ranging between 40 to over 25 metres wide, with about 24 percent of the in the range between 50-60 metres wide, and averaging 89 metres wide, and will increase the existing gap associated with Pilliga Forest Way in some locations. Operation of the rail line may affect movement of the Pilliga Mouse and create a risk of injury and mortality from train strike. Paull et al (2014) mapped areas of important habitat for the species. The majority of important habitat occurs south-east of the proposal site and east of the Newell Highway, however areas do occur to the north-west of the rail line. The Newell Highway is a major barrier between the eastern and western portions of the areas of important habitat. The proposal would create another major barrier for areas to the north-west and could fragment the important population into two or more populations. Impacts on gene flow may be mitigated by maintaining habitat connectivity through the construction of a variety of underpasses. Dedicated culverts will be located in PCT 141 to provide targeted crossing points for this species. Their size and number will be determined during detailed design. The species may also utilise the many bridges, other dedicated fauna culverts and drainage culverts to cross under the rail line. Tokushima and Jarman (2008) measured average movement distances of 50 metres (range 0–181 metres) for recaptured individuals, however, larger movement patterns cannot be disregarded, particularly during dispersal. Most culverts in the Pilliga would be 7.3 metres wide (perpendicular to the rail). One crossing loop is located in the Pilliga and culverts in this location would be 18.3 metres wide. Based on the average movement distances, this species is likely to be able to cross the rail line using culverts as 7.3 metres is well within the average movement distance of the species, however crossings depend on the willingness of the species to use culverts. Monitoring of culverts is recommended to assess usage and efficacy of the structures. Revegetation is proposed at culverts to encourage use by fauna. For many small- and medium-sized mammals drainage culverts can mitigate the potentially harmful effects of transport corridors by providing a vital habitat linkage (Clevenger et al 2002). A variety of predators have been found using wildlife passages regularly, for movement or as part of their territories, and this has been suggested as evidence of hunting behaviour or higher predator concentration at underpasses. Little et al (2002) found no evidence of passages commonly being exploited as prey-traps, however, no studies specifically examined predation rates in or near passages compared to areas further away. The potential for predators to use the rail corridor as a means of moving through the area, and their use of culverts may increase the risk of predation for the Pilliga Mouse.
Adversely affect habitat critical to the survival of a species	The potential distribution of “important habitat” for the Pilliga Mouse was mapped by Paull et al (2014) based on floristic and structural preferences and presented as a predictive map. Much of this habitat is located to the south-east of the proposal site in the Pilliga, with some to the north-west. Much of the alignment appears to pass through gaps in important habitat, however the proposal would impact some areas mapped by Paull et al (2014). The proposal has the potential to create a barrier to movement between areas of important habitat, although culverts and bridges may assist in retaining connectivity.

Criteria	Discussion
Disrupt the breeding cycle of an important population	The peak breeding season occurs from October to April. Studies suggest that its population erupts when environmental conditions are favourable before suddenly declining (Tokushima et al. 2008). A significant correlation between numbers of Pilliga Mice, in particular breeding sites and a well-developed low shrub cover < 50 centimetres high was observed by Paull (2009). Habitats having this type of cover, in particular Broombush and Kurricabah/Bloodwood scrublands were the only habitats where burrows of this species were detected. Pilliga Mice showed a preference for early and late post-fire stages of vegetation and an avoidance of intermediate age habitats post fire (5-15 years old) probably due to an absence of suitable low shrub cover in this age class (Paull 2009). Construction and operation of the proposal may potentially have an impact on the breeding cycle over the longer term if the proposal affects the species' ability to move between preferred and important habitat areas. Is unlikely to affect the breeding cycle of the important population, other than for a single season during construction for individuals that may occur near the rail line.
Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	The proposal will remove a total of 647.1 hectares of woodland and shrubland from within the Pilliga forests, including 31 hectares of PCT 141, which is important breeding habitat for the species, and 466.7 hectares of PCTs that contain *Acacia burrowii* and *Corymbia trachyphloia*, also identified as habitat for this species. This clearing will occur as a new 73 kilometre long linear gap through the forest. In some locations this would be adjacent to the existing five metres wide gap created by Pilliga Forest Way, while in other locations two parallel gaps would be created with linear strips of vegetation in between. Habitat for the Pilliga Mouse is not homogenous through the forest, and occurs as small patches depending on disturbance history. The proposal would fragment areas of preferred habitat and reduce their size. For much of the alignment through the Pilliga, the clearing occurs alongside Pilliga Forest Way, and would thus substantially widen the existing gap. Elsewhere in the proposal site, clearing will further fragment small isolated and linear patches of potential Pilliga Mouse habitat. The rail line would create a hostile gap and has the potential to limit gene flow across the rail line. At least 18 dedicated culverts are proposed for areas of potential breeding habitat. In addition, the 23 bridges, other dedicated fauna culverts and 130 drainage culverts spread along the alignment in the Pilliga would mitigate this if they are located in habitat of relevance and if the Pilliga Mouse uses them. This large area of clearing and fragmentation would further reduce the availability of habitat, particularly in the Pilliga, and may further add to the decline of the species.

Criteria	Discussion
Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat	Introduction of weeds is of particular concern in the Pilliga forests as they can reduce quality of vegetation and thus impact fauna and flora habitats. Weeds such as the Tiger Pear, are already common in the Pilliga, and may be further spread during construction. Operation of the proposal has the potential to spread weeds and pests into the Pilliga. The surroundings of railways (eg verges and embankments) often host a high diversity of non-native species (Gelbard and Belnap 2003; Hansen and Clevenger 2005), in many cases due to their transportation as stowaways in or on trains. Predation by feral species may be a threat to this species. Predator species have been shown to prefer moving down linear clearings, and therefore, clearings could increase predation risk for other species (Dawson et al 2017). The creation of a 73 kilometres linear gap through the Pilliga may increase the risk of fox and cat predation. There is little risk of establishment of predators elsewhere in the alignment as a result of the proposal.
Introduce disease that may cause the species to decline	The proposal is unlikely to introduce disease into the Pilliga that may cause the species to decline.
Interfere substantially with the recovery of the species	The Pilliga Mouse is predominantly restricted to the Pilliga, and located in areas subject to habitat loss and disturbance as a result of logging and gas exploration activities. Removal of habitat and predation by feral predators are significant threats to this species. The proposal will remove a total of 647.1 hectares of woodland and forest that is potential habitat for the species, including 31 hectares of PCT 141 and 466.7 hectares of PCTs that contain *Acacia burrowii* and *Corymbia trachyphloia*. This clearing will occur as a new 73 kilometres x 50 metres wide linear gap through the forest, exacerbating current fragmentation and further reducing habitat connectivity. Given the large area of clearing within the Pilliga, the proposal has the potential to interfere substantially with the recovery of the species.
Conclusion	The proposal is likely to have a significant impact on the Pilliga Mouse as: • The proposal will remove a total of 647.1 hectares of woodland and shrubland from within the Pilliga forests, which is potential habitat for the species, including 31 hectares of PCT 141 (preferred breeding habitat) and 466.7 hectares of PCTs that contain *Acacia burrowii* and *Corymbia trachyphloia*, also identified as habitat for this species. • This clearing will occur as a new 73 kilometres x 50 metres wide linear gap through the forest, impacting connectivity of habitat, and will exacerbate existing clearing and fragmentation already present in the forest. • The linear gap through the Pilliga may increase the risk of fox and cat predation by facilitating predator movements. • Small patches of preferred breeding and foraging habitat would become fragmented and isolated. • While culverts and bridges would provide some connectivity, there is likely to be a reduction in gene flow across the rail line.

Corben's Long-eared Bat (*Nyctophilus corbeni*) – vulnerable species

Distribution

Distribution of the species coincides approximately with the Murray Darling Basin, with the Pilliga Scrub region being the distinct stronghold for this species (EES 2019b).

Habitat requirements

Corben's Long-eared Bat inhabits a variety of vegetation types, including mallee, Bulloke (*Allocasuarina leuhmanni*) and box eucalypt dominated communities, but it is distinctly more common in box/ironbark/cypress-pine vegetation that occurs in a north-south belt along the western slopes and plains of NSW and southern Queensland. It roosts in tree hollows, crevices, and under loose bark (EES 2019b). The species avoids roosting in commercially thinned stands and selected old regrowth (Law et al 2016) and prefers larger remnants with a well-developed understorey (Turbill and Ellis 2006).

Habitat in the study area

One individual was trapped at Coolangala Creek (Trap site 1) in the Pilliga during surveys for the proposal. Calls of *Nyctophilus* species were also recorded at Rocky Creek (Trap site 6) and Trap Site 5 in the Pilliga, and sites near Narromine, although the precise species cannot be determined by Anabat analysis. The Lesser Long-eared bat (*N. geoffroyi*) was also trapped in the Pilliga and near Gilgandra during surveys.

Table M3: Assessment of significance for Corben's Long-eared Bat

Criteria	Discussion
According to the DotE (2013) 'significant impact criteria', an action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that it will:	An 'important population' is a population that is necessary for a species' long-term survival and recovery. Corben's Long-eared Bat has a scattered distribution mostly within the Murray-Darling Basin, with its stronghold occurring in the Pilliga Scrub (EES 2019b). As such, the population that occurs in the Pilliga area is considered an important population.
Lead to a long-term decrease in the size of an important population of a species	Construction would require the permanent removal of a maximum area of 1,107.4 hectares of potential habitat, including 615 hectares of forest and woodland habitat from the Pilliga. An estimated 14,503 - 41,103 hollow-bearing trees are likely to be removed, which are a critical breeding component of this species' habitat. Clearing of this forest and woodland vegetation would permanently remove foraging and breeding resources for Corben's Long-eared Bat. Clearing of vegetation has the potential to result in significant mortality of roosting individuals given the high number of hollow-bearing trees that would be removed. The Pilliga forests cover an areas of about 535,000 hectares, and comprise the single largest remaining tract of native forest and woodland in NSW west of the Great Dividing Range (Predavec 2016). While the proposal would remove a large area of habitat for this species, this is a small proportion of available habitat in the Pilliga area. Given the Pilliga is considered a stronghold for the species, the loss of 1,107.4 hectares of eucalypt woodland and forest and 14,503 - 41,103 hollow-bearing trees are likely to lead to a long-term decrease in the size of an important population of a species.

Criteria	Discussion
Reduce the area of occupancy of an important population	Corben's Long-eared Bat is known from a large area of central NSW, within the Murray-Darling Basin. The loss of 1,107.4 hectares of habitat along 300 kilometres alignment would not reduce the area of occupancy of the important population.
Fragment an existing important population into two or more populations	The proposal will create a new linear gap through the Pilliga forests, exacerbating the existing impacts on connectivity created by Pilliga Forest Way and the Newell Highway. Corben's Long-eared Bat is a slow flying agile bat, utilising the understorey to hunt non-flying prey. This species is at risk of injury and mortality from train strike during operation of the rail line. Given the low numbers of trains that would travel through the Pilliga at night, and the large areas of available habitat, this risk is considered to be relatively low. Given the mobility of the species and large area of available habitat, the proposal is unlikely to fragment an existing important population into two or more populations.
Adversely affect habitat critical to the survival of a species	This species inhabits a range of vegetation types, and is more common in box/ironbark/cypress-pine vegetation that dominates the Pilliga area. Habitat critical to its survival comprises hollow-bearing trees, which are a limiting resource. Logging and wildfires have impacted the availability of hollow-bearing trees. The proposal would clear 1,107.4 hectares of eucalypt woodland and forest habitat, including an estimated 14,503 - 41,103 hollow-bearing trees. Given the large numbers of hollow-bearing trees that would be removed, and the large extent of foraging habitat from within the Pilliga, which is the species' stronghold, the proposal is likely to adversely affect habitat critical to the survival of a species.
Disrupt the breeding cycle of an important population	Corben's Long-eared Bat mates in autumn, and young are born in late spring to early summer. Hollow-bearing trees are required for breeding. Construction would remove a significant number of hollow-bearing trees from an area of habitat which represents a stronghold for the species. Noise from construction may impact breeding success in adjacent areas for one breeding season, and train traffic would create a novel noise in the Pilliga forests and elsewhere which would create a novel noise impact and could disrupt breeding near the proposal. Given these points, the proposal is likely to disrupt a single breeding cycle of the important population.
Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	Construction would require the permanent removal of a maximum area of 1,107.4 hectares of eucalypt woodland and forest habitat, including a significant number of hollow-bearing trees. Clearing of this forest and woodland vegetation would permanently remove foraging and breeding resources for Corben's Long-eared Bat, and would have a substantial impact on the species' stronghold of the Pilliga forests. Clearing of vegetation has the potential to result in significant mortality of roosting individuals given the high number of hollow-bearing trees that would be removed. This species is at risk of injury and mortality from train strike during operation of the rail line. Given the low numbers of trains that would travel through the Pilliga at night, and the large areas of available habitat, this risk is considered to be relatively low. Given the large area of habitat and significant number of hollow-bearing trees to be removed, the proposal has the potential to lead to a decline of the species.

Criteria	Discussion
Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat	Introduction of weeds is of particular concern in the Pilliga forests as they can reduce quality of vegetation and thus impact fauna and flora habitats. Operation of the proposal has the potential to spread weeds and pests into the Pilliga. Introduction and spread of weeds is unlikely to substantially impact foraging habitat for this species. Predator species have been shown to prefer moving down linear clearings, and therefore, clearings could increase predation risk for other species (Dawson et al 2017). The creation of a 73 kilometres long linear gap through the Pilliga may increase the risk of fox and cat predation, although this risk would be low for this species. There is little risk of establishment of predators elsewhere in the alignment as a result of the proposal.
Introduce disease that may cause the species to decline	The proposal is unlikely to introduce disease into the Pilliga that may cause the species to decline.
Interfere substantially with the recovery of the species	The key threats to the viability of this species are loss, fragmentation and degradation of habitat. The proposal would clear 11,107.4 hectares of eucalypt woodland and forest habitat, including a significant number of hollow-bearing trees, which are a critical component of this species' habitat. A large area of habitat (615 hectares) would be removed from the species' stronghold in the Pilliga. The proposal therefore has the potential to interfere with the recovery of the species.
Conclusion	The proposal is likely to have a significant impact on Corben's Long-eared Bat as: • Construction would require the permanent removal of a maximum area of 1,107.4 hectares of eucalypt woodland and forest habitat, with 615 hectares of this clearing occurring in the species' stronghold in the Pilliga • An estimated 14,503 - 41,103 hollow-bearing trees would be removed. Hollow-bearing trees are a limiting resource essential for breeding, and logging and fire have already affected their density in the forest. • Clearing of vegetation has the potential to result in significant mortality of roosting individuals given the high number of hollow-bearing trees that would be removed within the species habitat stronghold. • Operation of trains has the potential to result in mortality from train strike, although this risk is low due to the low number of trains likely to pass through the forest at night.

Large-eared Pied Bat (*Chalinolobus dwyeri*) – vulnerable species

Distribution

The Large-eared Pied Bat is found mainly in areas with extensive cliffs and caves, from Rockhampton in Queensland south to Bungonia in the NSW Southern Highlands. It is generally rare with a very patchy distribution in NSW. There are scattered records from the New England Tablelands and North West Slopes (EES 2019b).

Habitat requirements

The Large-eared Pied Bat roosts in caves (near their entrances), crevices in cliffs, old mine workings and in the disused, bottle-shaped mud nests of the Fairy Martin (*Petrochelidon ariel*), frequenting low to mid-elevation dry open forest and woodland close to these features. Three communal maternity roosts are known from caves in the Pilliga Sandstone region (Pennay 2008), including sandstone outcrops in Pilliga Nature Reserve, about 35 kilometres to the east of Baradine.

Almost all records of the species are within several kilometres of cliff lines or rocky terrain, in fertile wooded valley habitat. This species has been recorded foraging in a range of vegetation types, including dry and wet sclerophyll forest, grassy woodland, Callitris dominated forest, tall open eucalypt forest with a rainforest sub-canopy, sub-alpine woodland and sandstone outcrop country (DERM 2011). Wing morphology suggests that it is a relatively slow-flying manoeuvrable species that forages predominantly below the canopy.

Habitat in the study area

Anabat surveys of six sites in the Pilliga by Law et al (2011) recorded only one call of this species over 920 hours of sampling. No individuals were trapped.

During the March 2019 surveys in the Pilliga for the proposal, probable calls of this species were recorded at Coolangala Creek (Trap site 1). No other evidence of this species was recorded along the alignment.

The Large-eared Pied Bat would forage in the Pilliga, particularly where forested habitat is in close proximity to sandstone outcrops. No sandstone outcrops suitable for breeding are located within two kilometres of the alignment.

Table M4: Assessment of significance for the Large-eared Pied Bat

Criteria	Discussion
According to the DotE (2013) 'significant impact criteria', an action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that it will:	An 'important population' is a population that is necessary for a species' long-term survival and recovery. The population associated with sandstone caves of the Pilliga is considered an important population.
Lead to a long-term decrease in the size of an important population of a species	The proposal would not impact any breeding or roosting habitat. No sandstone caves with dome roofs occur within two kilometres of the proposal site. Sandstone caves are known from Dandry Gorge and Pilliga Nature Reserve, about 35 kilometres to the east of Baradine. During the March 2019 surveys in the Pilliga for the proposal, probable calls of this species were recorded at Coolangala Creek. No other evidence of this species was recorded along the alignment. The proposal is located well away from sandstone caves and fertile wooded valley habitat. Occasional individuals may forage along the

Criteria	Discussion
	alignment. The proposal would remove 654 hectares of forested habitat, including 46 hectares of riparian habitat from within the Pilliga forests. This is not considered preferred habitat given the distance from sandstone caves. Given there would be no impact on roosting and breeding habitat, and potential foraging habitat to be removed is not located near sandstone cliffs and fertile wooded valley habitat within close proximity of each other, the proposal is unlikely to lead to a long-term decrease in the size of an important population of a species.
Reduce the area of occupancy of an important population	The large-eared pied bat is known from Shoalwater Bay, north of Rockhampton, QLD, south to the vicinity of Ulladulla in NSW, and west to the Pilliga (DERM 2011). The removal of a narrow linear area of habitat from within the Pilliga would not reduce the area of occupancy of the important population
Fragment an existing important population into two or more populations	The proposal will create a new linear gap through the Pilliga forests, exacerbating the existing impacts on connectivity created by Pilliga Forest Way and the Newell Highway. The Large eared Bat is a slow flying agile bat that forages below the canopy (DERM 2011). This species is at risk of injury and mortality from train strike during operation of the rail line. Given the low numbers of trains that would travel through the Pilliga at night, and the large areas of available habitat, this risk is considered to be relatively low. Given the mobility of the species and large area of available habitat, the proposal is unlikely to fragment an existing important population into two or more populations.
Adversely affect habitat critical to the survival of a species	The structure of maternity roosts appears to be very specific (arch caves with dome roofs). Caves need to be high and deep enough to allow juvenile bats to learn to fly safely inside and have indentations in the roof. Roosting bats cluster in these indentations, presumably to allow the capture of heat. These physical characteristics are very uncommon in the landscape and their scarcity presumably poses an important limiting factor in the distribution of the large-eared pied bat (Pennay 2008, DERM 2011) Sandstone cliffs and fertile wooded valley habitat within close proximity of each other should be considered habitat critical to the survival of the large-eared pied bat (DECC 2007). There would be no impact on roosting and breeding habitat, and potential foraging habitat to be removed is not located near sandstone cliffs and fertile wooded valley habitat within close proximity of each other. As such, the proposal would not adversely affect habitat critical to the survival of this species.
Disrupt the breeding cycle of an important population	Females have been recorded raising young in maternity caves (c. 20-40 females) from November through to January. They remain loyal to the same cave over many years (DERM 2011). The proposal would not impact any maternity caves or roost sites, and is unlikely to impact the movement of this species between breeding, roosting and foraging areas. As such, the proposal is unlikely to disrupt the breeding cycle of an important population.
Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	The proposal is located well away from sandstone caves and fertile wooded valley habitat. Occasional 654 may forage along the alignment. The proposal would remove 585 hectares of forested habitat, including 46 hectares of riparian habitat from within the Pilliga forests. This is not considered preferred habitat given the distance from sandstone caves. This species is at risk of injury and mortality from train strike during operation of the rail line. Given the low numbers of trains that would

Criteria	Discussion
	travel through the Pilliga at night, and the large areas of available habitat, this risk is considered to be relatively low. Given there would be no impact on roosting and breeding habitat, and potential foraging habitat to be removed is not located near sandstone cliffs and fertile wooded valley habitat within close proximity of each other, the proposal is unlikely to lead to a long-term decline of the species.
Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat	Introduction of weeds is of particular concern in the Pilliga forests as they can reduce quality of vegetation and thus impact fauna and flora habitats. Operation of the proposal has the potential to spread weeds and pests into the Pilliga. Introduction and spread of weeds is unlikely to substantially impact foraging habitat for this species. Predator species have been shown to prefer moving down linear clearings, and therefore, clearings could increase predation risk for other species (Dawson et al 2017). The creation of a 73 kilometres linear gap through the Pilliga may increase the risk of fox and cat predation, although this risk would be low for this species. Given the lack of breeding habitat near the alignment, the risk of impact from feral predators is negligible.
Introduce disease that may cause the species to decline	The proposal is unlikely to introduce disease into the Pilliga that may cause the species to decline.
Interfere substantially with the recovery of the species	The overall objective of the recovery plan for the Large-eared Pied Bat is to ensure the persistence of viable populations throughout its geographic range. Important actions comprise protection of maternity roosts (DERM 2011). Given there would be no impact on roosting and breeding habitat, and potential foraging habitat to be removed is not located near sandstone cliffs and fertile wooded valley habitat within close proximity of each other, the proposal is unlikely to interfere substantially with the recovery of the species.
Conclusion	The proposal is unlikely to result in a significant impact on the Large-eared Pied Bat as: • There would be no impact on roosting and breeding habitat • Potential foraging habitat to be removed is not preferred habitat (not located near sandstone cliffs and fertile wooded valley habitat within close proximity of each other) • While this species is at risk of injury and mortality from train strike during operation of the rail line, this risk is considered to be relatively low given the low numbers of trains that would travel through the Pilliga at night, and the large areas of available habitat. • Clearing of a 50 metres wide gap in the forest (and exacerbation of the existing gap) would not affect movement between foraging and breeding and roosting habitat.

Five-clawed Worm-skink (*Anomalopus mackayi*) – vulnerable species

Distribution

The Five-clawed Worm-skink has a patchy distribution on the North West Slopes and Plains of north-east NSW and south-east Queensland (EES 2019b). The species' known distribution in NSW is confined to the Namoi River and Gwydir River floodplains and the lower north-western slopes of the Great Dividing Range (DEE 2019b).

Habitat requirements

The Five-clawed Worm-skink is found in open woodland areas with low grass cover (usually between 5 to 10 centimetres) and scattered eucalypts, generally supported by redblack to black clay-loam soils (NPWS 1999). It occurs close to or on the lower slopes of slight rises in grassy White Box woodland on moist black soils, and River Red Gum-Coolibah-Bimble Box woodland on deep cracking loose clay soils (EES 2019b). Individuals also occur in open grassy paddocks with scattered eucalypts and moist black soil (NPWS 1999). It uses fallen logs and timber as sheltering sites and digs in loose soil to create permanent tunnel-like burrows (NPWS 1999).

The species shelters at the soil surface where moisture is sufficiently retained under decaying leaf litter, coarse woody debris or artificial debris. The species also lives in cavities in rotting tree bases, logs and in tussock bases.

Habitat in the study area

Scattered records of the Five-clawed Worm-skink occur from the Narrabri area north (EES 2019a). Limited areas of potential habitat occur in the proposal site given the clearing for agriculture and industry in this area.

Grey, Brown and Red clays occur north from the Namoi River (chainage 845.3 – 850.5), and Black Earths occur in the vicinity of Killarney Gap Road (chainage 850.5-852.0). About 6.7 kilometres of the proposal intersects with appropriate soil profiles for this species.

North of Wee Waa Road the proposal is predominantly located in cropped or highly modified land with minimal connectivity to areas of better quality habitat. The Five-clawed Worm-skink is highly unlikely to persist in this area.

South of Wee Waa Road, the proposal passes through cropped or highly modified land, as well as areas of PCT 78 River Red Gum riparian tall woodland, PCT 619 Derived Wire Grass grassland, and PCT 168 Derived Copperburr shrubland. Given the lower intensity of farming and presence of some remnant vegetation and paddock trees, there is potential for this species to occur. The Narrabri bridge will be located from north of Wee Waa Road south to Yarrie Lake Road (the Namoi River floodplain), and will cross about 2.73 kilometres of this area of potential habitat (ie all habitat south of Narrabri Creek), with an impact area of 7.27 hectares. This bridge will span agricultural land, and of the 7.27 hectares of native grassland located under the bridge, only 0.08 hectares would be directly impacted by the piers, and of the 1.51 hectares of riparian woodland located under the bridge, 0.04 hectares would be directly impacted by the piers. As such, connectivity of habitat will be retained in this area, although construction of piers would remove some potential habitat.

Targeted searches were conducted in the Narrabri area during preliminary geotechnical surveys in April 2021. No Five-clawed Worm-skinks were recorded during supervision of works.

Table M5: Assessment of significance for the Five-clawed Worm-skink

Criteria	Discussion
According to the DotE (2013) 'significant impact criteria', an action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that it will:	An 'important population' is a population that is necessary for a species' long-term survival and recovery. Given that this species is difficult to detect and population information is limited, important habitat is taken as a surrogate for important populations. Important habitat includes habitat near the limit of the species' known range (DSEWPAC 2011). Given the proposal is located at the southern edge of the species' range and there are records in the Narrabri area, an important population is considered likely to be present in the proposal site.
Lead to a long-term decrease in the size of an important population of a species	On the floodplains within its range in north-eastern NSW, the Five-clawed Worm-skink occurs in grasslands and grassy, open woodlands on heavy black and grey, alluvial cracking clay soils. All suitable habitat within floodplains and riparian zones, uncultivated grassy headlands and strips between cropped areas, road reserves, travelling stock routes and remnant vegetation on vacant lands is considered important habitat for this species (DSEWPAC 2011). Potential habitat for the species is present in the Narrabri area. Grey, Brown and Red clays occur north from the Namoi River (chainage 845.3 – 850.5), and Black Earths occur in the vicinity of Killarney Gap Road (chainage 850.5-852.0). About 6.7 kilometres of the proposal intersects with appropriate soil habitat for this species. North of Wee Waa Road the proposal is predominantly located in cropped or highly modified land with minimal connectivity to areas of better quality habitat. The Five-clawed Worm-skink is highly unlikely to persist in this area. South of Narrabri Creek, the proposal passes through cropped or highly modified land, as well as areas of PCT 78 River Red Gum riparian tall woodland, PCT 619 Derived Wire Grass grassland, and PCT 168 Derived Copperburr shrubland. Given the lower intensity of farming and presence of some remnant vegetation and paddock trees, there is potential for this species to occur. The Narrabri bridge will be located from north of Wee Waa road south to Yarrie Lake Road (the Namoi River floodplain), and will cross about 2.73 kilometres of this area of potential habitat south of Narrabri Creek, with an impact area of 7.27 hectares. This bridge will span agricultural land, and of the 0.6 hectares of native grassland located under the bridge, only 0.08 hectares would be directly impacted by the piers, and of the 1.51 hectares of riparian woodland located under the bridge, 0.04 hectares would be directly impacted by the piers. As such, connectivity of habitat will be retained in this area, although construction of piers would remove some potential habitat. Given the low potential for the species to occur north of Narrabri Creek, small area of potential habitat south of Narrabri Creek and retention of most of this habitat south of Narrabri Creek under the bridge, the proposal is unlikely to lead to a long-term decrease in the size of an important population of a species.
Reduce the area of occupancy of an important population	The species' known distribution in NSW is confined to the Namoi River and Gwydir River floodplains and the lower north-western slopes of the Great Dividing Range. The proposal will impact up to 2.03 hectares of potential habitat for this species in the Narrabri area. Much of the land to be impacted at this location is cropped or highly modified, and the use of an almost four kilometres bridge will allow retention of habitat and connectivity south of Narrabri Creek.

Criteria	Discussion
	The proposal is therefore unlikely to reduce the area of occupancy of an important population.
Fragment an existing important population into two or more populations	The proposal is located at the southern edge of the species' known range. North of Wee Waa Road the proposal is predominantly located in cropped or highly modified land with minimal connectivity to areas of better quality habitat. The Five-clawed Worm-skink is highly unlikely to persist in this area. The Narrabri bridge will be located from north of Wee Waa road south to Yarrie Lake Road, and will cross about 2.73 kilometres of this area of potential habitat (ie all habitat south of Narrabri Creek). As such, connectivity of habitat will be retained in this area, although construction of piers would remove some potential habitat. Given the low potential for the species to occur north of Narrabri Creek, and retention of habitat south of Narrabri Creek, the proposal is unlikely to fragment an existing important population into two or more populations.
Adversely affect habitat critical to the survival of a species	The Five-clawed Worm-skink relies on remnant and non-remnant woodlands and grasslands on cracking clay soils. Much of the proposal occurs in land highly modified by cropping and industry. In areas where potential habitat remains, the proposal would comprise a bridge across the Namoi River floodplain, and habitat and connectivity would be retained and only a small area (up to 2.03 hectares) of potential habitat would be removed. As such, the proposal is unlikely to adversely affect habitat critical to the survival of a species.
Disrupt the breeding cycle of an important population	Very little is known about the species' biology, however eggs are likely to be laid in burrows in cracking clay soils. The construction of piers across the Namoi River floodplain have the potential to remove habitat for the species and result in mortality of individuals. Given that construction of the bridge would minimise impacts on the majority of the floodplain and retain connectivity, the proposal is unlikely to disrupt the breeding cycle of an important population.
Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	Potential habitat for the species is present in the Narrabri area. Grey, Brown and Red clays occur north from the Namoi River and Black Earths occur in the vicinity of Killarney Gap Road. About 6.7 kilometres of the proposal intersects with potential habitat for this species, however about 2.73 kilometres of this area would be spanned by the Narrabri bridge. North of Wee Waa Road the proposal is predominantly located in cropped or highly modified land with minimal connectivity to areas of better quality habitat. The Five-clawed Worm-skink is highly unlikely to persist in this area. South of Narrabri Creek In this area, the proposal is passes through cropped or highly modified land, as well as areas of PCT 78 River Red Gum riparian tall woodland, PCT 619 Derived Wire Grass grassland, and PCT 168 Derived Copperburr shrubland. The proposal would remove up to 2.03 hectares of potential habitat in this area. The construction of piers across the Namoi River floodplain have the potential to remove habitat for the species and result in mortality of individuals, however potential habitat would be retained and connectivity maintained. Given the poor quality habitat north of Wee Waa Road, and that construction of the bridge would avoid impacts on the majority of the

Criteria	Discussion
	floodplain and retain habitat connectivity, the proposal is unlikely to lead to the decline of the species.
Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat	Operation of the proposal has the potential to spread weeds and pests. The surroundings of railways (eg verges and embankments) often host a high diversity of non-native species (Gelbard and Belnap 2003; Hansen and Clevenger 2005), in many cases due to their transportation as stowaways in or on trains. Predator species have been shown to prefer moving down linear clearings, and therefore, clearings could increase predation risk for other species (Dawson et al 2017). Feral species, such as cats and foxes, are a threat to this species. These species already occur in the Narrabri area, and the rail corridor is unlikely to substantially increase their numbers at this location. In addition, feral predators are not considered a key threat to this species.
Introduce disease that may cause the species to decline	The proposal is unlikely to introduce disease into the Pilliga that may cause the species to decline.
Interfere substantially with the recovery of the species	The proposal is located at the southern edge of the species' known range. The Five-clawed Worm-skink is highly unlikely to persist north of Wee Waa Road given an absence of suitable habitat. Up to 2.03 hectares would be impacted south of Narrabri Creek. Potential habitat in this area will be spanned by the bridge with only small areas affected by the piers. Given the low potential for the species to occur north of Narrabri Creek, and retention of potential habitat and connectivity south of Narrabri Creek, the proposal is unlikely to interfere substantially with the recovery of the species.
Conclusion	The proposal is unlikely to have a significant impact on the Five-clawed Worm-skink as: • The proposal site is located at the southern edge of the species' distribution and there are few recent records in the area. • The Five-clawed Worm-skink is highly unlikely to persist in this area north of Wee Waa Road in the proposal site given the land is predominantly cropped or highly modified with minimal connectivity to areas of better quality habitat. • Given the low potential for the species to occur north of Narrabri Creek, and retention of habitat south of Narrabri Creek, the proposal is unlikely to fragment an existing important population into two or more populations • The Narrabri bridge will be located from north of Wee Waa road south to Yarrie Lake Road, and will cross about 2.03 hectares of potential habitat (ie all habitat south of Narrabri Creek). As such, connectivity of habitat will be retained in this area, although construction of piers would remove some potential habitat.

Pink-tailed Legless Lizard (*Aprasia parapulchella*) – vulnerable species

Distribution

The Pink-tailed Legless Lizard has a patchy distribution from Bendigo in Victoria to Gunnedah in NSW. This species was previously thought to be confined to the Canberra region (EES 2019b). The majority of the proposal site is located west of the identified distribution of the species.

Borrow Pit A south of Narromine is located within the Inland Slopes Bioregion, where there are other records of the species (eg at West Wyalong). Potential habitat at this location is at the western edge of identified habitat range. There are no local records.

Habitat requirements

The Pink-tailed Legless Lizard inhabits sloping, open woodland areas with predominantly native grassy groundlayers, particularly those dominated by Kangaroo Grass (*Themeda australis*). Sites are typically well-drained, with rocky outcrops or scattered, partially-buried rocks. It is commonly found beneath small, partially-embedded rocks and appear to spend considerable time in burrows below these rocks; the burrows have been constructed by and are often still inhabited by small black ants and termites (EES 2019b).

The Pink-tailed Legless Lizard is only known from the Central and Southern Tablelands, and the South Western Slopes. There is a concentration of populations in the Canberra/Queanbeyan Region. Other populations have been recorded near Cooma, Yass, Bathurst, Albury and West Wyalong (EES 2019b).

The occurrence of the species appears to be correlated to the underlying geology with most occurrences on intermediate volcanics. Records suggest that the Pink-tailed Legless Lizard is sometimes found where the underlying geology is basalt, almost never on sedimentary rocks and never on alluvial soils (Corkery and Co 2016).

Records at Gunnedah and Dubbo are associated with the Mitchell Slopes physiographic region. This is a transitional landscape from tablelands, stepping down the slopes and breaking into detached hills. The regolith is dominated by highly weathered bedrock and residual materials with smaller areas of moderately weathered bedrock (Pain et al 2011), providing suitable rocky habitat for the Pink-tailed Legless Lizard.

Habitat in the study area

Much of the study area is located in the Upper Darling Plains physiographic region, which is characterised by branching rivers incised into a regolith of predominantly alluvial sediments (>50%) with minimal saprolite (weather rock) (<20%) (Pain et al 2011), which is not suitable habitat for this species due to the lack of surface rock.

Rocky woodland habitat is present at Borrow Pit A. This site is located on the edge of the Inland Slopes subregion and Mitchell Slopes physiographic region. Topographic relief is low, potentially suitable habitat is patchy, and there is minimal connectivity to better quality potential habitat located to the east.

The proposal site passes near three small outlying volcanic hills to the west of the Warrumbungles. Potential habitat is associated with these hillsides, however there are no records of the species associated with the Warrumbungles.

Table M6: Assessment of significance for the Pink-tailed Legless Lizard

Criteria	Discussion
According to the DotE (2013) 'significant impact criteria', an action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that it will:	An 'important population' is a population that is necessary for a species' long-term survival and recovery. Given that this species is difficult to detect and population information is limited, important habitat is taken as a surrogate for important populations. Important habitat includes habitat near the limit of the species' known range (DSEWPAC 2011). Given that Borrow Pit A is located beyond the western edge of the species' range and only marginal potential habitat is present, and there are no records associated with the Warrumbungles, an important population is unlikely to be present in the study area.
Lead to a long-term decrease in the size of an important population of a species	The proposal would remove 11.7 hectares of rocky woodland habitat from Borrow Pit A. This site is located in the Inner Slopes IBRA subregion, a subregion where this species is known to occur (although all records are located well to the east of the proposal). There are no known records near the proposal site and no individuals were recorded during surveys. Similar potential habitat is present throughout agricultural land in this area, however topographic relief is low, potentially suitable habitat is patchy, and there is minimal connectivity to better quality potential habitat located to the east. The proposal site passes near three small outlying volcanic hills to the west of the Warrumbungles. Potential habitat is associated with these hillsides, however there are no records of the species associated with the Warrumbungles. The species is unlikely to occur in the proposal site given the low incidence of surface rock, high level of modification of vegetation due to agriculture, and lack of records in the region. The majority of the study area is characterised by branching rivers incised into a regolith of predominantly alluvial sediments with minimal saprolite (weather rock), which is not suitable habitat for this species due to the lack of surface rock. The loss of potential marginal habitat is unlikely to lead to a decrease in the size of an important population of a species.
Reduce the area of occupancy of an important population	This species was thought to be confined to the Canberra region, however the species has more recently been recorded near Bathurst, Bendigo and south of Dubbo, indicating a wider distribution. There are no local records, and the proposal occurs beyond the western edge of the species' known range. The proposal is therefore unlikely to reduce the area of occupancy of an important population.
Fragment an existing important population into two or more populations	The proposal is located beyond the western edge of the species' potential range. The loss of potential marginal habitat at Borrow Pit A and outlying hills associated with the Warrumbungles is unlikely to fragment an existing important population into two or more populations, given the proposal is beyond the western edge of the species' known range, and limited suitable habitat in the proposal site.
Adversely affect habitat critical to the survival of a species	The Pink-tailed Legless Lizard requires partially embedded stones and boulders on hillsides and the upper slopes of river valleys. The majority of the study area is characterised by branching rivers incised into a regolith of predominantly alluvial sediments with minimal saprolite (weather rock), which is not suitable habitat for this species due to the lack of surface rock.

Criteria	Discussion
	Borrow Pit A is located in an area of low topographic relief, and potential habitat is considered marginal at best, and there are no local records. Similarly, the proposal site skirts outlying hills of the Warrumbungles, there is limited embedded rock in the proposal site at these locations, and no local records in this area. As such, the proposal is unlikely to adversely affect habitat critical to the survival of a species.
Disrupt the breeding cycle of an important population	Removal of surface rock has the potential to remove breeding burrows of this species. As noted above, potential habitat is marginal given the low topographic relief, fragmented habitat, and limited connectivity to better quality potential habitat located to the east. The proposal is therefore unlikely to disrupt the breeding cycle of an important population.
Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	The majority of the study area is characterised by branching rivers incised into a regolith of predominantly alluvial sediments with minimal saprolite (weather rock), which is not suitable habitat for this species due to the lack of surface rock. The proposal would remove small areas of marginal potential habitat from Borrow Pit A and from near outlying hills associated with the Warrumbungles. There are no known records near the proposal site. The majority of the proposal site does not contain appropriate geology for the species. Potentially suitable habitat is patchy, and there is minimal connectivity to better quality potential habitat located to the east. The loss of potential marginal habitat is unlikely to modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline.
Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat	Construction of the proposal has the potential to spread weeds and pests. Weed species already occur in the area, and the proposal is unlikely to substantially increase weeds at this location.
Introduce disease that may cause the species to decline	The proposal is unlikely to introduce disease that may cause the species to decline.
Interfere substantially with the recovery of the species	The proposal is located beyond the western edge of the species' potential range. Given the low potential for the species to occur at Borrow Pit A and in the Mt Tenandra area, marginal habitat and lack of evidence of any local populations, the proposal is unlikely to interfere substantially with the recovery of the species.
Conclusion	The proposal is unlikely to have a significant impact on the Pink-tailed Legless Lizard as: • The proposal site is located beyond the western edge of the species' distribution and there are no local records. • The majority of the proposal site does not comprise appropriate geology (embedded surface rock) • Potential habitat is considered marginal at best for this species.

Superb Parrot (*Polytelis swainsonii*) – vulnerable species

Distribution

The Superb Parrot is found in NSW and northern Victoria, where it occurs on the inland slopes of the Great Divide and on adjacent plains, especially along the major river-systems; vagrants have also been recorded in southern Queensland (DEE 2019b).

Habitat requirements

The breeding range of the Superb Parrot is divided into three main areas: the first, along the Murray and Edward Rivers; the second, along the Murrumbidgee River; and the third, in a triangle bounded by Molong, Yass and Young (DEE 2019a). Superb Parrots breed in either River Red Gum forests and woodlands or box woodlands (Webster 1998).

At least part of the population of the Superb Parrot undertakes regular seasonal movements, vacating the breeding area after the conclusion of the breeding season, and then returning in spring, while others remain in the breeding areas throughout the year. In central NSW, movements are said to occur when eucalypts flower, and when food becomes scarce due to drought and birds seek alternative sources of food (Higgins 1999).

The species seasonally occurs in Box-Cypress Pine (*Callitris* spp.) and Weeping Myall (*Acacia pendula*) woodlands (DEE 2019a). The Superb Parrot feeds mainly on the ground, on the seeds of grasses as well as cereal crops and spilt grain. They also eat the seed-pods of many understorey species of wattles, and flowers and fruits of eucalypts, berries of mistletoe and lerps (EES 2019a).

Habitat in the study area

A flock of four individuals was recorded in roadside vegetation north-east of Gunnedah during surveys. Vegetation comprised Box – Callitris woodland and was connected to a large patch of remnant vegetation located on private property to the east of this location. No River Red Gum habitat is located in close proximity to this location, and it is assumed that these individuals were non-breeding vagrants.

The recovery plan for the species maps the southern portion of the study area (south-west of Mount Tenandra) as where the species is likely to occur, while the northern portion is mapped as where the species may occur. No areas mapped as 'breeding likely to occur' are located in the study area, however there are scattered records of birds breeding outside these mapped areas (Baker-Gabb 2011). Based on the lack of known breeding habitat in the study area, an important population is not considered to be present.

Table M7: Assessment of significance for the Superb Parrot

Criteria	Discussion
According to the DotE (2013) 'significant impact criteria', an action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that it will:	An 'important population' is a population that is necessary for a species' long-term survival and recovery. No areas mapped as 'breeding likely to occur' are located in the study area (Baker-Gabb 2011). Individuals that occur are likely to be non-breeding visitors to the areas. Based on the lack of known breeding habitat in the study area, an important population is not considered to be present.
Lead to a long-term decrease in the size of an important population of a species	The proposal would not impact any known breeding habitat for the species. Species that occur in the area would be non-breeding visitors. Construction would require the permanent removal of a maximum area of 1,173 hectares of woodland and forest habitat along a 300 kilometres alignment. Clearing of this forest and woodland vegetation would permanently remove foraging resources for the species.

Criteria	Discussion
	The Superb Parrot is nomadic, moving large distance between breeding and non-breeding areas. The linear nature of clearing for the proposal is unlikely to affect movement of this species. Patches of vegetation would be retained throughout this foraging range. Birds are at risk of vehicle and train strike as they forage for seed on the ground. Grain spill in particular can lead to accidental road kill of many individuals (Baker-Gibb 2011). Transport of grain during operation has the potential to result in train-strike of individuals, however this would be limited to certain times of year and presence of individuals. Risk is likely to be low given the location of the proposal away from breeding areas where larger numbers of individual are likely to occur. Given the lack of impact on breeding habitat, and linear nature of clearing through scattered foraging habitat, the proposal is unlikely to lead to a long-term decrease in the size of an important population of a species.
Reduce the area of occupancy of an important population	The Superb Parrot occurs through the inland slopes and plains of NSW (including the Australian Capital Territory) to northern Victoria (Baker-Gibb 2011). Most birds undertake regular seasonal movements between breeding and non-breeding areas. The proposal would not reduce the area of occupancy of an important population given the lack of impact on breeding habitat.
Fragment an existing important population into two or more populations	Most Superb Parrots undertake regular seasonal movements between breeding and non-breeding areas. Riparian corridors are known to provide movement corridors for this species. Clearing of riparian vegetation will create narrow gaps in the corridors. There is also a risk of train strike during operation. Risk of train strike is low given the relatively low train traffic, lack of breeding habitat, and likely low numbers of individuals that may occur in riparian corridors in the proposal site. Given the high mobility of the species, and large area of NSW in which it occurs, and low risk of train strike, the proposal is unlikely to fragment an important population into two or more populations.
Adversely affect habitat critical to the survival of a species	Habitat critical to the survival of the species comprises breeding and foraging habitat (Baker-Gibb 2011). No breeding habitat occurs in the proposal site. After breeding, different populations move to different foraging grounds. Most of the breeding population from the inland slopes appears to move to the eucalypt-pine woodlands on the plains of west-central and north-central NSW (Webster 1988). The proposal would remove scattered patches of habitat along a linear construction site. The species is more likely to occur in the southern parts of the proposal site where vegetation is more fragmented. Given the lack of impact on breeding habitat, and linear nature of clearing through scattered foraging habitat, the proposal is unlikely to adversely affect habitat critical to the survival of a species.
Disrupt the breeding cycle of an important population	No breeding habitat occurs in or near the proposal site. Clearing of scattered patches of foraging habitat would not affect the ability of the species to move between breeding and non-breeding areas. As such, the proposal would not disrupt the breeding cycle of an important population.

Criteria	Discussion
Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	No breeding habitat occurs in or near the proposal site. Construction would require the permanent removal of a maximum area of 1,173 hectares of woodland and forest habitat along a 300 kilometres alignment. Clearing of scattered patches of foraging habitat would not affect the ability of the species to move between breeding and non-breeding areas. Given the lack of impact on breeding habitat, and linear nature of clearing through scattered foraging habitat, the proposal is unlikely to lead to a decline in the species.
Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat	Operation of the proposal has the potential to spread weeds and pests. The surroundings of railways (eg verges and embankments) often host a high diversity of non-native species (Gelbard and Belnap 2003; Hansen and Clevenger 2005), in many cases due to their transportation as stowaways in or on trains. Introduction of grasses may encourage birds to feed along the rail verge and could potentially result in risk of train strike. Predator species have been shown to prefer moving down linear clearings, and therefore, clearings could increase predation risk for other species (Dawson et al 2017). Feral species, such as cats and foxes, are a threat to this species. These species already occur throughout the study area.
Introduce disease that may cause the species to decline	Psittacine beak and feather disease is a common and potentially deadly disease of parrots. Susceptibility to the infection may be influenced by environmental factors, such as climate, nutrition, habitat quality and social factors (DEH 2005). The proposal is unlikely to introduce Psittacine beak and feather disease, however cumulative impacts of further land clearing and impacts on habitat has the potential to increase susceptibility of individuals.
Interfere substantially with the recovery of the species	The long-term objective of recovery is to minimise the probability of extinction of the Superb Parrot in the wild, and to increase the probability of important populations becoming self-sustaining in the long term (Baker-Gibb 2011). Priority management areas are focused on breeding habitat for the species. Other priority actions include the identification and protection of key movement corridors. The proposal would not impact any breeding habitat for this species. Construction of the proposal would remove foraging habitat and has the potential to impact riparian movement corridors. Clearing of riparian vegetation will create narrow gaps in riparian corridors. There is also a risk of train strike during operation. Risk of train strike is low given the relatively low train traffic, lack of breeding habitat, and likely low numbers of individuals that may occur in riparian corridors in the proposal site. The species is more likely to occur in the southern parts of the proposal site where vegetation is more fragmented. Individuals that occur in the study area are most likely to be non-breeding vagrants, and the proposal is unlikely to interfere substantially with the recovery of the species, given that no breeding habitat is likely to be removed and the linear nature of clearing through scattered foraging habitat.

Criteria	Discussion
Conclusion	The proposal is unlikely to have a significant impact on the Superb Parrot as: • No breeding habitat would be impacted • Clearing of patches of foraging habitat would not affect the ability of the species to move between breeding and non-breeding areas. • Loss of foraging habitat involves small patches along a long linear alignment in the southern part of the proposal site where the species is most likely to occur. The species is less likely to occur in the Pilliga, where large areas of vegetation would be removed • The proposal would create small gaps in vegetation along riparian corridors, but is not likely to substantially disrupt the movement of the species between breeding and foraging areas.

Painted Honeyeater (*Grantiella picta*) – vulnerable species

Distribution

The Painted Honeyeater is found in Queensland and NSW west of the Great Dividing Range, through to northern Victoria. It is dispersive and rare throughout its range (Birdlife Australia 2020).

Habitat requirements

The Painted Honeyeater inhabits dry open woodland and forests, particularly Boree/ Weeping Myall (*Acacia pendula*), Brigalow (*A. harpophylla*) and Box-Gum Woodlands and Box-Ironbark Forests. It is a specialist feeder on the fruits of mistletoes growing on woodland eucalypts and acacias, with a preference for the mistletoes of the genus *Amyema*. Insects and nectar from mistletoe or eucalypts are occasionally eaten (EES 2019b). It may also be found along rivers, on plains with scattered trees and on farmland with remnant vegetation. It has been seen in urban parks and gardens where large eucalypts are available (Birdlife Australia 2020).

The greatest concentrations and almost all records of breeding come from south of 26ºS, on inland slopes of the Great Dividing Range between the Grampians, Victoria and Roma, Queensland. The species exhibits seasonal north-south movements governed principally by the fruiting of mistletoe, with which its breeding season is closely aligned (Barea and Watson 2007)

The Painted Honeyeater nests from spring to autumn in a small, delicate nest hanging within the outer canopy of drooping eucalypts, she-oak, paperbark or mistletoe branches. It breeds in loose colonies, forming pair bonds for the duration of the breeding season. In some areas, the same nest or tree may be re-used over several years (Birdlife Australia 2020).

Habitat in the study area

This species would occur throughout the proposal site, and particularly the Pilliga forests. The whole Pilliga is important for the Painted Honeyeater with main habitat areas for this species comprising creek lines (Birdlife International 2020), possibly due to the higher number of mature trees, as these host more mistletoes. Mistletoes are also present in woodland patches elsewhere along the alignment.

Table M8: Assessment of significance for the Painted Honeyeater

Criteria	Discussion
According to the DotE (2013) 'significant impact criteria', an action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that it will:	An 'important population' is a population that is necessary for a species' long-term survival and recovery. The Painted Honeyeater is nomadic and occurs at low densities throughout its range. Considering its dispersive habits, the species is considered to have a single population (Garnett et al., 2011). As such, any individuals that occur along the alignment are considered part of an important population.
Lead to a long-term decrease in the size of an important population of a species	Construction would require the permanent removal of a maximum area of 1,107.4 hectares of eucalypt woodland and forest habitat along a 300 kilometres alignment. Vegetation would be removed is potential breeding and foraging habitat for the species. The whole Pilliga is important for woodland birds, including the Painted Honeyeater, given the large size of the forest. The Pilliga forests cover an areas of about 535,000 hectares, and comprise the single largest remaining tract of native forest and woodland in NSW west of the Great Dividing Range (Predavec 2016). The proposal would remove 615 hectares of forest and woodland from the Pilliga, a small proportion of available habitat in the Pilliga area. The main habitat areas for this species in the Pilliga comprise creek lines (Birdlife International 2020), possibly due to the higher number of mature trees, as these host more mistletoes. The proposal would result in the loss of extensive areas of vegetation containing mistletoe which is a critical resource for this species. While this species occurs at low densities, the removal of an extensive area of habitat may lead to long-term decrease in the size of an important population of the species.
Reduce the area of occupancy of an important population	The species is sparsely distributed from south-eastern Australia to north-western Queensland and eastern Northern Territory. The removal of 1,107.4 hectares of eucalypt woodland and forest habitat along a 300 kilometres alignment is not likely to reduce the area of occupancy of the important population.
Fragment an existing important population into two or more populations	The proposal will create a new linear gap through the Pilliga forests, exacerbating the existing impacts on connectivity created by Pilliga Forest Way and the Newell Highway. Elsewhere in the alignment, the proposal will further fragment patches of vegetation that occur in agricultural land and roadsides. The Painted Honeyeater is nomadic and occurs at low densities throughout its range. It often occurs in small fragments and isolated trees. Given the high mobility of the species, and linear nature of the proposal, the proposal is unlikely to fragment an important population into two or more populations.

Criteria	Discussion
Adversely affect habitat critical to the survival of a species	Habitat critical to the survival of the Painted Honeyeater includes all preferred foraging species within known and likely foraging habitat particularly mistletoes of the genus *Amyema* growing on forest and woodland eucalypts and acacias, and habitat for the long-term maintenance of the species, which includes the Pilliga key biodiversity area (DAWE 2020). The proposal will remove 1,107.4 hectares of eucalypt woodland and forest habitat containing mistletoes along a 300 kilometres alignment, including 615 hectares from within the Pilliga forests. Mistletoes occur sporadically along the alignment, however a high number of mistletoes would be removed along the alignment, and particularly from within the Pilliga. Given the loss of a large area of habitat, the proposal may adversely affect habitat critical to the survival of the species.
Disrupt the breeding cycle of an important population	The Painted Honeyeater is nomadic and occurs at low densities throughout its range. The greatest concentrations of the bird and almost all breeding occurs on the inland slopes of the Great Dividing Range in NSW, Victoria and southern Queensland. During the winter it is more likely to be found in the north of its distribution (EES 2019b). The removal of potential breeding habitat along a narrow linear corridor may disrupt breeding for individuals that occur along the route. Given the nomadic nature of the species, individuals would move to other areas of available habitat for breeding. As such, the proposal is not likely to disrupt the breeding cycle of the important population.
Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	Construction would require the permanent removal of a maximum area of 1,107.4 hectares of eucalypt woodland and forest habitat along a 300 kilometres alignment, including 615 hectares from within the Pilliga, an important area for this species. Vegetation that would be removed is potential breeding and foraging habitat for the species. While the proposal would remove a large area of habitat for this species, this is a small proportion of available habitat in the Pilliga area. Despite, this, the reliance on mistletoes that occur sporadically in the landscape makes this clearing more significant. The proposal is unlikely to fragment the population, given it is a highly mobile, nomadic species that can travel large distances across cleared landscapes. Given the large area of clearing, the proposal is may lead to a decline in the species.
Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat	Introduction of weeds is of particular concern in the Pilliga forests as they can reduce quality of vegetation and thus impact fauna and flora habitats. Operation of the proposal has the potential to spread weeds and pests into the Pilliga and elsewhere. Introduction and spread of weeds is unlikely to substantially impact foraging habitat for this species. Predator species have been shown to prefer moving down linear clearings, and therefore, clearings could increase predation risk for other species (Dawson et al 2017). The creation of a 73 kilometres linear gap through the Pilliga may increase the risk of fox and cat predation. There is little risk of establishment of predators elsewhere in the alignment as a result of the proposal.
Introduce disease that may cause the species to decline	The proposal is unlikely to introduce disease into the Pilliga that may cause the species to decline.

Criteria	Discussion
Interfere substantially with the recovery of the species	Habitat loss is a key threat to this species. Much of its breeding habitat has been cleared or has been reduced to ageing, widely-spaced trees, particularly in box-ironbark and boree woodlands. Its non-breeding habitat is also still being cleared for agriculture (Barea, 2008a). The proposal will remove 1,107.4 hectares of eucalypt woodland and forest habitat along a 300 kilometres alignment, including a substantial area of habitat from the Pilliga, a stronghold for the species. The proposal would result in the loss of extensive areas of vegetation containing mistletoe which is a critical resource for this species. Given these points, the proposal may interfere with the recovery of the species.
Conclusion	The proposal is likely to have a significant impact on the Painted Honeyeater as: • Construction would require the permanent removal of a maximum area of 1,107.4 hectares of eucalypt woodland and forest habitat along the 300 kilometres alignment, with 615 hectares of this clearing occurring in the species' stronghold in the Pilliga • It is highly specialised and predominantly forages on mistletoe. The proposal would result in the loss of extensive areas of vegetation containing mistletoe which is a critical resource for this species.

Australian Painted Snipe (*Rostratula australis*) – endangered species

Distribution

The Australian Painted Snipe has been recorded at wetlands in all states of Australia and is most common in eastern Australia.

Habitat Requirements

The Australian Painted Snipe is a wading bird inhabiting shallow, terrestrial, freshwater (occasionally brackish) wetlands in all states of Australia. These wetlands include temporary and permanent lakes, swamps, clay pans, inundated/waterlogged grasslands or saltmarsh, dams, rice crops, sewage dams and bore drains (DAWE 2020b).

This species is migratory, breeding in southern Australia from August to February (DAWE 2020b). Australian Painted Snipe breeding habitat requirements may be quite specific: shallow wetlands with areas of bare wet mud and both upper and canopy cover nearby. Nest records are all, or nearly all, from or near small islands in freshwater wetlands, provided that these islands are a combination of very shallow water, exposed mud, dense low cover and sometimes some tall dense cover (Rogers et al. 2005).

Habitat in the study area

There are a small number of records within 20 kilometres of the alignment, including a creekline in agricultural land north of Dubbo, Carmel Lagoon (a farm dam) north-west of Baradine, and Narrabri Lake (EES 2019b, Birdata 2020).

Limited wetland habitat is present in the study area. Small areas of mudflats and emergent reeds were observed near Narrabri Creek and Namoi River that could provide habitat for the species. Emergent reeds occur in the sandy bed of the Castlereagh River. Small areas of mudflats were observed near small remnant ponds. When under higher flows, areas of mudflats would reduce.

Table M9: Assessment of significance for the Australian Painted Snipe

Criteria	Discussion
According to the DotE (2013) 'significant impact criteria', an action is likely to have a significant impact on an endangered species if there is a real chance or possibility that it will: An 'important population' is a population that is necessary for a species' long-term survival and recovery.	
Lead to a long-term decrease in the size of a population of a species	The proposal will have limited impacts on wetland habitat. Bridges will be constructed across large rivers such as the Castlereagh River and the Namoi River/Narrabri River and disturbance of emergent vegetation at these locations would be limited. Mudflat habitat on the edge of Narrabri Creek would be retained, however this is impacted by grazing and little cover is present. Shading from the bridges may have indirect impacts on these areas. Areas of low quality potential habitat associated with farm dams would be removed where these occur along the alignment, however these would likely be replaced elsewhere on the properties. The Australian Painted Snipe is considered to occur in a single, contiguous breeding population (DAWE 2020b). There are three records of the species within 20 kilometres of the 300 kilometres alignment. No large wetlands would be impacted by the proposal. Given the limited habitat present, the proposal is unlikely to lead to a long-term decrease in the size of the population of the species.
Reduce the area of occupancy of the species	The Australian Painted Snipe has been recorded at wetlands in all states of Australia and is most common in eastern Australia. The area of occupancy has undoubtedly declined as approximately 50 percent of wetlands in Australia have been removed since European settlement (DAWE 2020b). The disturbance of patches of emergent reeds within riverine habitat and farm dams along a 300 kilometres alignment is not likely to reduce the area of occupancy of the species.
Fragment an existing population into two or more populations	Movement patterns are poorly known for this species and it is possibly dispersive or migratory (DAWE 2020b). The removal or disturbance of patches of emergent reeds within riverine habitat and farm dams along a 300 kilometres alignment is not likely to fragment the population of this mobile species.
Adversely affect habitat critical to the survival of a species	Australian Painted Snipe breeding habitat requirements may be quite specific: shallow wetlands with areas of bare wet mud and both upper and canopy cover nearby. Nest records are all, or nearly all, from or near small islands in freshwater wetlands, provided that these islands are a combination of very shallow water, exposed mud, dense low cover and sometimes some tall dense cover (Rogers et al. 2005). No preferred breeding habitat (islands in freshwater wetlands) is present, however areas of tall emergent reeds are present at the Castlereagh River and Namoi River, which may provide marginal breeding habitat. Bridges will be constructed across these rivers and direct impacts on breeding habitat are unlikely. The proposal would have limited impacts on wetland habitat. Areas of low quality habitat associated with farm dams would be removed. Mudflat habitat on the edge of Narrabri Creek would be retained, however this is impacted by grazing and little cover is present. Given the small area of wetland habitat present, the proposal is unlikely to adversely affect habitat critical to the survival of the species.

Criteria	Discussion
Disrupt the breeding cycle of a population	The Australian Painted Snipe may breed in response to wetland conditions rather than during a particular season. The nest is usually placed in a scrape in the ground, normally concealed in thick marshy vegetation (DAWE 2020b). No preferred breeding habitat (islands in freshwater wetlands) is present, however areas of tall emergent reeds are present at the Castlereagh River and Namoi River, which may provide marginal breeding habitat. The proposal will have limited impacts on wetland habitat. Bridges will be constructed across large rivers and direct impacts on breeding habitat are unlikely. Given the above points, the proposal is unlikely to disrupt the breeding cycle of a population.
Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	The proposal will have limited impacts on wetland habitat. Bridges will be constructed across large rivers such as the Castlereagh River and the Namoi River/Narrabri River, and direct impacts on breeding habitat are unlikely. Some shading may occur in these areas that may alter small sections of reedland patches. Areas of low quality habitat associated with farm dams would be removed. Removal of linear patches of vegetation along a 300 kilometres alignment is unlikely to affect movement of this species between wetland habitats. Given the small area of wetland habitat associated with farm dams and reedland in rivers that would be impacted, and limited number of records present, and lack of good quality breeding habitat, the proposal is unlikely to affect habitat such that the species declines.
Result in invasive species that are harmful to a vulnerable species becoming established in the endangered species' habitat	Operation of the proposal has the potential to spread weeds and pests. The surroundings of railways (eg verges and embankments) often host a high diversity of non-native species (Gelbard and Belnap 2003; Hansen and Clevenger 2005), in many cases due to their transportation as stowaways in or on trains. The proposal may spread environmental weeds in riparian areas, but is unlikely to introduce invasive aquatic weeds. Predator species have been shown to prefer moving down linear clearings, and therefore, clearings could increase predation risk for other species (Dawson et al 2017). Feral species, such as cats and foxes, are a threat to this species. These species already occur in the study area, and the rail corridor is unlikely to substantially increase their numbers in wetland and riparian habitats.
Introduce disease that may cause the species to decline	The proposal is unlikely to introduce disease that may cause the species to decline.
Interfere substantially with the recovery of the species	The Australian Painted Snipe has primarily been impacted by the loss of wetland habitat (DAWE 2020b). The proposal would have limited impacts on wetland habitat. No key breeding habitat (large freshwater wetlands) is located in the proposal site or would be affected by the proposal. Few local records are known. As such, the proposal is unlikely to interfere with the recovery of the species.

Criteria	Discussion
Conclusion	The proposal is unlikely to have a significant impact on the Australian Painted Snipe as: • No key breeding habitat is located in the proposal site or would be affected by the proposal • The proposal would have limited impacts on low quality habitat associated with farm dams • Bridges would be constructed above rivers, and there would be no direct impacts on mudflat habitats in these area • The proposal would not isolate any habitat or interrupt movements of the species between wetland habitats.

Australasian Bittern (*Botaurus poiciloptilus*) – endangered species

Distribution

The Australasian Bittern occurs from south-east Queensland to south-east South Australia. There is one record of the species within 20 kilometres of the 300 kilometres alignment.

Habitat requirements

The Australasian Bittern is a relatively large wetland bird (66 to 76 centimetres long) occurring in Australia in south east Queensland, south east Australia, Tasmania and south west Western Australia (DAWE 2020b). This species favours terrestrial wetlands (and rarely estuarine habitats) vegetated with tall, dense vegetation dominated by sedges, rushes and/or reeds (flora species from the genera *Phragmites, Cyperus, Eleocharis, Juncus, Typha, Baumea, Bolboschoenus* and *Gahnia*) on muddy/peaty substrates. The Australasian Bittern forages in still water of 30 centimetres maximum depth at the edges of pools or waterways, or platforms/mats of vegetation over deep water (DAWE 2020b).

Knowledge of the breeding habitats is poor, however data indicates that the species breeds in relatively deep, densely vegetated freshwater swamps and pools. The species builds nests in deep cover over shallow water (DAWE 2020b). Large numbers of bitterns may breed in rice crops of the New South Wales' Riverina each year (Bitterns in Rice Project 2018).

Habitat in the study area

There is one record of the species within 20 kilometres of the 300 kilometres alignment (EES 2019b). No Birdata (2020) records occur near the alignment.

Limited wetland habitat is present in the study area. Small areas of mudflats and emergent reeds were observed near Narrabri Creek and Namoi River that could provide habitat for the species. Emergent reeds occur in the sandy bed of the Castlereagh River. Small areas of mudflats were observed near small remnant ponds. When under higher flows, areas of mudflats would reduce.

Table M10: Assessment of significance for the Australasian Bittern

Criteria	Discussion
According to the DotE (2013) 'significant impact criteria', an action is likely to have a significant impact on a critically endangered or endangered species if there is a real chance or possibility that it will:	
Lead to a long-term decrease in the size of a population	The proposal will have limited impacts on wetland habitat. Bridges will be constructed across large rivers such as the Castlereagh River and the Namoi River/Narrabri River where large areas of emergent reeds were observed. Direct impacts on these habitats are unlikely, although the bridges would shade some areas of reeds, which could indirectly impact this habitat type. There is one record of the species within 20 kilometres of the 300 kilometres alignment. No large wetlands would be impacted by the proposal. Given the limited habitat present, the proposal is unlikely to lead to a long-term decrease in the size of a population.
Reduce the area of occupancy of the species	In Australia, the Australasian Bittern occurs from south-east Queensland to south-east South Australia as far as the Adelaide Region, southern Eyre Peninsula, Tasmania and in the southwest of Western Australia (Garnett et al. 2011). The area of occupancy of the Australasian Bittern in Australia is thought to have declined by 70 percent between 1977 and 2008. These declines are considered to have led to a comparable decline in the size of the adult population. The declines are primarily linked to the clearing or modification of wetlands for urban and agricultural development, as well as the extraction of water from wetlands for irrigation (TSSC 2011). The proposal will have limited impacts on wetland habitat. Bridges will be constructed across large rivers such as the Castlereagh River and the Namoi River/Narrabri River where large areas of emergent reeds were observed. The disturbance of small patches of emergent reeds within riverine habitat along a 300 kilometres alignment is not likely to reduce the area of occupancy of an important population.
Fragment an existing population into two or more populations	The Australasian Bittern was previously thought to be largely sedentary, however recent tracking studies have shown extensive movements (over hundreds of kilometres) between wetlands in southeast Australia (Bitterns in Rice Project 2016). Occasional movements to inland areas have also been recorded during extensive flooding events (Marchant and Higgins 1990). The disturbance of patches of emergent reeds within riverine habitat along a 300 kilometres alignment is not likely to fragment the population of this mobile species.
Adversely affect habitat critical to the survival of a species	Given that the Australasian Bittern is presumed to have undergone a severe reduction in numbers, based on historic habitat loss and degradation across the core part of its range, all natural habitat (including constructed wetlands with suitable habitat) in which the Australasian Bittern is known or likely to occur should be considered critical to the survival of the species. The proposal would have limited direct impacts on areas of emergent reeds as bridges would be constructed to span these areas. Areas of low quality habitat associated with farm dams would be removed. Small patches of emergent reeds in river beds may be disturbed or removed. Given the limited impact on reedland habitats, the proposal is unlikely to adversely affect habitat critical to the survival of the species.

Criteria	Discussion
Disrupt the breeding cycle of a population	The Australasian Bittern generally breeds in solitary pairs, although sometimes several nests may be placed in close proximity to each other (Marchant and Higgins 1990). The species nests adjacent to relatively deep, densely vegetated freshwater swamps and pools, building its nests under dense cover over shallow water (Marchant and Higgins 1990). Annual surveys conducted by the Bitterns in Rice Project since 2012 suggest that approximately 500-1000 Bitterns may breed in rice crops of the New South Wales' Riverina each year (Bitterns in Rice Project 2018). The proposal would not impact this key breeding habitat. The proposal will have limited impacts on ephemeral wetland habitat. Bridges will be constructed across large rivers such as the Castlereagh River and the Namoi River/Narrabri River where large areas of emergent reeds were observed, and direct impacts on breeding habitat are unlikely. Small patches may be removed and other areas shaded. Removal of linear patches of vegetation along a 300 kilometres alignment is unlikely to affect movement of this species between wetland habitats. Given the above points, the proposal is unlikely to disrupt the breeding cycle of a population.
Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	The proposal will have limited impacts on wetland habitat. Bridges will be constructed across large rivers such as the Castlereagh River and the Namoi River/Narrabri River where large areas of emergent reeds were observed, and direct impacts on breeding habitat are unlikely. Some shading may occur in these areas that may alter small sections of reedland patches. Low quality habitat associated with farm dams would be removed or disturbed. Removal of linear patches of vegetation along a 300 kilometres alignment is unlikely to affect movement of this species between wetland habitats. Given the limited impact on reedland habitats, the proposal is unlikely to affect habitat such that the species declines.
Result in invasive species that are harmful to the species becoming established in the species' habitat	Operation of the proposal has the potential to spread weeds and pests. The surroundings of railways (eg verges and embankments) often host a high diversity of non-native species (Gelbard and Belnap 2003; Hansen and Clevenger 2005), in many cases due to their transportation as stowaways in or on trains. The proposal may spread environmental weeds in riparian areas, but is unlikely to introduce invasive aquatic weeds. Predator species have been shown to prefer moving down linear clearings, and therefore, clearings could increase predation risk for other species (Dawson et al 2017). Feral species, such as cats and foxes, are a threat to this species. These species already occur in the study area, and the rail corridor is unlikely to substantially increase their numbers in wetland and riparian habitats.
Introduce disease that may cause the species to decline	The proposal is unlikely to introduce disease that may cause the species to decline.

Criteria	Discussion
Interfere with the recovery of the species	The Australasian Bittern has primarily been impacted by the loss of wetland habitat through the diversion of water away from wetlands; drainage of swamps; and clearing for urban and agricultural development (TSSC 2019). The proposal would have limited impacts on wetland habitat. No key breeding habitat is located in the proposal site or would be affected by the proposal. As such, the proposal is unlikely to interfere with the recovery of the species.
Conclusion	The proposal is unlikely to have a significant impact on the Australasian Bittern as: • No key breeding habitat is located in the proposal site or would be affected by the proposal • The proposal would remove low quality habitat associated with farm dams • Bridges would be constructed above reedland areas, and there would be limited direct impacts on this habitat type • The proposal would not isolate any habitat or interrupt movements of the species between wetland habitats.

Regent Honeyeater (*Anthochaera phrygia*) – critically endangered species

Distribution

The Regent Honeyeater has a patchy distribution which extends from south-east Queensland, through NSW and the ACT, to central Victoria. Records are widely distributed across its range, but it is only found regularly at a few localities in NSW and Victoria where most of the sightings have been recorded (DEE 2019b).

Habitat requirements

There are four known key breeding regions remaining for the Regent Honeyeater: north-east Victoria (Chiltern-Albury), and in NSW at Capertee Valley, the Bundarra-Barraba region near Gunnedah and the Hunter Valley. In NSW the distribution is very patchy and mainly confined to the two main breeding areas and surrounding fragmented woodlands. In some years flocks converge on flowering coastal woodlands and forests (EES 2019a).

The Regent Honeyeater is a generalist forager, although it feeds mainly on the nectar from a relatively small number of eucalypts that produce high volumes of nectar. Most records of regent honeyeaters come from box-ironbark eucalypt associations, where the species seems to prefer more fertile sites with higher soil water content, including creek flats, broad river valleys and lower slopes. Regent honeyeaters may use different areas in different years depending on food resources (DoE 2016).

Key eucalypt species include Mugga Ironbark, Yellow Box, White Box and Red ironbark. Flowering of associated species such as Thin-leaved Stringybark *Eucalyptus eugenioides* and other Stringybark species, and Broad-leaved Ironbark *E. fibrosa* can also contribute important nectar flows at times. Nectar and fruit from the mistletoes *Amyema miquelii, A. pendula* and *A. cambagei* are also utilised (EES 2019a). When nectar is scarce lerp and honeydew can comprise a large proportion of the diet. Insects make up about 15 percent of the total diet and are important components of the diet of nestlings

Habitat in the study area

There is one record of this species within 20 kilometres of the alignment in the last twenty years. No individuals were recorded during surveys.

The Regent Honeyeater is known to occur in the Inland Slopes, Pilliga, Liverpool Plains and Northern Basalts subregions.

PCT 398 which occurs in the Pilliga contains Yellow Box and Mugga Ironbark. Mugga Ironbark also occurs in PCT 255 and PCT 397 in the Pilliga. Red Ironbark can occur in PCT 404 and 406. *Amyema miquelii* was recorded in plots in PCT 394. This species was observed elsewhere in the Pilliga. Another mistletoe (*Amyema quandong*) was recorded in a plot in PCT 27 (Weeping Myall Woodland) and unidentified mistletoes (*Amyema* spp.) were recorded in a plot in PCT 244. A patchy distribution of mistletoes was recorded elsewhere throughout the alignment.

About 286.8 hectares of vegetation that contains preferred feed trees and mistletoes is present in the construction impact zone in the IBRA subregions this species is known to occur in. An additional 341 hectares of forest and woodland has the potential to contain foraging habitat (eg mistletoes and eucalypts).

The Recovery Plan notes the Pilliga forests are important for the species and maps this habitat area. It is located in the south-east of the forests, well away from the proposal site. The Baradine/Yearinan Creek in the central Pilliga is noted as being important habitat for the Regent Honeyeater (Birdlife International 2020). This is located south-east of the proposal site and would not be affected.

No important habitat (breeding areas) has been mapped in the study area by OEH (correspondence received January 2019, EES 2020).

Table M11: Assessment of significance for the Regent Honeyeater

Criteria	Discussion
According to the DotE (2013) 'significant impact criteria', an action is likely to have a significant impact on a critically endangered or endangered species if there is a real chance or possibility that it will:	
Lead to a long-term decrease in the size of a population	There is one record of this species within 20 kilometres of the alignment in the last twenty years. No individuals were recorded during surveys. No breeding habitat is known from the Pilliga or elsewhere along the alignment. No important habitat has been mapped in the study area (EES 2020). The Baradine/Yearinan Creek in the central Pilliga is noted as being important foraging habitat for the Regent Honeyeater (Birdlife International 2020). This area is located to the south-east of the proposal and would not be impacted. The proposal would remove 286.8 hectares containing preferred foraging species. While individuals may forage along the alignment on occasion, the habitat to be removed has not been identified as important foraging habitat for this species by Birdlife Australia (2020). This habitat loss will decrease the availability of winter forage for individual honeyeaters that disperse nomadically throughout the region (and the study area) during winter. As such, the proposal is unlikely to lead to a long-term decrease in the size of a population.

Criteria	Discussion
Reduce the area of occupancy of the species	The distributional range of the Regent Honeyeater extends from parts of Victoria, through NSW to southeast Queensland. The area of occupancy is estimated at 300,000 square kilometres. The extent of occurrence is likely to be declining based on historical declines and the present status of the species (DoE 2016). The study area is not considered an important foraging or breeding area of habitat for the Regent Honeyeater (Birdlife 2020, EES 2020). The removal of linear patches of habitat along the 300 kilometres alignment would be unlikely to reduce the area of occupancy of the species.
Fragment an existing population into two or more populations	Highly mobile species such as the Regent Honeyeater are expected to be less impacted by fragmentation and this species is well-adapted to accessing widely spaced habitat resources given its mobility and preference for seasonal foraging resources. Given the clearing occurs along a mainly 50 metres wide corridor, the high mobility of the species, and large areas of forest to be retained in the Pilliga, the proposal is unlikely to fragment a population into two or more populations.
Adversely affect habitat critical to the survival of a species	Habitat critical to the survival of the Regent Honeyeater includes any breeding or foraging areas where the species is likely to occur, and any newly discovered breeding or foraging locations. Three important breeding areas are known for the species in NSW: Barraba-Bundarra (located east of Mt Kaputar), the Capertee Valley and the Hunter Valley (DoE 2016). These breeding areas contain stands of box-gum trees growing on high quality sites where nectar production is copious and relatively predictable and constitute critical habitat for the survival of the species. As these areas are located at a substantial distance from the study area, and as there is no record of breeding within locality, it can be assumed that breeding is unlikely to occur within the study area. The Recovery Plan notes the Pilliga forests are important for the species and maps this habitat area. It is located in the south-east of the forests, well away from the proposal site. No important habitat has been identified in the study area by OEH (correspondence received January 2019, EES 2020). The proposal would remove 286.8 hectares of preferred foraging habitat. Individuals may forage on occasion in these areas, and the proposal may therefore adversely affect habitat critical to the survival of the species.
Disrupt the breeding cycle of a population	The Regent Honeyeater breeds on the western slopes of the Great Dividing Range in three key areas: Bundarra-Barraba, Capertee Valley and north-east Victoria. No breeding habitat is located in the proposal site. Habitat loss as a result of the proposal will decrease the availability of winter forage for individual honeyeaters that disperse nomadically throughout the region (and the study area) during winter. The reduced availability of foraging habitat, particularly during poor flowering seasons and/or drought periods, could reduce the health and condition of adult birds, which could in turn, lead to reduced breeding success. However, the study area is not considered critical to the Regent Honeyeater and it is unlikely that the condition and health of Regent Honeyeaters that may forage in the study area on occasion would be compromised to the extent that breeding success of individuals would be affected. Furthermore, the proposed action would not fragment a population

Criteria	Discussion
	of the Regent Honeyeater or create a barrier to local or regional movements of the species between foraging and breeding areas. Given the above considerations, the proposal is unlikely to significantly disrupt the breeding cycle of the Regent Honeyeater.
Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	The proposal would remove 286.8 hectares of preferred feed trees. No breeding habitat would be removed. No areas of important foraging habitat have been identified in the proposal site, although individuals may forage on occasion in the proposal site. The proposal would contribute to cumulative fragmentation of habitat in the landscape. Highly mobile species such as the Regent Honeyeater are expected to be less impacted by fragmentation and this species is well-adapted to accessing widely spaced habitat resources given its mobility and preference for seasonal foraging resources. Fragmentation of forested patches by the proposal would not impact movement of the species in the locality. While no breeding habitat and no important foraging habitat would be removed, the loss of 286.8 hectares of forest habitat containing preferred feed species may contribute to the overall decline of the species.
Result in invasive species that are harmful to the species becoming established in the species' habitat	Introduction of weeds is of particular concern in the Pilliga forests as they can reduce quality of vegetation and thus impact fauna and flora habitats. Operation of the proposal has the potential to spread weeds and pests into the Pilliga and elsewhere along the alignment. Introduction and spread of weeds is unlikely to substantially impact foraging habitat for this species. Predator species have been shown to prefer moving down linear clearings, and therefore, clearings could increase predation risk for other species (Dawson et al 2017). The creation of a 73 kilometres linear gap through the Pilliga may increase the risk of fox and cat predation. There is little risk of establishment of predators elsewhere in the alignment.
Introduce disease that may cause the species to decline	The proposal is unlikely to introduce disease into the study area that may cause the species to decline.
Interfere with the recovery of the species	'Significant reductions in extent of habitat' is listed as a key factor in the current threatened status of the Regent Honeyeater (DoE 2016). Vegetation removal associated with construction of the proposal would cause the permanent removal of 286.8 hectares of potential winter foraging habitat. This habitat loss will decrease the availability of winter forage for individual honeyeaters that disperse nomadically throughout the region (and the study area) during winter. However, the habitat to be is not considered to support critical habitat for this species. While no breeding habitat and no important foraging habitat would be removed, the loss of 286.8 hectares of forested habitat containing preferred feed species may interfere with the recovery of the species.
Conclusion	Although no breeding habitat and no important foraging habitat would be removed, and there would be no impact on the ability of this species to move from breeding areas to foraging areas, the proposal may still result in a significant impact on the Regent Honeyeater as 286.8 hectares of habitat containing preferred feed species would be removed.

Swift Parrot (*Lathamus discolor*) – critically endangered species

Distribution

The Swift Parrot breeds in Tasmania during the summer and the entire population migrates north to mainland Australia for the winter, with the majority being found in Victoria and NSW (DEE 2019b).

Habitat requirements

The Swift Parrot only breeds in Tasmania, arriving in August from the mainland to nest in hollows in old trees of a range of eucalypt species. Nest sites in eastern Tasmanian are usually located near the coast in dry forests on upper slopes and ridge tops (Parks 2010).

While on the mainland, Swift Parrots are nomadic, spending weeks or months at some sites and only a few hours at others, determined by the supply of nectar (Parks 2010). On the mainland they occur in areas where eucalypts are flowering profusely or where there are abundant lerp (from sap-sucking bugs) infestations (EES 2019b). Favoured feed trees include winter flowering species such as Swamp Mahogany *Eucalyptus robusta*, Spotted Gum *Corymbia maculata*, Red Bloodwood *C. gummifera*, Forest Red Gum *E. tereticornis*, Mugga Ironbark *E. sideroxylon*, and White Box *E. albens* (EES 2019b). Commonly used lerp infested trees include Inland Grey Box *E. microcarpa*, Grey Box *E. microcarpa*, Blackbutt *E. pilularis*, and Yellow Box *E. melliodora*. The Swift Parrot returns to some foraging sites on a cyclic basis depending on food availability (EES 2019b).

The extent of habitat use in each region varies according to food availability and competition, with Swift Parrots briefly passing through some habitats feeding opportunistically, and remaining in other habitats foraging for several days, weeks or months (). The north-west slopes and the tablelands are used when local conditions are favourable, but are not part of the core winter foraging area.

During drought swift parrot abundance was significantly correlated with rainfall, whereby most of the population either concentrated in a few regions or migrated longer distances (up to 1000 kilometres) to drought refuges in wetter coastal areas.

Habitat in the study area

The Swift Parrot has a patchy distribution of records between Narromine and Narrabri. Local records are known around Dubbo, Gunnedah, Warrumbungles National Park and Mt Kaputar National Park. No important habitat for the species has been mapped by OEH in the study area (email correspondence from OEH received January 2019). This species is known to occur in the Inland Slopes, Pilliga and Northern Basalts IBRA subregions, and is predicted to occur in the Pilliga Outwash and Northern Basalts subregions. No individuals were recorded during surveys for the proposal.

The eastern Pilliga is identified as being important for the Swift Parrot, with irregular records such as at Barkala in 2002 and Warrumbungle National Park in 2005 (Birdlife International 2020). Potential foraging habitat is present in the proposal site, particularly in the Pilliga area, with PCTs 88, 397, 398 and 399 containing preferred feed trees (Mugga Ironbark, Yellow Box and Grey Gum). In total 732.9 hectares of potential foraging habitat for this species occurs in the proposal site (in IBRA subregions which this species is known or predicted to occur), with 506 hectares of this in the Pilliga.

Table M12: Assessment of significance for the Swift Parrot

Criteria	Discussion
According to the DotE (2013) 'significant impact criteria', an action is likely to have a significant impact on a critically endangered or endangered species if there is a real chance or possibility that it will:	
Lead to a long-term decrease in the size of a population	The Swift Parrot breeds only in Tasmania, migrating to the mainland outside the breeding season. No important habitat for the species was identified by OEH (communication January 2019) in the study area. There is one record within 20 kilometres of the alignment in the last twenty years. The proposal would remove 732.9 hectares of potential foraging habitat for this species containing preferred feed trees. No clearing would occur in the eastern Pilliga which is identified as being important for the Swift Parrot (Birdlife International 2020). While individuals may forage along the alignment on occasion, the habitat to be removed has not been identified as important foraging habitat for this species by Birdlife Australia (2020). This habitat loss will decrease the availability of winter forage for individual honeyeaters that disperse nomadically throughout the region (and the study area) during winter. As such, the proposal is unlikely to lead to a long-term decrease in the size of a population.
Reduce the area of occupancy of the species	The distributional range of the Swift Parrot extends from Tasmania through parts of Victoria and NSW to southeast Queensland. Within this range, the area of occupancy for the species would include breeding grounds in Tasmania, migration routes and foraging habitats on mainland Australia. The study area is not considered a critical area of habitat for the Swift Parrot. The removal of linear patches of habitat along the 300 kilometres alignment would be unlikely to reduce the area of occupancy of the species.
Fragment an existing population into two or more populations	The Swift Parrot is a highly mobile species that routinely traverses large expanses of open water and open country, including Bass Straight, agricultural land and other clearings during its annual migration. The Swift Parrot would rely on 'stepping stones' of suitable foraging and roosting habitat during migrations and is thought to prefer 'corridors' of woodland vegetation over which to traverse. While the proposal would, in places, widen an existing gap, or create a new narrow linear gap in the forest canopy, dispersal or movement of the Swift Parrot across the landscape is unlikely to be affected as clearings created by the proposal would not be of a scale that would isolate habitat with respect to this species. As such, the proposal would not fragment the existing population into two or more populations.
Adversely affect habitat critical to the survival of a species	The *Recovery Plan for the Swift Parrot* (Swift Parrot Recovery Team 2001) notes the important breeding habitats for the species within Tasmania and important foraging habitats within mainland Australia. No important habitat for the species was identified by OEH (communication January 2019) in the study area. The eastern Pilliga is identified as being important for the Swift Parrot (Birdlife International 2020). There is one record within 20 kilometres of the alignment in the last twenty years. While individuals may forage along the alignment on occasion, the habitat to be removed is not likely to be important habitat for this species.

Criteria	Discussion
	As no breeding habitat and no preferred foraging habitat would be impacted, the proposal is unlikely to adversely affect habitat critical to the survival of a species.
Disrupt the breeding cycle of a population	Breeding does not occur on mainland Australia. Adult birds would only occur within the study area as part of seasonal foraging behaviour during winter. Habitat loss could decrease the availability of winter forage for individuals that disperse nomadically throughout the region (and the study area) during winter. The reduced availability of foraging habitat, particularly during poor flowering seasons and/or drought periods, could theoretically reduce the health and condition of adult birds, which could in turn, lead to poor condition and reduced breeding success. However, the habitats in the study area are not considered critical to the Swift Parrot and it is unlikely that the condition and health of individuals that may forage in the study area on occasion would be compromised to the extent that breeding success of individuals would be affected. Furthermore, the proposed action would not fragment a population of the Swift Parrot or create a barrier to local or regional movements of the species between foraging and breeding areas. Given the above points, the proposal is unlikely to disrupt the breeding cycle of a population of Swift Parrot.
Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	The proposal would remove 732.9 hectares of potential foraging habitat for this species containing preferred feed trees. No clearing would occur in the eastern Pilliga which is identified as being important for the Swift Parrot (Birdlife International 2020). The proposal would contribute to cumulative fragmentation of habitat in the landscape. Highly mobile species such as the Swift Parrot are expected to be less impacted by fragmentation and this species is well-adapted to accessing widely spaced habitat resources given its mobility and preference for seasonal foraging resources. Fragmentation of forested patches by the proposal would not impact movement of the species in the locality. Given that no breeding habitat would be impacted, no important foraging habitat would be removed, and that no areas of habitat would become isolated, it is unlikely that the proposal would result in the overall decline of the species.
Result in invasive species that are harmful to the species becoming established in the species' habitat	Introduction of weeds is of particular concern in the Pilliga forests as they can reduce quality of vegetation and thus impact fauna and flora habitats. Operation of the proposal has the potential to spread weeds and pests into the Pilliga and elsewhere along the alignment. Introduction and spread of weeds is unlikely to substantially impact foraging habitat for this species. Predator species have been shown to prefer moving down linear clearings, and therefore, clearings could increase predation risk for other species (Dawson et al 2017). The creation of a 73 kilometres linear gap through the Pilliga may increase the risk of fox and cat predation. There is little risk of establishment of predators elsewhere in the alignment.
Introduce disease that may cause the species to decline	Psittacine beak and feather disease is a common and potentially deadly disease of parrots. Susceptibility to the infection may be influenced by environmental factors, such as climate, nutrition, habitat quality and social factors (DEH 2005). The proposal is unlikely to introduce Psittacine beak and feather disease, however cumulative impacts of further land clearing and

Criteria	Discussion
	impacts on habitat has the potential to increase susceptibility of individuals.
Interfere with the recovery of the species	Habitat loss is a key factor in the current threatened status of the Swift Parrot. The proposal would remove 732.9 hectares of potential foraging habitat for this species containing preferred feed trees. No clearing would occur in the eastern Pilliga which is identified as being important for the Swift Parrot (Birdlife International 2020). This habitat loss will decrease the availability of winter forage for individual honeyeaters that disperse nomadically throughout the region (and the study area) during winter. However, the habitat to be is not considered to support critical habitat for this species. Given that there would be no impact on breeding habitat, no important foraging habitat would be removed, and the lack of records of the species in the locality, the proposal is unlikely to interfere with the recovery of the species.
Conclusion	Although no breeding habitat and no important foraging habitat would be removed, and there would be no impact on the ability of this species to move from breeding areas to foraging areas, the proposal may still result in a significant impact on the Swift Parrot as 732.9 hectares of potential foraging habitat containing preferred feed species for this species would be removed.

Slender Darling-pea – (*Swainsona murrayana*) – vulnerable species

Habitat requirements

Swainsona murrayana is distributed mainly throughout NSW, but is also found in Victoria, South Australia and Queensland (DoE 2020). Within NSW, *Swainsona murrayana* occurs is known to occur within the Pilliga IBRA sub-region in addition to being predicted within the Pilliga Outwash IBRA sub-region (OEH 2019a). *Swainsona murrayana* has been recorded in the Jerilderie and Deniliquin areas of the southern riverine plain, the Hay plain as far north as Willandra National Park, near Broken Hill and in various localities between Dubbo and Moree (OEH 2020).

Swainsona murrayana occurs on clay-based soils, ranging from grey, red and brown cracking clays to red-brown earths and loams with varied vegetation types, including Bladder Saltbush, Black Box and grassland communities on level plains, floodplains and depressions (OEH 2019b). Species associations for *Swainsona murrayana* include Maireana species (*Maireana* spp.), Wallaby-grass (*Austrodanthonia* spp), and Speargrass (*Austrostipa* spp.) (Harden 2002).

The population size of *Swainsona murrayana* is highly variable, and has been recorded from at least 60 geographically distinct sub populations in NSW, with up to 200 000 individuals estimated to occur within these sub populations (NSW SC 2008). Plant abundance is generally described as locally common to abundant in NSW, with counts ranging from single plants to at least 1000 plants made at various sites (DoE 2020). Small numbers appear to represent incidental records, with potential population sizes likely to be much larger (NSW SC 2008). Within the locality, a small number of records of *Swainsona murrayana* have been found, mostly associated with the towns of Baradine (eight kilometres from proposal site), Narrabri and Gulargambone (21 kilometres from proposal site) (OEH 2019c). Isolated recordings also occur within Pilliga East (42 kilometres from proposal site). The closest records to the proposal site are in Narrabri about 500 metres to the east near the Namoi River. This record has no date and is from a Royal Botanic Gardens Specimen.

Swainsona murrayana is a perennial herb, which produces a winter-spring growth (PlantNET, 2020; OEH 2020). The species flowers in spring to early summer and then dies back after flowering. It re-shoots readily and often carpets the landscape after good cool-season rains (OEH 2020). It is suspected that the species may require some disturbance and has been known to occur in paddocks that have been moderately grazed or occasionally cultivated (DEWHA 2008a). One study on the Murray Valley Plain, in northern Victoria, found that *Swainsona murrayana* was only pollinated by *Trichocolletes maximus*, a solitary, ground nesting bee (DoE 2020). The bee may fare poorly during extended drought and *Swainsona murrayana* may be susceptible to reproductive failure if this specialist pollinator declines (Morgan and Williams 2015).

Habitat in the study area

Swainsona murrayana was not recorded during targeted surveys during the recommended survey period. This included targeted surveys in Spring 2020 in areas within the proposal site mapped as part of a species polygon for the species during EIS exhibition. No individuals were recorded despite targeted survey effort in good climatic conditions and where other *Swainsona* species were observed.

Potential habitat was identified in mostly grassy native dominant and forb rich PCTs for which the species has a known association. These include:

- PCT 444 – Silver-leaved Ironbark grassy tall woodland on clay-loam soils on plains in the Brigalow Belt South Bioregion.
- PCT 414 – White Mallee - Dwyer's Red Gum mallee heath on sands in the Goonoo - Pilliga region, Brigalow Belt South Bioregion.
- PCT 49 – Partly derived Windmill Grass - Copperburr alluvial plains shrubby grassland of the Darling Riverine Plains Bioregion and Brigalow Belt South Bioregion.

This species has the potential to occur in a number of other locations within the proposal site that contain known associated PCTs but which could not be accessed due to either remote access or private property with no approval to access. In the absence of survey effort in these areas, the species is assumed to occur. Assumed habitat in unsurveyed areas for this species is 50 hectares.

These PCTs provide suitable clayey woodland and grassland habitat but the species was not recorded during targeted surveys. While this species has associations with other PCTs identified in the proposal site, the likelihood of the species occurring in these areas is unlikely based on a number of factors observed during field surveys:

- small patch size and less about 10 metres wide in Box-Gum woodland area with roads and cropped areas on each side
- low native species diversity and prevalence of introduced species
- past and grazing by introduced livestock
- within some Pilliga areas, dense regrowth areas of White Cypress Pine and Buloke with high litter cover and low grass and forb cover.

Table M13 Slender Darling Pea

Criteria	Discussion
According to the DotE (2013) 'significant impact criteria', an action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that it will:	Despite *Swainsona murrayana* not being found within the construction footprint during targeted surveys, consideration has been given to its potential occurrence in unsurveyed inaccessible areas due to its occurrence within the locality. *Swainsona murrayana* has a widespread and diverse range across NSW, Victoria, South Australia and in a small area of Queensland. In the proposal site, previous records are from scattered and isolated occurrences mostly near town centres that are not recent. Any potential occurrence of *Swainsona murrayana* within the construction footprint would also occur within the middle of its range, both in NSW and throughout Australia. Based on the above considerations, the occurrence of *Swainsona murrayana* within the areas of potential habitat in the proposal site is not likely to be an 'important population'.
Lead to a long-term decrease in the size of an important population of a species	As the species has not been found within the construction footprint and also has a small number of records within the locality, the likelihood that the species would decline as a result of the proposal is minor. About 50.0 hectares of assumed potential habitat occurs within the proposal site and will be removed. Most potential habitat for this species occurs within open grassy woodlands and derived grasslands that have not been severely disturbed. These are not common in the proposal site. Despite suitable potential habitat occurring within the proposal site, the species was not recorded during targeted surveys, the proposal is unlikely to lead to a long-term decrease in the size of any important population of *Swainsona murrayana* within the proposal site.
Reduce the area of occupancy of an important population	Complete vegetation clearance is proposed within the construction footprint of the proposal. *Swainsona murrayana* has the potential to occur within or adjacent to the proposal and is known to occur within the wider locality of the proposal. Assumed presence suitable habitat to be impacted by the proposal is about 50.0 hectares, but despite targeted surveys in other accessible potential habitats in suitable seasons, the species was not recorded. As the proposal will clear about 50.0 hectares of suitable potential habitat within the construction footprint, the proposal is likely to reduce the area of occupancy for an important population *Swainsona murrayana* if this species occurs within the proposal.
Fragment an existing important population into two or more populations	The proposal is located in close proximity to roadsides and access tracks within the Pilliga forests and at various locations between Narromine and Narrabri. With the exception of Segment 10 (Pilliga), the proposal traverses mostly agricultural land which has been extensively cleared for agriculture including cropping and intensive grazing. This has resulted in isolated patches of remnant native vegetation and small connected patches, mostly limited to roadside reserves and smaller patches on private properties. Potential habitat for this species that may occur in the proposal site, occurs in an already highly fragmented landscape for this species. The addition of a generally 50-60 metres wide corridor of

Criteria	Discussion
	clearing is in an already highly fragmented and modified landscape is unlikely to fragment any population into two or more populations.
Adversely affect habitat critical to the survival of a species	There is no registered critical habitat for *Swainsona murrayana* on the Register of Critical Habitat (DAWE, 2020). About 50.0 hectares of assumed potential habitat occurs in the proposal site that has not be surveyed due to access constraints. Habitat critical to the survival of the species include grassy open woodland on fertile clay rich soils where there has been less disturbance and only moderate historical grazing. The 50.0 hectares of potential habitat occurs as scattered patches in derived and grassy open woodlands in the north of the proposal and within remote sections of woodland in the Pilliga forests. Despite targeted surveys in other potential habitats in suitable seasons, the species was not recorded. Due to the already highly fragmented nature and grazing by livestock of potential habitat scattered along the proposal site, the proposal is unlikely to adversely affect habitat critical to the survival of *Swainsona murrayana.*
Disrupt the breeding cycle of an important population	The pollination of *Swainsona murrayana* is thought to occur by one bee species, *Trichocolletes maximus* (Williams et al., 2015). Given the small size of this pollinator bee species, it is likely to have a home range of only a few kilometres. Given the proposal is generally 50-60 metres wide and the ability of this pollinator to move over kilometres, the proposal is unlikely to inhibit the movement of this pollinator. This species is known to tolerate moderate levels of grazing and disturbance and if this species was to occur, slight disturbances may potentially encourage the species to germinate. Due to the pollination requirements and nature of the species in disturbed habitat, the proposal is unlikely to disrupt the breeding cycle of potential occurrences of *Swainsona murrayana* within the proposal.
Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	The proposal will remove about 50.0 hectares of assumed potential habitat for this species within the proposal site. Despite targeted surveys in some potential habitats that could be accessed in suitable seasons, the species was not recorded. Potential habitat for this species is scattered in isolated patches through the proposal site and mostly occurs as small patches depending on disturbance history mostly in the north of the proposal with possible scattered areas in woodland in the remote Pilliga sections. The proposal would remove some areas of assumed habitat and reduce potential habitat availability for the species. The proposal will likely decrease the availability and quality of potential habitat for the species. However, given the widespread and already fragmented nature of potential habitat for the species in the proposal site, it is not likely to occur to an extent that the species is likely to further decline.
Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat	The proposal has the potential to introduce a number of invasive flora to the areas in which *Swainsona murrayana* may occur. This is due to the use of plant and machinery introducing weed seed into the proposal site and adjacent areas. As the majority of the construction footprint runs adjacent to existing access tracks and roads, a number of invasive species were recorded including

Criteria	Discussion
	Opuntia species which is common and widespread along the entire proposal site. Provided that appropriate plant and machinery hygiene measures are taken, the proposal is unlikely to facilitate the spread of invasive flora to the extent of a significant impact to *Swainsona murrayana*. In addition to invasive flora, a number of threat abatement plans have been established for the species, including those regarding rabbits, feral pigs and goats (DEE, 2016, 2017; DEWHA, 2008). Impacts from these species include habitat degradation, grazing and introduction of weed species. As the proposal occurs mostly adjacent to existing access tracks and within intensive agricultural land, the proposal is unlikely to further facilitate the spread of invasive species to the extent that this species would be further impacted.
Introduce disease that may cause the species to decline	The proposal is unlikely to introduce disease into the proposal site that may cause the species to decline. There are no diseases that are known to affect this species.
Interfere substantially with the recovery of the species	There is no recovery plan for this species. There are a number of general flora species threat abatement plans (not *S. murrayana* specific), including those regarding rabbits, feral pigs and goats (DEE, 2016, 2017; DEWHA, 2008). These threat abatement plans indicate that a number of threats likely to be associated with these species occur, including: • habitat degradation • preventing plant regeneration • overgrazing and damage to plants • promotion of introduced weed growth. As the proposal occurs adjacent to existing access tracks and within an already highly fragmented landscape where weeds are common and widespread due to access and spread by some feral fauna, the proposal is unlikely to increase the opportunity for these species to increase their range throughout the locality and impact on *Swainsona murrayana*.
Conclusion	The proposal is unlikely to have a significant impact on *Swainsona murrayana* given: • That an important population is not likely to occur in the proposal site or study area. • That 50.0 hectares of assumed presence potential habitat within remote parts of the Pilliga forests and in a fragmented and modified agricultural landscape would be removed where the species was not detected during targeted surveys under suitable survey conditions. • the proposal would not isolate any known or potential habitat for the species further than has already occurred in the highly modified proposal site in which it could potentially occur.

Commersonia procumbens – vulnerable species

Habitat requirements

Commersonia procumbens (syn. *Androcalva procumbens* and *Rulingia procumbens*) is endemic to NSW, mainly confined to the Dubbo-Mendooran-Gilgandra region, but also in the Pilliga and Nymagee areas (OEH, 2020a). Similarly, these areas correspond to its known distribution in the Pilliga IBRA sub-region and predicted occurrence in the Pilliga Outwash IBRA sub-region (OEH, 2019a). Populations of *Commersonia procumbens* are known in Goonoo State Forest, Mt Kaputar National Park, and Pilliga Nature Reserve with additional populations occurring on crown land, state forests, and private land (DEWHA, 2008). The mapped range of this species reaches from Goobang National Park south of Dubbo, to Yelarbon State Forest on the NSW/QLD border (DoE, 2020).

Commersonia procumbens occurs on sandy soils in woodland or scrub communities and are often, but not always, associated with disturbed habitats such as road verges, quarry boundaries, gravel stockpiles, and power line easements (OEH, 2019b; DEWHA, 2008). Canopy species associated with *Commersonia procumbens* include *Eucalyptus dealbata* and *Eucalyptus sideroxylon* communities, *Melaleuca uncinata* scrub, under mallee eucalypts with a *Calytrix tetragona* understorey in addition to *Eucalyptus fibrosa* subsp. *nubila, Eucalyptus dealbata, Eucalyptus albens* and *Callitris glaucophylla* woodlands north of Dubbo (OEH, 2019b).

Whilst previous records indicate that this species is abundant in the Pilliga and its locality (OEH, 2019c), biodiversity surveys of Brigalow Belt South in 2002 recorded *Commersonia procumbens* at only one of 32 previously known locations (DEWHA, 2008). It was not relocated at Pilliga East State Forest, Goonoo State Forest or Trinkey State Forest. The species has been recorded in populations of 50+ individuals of various ages, with individual numbers of populations corresponding to environmental conditions such as amount of received sunlight.

Commersonia procumbens appears to respond to fire moderately well, with adaptive abilities regarding reproduction. Populations have been found in a recently burnt Ironbark and Callitris area (OEH, 2019b). *Commersonia procumbens* is a pioneer species, potentially due to a persistent soil seed bank which responds positively to fire (OEH, 2020). Despite this, suitable habitat for the species should not be burnt more frequently than once every seven years (NSW RFS, 2004). The species is also thought to be clonal, with the potential for populations to comprise of a single cohort, or have a multi-aged structure where some individuals appear to be older (OEH, 2019b).

The flowering period of C*ommersonia procumbens* is from August to December followed by fruiting from summer to autumn with the recommended survey period between August and May (OEH, 2020). The species will however appear after one to two seasons after fire, which is essential for above ground identification. When conditions are not favourable, the species will appear senescent and return to an underground root stock (OEH, 2020). This shrub species is most likely pollinated by insect species (PlantNET, 2020).

Within the locality, most records are known from the Pilliga east of the Newell Highway and a few scattered records in Pilliga East forest west of the Newell Highway. The closest records to the proposal are within Pilliga East forest and are about 2.5 kilometres from the proposal site recorded in 2012 (about 50 plants). Most other records are from Goonoo Conservation Area (about 30 kilometres east of the proposal).

Habitat in the study area

Commersonia procumbens was not recorded during targeted surveys during the recommended survey period. Within this period, well below average rainfall was recorded across the study area for the two years over which surveys were completed. These conditions resulted in a reduced ability to detect the species as the species is unlikely to have sprouted. In addition, there have been no known recent fires in the proposal site within potential habitat. However, targeted surveys under more favourable climatic conditions in spring 2020 also did not detect the species. There were no recent (<2 years) fires in potential habitats within the proposal site which also reduces detectability of this species.

Of the native vegetation to be impacted about 573.0 hectares represents potential habitat for *Commersonia procumbens*. These areas are mostly represented by sandy soils in scrubby woodland communities for which the species has a known association. These include:

- PCT 88 – Pilliga Box - White Cypress Pine - Buloke shrubby woodland in the Brigalow Belt South Bioregion
- PCT 141 – Broombush - wattle very tall shrubland of the Pilliga to Goonoo regions, Brigalow Belt South Bioregion
- PCT 397 – Poplar Box - White Cypress Pine shrub grass tall woodland of the Pilliga - Warialda region, Brigalow Belt South Bioregion
- PCT 399 – Red gum - Rough-barked Apple +/- tea tree sandy creek woodland (wetland) in the Pilliga - Goonoo sandstone forests, Brigalow Belt South Bioregion
- PCT 404 – Red Ironbark - White Bloodwood +/- Burrows Wattle heathy woodland on sandy soil in the Pilliga forests
- PCT 406 – White Bloodwood - Motherumbah - Red Ironbark shrubby sandstone hill woodland / open forest mainly in east Pilliga forests
- PCT 409 – Dirty (Baradine) Gum - White Bloodwood - White Cypress Pine - Motherumbah shrubby woodland on sandy soils in the Pilliga Scrub and surrounding region, Brigalow Belt South Bioregion
- PCT 414 – White Mallee - Dwyer's Red Gum mallee heath on sands in the Goonoo - Pilliga region, Brigalow Belt South Bioregion
- PCT 1384 – White Cypress Pine - Bulloak - ironbark woodland of the Pilliga area of the Brigalow Belt South Bioregion

These PCTs provide suitable sandy woodland and scrub communities in addition to the areas within the proposal site providing areas of previously disturbed access tracks.

Table M14 Assessment of significance – *Commersonia procumbens*

Criteria	Discussion
According to the DotE (2013) 'significant impact criteria', an action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that it will:	The main records for this species occur in Pilliga forests and Goonoo State Conservation Area. There are known and recent records within the investigation corridor and in the study area of the proposal site. Given that this species is known mostly from two locations, the population in the Pilliga would be considered an important population.
Lead to a long-term decrease in the size of an important population of a species	Suitable potential habitat occurs throughout the Pilliga forests and within the proposal site, but the species distribution is influenced by site specific factors, including local floristic variation, and different disturbance and fire histories across the forest. Populations of *Commersonia procumbens* have been in apparent decline, with the exclusion of the population within Goonoo State Conservation Area. Described population sizes are approximately 50+ individuals, which suggests that the species is limited in genetic diversity and reproductive opportunity. Due to the species observed response to fire, it is likely that populations are dependent on fire to germinate. The extensiveness of the soil seed bank nor the frequency or location of fires however cannot be determined, and can therefore not be relied upon to maintain the genetic diversity of the population. The proposal will result in the removal of 573.0 hectares of suitable potential habitat for the species. The proposal will result in the clearing of a large area of potential habitat in Segment 10 (Pilliga), and may impact gene flow and germination between areas of potential habitat. The proposal has the potential to lead to a long-term decrease in the size of the important population.

Criteria	Discussion
Reduce the area of occupancy of an important population	The proposal will remove a total of 573.0 hectares of assumed potential habitat in Segment 10 (Pilliga). This clearing will occur as a new 73 kilometres x generally 50-60 metres wide linear gap through the forest and adjacent to existing cleared areas of Pilliga Forest Way for much of the segment. Roadside populations of *Commersonia procumbens* near Pilliga Forest Way have the potential to occur within or adjacent to the proposal. The proposal is likely to reduce the area of occupancy given the large amount of potential habitat removal.
Fragment an existing important population into two or more populations	The proposal is located in close proximity to roadsides and access tracks within the Pilliga. Whilst the proposal runs through suitable habitat adjacent to important populations, it also runs adjacent to existing access tracks and roads which are known habitat for this species as it can sometimes favour previously modified roadside verges. The proposal is unlikely to further fragment the important population into two or more populations given the existing cleared areas in the Pilliga and the species ability to adapt to some modification.
Adversely affect habitat critical to the survival of a species	Within the Pilliga where the species occurs, there are known records on both the eastern and western side of the proposal site. The species often occurs in post fire areas and is sometimes associated with moderate levels of disturbance particularly on the edges of roads such as occurs parallel to Pilliga Forest Way. Individuals which may occur within the proposal, may be critical to the long-term genetic diversity of the species in habitat which is suitable for reproduction and dispersal. Reducing the potential area of occupancy of this species may subsequently reduce the reproduction potential of the species. Approximately 573.0 hectares of suitable habitat would be cleared as a result of the proposal. Despite not being found during targeted surveys, the proposal site has suitable potential habitat for this species that would be removed. Whilst *Commersonia procumbens* is not listed on the Register of Critical Habitat (DAWE 2020), the proposal may adversely affect potential habitat critical to the survival of *Commersonia procumbens.*
Disrupt the breeding cycle of an important population	The potential genetic population within the proposal site may contribute to the overall population within the study area and locality resulting in a reduced opportunity for the species to reproduce and disperse. There is potential for the proposal to disrupt the reproduction and germination cycle of the population.
Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	The proposal will result in the removal of 573.0 hectares of suitable potential habitat for the species in Segment 10 (Pilliga). Due to the apparent decline in previously known populations, and that suitable potential habitat would be removed, the proposal will likely decrease the availability or quality of habitat to the extent that the species is likely to decline.
Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat	Introduction of weeds is of particular concern in the Pilliga forests as they can reduce the quality of vegetation and thus impact flora habitats. Weeds such as the Tiger Pear (*Opuntia aurantiaca*), are already common in the Pilliga, and may be further spread during construction. Operation of the proposal has the potential to spread weeds and pests into the Pilliga. The surroundings of railways (eg verges and

Criteria	Discussion
	embankments) often host a high diversity of non-native species (Gelbard and Belnap 2003; Hansen and Clevenger 2005), in many cases due to their transportation as stowaways in or on trains. Provided that appropriate plant and machinery hygiene measures are taken, the proposal is unlikely to facilitate the spread of invasive flora to the extent of a significant impact to *Commersonia procumbens*.
Introduce disease that may cause the species to decline	The proposal is unlikely to introduce disease into the proposal site that may cause the species to decline. There are no diseases that are known to affect this species.
Interfere substantially with the recovery of the species	There is no recovery plan for *Commersonia procumbens*. Despite this, the *Pilliga Nature Reserve Plan of Management* (NPWS 2015), identifies developments or activities in or near the Pilliga Nature Reserve that may compromise the recovery of species should be opposed. Road grading and altered fire regimes are a particular threat to the species (OEH 2019b). The proposal requires the removal of 573.0 hectares of suitable potential habitat for *Commersonia procumbens*. Due to the large area of suitable habitat of *Commersonia procumbens* within the proposal site to be removed near known records of the species, the proposal may interfere with the recovery of *Commersonia procumbens.*
Conclusion	The proposal is likely to have a significant impact on *Commersonia procumbens* given: • the large area of suitable potential habitat of 573.0 hectares to be impacted which may decrease the availability and quality of habitat to the extent that the species is likely to decline • the occurrence of nearby records in similar habitats and therefore its likely occurrence in the proposal site • The low genetic diversity of the species of which any loss of plants is likely to further impact genetic diversity of the species.

Spiny Peppercress – (*Lepidium aschersonii*) – vulnerable species

Habitat requirements

Lepidium aschersonii is not widespread however this species is known to occur within the Pilliga and Pilliga Outwash IBRA sub-regions (OEH 2019a). This species occurs in the marginal central-western slopes and north-western plains regions of NSW including within Brigalow Nature Reserve, Brigalow State Conservation Area, Leard State Conservation Area and Bobbiwaa State Conservation Area (OEH 2020; 2019b).

Lepidium aschersonii is mainly found on ridges of gilgai clays dominated by open to dense vegetation structures with sparse grassy understoreys and moderate leaf litter (OEH 2020). Associated canopy species include Brigalow *(Acacia harpophylla),* Belah *(Casuarina cristata),* Buloke *(Allocasuarina luehmanii)* and Grey Box *(Eucalyptus microcarpa)* (OEH 2020). In the south, the species has also been recorded growing in Bull Mallee *(Eucalyptus behriana).*

Recorded population sizes of *Lepidium aschersonii* vary from 18 to 5000+ individual plants with 50 percent of the total *Lepidium aschersonii* recorded for Australia occurring in NSW. (OEH 2020; 2019b). The National Recovery Plan for *Lepidium aschersonii* has indicated that one population in Brigalow Park Nature Reserve near Narrabri contains 'many thousands' of individuals and may be the largest remaining population of *Lepidium aschersonii* (Carter 2010). A number of smaller populations also occur along roadsides within Narrabri, with populations ranging from 18 individuals to around 600 individuals (both recorded in 1994) (Carter, 2010). The closest records to the proposal site are in Segment 11 between Pilliga and Narrabri about 165 metres from the proposal site (records from 2017).

Plant numbers fluctuate depending on surrounding environment and appear to be influenced by hydrological processes. Population numbers may be negatively correlated with an increasing overstorey density with a lack of individuals where Brigalow canopy cover exceeded approximately 60 percent (OEH 2019b). Populations have also been known to disappear from the site following flood inundation to reappear years later, whilst conversely increasing in numbers during drought conditions (OEH 2020). When this occurs, *Lepidium aschersonii* is often described as a “weed” where it dominates paddocks.

Lepidium aschersonii is a small annual herb (PlantNET 2020), which flowers from Spring to Autumn (OEH 2020). The recommended survey period for *Lepidium aschersonii* is November to April, with some populations known to produce abundant seed, due to the short-lived occurrence of the species and high population sizes when observed (OEH 2020).

Habitat in the study area

Lepidium aschersonii was not recorded during targeted surveys during the recommended survey period. Within this period, well below average rainfall was recorded across the study area for the two years over which surveys were completed. In addition, no land access agreements were available for the nearest locations previous locations of this species. Some areas of suitable potential habitat within Segment 11 and any remote sections of the Pilliga could not be accessed, and in these areas potential habitat has been assumed for the species. These conditions resulted in a reduced ability to detect the species as the species is unlikely to have sprouted and seeded.

Additional targeted surveys planned for this species in early April 2020 due to increased rainfall, were cancelled due to the global coronavirus pandemic and associated travel restrictions. However further targeted surveys were completed in November 2020.

Habitat for *Lepidium aschersonii* has been defined as PCTs, of which a total of four are located within the construction footprint and include:

- PCT35 – Brigalow - Belah open forest / woodland on alluvial often gilgaied clay from Pilliga Scrub to Goondiwindi, Brigalow Belt South Bioregion.
- PCT 56 – Poplar Box - Belah woodland on clay-loam soils on alluvial plains of north-central NSW.
- PCT 88 – Pilliga Box - White Cypress Pine- Buloke shrubby woodland in the Brigalow Belt South Bioregion.
- PCT 256 – Green Mallee tall mallee woodland on rises in the Pilliga - Goonoo regions, southern Brigalow Belt South Bioregion.

These PCTs potentially provide suitable alluvial open to closed woodlands associated with the gilgai clays of the region.

Table M15 Assessment of significance – Spiny Peppercress

Criteria	Discussion
According to the DotE (2013) 'significant impact criteria', an action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that it will:	*Lepidium aschersonii* was not observed in the proposal site during targeted surveys. The species is assumed to occur in a number of inaccessible locations. Its occurrence is assumed presence based on previous records in the study area and observed potential habitats. In areas surrounding Narrabri (segment 11), records for the species occurs within 200 meters of the proposal site, however most known populations of this species are restricted to Brigalow Nature Reserve and the Brigalow State Conservation Area which are located about six kilometres west of the proposal site. The occurrence of the roadside populations within Narrabri, however, are located closer to the proposal site. Although roadside populations in the Narrabri region are small, these populations have been included in the *National Recovery Plan* (Carter, 2010). These populations may contribute to the dispersal of the species within the north and south of its range therefore populations in this region must be considered an 'important population'.
Lead to a long-term decrease in the size of an important population of a species	Within the limitations outlined above, targeted surveying and database records do not indicate that the species occurs within the proposal site. Habitat for this species is limited in the proposal site and surrounding study area, and known populations for the species are mostly limited to the Brigalow Nature Reserve and the Brigalow State Conservation Areas. However, there are a number of known associated PCTs that could not be surveyed due to access constraints where the species is assumed to occur. Given the proximity of some roadside records to the proposal site in the Narrabri area, this species may occur in suitable potential habitat within the proposal site. About 338.7 hectares of potential habitat occurs within the proposal site based on observed habitats and the species known associated PCTs. Most potential habitat for this species occurs within open grassy woodlands and derived grasslands that have not been severely disturbed. These are not common in the proposal site. Some potential habitat also occurs in remote sections of the Pilliga forests. Due to the lack of survey access to suitable potential habitat occurring within the proposal site, the proposal may to lead to a long-term decrease in the size of any important population of *Lepidium aschersonii* within the proposal site.

Criteria	Discussion
Reduce the area of occupancy of an important population	Complete vegetation clearance will occur within the proposal site. About 338.7 hectares of assumed presence associated PCTs with some suitable potential habitat, including gilgai clays dominated by Brigalow (*Acacia harpophylla*), Belah (*Casuarina cristata*) and Buloke (*Allocasuarina luehmanii*) has been identified during plot surveys and targeted flora surveys within the proposal site. The removal of this assumed presence potential habitat will reduce the area of potential occupancy for the species. There are records for the species in the wider locality including in conservation reserves, and the proposal site will reduce a further potential 338.7 hectares of suitable potential habitat within the proposal site, and the area of occupancy for *Lepidium aschersonii* may be reduced.
Fragment an existing important population into two or more populations	The proposal site is located in close proximity to roadside populations surrounding Narrabri. Vegetation clearing associated with the proposal will potentially fragment known populations of the species occurring on the eastern side of the proposal site, from potential populations occurring on the western side of the proposal site by at least 40 meters. With the exception of Segment 10 (Pilliga), the proposal site traverses mostly agricultural land, and roadsides which has been extensively cleared for agriculture including cropping and intensive grazing, and for the construction of roadways. This has resulted in isolated patches of remnant native vegetation and small connected patches, mostly limited to roadside reserves and smaller patches on private properties. Any important population that may occur in the proposal site, would occur in an already highly fragmented landscape for this species. The addition of a generally 50-60 metre wide corridor of clearing in an already highly fragmented may further fragment any populations into two or more populations.
Adversely affect habitat critical to the survival of a species	There is no registered critical habitat for *Lepidium aschersonii* on the Register of Critical Habitat (DAWE, 2020). Additionally, the recovery plan for *Lepidium aschersonii* does not identify habitat critical for the species. In total, the proposal will remove assumed presence associated PCTs of 338.7 hectares of suitable potential habitat for the species. This includes Brigalow- Belah woodland on gilgaied clays, Poplar Box- Belah woodland and Pilliga Box – White Cypress Pine – Buloke shrubby woodland and derived grasslands from these communities recorded in the proposal site. Given the lack of records for species within the proposal site, the abundance of records within more suitable habitat in the surrounding locality and the suitable habitat in conservation reserves in the surrounding locality, it is unlikely that the removal of assumed presence habitat from the proposal site will adversely affect habitat critical to the survival of *Lepidium aschersonii.*

Criteria	Discussion
Disrupt the breeding cycle of an important population	The species exhibits a short-lived lifecycle, and an ability to re-appear several seasons after disturbance occurs. This species also typically produces abundant seed during favourable conditions. If vegetation clearing impacted on individuals or populations of this species, it is likely that seed dispersion of the species would still occur. The species was not recorded during targeted surveys, however, not all associated PCTs could be accessed to complete surveys and an assumed presence of 338.7 hectares for this species is possible. Some of the assumed presence potential habitat is within 500 metres of existing records and a seed bank for the species could occur in the proposal site. These records form part of the wider population in the locality. As such, for the reasons discussed above, it is possible that vegetation clearing within the proposal site will disrupt the breeding cycle of an important population of *Lepidium aschersonii* if it occurs in unsurveyed areas.
Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	The proposal will remove about 338.7 hectares of assumed presence potential habitat for *Lepidium aschersonii* from the proposal site. This will decrease the availability and quality of potential habitat for the species in the proposal site, however, no known records for the species exist within habitat to be removed from the proposal site. Known and suitable potential habitat for this species exists in the surrounding study area and locality including in dedicated conservation reserves. The species may occur in parts of the proposal site that could not be accessed for targeted surveys where associated PCTs occur. It is possible that the proposal may modify, destroy, remove, isolate or decrease the availability or quality of habitat to an extent that the species may further decline.
Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat	Given the occurrence of *Lepidium aschersonii* in areas surrounding Narrabri, the species already occurs in a highly modified landscape likely to support a wide array of introduced and invasive flora species. The proposal has the potential to further introduce a number of invasive flora species to areas occupied by *Lepidium aschersonii*. Introduction of weed species via vehicles and machinery operating in the proposal site could occur, as vehicles would be required to traverse a large area and variety of landscapes, including highly modified agricultural land and disturbed roadsides containing an abundance of introduced and invasive flora species (eg Mother of Millions and Tiger Pear). Given the implementation of safeguards and management measures pertaining to weed hygiene, it is unlikely that invasive species harmful to *Lepidium aschersonii* would become further established in the species habitat. In addition to invasive flora, a number of feral fauna such as rabbits, feral pigs and goats can impact the species. Impacts from these species include habitat degradation, grazing and introduction of weed species. It is unlikely that the proposal will further facilitate the spread or establishment of feral fauna species in the proposal site. For the reasons discussed above, it is unlikely that the proposal will result in invasive species that are harmful to *Lepidium aschersonii* becoming established in habitat available for the species any more than already occurs.

Criteria	Discussion
Introduce disease that may cause the species to decline	The proposal is unlikely to introduce disease into the proposal site that may cause the species to decline.
Interfere substantially with the recovery of the species	The recovery plan for *Lepidium aschersonii* identifies a number of threats to the occurrence of populations of the species occurring around Narrabri, including weed invasion, grazing and disturbance by feral animals and livestock, habitat destruction and roadworks (Carter 2010). The proposal will remove about 338.7 hectares of assumed presence potential habitat for *Lepidium aschersonii* from the proposal site, however no known records for the species exist within habitat to be removed. Given that impacts of the proposal do not occur within areas known to contain populations of the species and it is unlikely that the proposal will contribute further to any known threats to the species, it is unlikely that the proposal will interfere with the recovery of the species.
Conclusion	The proposal could potentially have a significant impact on *Lepidium aschersonii* given: • Removal of assumed presence potential habitat for the species is 338.7 hectares. Potential habitat to be removed is of moderate quality, as it occurs within a fragmented and modified agricultural landscape which the species is known to persist in.

Tylophora linearis – endangered species

Habitat requirements

Tylophora linearis has been recorded within Goonoo, Pilliga West, Pilliga East, Bibblewindi, Cumbil and Eura State Forests, Coolbaggie National Reserve, Goobang National Park and Beni State Conservation Area (OEH 2019a). It has also been recorded at Hiawatha State Forest near West Wyalong in the south and there are old records as far north as Crow Mountain near Barraba and near Glenmorgan in the western Darling Downs in addition to Pilliga Nature Reserve (DEWHA 2008). The species is also mapped as known to occur within the Pilliga and Pilliga Outwash IBRA sub-regions (OEH 2019b).

Tylophora linearis grows in dry scrub to open forest and has been recorded from low-altitude sedimentary flats in dry woodlands (OEH 2020). *Tylophora linearis* grows in association with many different canopy and shrub species including *Melaleuca uncinata, Eucalyptus fibrosa, E. sideroxylon, E. albens, Callitris endlicheri, C. glaucophylla, Allocasuarina luehmannii, Acacia hakeoides, A. lineata, Myoporum spp., and Casuarina spp* (DEWHA 2008).

The total population of *Tylophora linearis* in NSW is estimated to include at least 250-500 mature individuals (Copeland 2008). However, no data is available to estimate the size of several of the known populations and estimates are also complicated by difficulties in positively identifying plants that may not be flowering at the time of survey. Although the total population *of Tylophora linearis* may be larger than current estimates suggest, there are unlikely to be more than 1000 mature individuals (NSW SC 2019).

Tylophora linearis is a herbaceous twiner which reproduces through rhizomatous roots but is also assumed to be insect-pollinated (PlantNET 2020; Forster *et al.* 2004). This species flowers in spring with flowers recorded in November or May with fruiting probably two to three months later. This species is easily confused with other climbers when not in flower or fruit, however has a recommended survey period of October to May (OEH 2020).

Within the locality, most records are known from Pilliga East forest and within Segment 10. There are a number of records close to the proposal site including within 20 metres, 210 and 260 metres within Pilliga East and Euligal state forests. Three individual plants were recorded in the proposal site in the Pilliga forests which represents about 0.3 percent of the estimated 1,000 mature individuals of the total population.

Habitat in the study area

d) Three individual plants were recorded in the proposal site in the Pilliga forests which represents about 0.3 percent of the estimated 1000 mature individuals of the total population.

Of the native vegetation to be impacted about 16 hectares represents known habitat for *Tylophora linearis* and a further 21.9 hectares of assumed presence potential habitat occurs that would be impacted. These areas are mostly represented by areas within the Pilliga (Segment 10) and small parts of Segment 11 for which the species has a known association. PCTs this species was recorded in within the Pilliga include:

- PCT 141 – Broombush - wattle very tall shrubland of the Pilliga to Goonoo regions, Brigalow Belt South Bioregion.
- PCT 398 – Narrow-leaved Ironbark - White Cypress Pine - Buloke tall open forest on lower slopes and flats in the Pilliga Scrub and surrounding forests in the central north Brigalow Belt South Bioregion.
- PCT 1384 – White Cypress Pine - Bulloak - ironbark woodland of the Pilliga area of the Brigalow Belt South Bioregion.

These PCTs provide suitable dry scrub and open forest within the mapped known distributions. The species has associations with seven other PCTs in the proposal site, however the species was not recorded in these in the proposal site despite targeted survey effort in these PCTs.

Table M16 Assessment of significance – *Tylophora linearis*

Criteria	Discussion
According to the DotE (2013) 'significant impact criteria', an action is likely to have a significant impact on a critically endangered or endangered species if there is a real chance or possibility that it will:	
Lead to a long-term decrease in the size of a population	This species is a small climber with a limited range for pollination. Its estimated population of no more than 1000 individuals indicates that any occurrences of this species are likely to be important to the population. It is known from previous records within 20 metres of the proposal site and in the wider investigation corridor. In the proposal site, three PCTs are known habitat for this species and a total of 16 hectares of known habitat and a further 21.9 hectares of assumed presence potential habitat will be removed as a result of the proposal. Given the area of known and potential habitat to be cleared and that the species is known to occur in the proposal site and has a very limited population size, the proposal is likely to lead to a long-term decrease in the size of the population.

Criteria	Discussion
Reduce the area of occupancy of the species	The proposal would remove a total of 16 hectares of known habitat and 21.9 hectares of assumed presence potential habitat mostly in Segment 10 (Pilliga). Although the species was not recorded in other areas of suitable habitat, it still has the ability to further spread and colonise these areas of potential habitats. This clearing will occur as a new 73 kilometres x generally 50-60 metres wide linear gap through the forest and adjacent to existing cleared areas of Pilliga Forest Way for much of the segment. Given the large area of known and potential habitat to be cleared within and near known records for this species, the proposal is likely to reduce the area of occupancy of the species.
Fragment an existing population into two or more populations	The construction footprint runs through the middle of the Pilliga forests. Whilst possibly causing fragmentation of potential habitat, it also runs adjacent to existing access tracks. These tracks cause existing fragmentation throughout the Pilliga forests. The proposal is located in close proximity to roadsides and access tracks within the Pilliga. The proposal is unlikely to further fragment the important population into two or more populations given the existing uncleared areas in the Pilliga.
Adversely affect habitat critical to the survival of a species	The population size of 1,000 individuals of *Tylophora linearis* indicates that the genetic pool for this species is limited, particularly when considering its distribution is wide. Individuals that occur within the proposal site, may be critical to the long-term genetic diversity of the species. Reducing the area of occupancy of this species would subsequently reduce the reproduction potential of the species. About 16 hectares of known habitat and 21.9 hectares of assumed presence potential habitat would be cleared as a result of the proposal. Although the species was not recorded in other areas of suitable habitat, it still has the ability to further spread and colonise these areas of potential habitats outside the proposal site. Whilst *Tylophora linearis* is not listed on the Register of Critical Habitat (DAWE 2020), the proposal may adversely affect potential habitat critical to the survival of *Tylophora linearis.*
Disrupt the breeding cycle of a population	As *Tylophora linearis* is insect pollinated and reproduces vegetatively through rhizomatous roots, clearing of potential habitat, or species will disrupt the breeding cycle of the population. The potential genetic population within the proposal site may contribute to the overall population within the locality, resulting in a reduced opportunity for the species to reproduce and disperse. The proposal is likely to disrupt the reproduction and germination cycle of the population.
Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	The proposal will result in the removal of 16 hectares of known habitat and 21.9 hectares of assumed presence potential habitat for the species mostly in Segment 10 (Pilliga). Although the species was not recorded in other areas of suitable habitat, it still has the ability to further spread and colonise these areas of potential habitats. Due to the apparent decline in previously known populations, and that suitable potential habitat would be removed, the proposal will likely decrease the availability or quality of habitat to the extent that the species is likely to decline.

Criteria	Discussion
Result in invasive species that are harmful to the species becoming established in the species' habitat	Introduction of weeds is of particular concern in the Pilliga forests as they can reduce the quality of vegetation and thus impact flora habitats. Weeds such as the Tiger Pear (*Opuntia aurantiaca*), are already common in the Pilliga, and may be further spread during construction. Operation of the proposal has the potential to spread weeds and pests into the Pilliga. The surroundings of railways (eg verges and embankments) often host a high diversity of non-native species (Gelbard and Belnap 2003; Hansen and Clevenger 2005), in many cases due to their transportation as stowaways in or on trains. Provided that appropriate plant and machinery hygiene measures are taken, the proposal is unlikely to facilitate the spread of invasive flora to the extent of a significant impact to *Tylophora llinearis.*
Introduce disease that may cause the species to decline	The proposal is unlikely to introduce disease into the proposal site that may cause the species to decline. There are no diseases that are known to affect this species.
Interfere with the recovery of the species	There is no recovery plan for *Tylophora linearis*. Despite this, the *Pilliga Nature Reserve Plan of Management* (NPWS 2015), identifies developments or activities in or near the Pilliga Nature Reserve that may compromise the recovery of species should be opposed. The proposal requires the removal of 16 hectares of known habitat and 21.9 hectares of assumed presence potential habitat for *Tylophora linearis*. Although the species was not recorded in other areas of suitable habitat, it still has the ability to further spread and colonise these areas of potential habitats. Due to the large area of known and suitable habitat of *Tylophora linearis* within the proposal site to be removed near known records of the species, the proposal may interfere with the recovery of *Tylophora linearis.*
Conclusion	The proposal is likely to have a significant impact on *Tylophora linearis* given: • the proposal will remove 16 hectares of known habitat for this species and 21.9 hectares of assumed presence potential habitat • the large area of suitable potential habitat to be impacted which may decrease the availability and quality of habitat to the extent that the species is likely to decline • the occurrence of nearby records in similar habitats • the low number of estimated plants (1,000 individuals) suggests a low genetic diversity and any loss of plants is likely to further impact genetic diversity of the species.

Coolabah Bertya – (*Bertya opponens*) – vulnerable species

Habitat requirements

Bertya opponens has been mapped as having a known distribution within QLD and NSW, specifically within the Pilliga, and north-east of Cobar (DoE 2020; OEH 2019). Within the Pilliga, the species is known to occur at Jacks Creek State Forest south of Narrabri with a population size of at least 5 000 000 plants (NPWS 2002) and a second population of five plants 12 kilometres to the north-west (DoE 2020).

Another known population also occurs at Nurrungal (formerly Elmore Station) north-east of Cobar, however the population of approximately 500-600 plants has been recorded to be in poor condition (DoE 2020). The recovery plan for the species outlines that this population may have been two to three times this number originally, with senescent individuals either dying or being blown-out gradually over the past 20 years (NPWS 2002).

Bertya opponens is usually associated with gravelly ridges, shallow or skeletal soils, or sandy gullies, stony mallee ridges and cypress pine forest on red soils, like that which occur in the Pilliga forests (OEH 2020a). Suitable habitat of the species is highly variable and whilst being associated with sandy loam and red earth soils, it can also be associated with rhyolite, shale and metasediments (QLD DEHP 2013). Suitable hydrology for the species is also variable, with habitat being described as shallow and rocky to deep and well-drained (NSW SC 2009). Known associations of canopy species for *Bertya opponens* include *Eucalyptus chloroclada, Callitris glaucophylla* and *Eucalyptus fibrosa* (OEH 2020a).

The recent 2019/2020 bush fires within southern and eastern Australia has reduced the potential population of *Bertya opponens* (DAWE 2020a). The recent bushfires have resulted in a reduction of 10-30 percent of suitable habitat, based on its known distribution within fire affected areas. This species is suspected to positively respond to fire and disturbance, with the population at Jacks Creek State Forest responding to ground disturbance through grading (NPWS, 2002), and wildfires increasing the rate of germination from the seed bank (NSW SC 2009).

The largest known population of *Bertya opponens*, which occurs at Jacks Creek State Forest consists of an even distribution of male and female plants and an even distribution of seedlings (NPWS, 2002). Reproductive and germination success does not appear to be limited given the high densities of *Bertya opponens* in some areas. Although this population may be thriving, the continued drought conditions and bushfire may be attributed to the decline of the Nurrungal population (DoE, 2020). The larger population size of the Jacks Creek State Forest population may contribute to the resilience of the species due to the density of the population.

Habitat in the study area

Bertya opponens was known from a recent record of five plants within the proposal site near the Bohena Creek rest area. Despite targeted surveys over multiple seasons and years including a year of above average rainfall, plants from this record could not be relocated. No individuals were recorded during targeted surveys in the Pilliga.

Table M17 Assessment of significance – Coolabah Bertya

Criteria	Discussion
According to the DotE (2013) 'significant impact criteria', an action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that it will:	This species was not recorded during field surveys. However, one database record for *Bertya opponens* exists within the proposal site for the species. This record occurs at the Bohena Creek rest area, and incuded five (at the time juvenile) individuals of the species from 2001. Despite targeted surveys over multiple seasons and years including a year of above average rainfall, plants from this record could not be relocated. These individuals are considered to no longer occur at this location. No other evidence of the species was found during surveys in the Pilliga forests. Jacks Creek State Forest, which occurs about 14 kilometres east of the proposal site contains the largest known population of reproducing *Bertya opponens*. However it occurs well outside the impact area of the proposal. *Bertya opponens* has a widespread and diverse range across NSW and Queensland, and is specifically known to be distributed in the Pilliga and north-east of Cobar. Based on the above considerations, the occurrence of *Bertya opponens* within the proposal is not likely to be an 'important population' given the lack of evidence of the species.
Lead to a long-term decrease in the size of an important population of a species	As described above, a population within Jacks Creek State Forest, about 14 kilometres east of the proposal site is the largest known population with an estimated population of five million plants. This will not be impacted by the proposal. One record for this species (which could not be relocated), and potentially suitable habitat exists within the proposal site. No *Bertya opponens* were recorded in the surveys in the Pilliga. This species tends to respond to mechanical disturbance (eg track maintenance), and if present would likely be obvious along disturbed track edges. Due to a lack of records for the species throughout the surveyed areas of the proposal site, and limited suitable habitat in the proposal site, it is unlikely that the proposal site contains an important population of the species. In addition, despite targeted surveys over multiple seasons and years including a year of above average rainfall, plants from the existing record could not be relocated. As such, the proposal is unlikely to lead to a long-term decrease in the size of any important population of *Bertya opponens* within the proposal site, as described above.
Reduce the area of occupancy of an important population	As discussed above, a record of five plants of *Bertya opponens* occurring within the proposal site near Bohena Creek rest area is unlikely to represent an important population of the species. In addition, despite targeted surveys over multiple seasons and years including a year of above average rainfall, plants from the existing record could not be relocated. Multiple surveys in the Pilliga forests also did not record the species. As such, the proposal is unlikely to significantly reduce the area of occupancy of an important population.

Criteria	Discussion
Fragment an existing important population into two or more populations	As described above, one isolated record for *Bertya opponens* previously existed within the proposal site, and a large population of the species exists 14 kilometres to the east of the proposal site within Jacks Creek State Forest. This population will not be impacted by the proposal. With the exception of Segment 10 (Pilliga), the proposal site traverses mostly agricultural land which has been extensively cleared for agriculture including cropping and intensive grazing. This has resulted in isolated patches of remnant native vegetation and small connected patches, mostly limited to roadside reserves and smaller patches on private properties. The CIZ generally ranges between 50-80 metres wide in the area where this species is assumed to occur, with larger gaps of 120-190 metres present where compound sites would be located. Wind and insect pollination would continue across this gap, and seed dispersal across the gap is likely to be possible along creeklines. Any important population that may occur near the proposal site, would occur in an already highly fragmented landscape for this species. The addition of a generally 50-80 metre wide corridor of clearing is in an already highly fragmented and modified landscape is unlikely to fragment an important the population into two or more populations.
Adversely affect habitat critical to the survival of a species	There is no registered critical habitat for *Bertya opponens* on the Register of Critical Habitat (DAWE 2020) The wide variation of habitat types between populations of this species makes the identification of critical habitat difficult. Given the lack of records for the species in the study area, and limited suitable habitat for the species within the proposal site, it is unlikely that the proposal will affect habitat critical to the survival of the species.
Disrupt the breeding cycle of an important population	Given that the disturbance agents of fire and mechanical disturbance appear to trigger germination and/or suckering of *Bertya opponens*, it is possible that potential construction disturbance could trigger the species to germinate. The CIZ generally ranges between 50-80 metres wide in the species polygon for this species, with larger gaps of 120-190 metres present where compound sites would be located. This species tends to respond to mechanical disturbance (eg track maintenance), and if present would likely increase in densities along the edge of the rail corridor. The primary mechanism for pollen dispersal in *Bertya opponens* is probably wind given that the flowers lack chemical and colour attractants and the styles and anthers are exposed. However, European honeybees have been observed visiting Bertya sp. Cobar-Coolabah flowers (NPWS 2002). Wind and bees would be able to travel across these gaps, allowing for continues genetic interchange across the rail corridor. Seed dispersal is via explosive release, with seeds likely to fall relatively close to the parent plant. Movement by water may aid seed dispersal (NPWS 2002). Provision of bridges and drainage culverts would allow seed dispersal across the rail corridor at riparian corridors. Additionally, as described above, the proposal is unlikely to impact on an important population of the species, due to a lack of records within the proposal site, and limited availability if suitable potential habitat.

Criteria	Discussion
	As such, the proposal is unlikely to disrupt the breeding cycle of an important population of the species.
Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	The proposal will remove potentially suitable habitat for *Bertya opponens* from the proposal site*.* This will decrease the availability and quality of potential habitat for the species in the proposal site. Clearing of vegetation may encourage growth of plants along disturbed edges. The removal and disturbance of potential habitat from the Bohena Creek rest area will remove habitat previously known to support the species. However, despite targeted surveys over multiple seasons and years including a year of above average rainfall, plants from the existing record could not be relocated. Known and suitable potential known habitat for this species exists in the surrounding locality, particularly in Jacks Creek State Forest where an important population occurs. The proposal will likely decrease the availability and quality of potential habitat for the species. However, given the widespread and already fragmented nature of potential habitat for the species in the proposal site, and lack of evidence of the species during surveys, it is not likely to occur to an extent that the species is likely to further decline.
Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat	The proposal has the potential to further introduce a number of invasive flora species to areas of potential habitat for *Bertya opponens*. Introduction of weed species via vehicles and machinery operating in the proposal site could occur, as vehicles would be required to traverse a large area and variety of landscapes, including highly modified agricultural land and disturbed roadsides containing an abundance of introduced and invasive flora species. Given the implementation of safeguards and management measures pertaining to weed hygiene, it is unlikely that invasive species harmful to *Bertya opponens* would become further established in the species habitat. In addition to invasive flora, a number of feral fauna such as rabbits, feral pigs and goats can impact the species. Impacts from these species include habitat degradation, grazing and introduction of weed species. It is unlikely that the proposal will further facilitate the spread or establishment of feral fauna species in the proposal site. For the reasons discussed above, it is unlikely that the proposal will result in invasive species that are harmful to *Bertya opponens* becoming established in habitat available for the species.
Introduce disease that may cause the species to decline	The proposal is unlikely to introduce disease into the proposal site that may cause the species to decline.
Interfere substantially with the recovery of the species	The recovery plan for *Bertya opponens* (NPWS, 2002) identifies a number of threats to the occurrence of the species including clearing, disturbance and drought. Although disturbance is listed as a threat to the species fire and mechanical disturbance triggers germination in the species, some disturbance generated by the construction of the proposal may be beneficial. Despite targeted surveys over multiple seasons and years including a year of above average rainfall, plants from the existing record could not be relocated.

Criteria	Discussion
	Given that impacts of the proposal do not occur within areas known to contain significant or important populations of the species, it is unlikely that the proposal will contribute to any known threats likely to interfere with the recovery of the species.
Conclusion	The proposal is unlikely to have a significant impact on *Bertya opponens* given: • That an important population is not likely to occur in the proposal site or study area. • Records from the proposal site are limited to a record from 2001 for five plants (at the time juvenile) at the Bohena Creek rest area and presence potential habitat in the northern Pilliga. Despite targeted surveys over multiple seasons and years including a year of above average rainfall, plants from the existing record could not be relocated, and it is presumed these individuals no longer occur at this location. • This is unlikely to represent a significant population of the species. • No *Bertya opponens* were recorded in the surveys in the Pilliga. If the species is found to occur in areas of potential habitat, it would also occur in adjacent areas, and the individuals (if present) would be part of a much larger population. • No additional invasive species that are harmful to the species are likely to be introduced, further than those that already occur.

Winged Peppercress – (*Lepidium monoplocoides*) – endangered species

Habitat requirements

Lepidium monoplocoides is known to occur within the Pilliga Outwash IBRA sub-region (OEH 2019a). This species occurs within western NSW and Victoria, with one record at Narrandera in 1995 (DoE 2020). Excluding this record however, it has not been recorded since 1950 (Leigh et al. 1984). The species has been collected from scattered locations, with historical records occurring in Bourke, Cobar, Urana, Lake Cargelligo, Balranald, Wanganella and Deniliquin (OEH, 2019b).

Lepidium monoplocoides occurs in mallee scrub in semi-arid areas (Leigh et al. 1984) but can also occur in wetland-grassland communities (OEH 2019b). This species occurs on areas which are seasonally moist to water-logged with heavy, fertile soils and a mean annual rainfall of around 300 to 500 millimetres (OEH 2019b; DoE 2020). Previous observations of this species within ephemeral locations, suggest that this species is opportunistic and is able to take advantage of seasonally available habitat (Mavromihalis 2010). *Lepidium monoplocoides* can be associated with open woodland habitat dominated by *Allocasuarina luehmannii* (Bulloak) and/or eucalypts, particularly *Eucalyptus largiflorens* (Black Box) or *Eucalyptus populnea* (Poplar Box), however it has also been known to occur with wetland-grassland species including *Eragrostis australasicus, Agrostis avenacea, Austrodanthonia duttoniana, Homopholis proluta, Myriophyllum crispatum, Utricularia dichotoma* and *Pycnosorus globosus* (OEH 2019b).

Due to limited recordings of the species, the population size of *Lepidium monoplocoides* is also limited. *Lepidium monoplocoides* is currently known from 13 locations, six in Victoria and seven in NSW (DSE 2010). The recovery plan describes that the largest population size recorded within NSW is located at Lake Urana Nature Reserve with a population of 2000 individuals in the year 2000, an increase from 600 individuals in 1996. Despite this increase, a general decline in the population sizes within both Victoria and NSW is occurring.

There is a single record of this species from 2017 from the edge of the Narrabri multi-function compound (Segment 3) and there is suitable potential habitat for this species within Segment 3 and Segment 11. In addition, there is a large population about five kilometres west of the record near Segment 3 with multiple records (Santos Wilga Park power station).

Lepidium monoplocoides is a small annual herb (PlantNET 2020), which flowers from August to October (DoE 2020) with pollination likely from insects. Despite this observation, the recommended survey period for this species is November to February, potentially due to the plant behavior of emerging one month after rain and persisting for a few months (OEH 2020). The number of plants at each site varies greatly with seasonal conditions, but sites tend to be small in area with local concentrations of the plant (OEH 2020).

Habitat in the study area

Lepidium monoplocoides was not recorded during targeted surveys during the recommended survey period including surveys in more favourable rainfall conditions in 2020.

Of the native vegetation to be impacted about 177.5 hectares represents assumed presence potential habitat for *Lepidium monoplocoides*. These areas are mostly near Narrabri within Segment 3 (Narrabri multi-function compound) and 11 (Pilliga to Narrabri). This species is assumed to occur in these locations due to known and potential habitat and not being able to access the locations on private properties.

PCTs within these segments for which suitable habitat is present include:

- PCT 78 – River Red Gum riparian tall woodland / open forest wetland in the Nandewar Bioregion and Brigalow Belt South Bioregion (within 150 metres buffer of a known record).
- PCT88 – Pilliga Box - White Cypress Pine - Buloke shrubby woodland (DNG)
- PCT148 – Dirty Gum - Buloke - White cypress pine - ironbark shrubby woodland (Good and DNG condition)
- PCT 473 – Red gum - Rough-barked Apple - Narrow-leaved Ironbark - cypress pine grassy open forest on flats and drainage lines (Good and DNG condition).

These PCTs provide suitable open woodland and ephemeral habitat within the mapped known distributions.

Table M18 Assessment of significance – Winged peppercress

Criteria	Discussion
According to the DotE (2013) 'significant impact criteria', an action is likely to have a significant impact on a critically endangered or endangered species if there is a real chance or possibility that it will:	
Lead to a long-term decrease in the size of a population	Population sizes of *Lepidium monoplocoides* are quite small and variable (as high as 2,000 individuals at Lake Urana Nature Reserve and as low as no plants in some previously known populations (Mavromihalis 2010)) with a general decline occurring in most populations throughout NSW. Despite not being recorded during field surveys, suitable habitat totalling 177.5 hectares occurs within the proposal site. Whilst the population decline is occurring prior to the proposal occurring, any further clearing of suitable habitat would decrease the size of a potential population of *Lepidium monoplocoides* within the proposal. Therefore, the proposal may lead to a long-term decrease in the size of a population.

Criteria	Discussion
Reduce the area of occupancy of the species	*Lepidium monoplocoides* is known to occur within the Pilliga Outwash IBRA sub-region. About 177.5 hectares of suitable known and potential habitat for *Lepidium monoplocoides* will be removed as a result of the proposal including within 150 metres of a known record of which similar habitat extends into Segment 3 and further south into derived native grasslands. The removal of 177.5 hectares will likely result in a reduced area of occupancy of potential habitat for the species.
Fragment an existing population into two or more populations	Within segment 11 and 3 where most potential habitat occurs in the proposal site, there is extensive fragmentation and clearing of native vegetation for agriculture. Records of this species occur mostly as scattered plants throughout the Narrabri area and are already highly fragmented. For this reason, the proposal is unlikely to further fragment the important population into two or more populations given the existing cleared areas in the potential habitat areas.
Adversely affect habitat critical to the survival of a species	Habitat of *Lepidium monoplocoides* is variable within the proposal, due to the open woodland and wetland-grassland characteristic associated with the species occurrence. Despite having a range of suitable habitat, it appears that the occurrence of the species is mainly associated with hydrological flows associated with ephemeral processes. Within segment 11, there are gilgaied and derived grassland areas that would be impacted and that are providing good quality potential habitat for the species. The general decline in the species populations also suggests that these ephemeral gilgai areas are critical to the recovery of the species. A number of ephemeral drainage lines and PCTs occur within the construction footprint, which indicates that habitat critical to the survival of the species may occur. The recovery plan for *Lepidium monoplocoides* does not identify habitat critical for the species, nor is the species listed on the Register of Critical Habitat (Mavromihalis 2010; DAWE 2020). The recovery plan does however identify the need to include survey for and mapping of habitat that is critical to the survival of *Lepidium monoplocoides*. As a result of the above discussion, the proposal is likely to adversely affect habitat critical to the survival of *Lepidium monoplocoides.*
Disrupt the breeding cycle of a population	The potential genetic population within the proposal site may contribute to the overall population within the study area and locality resulting in a reduced opportunity for the species to reproduce and disperse. There is potential for the proposal to disrupt the reproduction and germination cycle of the population.
Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	The proposal will result in the removal of 177.5 hectares of suitable potential habitat for the species in Segment 11 and 3 (Pilliga to Narrabri and Narrabri multi-function compound). Due to the apparent decline in previously known populations, and that suitable potential habitat would be removed, the proposal will likely decrease the availability or quality of habitat to the extent that the species is likely to decline.
Result in invasive species that are harmful to the species becoming established in the species' habitat	The proposal has the potential to introduce a number of invasive flora species to the areas of potential habitat for *Lepidium monoplocoides*. This is due to the use of plant and machinery introducing weed seed into the proposal and adjacent areas within the study area. As the majority of the construction footprint runs adjacent to existing access tracks and

Criteria	Discussion
	roads, a number of invasive species may potentially occur, including Tiger Pear which is common and widespread in Segment 11 and 3. *Lepidium monoplocoides* is also susceptible to habitat degradation, particularly by feral pigs and rabbits (Doe, 2020; DEE, 2017). The Threat Abatement Plan indicates that Feral Pigs may impact on *Lepidium monoplocoides* due to 'reduced or failed recruitment of new plants, spread of weeds through spreading seeds via faeces or in fur and creation of habitat suitable for plant disease vectors'. Provided that appropriate plant and machinery hygiene measures are taken, the proposal is unlikely to facilitate the spread of invasive flora in more than has already occurred to the extent that a harmful species would become established in the species habitat.
Introduce disease that may cause the species to decline	The proposal is unlikely to introduce disease into the proposal site that may cause the species to decline. There are no diseases that are known to affect this species.
Interfere with the recovery of the species	The recovery plan for *Lepidium monoplocoides* identifies a number of threats to the occurrence of the species including weed invasion, physical damage and drought and climate change (Mavromihalis, 2010). The proposal is likely contribute to the physical damage of suitable habitat due to the vegetation clearing associated with the proposal. Weed invasion may also occur due to the use of plant and machinery introducing weed seed into the construction footprint and adjacent area within the locality. This impact is likely to be minor however with weed invasion greater than that which has already occurred and the use of appropriate plant and machinery hygiene measures. The recovery plan suggests that pro-longed drought may be a major threat to the recovery of the species, particularly due to the unknown viability of the seed within the soil for extended dry periods and reduction of favourable habitat (Mavromihalis, 2010). The clearing of suitable habitat within the construction footprint would also increase the impact of recovery (in conjunction with drought conditions), which has historically been unsuccessful. As a result of the discussion above, the proposal is likely to interfere with the recovery of the species, both directly and indirectly.
Conclusion	The proposal is likely to have a significant impact on *Lepidium monoplocoides* given: • the large area of assumed presence potential habitat of 177.5 hectares to be impacted which may decrease the availability and quality of habitat to the extent that the species is likely to decline • the species likely occurrence in the proposal site due to the occurrence of nearby records in similar habitats • the species poor ability to recover from drought conditions.

Bluegrass – (*Dichanthium setosum*) – vulnerable

Habitat requirements

Bluegrass occurs on the New England Tablelands, North West Slopes and Plains and the Central Western Slopes of NSW, extending to northern Queensland. It occurs widely on private property, including in the Inverell, Guyra, Armidale and Glen Innes areas. It is associated with heavy basaltic black soils and red-brown loams with clay subsoil. It is often found in moderately disturbed areas such as cleared woodland, grassy roadside remnants and highly disturbed pasture.

Bluegrass is an upright grass less than one metre tall. It has mostly hairless leaves about 2-3 millimetres wide. The flowers are densely hairy and are clustered together along a stalk in a cylinder-shape. The flower-clusters grow in pairs at the end of an 8 cm-long stem and appear mostly during summer (TBDC 2021).

Bluegrass is often found in moderately disturbed areas such as cleared woodland, grassy roadside remnants and highly disturbed pasture. It is often collected from disturbed open grassy woodlands on the northern tablelands, where the habitat has been variously grazed, nutrient-enriched and water-enriched. The species may tolerate or benefit from disturbance, otherwise, disturbance is indicative of threatening processes in its habitat (NSW OEH 2013a).

Habitat in the study area

Of the native vegetation to be impacted about 3.5 hectares represents assumed presence potential habitat for this species. Bluegrass is known from two historical (1885) records from Narrabri at the northern end of the proposal site. The nearest recent (2020) records are about 40 kilometres to the south east near Leard State Forest. Despite targeted surveys over multiple seasons and years including a year of above average rainfall, this species was not recorded.

Within the proposal site, assumed presence potential habitat occurs within PCT 202 - Fuzzy Box woodland on colluvium and alluvial flats in the Brigalow Belt South and Nandewar Bioregion (including Pilliga) where no access was possible beyond the public roadsides. The soils types of this area are not well known due to limited access and therefore the species could not be reliably excluded in the absence of targeted survey.

This species was not located during targeted field surveys, despite the surveys being conducted after suitable spring rains into late spring and early summer (OEH, 2020a).

Table M19 Assessment of significance – Bluegrass

Criteria	Discussion
According to the DotE (2013) 'significant impact criteria', an action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that it will:	This species was not recorded during field surveys. However, there is one historical (1885) database record for this species within 500 metres of the proposal site near the Namoi River.. Despite targeted surveys including a year of above average rainfall, plants from this record could not be relocated and the property is heavily grazed by livestock. These are unlikely to represent key population for breeding or dispersal, or be necessary for the maintenance of genetic diversity of the species. The historical records at Narrabri are at the western edge of the species range. There is no known important population within the proposal site or within the locality of the proposal site. Observed black basaltic soils are mostly limited to around Narrabri where targeted surveys were conducted but the species was not identified. *Bertya opponens* has a widespread and diverse range across NSW and Queensland, and is specifically known to be distributed throughout southern and central eastern Queensland. Based on the above considerations, the assumed presence occurrence of Bluegrass within the proposal is not likely to be an 'important population'.
Lead to a long-term decrease in the size of an important population of a species	As described above, the nearest records and population are about 40 kilometres to south east of the proposal site with larger population occurring to the north east north of Armidale and to the Queensland border. These populations will not be impacted by the proposal About 3.5 hectares of assumed presence potential suitable habitat exists within the proposal site. Due to a lack of records for the species, and limited suitable habitat in the proposal site, it is unlikely that the proposal site contains an important population of the species. In addition, despite targeted surveys over multiple seasons and years including a year of above average rainfall, the species was not recorded in other suitable potential habitats that could be accessed. As such, the proposal is unlikely to lead to a long-term decrease in the size of any important population of Bluegrass within the proposal site, as described above.
Reduce the area of occupancy of an important population	The proposal will remove 3.5 hectares of assumed presence suitable potential habitat for the species. As discussed above, the historical 1885 record of the species within the study area of the proposal site near the Namoi River is unlikely to represent an important population of the species. In addition, despite targeted surveys over multiple seasons and years including a year of above average rainfall, the species was not observed. As such, the potential impact to this population during construction, and the removal of 3.5 hectares of potential habitat from the proposal site is unlikely to significantly reduce the area of occupancy of an important population it if occurs.

Criteria	Discussion
Fragment an existing important population into two or more populations	As described above, there are no important populations in the proposal site and all records of the species occur to the east of the proposal. With the exception of Segment 10 (Pilliga), the proposal site traverses mostly agricultural land which has been extensively cleared for agriculture including cropping and intensive grazing. This has resulted in isolated patches of remnant native vegetation and small connected patches, mostly limited to roadside reserves and smaller patches on private properties. Any important population that may occur in the proposal site, would occur in an already highly fragmented landscape for this species. The addition of a generally 50-60 metre wide corridor of clearing is in an already highly fragmented and modified landscape is unlikely to fragment an important the population into two or more populations.
Adversely affect habitat critical to the survival of a species	There is no registered critical habitat for Bluegrass on the Register of Critical Habitat (DAWE, 2020) The wide variation of habitat types between populations of this species makes the identification of critical habitat difficult. In total, the proposal will remove 3.5 hectares of vegetation with a PCT association with this species. Given the lack of records for the species in the study area, and limited suitable habitat for the species within the proposal site, it is unlikely that the proposal will affect habitat critical to the survival of the species.
Disrupt the breeding cycle of an important population	Given that some minor disturbance may benefit the species growth and persistence, it is possible that potential construction disturbance could promote germination. However, complete removal of potential habitats would remove plants and disrupt the breeding cycle of a populations if it occurs. Additionally, as described above, the proposal is unlikely to impact on an important population of the species, due to a lack of records within the proposal site, and limited availability if suitable potential habitat. As such, the proposal is unlikely to disrupt the breeding cycle of an important population of the species.
Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	The proposal will remove about 3.5 hectares of assumed presence potential habitat for Bluegrass from the proposal site. This will decrease the availability and quality of potential habitat for the species in the proposal site. Despite targeted surveys over multiple seasons and years including a year of above average rainfall, plants from other suitable associated PCTs were not recorded. The proposal will likely decrease the availability and quality of potential habitat for the species. However, given the widespread and already fragmented nature of potential habitat for the species in the proposal site, it is not likely to occur to an extent that the species is likely to further decline.

Criteria	Discussion
Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat	The proposal has the potential to further introduce a number of invasive flora species to areas of potential habitat for Bluegrass. Introduction of weed species via vehicles and machinery operating in the proposal site could occur, as vehicles would be required to traverse a large area and variety of landscapes, including highly modified agricultural land and disturbed roadsides containing an abundance of introduced and invasive flora species. Given the implementation of safeguards and management measures pertaining to weed hygiene, it is unlikely that invasive species harmful to Bluegrass would become further established in the species habitat. In addition to invasive flora, a number of feral fauna such as rabbits, feral pigs and goats can impact the species. Impacts from these species include habitat degradation, grazing and introduction of weed species. It is unlikely that the proposal will further facilitate the spread or establishment of feral fauna species in the proposal site. For the reasons discussed above, it is unlikely that the proposal will result in invasive species that are harmful to Bluegrass becoming established in habitat available for the species.
Introduce disease that may cause the species to decline	The proposal is unlikely to introduce disease into the proposal site that may cause the species to decline.
Interfere substantially with the recovery of the species	There is no recovery plan for Bluegrass. The proposal requires the removal of 3.5 hectares of assumed presence potential habitat for Bluegrass. Although the species was not recorded in other areas of suitable habitat, it still has the ability to further spread and colonise these areas of potential habitats. Due to the limited areas of known and suitable potential habitat of Bluegrass within the proposal site it is unlikely to interfere with the recovery of the species.
Conclusion	The proposal is unlikely to have a significant impact on Bluegrass given: • That an important population is not likely to occur in the proposal site or study area. • Records from the proposal site are limited to a record from 1885 and surveys of this site and other associated PCTs in the Narrabri area did not record the species. • This is unlikely to represent a significant population of the species. • Removal of potential habitat for the species is limited to 3.5 hectares of assumed presence. • No additional invasive species that are harmful to the species are likely to be introduced, further than those that already occur.

Keiths Zieria – (*Zieria ingramii*) – endangered

Habitat requirements

Known predominately from Goonoo and Cobbora SCA, about 40 kilometres north-east of Dubbo. *Zieria ingramii* is endemic to NSW and has a very restricted distribution. There is no evidence to suggest that the species was ever 'common' in the Dubbo area or anywhere else and it appears that it is a species of natural rarity (Mackay and Gross 1998). Historically, the species has been recorded in three separate localities within Central West NSW. These include Goonoo Forest and Cobbora Forest north east of Dubbo and Goobang National Park north east of Parkes.

It is a Slender, spindly shrub to 0.6 metres high, with distinctly aromatic trifoliolate leaves. *Zieria ingramii* has been recorded on gentle slopes or near the crests of low rises, in undulating terrains, mostly on northerly, westerly or southerly aspects, at altitudes of 390- 440m above sea level. Plants tend to occur on light sandy soils that have, in general, been described as red-brown to yellow-brown sandy or clay loams, overlying sedimentary rock, which may be outcropping (Briggs and Leigh 1990). Zieria ingramii typically occurs in Eucalyptus-Callitris woodland or open forest communities containing Black Cypress Pine (*Callitris endlicheri*) and Blue-leaved Ironbark (*Eucalyptus nubila*) and a shrubby to heathy understorey (Briggs and Leigh 1990). In Goonoo Forest in particular, Dwyer's Red Gum (*Eucalyptus dwyeri*) appears to be a key predictor of the species. It has also been noted that it is rare to find the species without another species of Rutaceae (DEC 2007).

In general, species of *Zieria* are pollinated mostly by flies but also occasionally by butterflies, bees and beetles (Armstrong 2002 in Auld 2001), indicating the type of pollination vectors that may be associated with the species.

Habitat in the study area

Of the native vegetation to be impacted about 48.6 hectares represents assumed presence potential habitat for this species within remote unsurveyed sections of the Pilliga forests.

The nearest records for the species to the proposal site are in Goonoo Conservation Reserve about 50 kilometres to the south east.

Within the proposal site, suitable potential habitat is known from PCT 398 - Narrow-leaved Ironbark - White Cypress Pine - Buloke tall open forest on lower slopes and flats in the Pilliga Scrub and surrounding forests in the central north Brigalow Belt South Bioregion in the Pilliga subregion only.

This species was not located during targeted field surveys in accessible parts of the proposal, despite the surveys being conducted in suitable survey months. Some remote access sections of the Pilliga forests were not surveyed and the species is assumed to occur in these unsurveyed areas.

Table M20: Assessment of significance – Keiths Zieria

Criteria	Discussion
According to the DotE (2013) 'significant impact criteria', an action is likely to have a significant impact on a critically endangered or endangered species if there is a real chance or possibility that it will:	
Lead to a long-term decrease in the size of a population	*Zieria ingramii* is a small, distinctively aromatic shrub that grows between 40 centimetres and 60 centimetres but may reach up to one metre in height. Plants are usually slender and spindly but occasionally may be bushy. The estimated population of about 2000 plants is currently known only from Goonoo Conservation Reerve with a few smaller outlying populations to the south west. In the proposal site, there is no known habitat for the species. However there is 48.6 hectares of assumed presence potential habitat where remote access did not allow targeted surveys to exclude the species occurrence. If a population was to occur in the assumed presence unsurveyed areas they would be a new and separate population to those previously identified. Given the area of known and potential habitat to be cleared and that the species is known to occur in the proposal site and has a very limited population size, the proposal is likely to lead to a long-term decrease in the size of the population if it occurs.
Reduce the area of occupancy of the species	The proposal would remove a total of 48.6 hectares of assumed presence potential habitat mostly in Segment 10 (Pilliga). This clearing will occur as a new 73 kilometres x generally 50-60 metres wide linear gap through the forest and adjacent to existing cleared areas of Pilliga Forest Way for much of the segment. Given the limited area of assumed potential habitat to be cleared and that the species was not recorded in adjacent accessible areas and is not within or near known records for this species, the proposal is unlikely to reduce the area of occupancy of the species.
Fragment an existing population into two or more populations	The construction footprint runs through the middle of the Pilliga forests. Whilst possibly causing fragmentation of potential habitat, it also runs adjacent to existing access tracks. These tracks cause existing fragmentation throughout the Pilliga forests. The proposal is located in close proximity to roadsides and access tracks within the Pilliga. The proposal is unlikely to further fragment a population into two or more populations (if it occurs) given the existing uncleared areas in the Pilliga.
Adversely affect habitat critical to the survival of a species	The population size of just over 2,000 individuals of *Zieria ingramii* indicates that the genetic pool for this species is limited and it also has a very limited geographic distribution. About 46.8 hectares of assumed presence potential habitat would be cleared as a result of the proposal. Although the species was not recorded in other areas of suitable habitat, it still has the ability to further spread and colonise these areas of potential habitats outside the proposal site. *Zieria ingramii* is not listed on the Register of Critical Habitat (DAWE 2020). If a population did occur, the proposal may adversely affect potential habitat critical to the survival of the species.

Criteria	Discussion
Disrupt the breeding cycle of a population	Species of Zieria in general are pollinated mostly by flies but also occasionally by butterflies, bees and beetles (Armstrong 2002 in Auld 2001), indicating the type of pollination vectors that may be associated with *Zieria ingramii*. The potential genetic population within the proposal site may contribute to the overall population within the locality, resulting in a reduced opportunity for the species to reproduce and disperse. The potential genetic population within the proposal site (if one occurs) would contribute to the overall population within the study area and locality resulting in a reduced opportunity for the species to reproduce and disperse. There is potential for the proposal to disrupt the reproduction and germination cycle of the population if it occurs.
Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	The proposal will result in the removal of 46.8 hectares of assumed presence potential habitat for the species mostly in Segment 10 (Pilliga). Although the species was not recorded in other areas of suitable habitat nearby. Given the lack of records for the species in the study area, and widespread occurrence of the associated PCT in the study area surrounding the proposal site, it is unlikely that the proposal will isolate or decrease the availability of habitat to the extent that the species will decline.
Result in invasive species that are harmful to the species becoming established in the species' habitat	Introduction of weeds is of particular concern in the Pilliga forests as they can reduce the quality of vegetation and thus impact flora habitats. Weeds such as the Tiger Pear (*Opuntia aurantiaca*), are already common in the Pilliga, and may be further spread during construction. Operation of the proposal has the potential to spread weeds and pests into the Pilliga. The surroundings of railways (eg verges and embankments) often host a high diversity of non-native species (Gelbard and Belnap 2003; Hansen and Clevenger 2005), in many cases due to their transportation as stowaways in or on trains. Provided that appropriate plant and machinery hygiene measures are taken, the proposal is unlikely to facilitate the spread of invasive flora to the extent of a significant impact to *Zieria ingramii*.
Introduce disease that may cause the species to decline	The proposal is unlikely to introduce disease into the proposal site that may cause the species to decline. There are no diseases that are known to affect this species.
Interfere with the recovery of the species	There is an approved recovery plan for *Zieria ingramii*. Although it is recognised that this species occurs mostly in Goonoo Conservation Reserve and most recovery objectives are targeted at this population, it does also include an objective of survey and data collection. The species is currently assumed to occur in 46.8 hectares of potential habitat and further surveys are proposed in autumn 2022 to determine if the species occurs in these areas. Any further survey effort would assist with identifying or not if the species occurs in the proposal site and Pilliga State Forest. The proposal requires the removal of 46.8 hectares of assumed presence potential habitat for *Zieria ingramii*. The species was not recorded during targeted surveys in accessible areas. Due to the large area of similar suitable potential habitat in associated PCTs where there are no existing records of the proposal is unlikely to interfere with the recovery of the species.

Criteria	Discussion
Conclusion	The proposal is unlikely to have a significant impact on *Zieria ingramii* given: • The proposal will remove 46.8 hectares of assumed presence potential habitat (associated PCT with no current survey) more than 200 kilometres from the nearest records for the species. • That a known population is not likely to occur in the proposal site or study area. • No additional invasive species that are harmful to the species are likely to be introduced, further than those that already occur.

Weeping Myall Woodlands – Endangered Ecological Community

Diagnostic features

Weeping Myall Woodlands occur as mid-high and low woodland to open woodland. Weeping Myall (*Acacia pendula*) is the sole or dominant overstorey species sometimes occurring with other canopy species such as Belah (*Casuarina cristata*) and Poplar Box (*Eucalyptus populnea* subsp. *bimbil*). The understorey includes an open layer of chenopod shrubs and forbs with an open ground layer of grasses and herbs (DEWHA, 2008b).

This community can vary in structure throughout its range. In higher rainfall areas it typically forms an open woodland. As rainfall decreases the ecological community becomes increasingly restricted, tending to sparse or scattered stands of woodland occurring in discrete bands fringing better-watered country.

Geographic distribution

This community generally occurs on the inland alluvial plains west of the Great Dividing Range in NSW and QLD. It occurs on flat areas shallow depressions on raised alluvial plains. Throughout this range it occurs in small pockets of isolated remnant vegetation. Due to the occurrence of this community on highly fertile soils large areas have been cleared for agricultural use.

Extent

The current national extent lies within the range of 220,000 to 361,000 hectares, a decline within the range of 82.1 to 93.5 percent from its pre-European extent (Accad *et al.* 2006; Benson 2006). Three is no more recent literature that provides updated extent since the listing advice publication. The extent of this community is likely to have further reduced since these estimates were published. Within NSW, the Weeping Myall Woodlands have declined from an estimated original extent between 1,900,000 and 3,300,000 hectares to a current extent of between 190,000 and 330,000 hectares (Benson 2006). These estimates do not consider the condition of these remnants. Poor land management practices, minimal regeneration and destruction of the understorey make it likely that much of the remaining Weeping Myall Woodlands is in poor condition.

Threats

The Weeping Myall Woodlands ecological community is listed as endangered under the EPBC Act due its decline in geographic distribution (DEWHA 2008b). Other contributing factors have put stress on the Weeping Myall Woodlands. Clearing and lopping for drought fodder has removed Weeping Myall trees, and grazing combined with drought and changed fire regimes has eliminated much of the understorey. Most areas remaining in good condition are on lightly-grazed, uncropped sites, including areas conserved by farmers, road reserves and Travelling Stock Routes and Reserves. Weeping Myall is also highly susceptible to attack by the Bag-Shelter Moth (*Ochrogaster lunifer*) which can defoliate large trees to such an extent that they do not recover. Introduction of invasive species has impacted areas due to the poor ability of important species like chenopods to recover due to limited seed longevity and low competitive abilities (DEWHA 2008b).

Occurrence in the study area

This community occurs occurs approximately 20 kilometres south-east of Gulargambone and is part of a larger patch of about 25 hectares of which about three hectares would be removed. The patch will be fragmented into two patches following construction of about 17 hectares to the west and four hectares to the east. The patch to the west is connected to other linear patches of native vegetation. The patch to the east would not be connected to another native vegetation. Despite the drought conditions, species diversity was dominated by native species and in moderate condition.

Table M21 Assessment of significance – Weeping Myall Woodland

Criteria	Discussion
According to the DotE (2013) 'significant impact criteria', an action is likely to have a significant impact on a critically endangered or endangered ecological community if there is a real chance or possibility that it will:	
Reduce the extent of an ecological community	The proposal will remove a total of 6.5 hectares of Weeping Myall Woodlands from one patch and isolated paddock trees within private property, and a small section of roadside vegetation. The removal of 6.5 hectares of this community represents about 11 percent of the extent of the community in the investigation corridor. The community is known to occur in other roadside patches and on private property in the wider locality including John Renshaw Parkway (about nine kilometres east of the proposal). The listing advice for this community estimated the extent of the community to be about between 220,000 to 361,000 hectares when published in 2009. This amount is likely to have further to decreased since 2009. Using a conservative estimate of 200,000 hectares remaining, the removal of 409 hectares represents about 0.001 percent of the remaining extent of the community.
Fragment or increase fragmentation of an ecological community, for example by clearing vegetation for roads or transmission lines	Weeping Myall Woodlands occur on highly fertile and arable soils where there is considerable pressure to clear for cropping. This has resulted in this ecological community occurring predominantly as small, varied and fragmented patches (DEWHA, 2008b). Both patches are already occur in a highly fragmented landscape surrounded by high intensity agriculture. Remaining patches of native vegetation are mostly restricted to roadside linear corridors and patches of crown land. The patch to the south occurs as part of a larger patch of about 25 hectares of which about 6.5 hectares would be removed. The patch will be fragmented into two patches following construction of about 17 hectares to the west and four hectares to the east. The patch to the west is connected to other linear patches of native vegetation. The patch to the east would not be connected to any other native vegetation. Construction will result in the clearing of a 40 metre wide corridor that will pass through this patch of Weeping Myall Woodland. Disturbance as a result of construction will likely exacerbate fragmentation, with introduction of weeds being of particular concern

Criteria	Discussion
	due to the poor ability of important species like chenopods to recover due to limited seed longevity and low competitive abilities.
Adversely affect habitat critical to the survival of an ecological community	No critical habitat has been listed for the Weeping Myall Woodland ecological community under the EPBC Act. Habitat critical to the survival of a species or ecological community also refers to areas that are necessary: • for activities such as foraging, breeding, roosting or dispersal • for the long-term maintenance of the species or ecological community (including the maintenance of species essential to the survival of the species or ecological community, such as pollinators) • to maintain genetic diversity and long term evolutionary development, or • for the reintroduction of populations or recovery of the species or ecological community (DoE, 2013). Due to the limited area of Weeping Myall Woodlands remaining across the landscape this patch of vegetation is important and its removal will contribute to the reduction of geographical extent of this community in NSW. However, it is unlikely that the proposal will damage habitat necessary for dispersal, maintenance, genetic diversity or recovery of Weeping Myall Woodlands as the areas to be impacted are isolated from other patches of Weeping Myall Woodland and therefore is not critical to the survival of the community.
Modify or destroy abiotic (non-living) factors (such as water, nutrients, or soil) necessary for an ecological community's survival, including reduction of groundwater levels, or substantial alteration of surface water drainage patterns	The Weeping Myall Woodlands is associated with flat areas, depressions, or gilgais on raised alluvial plains on heavy clays and alluvials. These areas are not associated with active channels and are rarely flooded, although the depressions and microreliefs may hold water during significant rain events. The proposal will involve earthworks as part of the construction of the proposal and may alter local surface drainage flows within the proposal site. However, it is unlikely to cause substantial alterations of surface water drainage patterns where the community occurs that are necessary for the long-term survival of the ecological community. The earthworks have the potential to cause soil erosion in the proposal site which may run off into the study area, with the potential to impact on surface water quality to the remnant patches of Weeping Myall Woodland, particularly at the southern patch which will be fragmented into to smaller patches. Additionally, vehicle and machinery traffic could cause compaction of soil, which can lead to increased surface run-off and hence greater erosion potential. Although soil disturbance may have adverse impacts on the community, for example, by exacerbating weed impacts on functionally important species such as chenopods and Weeping Myall trees, the proposal is unlikely to significantly modify abiotic factors critical to the long-term survival of the community.

Criteria	Discussion
Cause a substantial change in the species composition of an occurrence of an ecological community, including causing a decline or loss of functionally important species, for example through regular burning or flora or fauna harvesting	The chenopod shrubs that constitute the understorey and the Weeping Myall trees are functionally important to this ecological community. Construction will result in the removal of 6.5 hectares of this community. Disturbance as a result of construction has potential to indirectly affect remaining occurrences of chenopod shrubs, with introduction of weeds being of particular concern due to the poor ability of chenopods to recover as a result of limited seed longevity and low competitive abilities (DEWHA, 2008b). Vegetation that occurs on the edges of the proposal may be subject to increased weed invasion and it is possible that any weeds that are introduced may change and transform the composition of the ecological community by outcompeting chenopod shrubs, resulting in a loss of functionally important species.
Cause a substantial reduction in the quality or integrity of an occurrence of an ecological community, including, but not limited to: -assisting invasive species, that are harmful to the listed ecological community, to become established, or	Within the proposal site, Weeping Myall Woodlands occur as a stand of canopy species over a predominantly native understorey. The proposal would result in the complete removal of all vegetation (native and exotic) from within the proposal site. Vegetation outside of the proposal site that would not be directly impacted by the proposal is at some risk of indirect impacts resulting from the proposal, if appropriate mitigation measures are not adopted and implemented. The introduction of weeds poses a heightened threat due to the poor ability of important species like chenopods to recover as a result of limited seed longevity and low competitive abilities.
-causing regular mobilisation of fertilisers, herbicides or other chemicals or pollutants in to the ecological community which kill or inhibit the growth of species in the ecological community	Construction of the proposal has the potential to result in the mobilisation of contaminated sediments or chemical spill from vehicles or plants. The introduction of pollutants into the surrounding environment, if uncontrolled, could impact on surrounding areas of Weeping Myall Woodlands.
Interfere with the recovery of an ecological community	There is no national recovery plan for this ecological community. Given the occurrence of this community in the proposal site as small isolated patches, the proposal is unlikely to interfere with the recovery of the community due to the patches being impacted already being fragmented and isolated from other patches. Relevant priority recovery and threat abatement actions listed in the approved conservation advice relevant to the proposal include (DEWHA 2008b): • Use of lopping methods near the edge of required clearing that do not result in the death of the dominant tree species • Protecting remnants of the listed ecological community through the development of conservation agreements and covenants. Spread of invasive species as a result of clearing is a threat that may be exacerbated by the proposal. The proposal will result in the clearing of 6.5 hectares of Weeping Myall Woodlands and result in the fragmentation of two isolated patches of this community into two smaller patches. The amount of this community to be impacted is small in the context of the NSW community occurrence (6.5 hectare; or <0.001 percent of the estimated NSW extent). Given the isolated nature of the two patches to be impacted, they are unlikely to be viable patches that are contributing to the recovery of

Criteria	Discussion
	the community in the long term and the proposal is unlikely to interfere with the recovery of the ecological community. The proposal will require the acquisition of biodiversity offsets that will protect remnants of native vegetation including the requirement to protect this community.
Conclusion	The community has a relatively widespread although patchy and fragmented distribution. The proposal will impact on the community through the removal of 6.5 hectares (about 0.001 percent of the community in NSW). Given the isolated nature of the area to be impacted, it is unlikely to be contributing to the recovery of the community and the proposal is unlikely to significantly impact the occurrence of the community. However, it is acknowledged that the proposal: • Is likely to increase the fragmentation of the southern patch of the community • Has potential to result in a reduction in the quality of the community, by increasing the risk of establishment of potentially invasive species harmful to the community. These risks would be managed through the implementation of construction controls and other mitigation measures as part of the proposal.

Brigalow (*Acacia harpophylla* dominant and co-dominant) – endangered ecological community

Diagnostic features

The Brigalow ecological community is characterised by the presence of *Acacia harpophylla* (Brigalow) as one of the most abundant tree species (Butler, 2007). This ecological community has a considerable range of vegetation structure and composition. The canopy varies from nine metres in low rainfall areas up to 25 metres in higher rainfall areas. Although usually dominated by Brigalow, the canopy may also be scattered with *Casuarina cristata* (Belah), or various *Eucalyptus* sp. The understorey consists of a moderately dense low tree and shrub layer. Litter on the floor of brigalows woodlands is important to certain fauna, particularly reptiles and insects. Mature *Casurina cristata* trees are key habitat factor for species such as the Glossy Black-Cockatoo and large *Eucalyptus* species provide hollows of various sizes that provide important roost and nesting sites for many birds and mammals.

Geographic distribution

The Brigalow ecological community occurs over a substantial geographic area in semi-arid eastern Australia. Brigalow woodlands are found mostly west of the Great Dividing Range, stretching from Narrabri to Townsville. Minor occurrences of this ecological community have also been found in the Pilliga East State Forest (Benson *et al*. 2006).

Extent

In NSW, specifically in the Western Plains botanical region, the historical extent of the Brigalow ecological community is thought to have covered approximately 300,000 hectares, with only one third remaining largely as fragments within substantially modified landscapes. The majority of historical clearing of this community occurred in QLD, which had an estimated historical extent of 7.3 million hectares (DAWE 2020b). Nationally, the community has been reduced in extent to about 10 percent of its former area.

Of an estimated original extent of 304,200 hectares in NSW approximately 142,950 hectares of the Brigalow endangered community remain (DEWHA, 2010).

Threats

The Brigalow ecological community is listed as endangered under the EPBC act due to its decline in geographic distribution (DoE, 2013). Other threats to the Brigalow ecological community fire, invasive species and inappropriate land management techniques, which may further reduce its extent or result in a decline of condition.

Occurrence in the study area

This community occurs as within the study area as a low open woodland dominated by *Acacia harpophylla* with a sparse understorey characterised by low abundances of saltbush species and native grasses. It also occurs as a derived native grassland where the canopy layer is absent. The canopy layer includes occasional occurrences of Poplar Box (*Eucalyptus populnea*) and Pilliga Box (*Eucalyptus pilligaensis*). The low shrub layer is characterised by Ruby Saltbush (*Enchylaena tomentosa*), Berry Saltbush (*Einadia hastata*) and *Maireana enchylaenoides*. The proposal will result in the clearing 7.2 hectares of this community (1.3 hectares of woodland and 5.9 hectares of derived native grassland) in a long linear woodland section that is part of a larger patch of the community that runs parallel to the Newell Highway and extending onto small adjacent private properties. It then extends to derived native grasslands of this community on private properties within the proposal site and wider study area. The vegetation to be cleared occurs on the edge of a larger patch, with other scattered patches occurring throughout the northern end of segment 11 in the investigation area and wider study area and locality. The area to be removed forms part of a viable patch that is connected to other patches of this and other native vegetation communities in the study area.

Table M22: Assessment of significance – Brigalow

Criteria	Discussion
According to the DotE (2013) 'significant impact criteria', an action is likely to have a significant impact on a critically endangered or endangered ecological community if there is a real chance or possibility that it will:	
Reduce the extent of an ecological community	Of an estimated original extent of 304,200 hectares in NSW approximately 142 950 hectares of the Brigalow endangered community remain (DEWHA, 2010). The proposal will remove a total of 7.3 hectares of this community. The vegetation to be removed is a small linear patch found along the Newell Highway that extends onto private properties and then extending to derived native grasslands of this community. This represents a clearing of less than 0.005 percent of the current estimated remaining Brigalow ecological community in NSW. The clearing from this community will occur on the eastern edge of the existing patch of the community and the retained patch of the community would remain connected to other patches including derived native grasslands of this and other native vegetation. The viability of the patch would not to be compromised.

Criteria	Discussion
Fragment or increase fragmentation of an ecological community, for example by clearing vegetation for roads or transmission lines	The Brigalow ecological community now occurs largely as fragments within modified landscapes (TSSC 2001). The proposal will remove 7.2 hectares of vegetation commensurate with this SAII entity from the northern and southern edges of an existing patch. Much of this vegetation to be cleared is derived native grassland adjacent to the woodland areas, and already subject to disturbance from agriculture. One small area of good quality Brigalow to be removed occurs within a vegetated 'laneway' along a property boundary, and would create a gap of 160 metres between remnant areas. The remaining vegetation in the large, connected patch along the Newell Highway is about 10.5 hectares in size, which would remain as a patch similar to its existing state due to clearing being limited to the edges of the patch. Vegetation that is retained is likely to be subject to increased indirect impacts resulting from the proposal. These would be in addition to the impacts already occurring given the community occurs as roadside vegetation and within private properties used for agricultural purposes.
Adversely affect habitat critical to the survival of an ecological community	No critical habitat has been listed for the Brigalow ecological community under the EPBC Act. However, habitat critical to the survival of the ecological community is described in the conservation advice (TSSC 2001) as all patches that meet the key diagnostic characteristics and condition thresholds for the ecological community; plus the buffer zones, particularly where these include native vegetation. Habitat critical to the survival of a species or ecological community also refers to areas that are necessary: • For activities such as foraging, breeding, roosting or dispersal • For the long-term maintenance of the species or ecological community (including the maintenance of species essential to the survival of the species or ecological community, such as pollinators) • To maintain genetic diversity and long term evolutionary development, or • For the reintroduction of populations or recovery of the species or ecological community (DoE 2013). Due to the limited area of Brigalow Woodlands remaining across the landscape this patch of vegetation is important and its removal will contribute to the reduction of geographical extent of this community in NSW. However, it is unlikely that the proposal will damage habitat necessary for dispersal, maintenance, genetic diversity or recovery of Brigalow Woodlands as the area to be impacted occurs on the edge of a larger 10 hectare patch. This patch may be larger as derived native grasslands from the community that extend beyond the investigation area of the proposal. Vegetation surrounding the community is largely grassland and derived native grassland to the west and Brigalow and other native woodland vegetation to the east and would not be considered as habitat critical to the survival of this ecological community.

Criteria	Discussion
Modify or destroy abiotic (non-living) factors (such as water, nutrients, or soil) necessary for an ecological community's survival, including reduction of groundwater levels, or substantial alteration of surface water drainage patterns	This community often occurs associated with gilgaied clay soils on flat land. The proposal will involve earthworks as part of the construction of the proposal and may alter local surface drainage flows within the proposal site. However, it is unlikely to cause substantial alterations of surface water drainage patterns where the community occurs that are necessary for the long-term survival of the ecological community. The earthworks have the potential to cause soil erosion in the proposal site which may run off into the study area, with the potential to impact on surface water quality to the remnant patches of Brigalow woodland. Additionally, vehicle and machinery traffic could cause compaction of soil, which can lead to increased surface run-off and hence greater erosion potential. Although soil disturbance may have adverse impacts on the community, for example, by exacerbating weed impacts to the canopy and regenerating trees. The proposal is unlikely to significantly modify abiotic factors critical to the long-term survival of the community.
Cause a substantial change in the species composition of an occurrence of an ecological community, including causing a decline or loss of functionally important species, for example through regular burning or flora or fauna harvesting	The proposal will remove about five percent of the occurrence of the community within the proposal site. The occurrence of the overall patch will be retained but the proposal may increase edge impacts that may have long-term impacts on the condition of the understorey and species composition. Disturbance as a result of construction has potential to indirectly affect remaining occurrences of Brigalow regeneration, with introduction of weeds likely to impact the recovery of community as a result of competition from weed species. Vegetation that occurs on the edges of the proposal may be subject to increased weed invasion and it is possible that any weeds that are introduced may change and transform the composition of the ecological community by outcompeting chenopod shrubs, resulting in a loss of functionally important species.
Cause a substantial reduction in the quality or integrity of an occurrence of an ecological community, including, but not limited to: -assisting invasive species, that are harmful to the listed ecological community, to become established, or	Within the proposal site, Brigalow Woodland occur as a stand of canopy species over a mixed native and introduced understorey. The proposal would result in the complete removal of all vegetation (native and exotic) from within the proposal site. Vegetation outside of the proposal site that would not be directly impacted by the proposal is at some risk of indirect impacts resulting from the proposal, if appropriate mitigation measures are not adopted and implemented. The clearing of the linear patch connected to the remaining Brigalow ecological community has the potential to introduce weeds that may be harmful to quality and integrity of the ecological community. Introduced grasses, such as Buffel grass, Rhodes grass and Green panic grass, pose the greatest threat by drawing fires into the Brigalow ecological community and increasing fire severity (DEWHA 2013). However, none of these species were observed in the investigation corridor during field surveys. Succulent type plants are known to thrive in this community. This includes the invasive Mother of Millions (*Kalanchoe daigremntiana*) which was observed in the Brigalow community in the wider investigation corridor.

Criteria	Discussion
-causing regular mobilisation of fertilisers, herbicides or other chemicals or pollutants in to the ecological community which kill or inhibit the growth of species in the ecological community	Construction of the proposal has the potential to result in the mobilisation of contaminated sediments or chemical spill from vehicles or plants. The introduction of pollutants into the surrounding environment, if uncontrolled, could impact on surrounding areas of Brigalow Woodlands.
Interfere with the recovery of an ecological community	There is no national recovery plan for this ecological community. Given the occurrence of this community in the proposal site as small isolated patches, the proposal is unlikely to interfere with the recovery of the community due to the patches being impacted already being fragmented and isolated from other patches. Threat reduction and control actions listed in the approved conservation advice relevant to the proposal include (DEWHA 2010): • Where further clearance is unavoidable: – mitigate the severity of impacts (eg avoid higher quality areas, avoid dissection of patches, act to minimise hydrological disruption and the spread of weeds) – offsetting should consider the location and emulate qualities of affected patches. The proposal will result in the clearing of 7.2 hectares of the Brigalow ecological community from the edge of a viable patch. This patch is likely to remain viable with the vegetation to be removed to occur on the edge of one side of the patch and within derived grasslands. The proposal will require the acquisition of biodiversity offsets that will protect remnants of native vegetation including the requirement to protect this community.
Conclusion	The proposal is not likely to have a significant impact on the endangered Brigalow Woodlands ecological community given that the community occurs only in segment 11 which is at the southern edge of the communities distribution. The community, although widespread further to the north of the proposal has a relatively patchy and fragmented distribution. The proposal will impact on the edge of one patch and remove 7.2 hectares (less than 0.005 percent of the community in NSW). Although the proposal will result in the removal of 7.2 hectares of the community, the removal will generally occur on the edge of the patch and the patch would remain viable and connected to other native vegetation and the proposal is unlikely to significantly impact the occurrence of the community. However, it is acknowledged that the proposal has potential to result in a reduction in the quality of the community, by increasing the risk of establishment of potentially invasive species harmful to the community These risks would be managed through the implementation of construction and operational mitigation measures as part of the proposal.

Grey Box (*Eucalyptus microcarpa*) Grassy Woodlands and derived native grasslands of South-eastern Australia – endangered ecological community

Diagnostic features

This community is a grassy woodland dominated by dominated or co-dominated by Grey Box (*Eucalyptus microcarpa*). The community also includes grassland understorey derived from the historic clearing of the woody components of the woodland. Both the grassy woodland and the derived native grassland provide vital support to a diverse range of native flora and fauna that are important to retaining regional, state and national biodiversity.

In grassy woodland occurrences, the shrub layer is variable, ranging from absent in areas of intense grazing, to moderately dense cover. In many situations, regrowth of the canopy trees may also be present in the mid layer. This community is heavily influenced by landscape factors and past land management practices. The ground layer varies in compositions, with a combination of grasses, herbs and smaller chenopods.

This community supports fauna species from a variety of conditions, ranging from wetter forest and woodland ecosystems further east and south to the semi-arid environment to the west and north. The Grey Box Grassy Woodlands have a strong influence on bird assemblage composition and provides foraging, roosting and breeding habitat. Larger mammals such as kangaroos and wallabies often utilise this community for grazing and arboreal species such as possums utilise tree-hollows for shelter and breeding (TSSC, 2010).

Geographic distribution

The Grey Box (*Eucalyptus microcarpa*) Grassy Woodlands and Derived Native Grasslands of South-Eastern Australia occurs from central NSW, through northern and central Victoria into eastern South Australia (TSSC, 2001)

Extent

This community was once widespread throughout south-eastern Australia but now, across its national range, only 10 to 15 percent of the original extent remains. The community is found in wheat-sheep belt of eastern Australia and as a result has been extensively cleared since European settlement. It is estimated that the extent of the ecological community has declined from between 1.8 to 2.0 million hectares to a present extent between 300 000 and 330 000 hectares in NSW. Most of the remaining areas of this ecological community occur on private land. At present, less than one percent of what remains of the community in NSW is in formal conservation reserves (TSSC, 2001).

Threats

The Grey Box ecological community is listed as an endangered ecological community due to the significant loss of integrity throughout much of its extent. This includes both vegetation and fauna components, combined with weed invasion, fragmentation and degradation of habitat. Clearing of this community continues to pose serious threats to the Grey Box Grassy Woodlands ecological community. Unfavourable management practices and a lack of protection in reserves are also highlighted as key threats for this ecological community (DEWHA, 2010).

Occurrence in the study area

Within the study area the community is a tall woodland averaging about 14 metres high with a mix of a number of tree species including Grey Box (*E. microcarpa*), Pilliga Box (*E. pilligaensis*), Fuzzy Box (*E. conica*) and Poplar Box (*E. populnea subsp. bimbil*). Although similar communities were found within the study area, only one occurrence of this community, occurring between the Mitchell highway and the Macquarie River is commensurate Grey Box (*Eucalyptus microcarpa*) Grassy Woodlands and Derived Native Grasslands of South-eastern Australia (EPBC Act). This area occurs mostly within the Crown Reserve between the Macquarie River and Mitchell Highway near Narromine and extending into roadside reserves in the wider investigation corridor and study area. The proposal will result in the clearing of 15.9 hectares of this community from a 160 hectare patch.

Table M23: Assessment of significance – Grey Box Woodland

Criteria	Discussion
According to the DotE (2013) 'significant impact criteria', an action is likely to have a significant impact on a critically endangered or endangered ecological community if there is a real chance or possibility that it will:	
Reduce the extent of an ecological community	The proposal will result in the removal of 15.9 hectares of the Grey Box ecological community from a larger 160 hectare patch (about nine percent of the patch). The vegetation occurs as one patch within roadside vegetation and connected Crown Reserve. This represents a clearing of less than 0.005 of the current estimated remaining Grey Box ecological community in NSW. The removal of 15.9 hectares of this community represents about nine percent of the extent of the community in the study area. The community is known to occur in other roadside patches and on private property in the wider locality mostly to the south where the community is more common and widespread. The listing advice for this community estimated the extent of the community to be about between 300,000 to 330,000 hectares. Using a conservative estimate of 300,000 hectares remaining, the removal of 15.9 hectares represents about 0.005 percent of the remaining extent of the community in NSW.
Fragment or increase fragmentation of an ecological community, for example by clearing vegetation for roads or transmission lines	The proposed clearing will result in the fragmentation of this patch of the Grey Box ecological community. This community is already highly fragmented due to historical clearing throughout NSW. The patch of vegetation to be impacted by the works is currently fragmented due to the Mitchell Highway and another minor road and railway line passing through it from east to west. The patch occurs in a highly fragmented landscape surrounded by high intensity agriculture. Remaining patches of native vegetation are mostly restricted to roadside linear corridors and patches of Crown land. The vegetation to be removed occurs as part of a larger 160 hectare patch of this community. The patch will be fragmented into two patches following construction of about 17 hectares to the west and four hectares to the east. Both the east and west patches would remain connected to other roadside native vegetation and would not be isolated from other linear roadside vegetation. Disturbance as a result of construction will likely exacerbate fragmentation, with further introduce weeds that already occur in the study area.

Criteria	Discussion
Adversely affect habitat critical to the survival of an ecological community	No critical habitat has been listed for the Grey Box Woodland ecological community under the EPBC Act 1999. Habitat critical to the survival of a species or ecological community also refers to areas that are necessary: • For activities such as foraging, breeding, roosting or dispersal • For the long-term maintenance of the species or ecological community (including the maintenance of species essential to the survival of the species or ecological community, such as pollinators) • To maintain genetic diversity and long term evolutionary development, or • For the reintroduction of populations or recovery of the species or ecological community (DoE, 2013). Due to the limited area of Grey Box Woodlands remaining across the landscape, this patch of vegetation is important and its removal will contribute to the reduction of geographical extent of this community in NSW, especially given this patch occurs at the northern extent of the species distribution in NSW. However, it is unlikely that the proposal will damage habitat necessary for dispersal, maintenance, genetic diversity or recovery of Grey Box Woodlands as the areas to be impacted occur as part of a larger patch and connected linear roadside corridors and therefore is not critical to the survival of the community.
Modify or destroy abiotic (non-living) factors (such as water, nutrients, or soil) necessary for an ecological community's survival, including reduction of groundwater levels, or substantial alteration of surface water drainage patterns	The proposal will involve earthworks as part of the construction of the proposal and may alter local surface drainage flows within the proposal site. However, it is unlikely to cause substantial alterations of surface water drainage patterns where the community occurs that are necessary for the long-term survival of the ecological community. The earthworks have the potential to cause soil erosion in the proposal site which may run off into the study area, with the potential to impact on surface water quality to the remnant patches of Grey Box woodland, particularly where it occurs in the Crown Reserve adjacent to the Macquarie River. Additionally, vehicle and machinery traffic could cause compaction of soil, which can lead to increased surface run-off and hence greater erosion potential. Although soil disturbance may have adverse impacts on the community, for example, by exacerbating weed impacts on functionally important species such as chenopods and Weeping Myall trees, the proposal is unlikely to significantly modify abiotic factors critical to the long-term survival of the community.
Cause a substantial change in the species composition of an occurrence of an ecological community, including causing a decline or loss of functionally important species, for example through regular burning or flora or fauna harvesting	The proposal will 15.9 hectares of the community from a 160 hectare patch in the proposal site. The occurrence of the overall patch will be retained but the proposal is likely to fragment the patch and increase edge impacts; these may have long-term impacts on the condition of the understorey and species composition of retained areas of this community. Vegetation that occurs on the edges of the proposal may be subject to increased weed invasion and it is possible that any weeds that are introduced may change the composition of the ecological community by outcompeting native understorey, resulting in a loss of functionally important species.

Criteria	Discussion
Cause a substantial reduction in the quality or integrity of an occurrence of an ecological community, including, but not limited to: -assisting invasive species, that are harmful to the listed ecological community, to become established, or	The Grey Box ecological community is listed as an endangered ecological community due to the significant loss of integrity throughout much of its extent. This includes both vegetative and faunal components, combined with weed invasion, fragmentation and degradation of habitat. Part of the patch occurs in a Crown Reserve close to the town of Narromine and hence already contains a high weed component due to intensive use for recreation. The proposal will result in the removal of 15.8 hectares of this community, exacerbating the impacts of edge effects and weed invasion. Connected patches of this community would remain in the roadside reserve of the Mitchell Highway, Narromine Crown Reserve and roadside reserves to the south. All are in a similar condition to the area to be removed due to similar management. The introduction of invasive weed species are a key factor contributing to the degradation of this ecological community. The works have the potential to further contribute to this threat through the disturbance of the area to be cleared.
causing regular mobilisation of fertilisers, herbicides or other chemicals or pollutants in to the ecological community which kill or inhibit the growth of species in the ecological community	Construction of the proposal has the potential to result in the mobilisation of contaminated sediments or chemical spill from vehicles or plants. The introduction of pollutants into the surrounding environment, if uncontrolled, could impact on surrounding areas of Grey Box Woodlands.
Interfere with the recovery of an ecological community	There is no national recovery plan for this ecological community. This community occurs in the proposal site as mostly small, isolated patches in roadside vegetation in the Narromine Crown Reserve. The proposal is unlikely to interfere with the recovery of the community given the patches being impacted are already affected by fragmentation from other linear and residential infrastructure and agricultural development. Priority recovery and threat abatement actions listed in the approved conservation advice relevant to the proposal include: • Enabling recovery of additional sites. This would occur through future biodiversity offsets required for the proposal and impacts to this community. • Protecting remnants of the listed ecological community through the development of conservation agreements and covenants. Spread of invasive species as a result of clearing is a threat that may be exacerbated by the proposal. The remaining two patches split by the proposal are likely to still function as viable patches and contribute to the recovery of the ecological community.

Criteria	Discussion
Conclusion	The proposal is not likely to have a significant impact on the endangered Grey Box Woodlands ecological community given: • The small area to be removed (about 15.9 hectares) from a larger 160 hectares patch. • The area to be removed represents less than 0.01 percent of the occurrence of the community in NSW. The community has a relatively widespread although patchy and fragmented distribution which occurs mostly to the south of the proposal. The proposal will remove 15.9 hectares (about 0.005 percent) of the community in NSW. The remain two patches that would be fragmented after the proposal are likely to still remain as viable patches due to the connectivity to other roadside linear vegetation. However, it is acknowledged that the proposal: • Is likely to increase the fragmentation of the community of the patch in general which is already fragmented from east to west by roads and other linear infrastructure. • Has potential to result in a reduction in the quality of the community, by increasing the risk of establishment of potentially invasive species harmful to the community. These risks would be managed through the implementation of construction and operational mitigation measures as part of the proposal.

Poplar Box grassy woodland on alluvial plains- endangered ecological community

Diagnostic features

The Poplar Box grassy woodland endangered ecological community is variable, ranging from grassy woodland to grassy open woodland, and can resemble an open forest structure. The canopy is dominated by Poplar Box (E*ucalyptus populnea*) with an understorey of forbs and grasses. Low density shrubs are sometimes present within this community in areas of lower nutrient and sandier soils, but taller shrubs are general lacking. The mid layer also often includes juvenile trees of canopy species and in some circumstances this layer may occur as a thicket.

Geographic distribution

The Poplar Box ecological community occurs on paleo and recent depositional soils on flat terrain within the Brigalow Belt North, Brigalow Belt South, Southeast Queensland, Cobar Peneplain, Darling Riverine Plains, NSW South Western Slopes and Riverina IBRA bioregions. It occasionally is found in proximity to ephemeral watercourses and depressions. With decreasing soil fertility and increasing topographic relief this community is replaced by woodlands dominated by shrubby *Eucalyptus* sp. as well as Ironbark and Cypress pine communities.

Extent

Prior to European settlement it is estimated that Poplar Box Grassy Woodland occupied over five million hectares throughout NSW and QLD. The historic extent in NSW is estimated to be approximately 2.57 million hectares (Benson, 2006). Estimates indicate that the ecological community has declined in NSW to the present extent of approximately 705,000 hectares. This ecological community has undergone a decline in extent throughout Australia of at least 75 percent.

Threats

Clearing, fragmentation, weed invasion, inappropriate land management practices and loss of faunal components have resulted in severe degradation of the community and its habitat (Conservation advice).

Occurrence in the study area

The Poplar Box ecological community occurs as scattered smaller remnant patches throughout the investigation area. Small fragmented areas, predominantly consisting of small patches within agricultural areas and to a lesser extent, roadside vegetation, will be cleared in Segment 8 (Narromine to Curban) but the majority of the clearing will occur in Segment 9 (Curban to Pilliga). Within the study area the vegetation consisted of mid-high to tall woodland or open woodland, averaging 13 metres high, dominated by *Eucalyptus populnea subsp. bimbil* (Poplar Box) with sparse occurrences of *Brachychiton populneus* (Kurrajong). The shrub layer is absent or sparse. Although the ground cover is likely to usually be mid-dense to sparse, during the survey period it was very low and in most cases had been heavily grazed.

Of the 309 hectares of the woodland form of this community identified in the investigation corridor, 76.3 hectares will be removed by the proposal (24 percent of the occurrence of the community in the investigation corridor).

Table M24: Assessment of significance – Poplar Box grassy woodland

Criteria	Discussion
According to the DotE (2013) 'significant impact criteria', an action is likely to have a significant impact on a critically endangered or endangered ecological community if there is a real chance or possibility that it will:	
Reduce the extent of an ecological community	The proposal will remove a total of 76.3 hectares of Poplar Box Woodland from about 20 separate small patches and isolated paddock trees across private property and some roadside reserves. The vegetation to be removed occurs as small fragmented patches of vegetation throughout Segment 8 (Narromine to Curban) and 9 (Curban to Pilliga). Large sections of Segment 9 could not be accessed during the survey period and plant community type allocation is based on the method outlined in BDAR and previous broad vegetation type mapping. Most of these small patches occur as small isolated patches within an agricultural matrix of crops and livestock grazing. The proposal will remove about 76.3 hectares of the 309 hectares (24 percent) mapped in the investigation corridor. The community was commonly observed in roadside reserves and as scattered patches in private property in the wider locality of Segment 9 during field surveys and also occurs outside the investigation corridor in the wider study and locality. The listing advice for this community estimated the extent of the community to be about between 705,000 hectares. This amount is likely to have further to decreased. Using a conservative estimate of 650,000 hectares remaining, the removal of 76.3 hectares represents about 0.005 percent of the remaining extent of the community in NSW.

Criteria	Discussion
Fragment or increase fragmentation of an ecological community, for example by clearing vegetation for roads or transmission lines	Fragmentation is a key cause of the loss of integrity of Poplar Box communities throughout Australia. The proposal in areas will reduce the size of small fragments of this community and will also divide larger patches, causing a loss in connectivity and further fragmentation. Disturbance as a result of construction may introduce weeds and increase edge effects further exacerbating the fragmentation of this community. Poplar Box Woodlands occur on highly fertile and arable soils where there is considerable pressure to clear for agriculture. This has resulted in this ecological community occurring predominantly as small, varied and fragmented patches. Two locations of this community to be removed occur along small ephemeral creeks and connectivity of woodland vegetation along these creeks will be retained after construction of the proposal. The remanent patches to be removed occur mostly as scattered open woodland patches that are not connected to other remnant vegetation. Disturbance as a result of construction will likely exacerbate fragmentation of these patches that are already highly fragmented and not connected to other woodland patches.
Adversely affect habitat critical to the survival of an ecological community	No critical habitat has been listed for the Poplar Box ecological community under the EPBC Act. The area's most critical to the survival of the Poplar Box ecological community are described by DAWE in their conservation advice (DoEE 2019) as being the best quality, most intact patches of the ecological community. These patches represent those parts of the ecological community that retain the highest diversity and degree of structure and ecological functions. They represent those sites closest to the original, benchmark values of the ecological community and that must retain their inherent values through protection and ongoing management (DoEE 2019). The areas of Poplar Box Grassy Woodland to be removed by the proposal occurs scattered in small patches throughout the proposal site. This vegetation is largely modified and disturbed and occur within active agricultural land. During field surveys, where accessed, this community was one of the plant community types most heavily impacted by overgrazing and drought conditions and had a ground layer dominated by introduced species. As such, the proposal will not affect any habitat critical to the survival of an ecological community.

Criteria	Discussion
Modify or destroy abiotic (non-living) factors (such as water, nutrients, or soil) necessary for an ecological community's survival, including reduction of groundwater levels, or substantial alteration of surface water drainage patterns	The proposal would modify surface water flows and other abiotic factors within the proposal site by removing native vegetation and modifying the natural landform during construction and operation. The proposal will involve earthworks as part of the construction of the proposal and may alter local surface drainage flows within the proposal site. However, it is unlikely to cause substantial alterations of surface water drainage patterns where the community occurs that are necessary for the long-term survival of the ecological community. The earthworks have the potential to cause soil erosion in the proposal site which may run off into the study area, with the potential to impact on surface water quality to the remnant patches of Poplar Box woodland, particularly in the two locations where they occur near ephemeral waterways. Although soil disturbance may have adverse impacts on the community, for example, by exacerbating weed impacts on groundcover species regeneration. The proposal is unlikely to significantly modify abiotic factors critical to the long-term survival of the community due to the gap created by the proposal and the wider extent of the community in the investigation corridor and locality. The proposal would cause soil disturbance due to the earthworks required for the construction of the proposal. The earthworks have the potential to cause soil erosion in the proposal site which may run off into the study area, with the potential to impact on surface water quality throughout the community. Additionally, vehicle and machinery traffic could cause compaction of soil, which can lead to increased surface run-off and hence greater erosion potential.
Cause a substantial change in the species composition of an occurrence of an ecological community, including causing a decline or loss of functionally important species, for example through regular burning or flora or fauna harvesting	The proposal will reduce the size of small fragments of this community and will also reduce the extent of two larger patches along ephemeral waterways. During field surveys, this community was one of the most heavily impacted by overgrazing and drought conditions and has been previously and currently been heavily modified for agriculture. These may have long-term impacts on the condition of the understorey and species composition of retained areas of this community, without implementation of mitigation measures during construction. However, the proposal is unlikely to result in a substantial change in the species composition of the retained occurrences of the Poplar Box ecological community due to its already highly modified condition due to agriculture.
Cause a substantial reduction in the quality or integrity of an occurrence of an ecological community, including, but not limited to: -assisting invasive species, that are harmful to the listed ecological community, to become established, or	Within the proposal site, Poplar Box Woodlands occur mostly as scattered smaller patches within the agricultural matrix of crops and livestock grazing. Where accessed, the occurrences of this community in the proposal site had a degraded groundcover layer, dominated by introduced species and with low percent cover and abundance. The proposal would result in the complete removal of all vegetation (native and exotic) from within the proposal site. Vegetation outside of the proposal site that would not be directly impacted by the proposal is at some risk of indirect impacts resulting from the proposal, if appropriate mitigation measures are not adopted and implemented. The further introduction of weeds poses a threat due to the already degraded groundcover layer of most of these patches.

Criteria	Discussion
	The proposed works will result in the complete removal of 76.3 hectares of this community, exacerbating the impacts of edge effects. The introduction of invasive weed species are a key factor contributing to the degradation of this ecological community and the proposal could further increase this.
-causing regular mobilisation of fertilisers, herbicides or other chemicals or pollutants in to the ecological community which kill or inhibit the growth of species in the ecological community	Construction of the proposal has the potential to result in the mobilisation of contaminated sediments or chemical spill from vehicles or plants. The introduction of pollutants into the surrounding environment, if uncontrolled, could impact on surrounding areas of Poplar Box Grassy Woodlands.
Interfere with the recovery of an ecological community	There is no national recovery plan for this ecological community. Given the occurrence of this community in the proposal site as small isolated patches, the proposal is unlikely to interfere with the recovery of the community due to the patches being impacted already being fragmented and isolated from other patches. The conservation advice (DoEE 2019) outlines four key approaches to achieve their conservation objectives for Poplar Box Grassy Woodlands of which one may be relevant: • Protect the ecological community to prevent further loss of extent and condition. The proposal will require the acquisition of biodiversity offsets that will protect remnants of native vegetation including the requirement to protect this community. While the smaller patches will in most cases be completely removed by the proposal, the viability of the patches on the ephemeral creek lines is likely to be retained. The smaller patches are unlikely to be contributing to the recovery of the community in the long term and the proposal is unlikely to interfere with the recovery of the ecological community.
Conclusion	The community has a relatively widespread although patchy and fragmented distribution. The proposal will impact on about 20 patches and three hectares of isolated paddock trees within the known range of the community through the removal of 76.3 hectares of the community (about 0.005 percent of the community in NSW). Given the isolated nature of most of patches to be impacted, they are unlikely to be viable patches that are contributing to the recovery of the community and the proposal is unlikely to significantly impact the occurrence of the community. However, it is acknowledged that the proposal: • Is likely to increase the fragmentation of the occurrence of this community in two locations on ephemeral waterways • Has potential to result in a further reduction in the already highly degraded quality of the community, by increasing the risk of establishment of potentially invasive species harmful to the community. These risks would be managed through the implementation of construction controls and other mitigation measures as part of the proposal.

White Box - Yellow Box - Blakely's Red Gum Grassy Woodland and Derived Native Grassland- Critically Endangered Ecological Community

Diagnostic features

The White Box Yellow Box Blakey's Red Gum Grassy Woodlands and Derived Grasslands ecological community (Box-Gum Grassy woodland) has a canopy that is, or once was, dominated by *Eucalyptus albens* (White Box), *Eucalyptus melliodora* (Yellow Box) or *Eucalyptus blakelyi* (Blakely's Red Gum). This community can occur as either a woodland or a derived grassland. It has a ground layer of native tussock grasses and herbs, with a sparse, scattered shrub layer. At the western end of the community's distributional range White Box is more prevalent, with Yellow Box and Blakely's Red Gum occurring more frequently in the east (TSSC, 2006).

Geographic distribution

The Box – Gum Grassy Woodland critically endangered ecological community occurs in an arc along the western slopes and tablelands of the Great Dividing Range. Its extent ranges from Southern Queensland through NSW to Victoria. This ecological community occurs on moderate to highly fertile soils at altitudes of 170 to 1200 metres in areas where rainfall is between 400 and 1200 millimetres per year (TSSC 2006).

Extent

A large portion of the original extent of the Box –Gum Grassy Woodland ecological community has been cleared for agriculture. This community commonly occurs as fragmented and highly disturbed patches, with few healthy and intact areas remaining. In NSW it is estimated that the historical extent of this community was approximately 3,717,000 hectares. The current extent is estimated to be approximately 251,000 hectares, a decline of 93 percent in NSW. It is estimated that less than 0.1 percent of this ecological community remains in high condition. High condition areas tend to occur on public land that has not been used for agriculture, such as cemeteries, travelling stock routes and road verges (TSSC 2006)

Threats

Due to a severe geographic decline throughout Australia, including NSW, this community has been listed as critically endangered. The majority of remaining vegetation of this community is highly fragmented, occurring in small isolated patches within agricultural land. Continued modification and degradation of this community as a result of fire, weed invasion and a loss of functionally important species is also identified as a criteria for the listing of this community as critically endangered. It is unlikely that re-establishment of composition and community structure to original levels is possible, even with immediate positive human intervention (TSSC 2006).

Occurrence in the study area

Within the investigation corridor Box – Gum Grassy Woodland occurs at two locations about 200 kilometres apart. One area occurs as a roadside patch of vegetation that extends to a small patch of vegetation on private property. This patch is about 14.8 hectares and occurs south of the Macquarie River near Narromine in Segment 8. The vegetation within in this area is dominated by *Eucalyptus blakelyi* (Blakely's Red Gum) and *Eucalyptus melliodora* (Yellow Box) with occurrences of *Eucalyptus microcarpa* (Grey Box). Ground cover and shrub layer was sparse and dominated by grasses and forbs. The proposal will remove about three hectares of the community from the 5.5 hectare patch (55 percent of the local occurrence). The retained part of the patch will occur as one patch and will not be split into two fragments. The second location is at Baradine, where the vegetation occurs as a

0.3 hectare patch of woodland adjacent to a 5.06 patch of derived native grassland. This patch is part of a much larger area of connected vegetation

Table M25: Assessment of significance – Box-Gum Grassy Woodland

Criteria	Discussion
According to the DotE (2013) 'significant impact criteria', an action is likely to have a significant impact on a critically endangered or endangered ecological community if there is a real chance or possibility that it will:	
Reduce the extent of an ecological community	The proposal will remove three hectares of Box-Gum Woodland from one patch within private property within Segment 8 near Narromine. The area to be removed is part of a larger patch. The removal of three hectares represents about 55 percent of the local patch. The retained part of the patch will occur as one patch to the west of the proposal and will not be split into two fragments. The remaining fragment would be about 2.5 hectares. This is the only occurrence of the community in the proposal. The clearing of three hectares represents a loss of less than 0.001 percent of the remaining Box – Gum Grassy Woodland ecological community within NSW.
Fragment or increase fragmentation of an ecological community, for example by clearing vegetation for roads or transmission lines	Box-Gum Grassy Woodlands occur on highly fertile and arable soils where there is considerable pressure to clear for agriculture. Impacts on this community south of Narromine will result in the reduction in the overall size of the patch but will not result in the new fragmentation of any patches. The proposal will remove about three hectares from the patch, and about 2.5 hectares would be retained to the west of the proposal. Additional areas are also mapped outside the proposal site on the eastern side of the area to be removed, however these are already fragmented by the presence of a road. Broad-scale regional vegetation mapping indicates that there are scattered patches of Box-Gum Woodland in the vicinity of Mt Tenandra, north-east of Gilgandra (as shown on Figure 10.1). None of the vegetation with the proposal site or surrounds near this location was identified as Box-Gum Woodland during surveys of the wider investigation area. As such, it is likely that this vegetation is not Box-Gum Woodland. Vegetation to be impacted at Baradine is part of a larger patch, with the derived grassland form extending across the Baradine showground. Canopy vegetation also extends around the showground and has wider connectivity in the area, including travelling stock reserves along Gulargambone-Baradine Road to the south, Baradine Road to the west, and Gwabegar Road and the Pilliga forests to the north. Removal of 5.4 hectares in this area would result in a reduction in the amount of this SAII entity, however, would not result in any new fragmentation or isolation of retained vegetation as the area to be removed is located on the edge of a much larger patch. Loss of integrity and continued degradation as a result of fragmentation was highlighted as one of the key threats facing this ecological community. The proposal will reduce the size of the patches of this community to be impacted and will exacerbate the fragmentation currently present as a result of the road. Disturbance related to construction also has the potential to introduce weeds and increase edge effects, adding to the fragmentation of this community.

Criteria	Discussion
Adversely affect habitat critical to the survival of an ecological community	No critical habitat has been listed for the Box – Gum Grassy Woodland ecological community ecological community under the EPBC Act. Within NSW where the proposal occurs, habitat critical to the survival of Box-Gum Grassy Woodland is on the moderate to highly fertile soils of the western slopes of NSW. Due to the limited area of the Box – Gum Grassy Woodland ecological community remaining across the landscape, this patch of vegetation is important, and its removal will contribute to the reduction of geographical extent of this community in NSW. The patch is surrounded on all sides by intensive agriculture and is not connected to any other vegetation patches in the investigation corridor or wider study area. However, it is unlikely that the proposed works will damage habitat necessary for dispersal, maintenance, genetic diversity or recovery of the Box – Gum Grassy Woodland ecological community.
Modify or destroy abiotic (non-living) factors (such as water, nutrients, or soil) necessary for an ecological community's survival, including reduction of groundwater levels, or substantial alteration of surface water drainage patterns	The majority of the works will occur in crops and adjacent to the existing road where the patch occurs as roadside vegetation in low condition. Erosion and compaction are not likely to significantly vary from existing conditions in these areas. The proposal would modify surface water flows and other abiotic factors within the proposal site by removing native vegetation, modifying the natural landform, and constructing the proposal. The proposal will involve earthworks as part of the construction of the proposal and may alter local surface drainage flows within the proposal site. However, it is unlikely to cause substantial alterations of surface water drainage patterns where the community occurs that are necessary for the long-term survival of the ecological community. The earthworks have the potential to cause soil erosion in the proposal site which may run off into the study area, with the potential to impact on surface water quality to the isolated remnant patches of Box-Gum Grassy woodland. Additionally, vehicle and machinery traffic could cause compaction of soil, which can lead to increased surface run-off and hence greater erosion potential. Although soil disturbance may have adverse impacts on the community, for example, by exacerbating weed impacts the community. The proposal is unlikely to significantly modify abiotic factors critical to the long-term survival of the community.
Cause a substantial change in the species composition of an occurrence of an ecological community, including causing a decline or loss of functionally important species, for example through regular burning or flora or fauna harvesting	Construction will result in the removal of three hectares of this community from south of Narromine and 5.4 hectares from near Baradine. Disturbance as a result of construction has potential to indirectly affect remaining occurrences of groundcover species which are characteristic of this forb rich community. The continued introduction of weeds and increased edge effects from construction is likely to further compromise the species composition of this patch of the community.

Criteria	Discussion
Cause a substantial reduction in the quality or integrity of an occurrence of an ecological community, including, but not limited to: -assisting invasive species, that are harmful to the listed ecological community, to become established, or	Loss of integrity and continued degradation as a result of fragmentation is one of the key threats facing this ecological community. The proposal will result in the complete removal of 8.4 hectares of this ecological community. Although already fragmented, it is likely that the proposal will further exacerbate edge effects and fragmentation for this community as the patches to be removed already occur as part of a small patches isolated within an agricultural matrix. The likely further introduction of invasive weed species is highlighted as a factor contributing to the loss of integrity for this community. The proposal has the potential to contribute to this threat through the disturbance of the area proposed to be cleared.
-causing regular mobilisation of fertilisers, herbicides or other chemicals or pollutants in to the ecological community which kill or inhibit the growth of species in the ecological community	Construction of the proposal has the potential to result in the mobilisation of contaminated sediments or chemical spill from vehicles or plants. The introduction of pollutants into the surrounding environment, if uncontrolled, could impact on surrounding areas Box – Gum Grassy Woodland ecological community.
Interfere with the recovery of an ecological community	The adopted recovery plan for the Box – Gum Grassy Woodland ecological community outlines five recovery plan objectives of which those listed below are relevant to the proposal (DECC 2010): • Achieving no net loss in extent and condition of the ecological community throughout its geographic distribution. • Increasing landscape functionality of the ecological community through management and restoration of degraded sites. The proposal will result in the clearing of 8.4 hectares through a patch of an already fragmented and disturbed patch of Box-Gum Grassy Woodland. The proposal will interfere with recovery objectives listed above.
Conclusion	The community has a relatively widespread although patchy and fragmented distribution. The proposal will impact one patch within the known range of the community through the removal of 8.4 hectares (about 0.001 percent of the community in NSW). Given the already isolated nature, high edge effects and current exposure to weed invasion, it is unlikely to be a viable patch that is contributing to the recovery of the community and the proposal is unlikely to significantly impact the occurrence of the community. However, it is acknowledged that the proposal: • Has potential to result in a reduction in the quality of the patch of the community by increasing the risk of further establishment of potentially invasive species harmful to the community. • These risks would be managed through the implementation of construction controls and other mitigation measures as part of the proposal. The total 8.4 hectares to be removed occurs as an already isolated patches located 200 kilometres apart.

TECHNICAL REPORT 01

Biodiversity development assessment report

Appendix N Expert reports and thermal drone survey report

NARROMINE TO NARRABRI RESPONSE TO SUBMISSIONS

Assessment of koalas and their habitat along the Narromine to Narrabri Inland Rail alignment: expert report for purposes of the *Biodiversity Assessment Method 2020*

Report to JacobsGHD

Revised Final Report: June 2022

AustIcon Consulting

Managing Australia's Iconic Threatened Species

PO Box 3196 Uki NSW

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Citation:

Phillips, S. (2022). *Assessment of koala habitat along the Narromine to Narrabri Inland Rail alignment: expert report for purposes of the Biodiversity Assessment Method*. Final report to GHD. AustIcon Consulting, Uki NSW.

Summary

A section of the proposed Inland Rail alignment between Narromine and Narrabri was assessed for the presence of suitable habitat and associated occupancy by koalas (*Phascolarctos cinereus*). Because access to all areas along the alignment was not possible, a partitioned chronological analysis of contemporaneous koala records to identify areas of koala generational persistence (occupancy by resident populations) was included as part of the overall survey program. This analysis indicated that approximately 14.8 km of the alignment in two discrete areas between Baradine and Etoo Creeks, and a third area approximately 5.5 km in length to the southwest of Narrabri in the north, traversed areas of koala generational persistence.

Coding of PCTs based on the presence and relative abundance of food tree species known to be preferentially utilised by koalas within the assessment area resulted in **1,422.63 ha** of potentially suitable habitat being identified.

Thirty-four field sites were assessed, with evidence of koalas detected in one field site to the northwest of Gilgandra between the Oxley and Castlereagh Highways. Collectively, knowledge of locations exhibiting generational persistence, as well as field survey data enabled identification of a habitat-informed species credit polygon of **260.44 ha**.

Introduction

Recent decades have seen a significant decline in koala occupancy rates across the Pilliga region, data arising from field surveys between 2013 – 2014 by teams of independent researchers from a variety of sources concluding that over the preceding three koala generations (*i.e.,* 18 – 20 years) a reduction of as much as 79% in habitat use by koalas had occurred (Lunney *et al*., 2017). In 2019, survey results from 104 sites distributed across the southern half of the Pilliga, and into the northern portions of the Gilgandra Shire failed to find any substantive evidence of recent habitat use by koalas. Elsewhere, field survey data implies that koalas are also on a steep decline in the Gunnedah LGA to the east, a 2020 field survey of the former Shenhua – Watermark site reporting a drop in koala density from 0.31 koalas^{-ha} in 2011 to 0.026 koala^{-ha} in 2020, a decline of > 90% (Greencap 2020). The reasons for these declines remain to be determined beyond speculation, but collectively include the effects of a long period of drought and high summer temperatures, compounded in the case of the Pilliga by the cumulative impacts of high frequency and severe wildfire events, all of which are arguably a progressive consequence of anthropogenic climate change.

This expert report has been prepared for JacobsGHD acting on behalf of Australian Rail Transport Corporation (ARTC) and relates to a section of the proposed Inland Rail alignment approximately 300 km in length which runs between Narromine and Narrabri (hereafter referred to as the N2N alignment) in central western New South Wales. The report addresses two matters:

a) the nature and extent of potentially suitable koala habitat that occurs along the alignment, and
b) the provision of evidence of contemporaneous habitat utilisation / occupancy by koalas that likely indicates the presence of resident populations.

Koalas are species credit species for purposes of the *Biodiversity Assessment Method 2020* (hereafter referred to as the BAM). Given the backdrop of widespread decline / population attrition, the longer-term persistence of koalas in the central west of NSW (including the area of the N2N alignment) in the face of ongoing and incremental impacts associated with climate change is arguable. Conversely, areas currently returning evidence of occupancy point to the presence of individuals / populations that may be more resilient to change and thus of heightened conservation importance.

The report has been prepared in accordance with the BAM (Box 3 refers) to determine the location and extent of a species polygon for the koala that may be present along the N2N corridor. An expert report was considered necessary given the widespread decline / population attrition of the koala in the region and difficulty in identifying occupied habitat. The field assessment and associated reporting was undertaken by Dr. Stephen Phillips. Dr. Phillips is an expert assessor (koala) for purposes of the BAM; he has more than 40 years of experience in koala habitat identification and population management, is internationally recognised as an authority on koalas and has published widely in the peer-reviewed scientific literature on various aspects of the species' ecology and management. Further details of Dr. Phillips' experience and qualifications as required for BAM expert reporting purposes are provided in **Appendix I**.

Site context

The N2N alignment is a narrow linear transport corridor approximately 300 km in length and 65 m in width[1] located between the towns of Narromine and Narrabri in the central west of NSW (**Figure 1**). At least thirty-six Plant Community Types (PCTs) are represented in the broad floristic amalgum that occurs along the alignment, ranging from crops and introduced grasslands to shrublands variously dominated by wattles, broom and the introduced copper burr, to riparian areas and woodlands variously dominated by red gums, boxes, ironbarks, bloodwoods, mallee, buloke and cypress pine.

[1] Excludes misc. ancillary infrastructure (*e.g.*, borrow pits)

Parts of the N2N alignment between Baradine and Narrabri traverse an *Area of Regional Koala Significance* (ARKS) identified by Rennison & Fisher (2019).

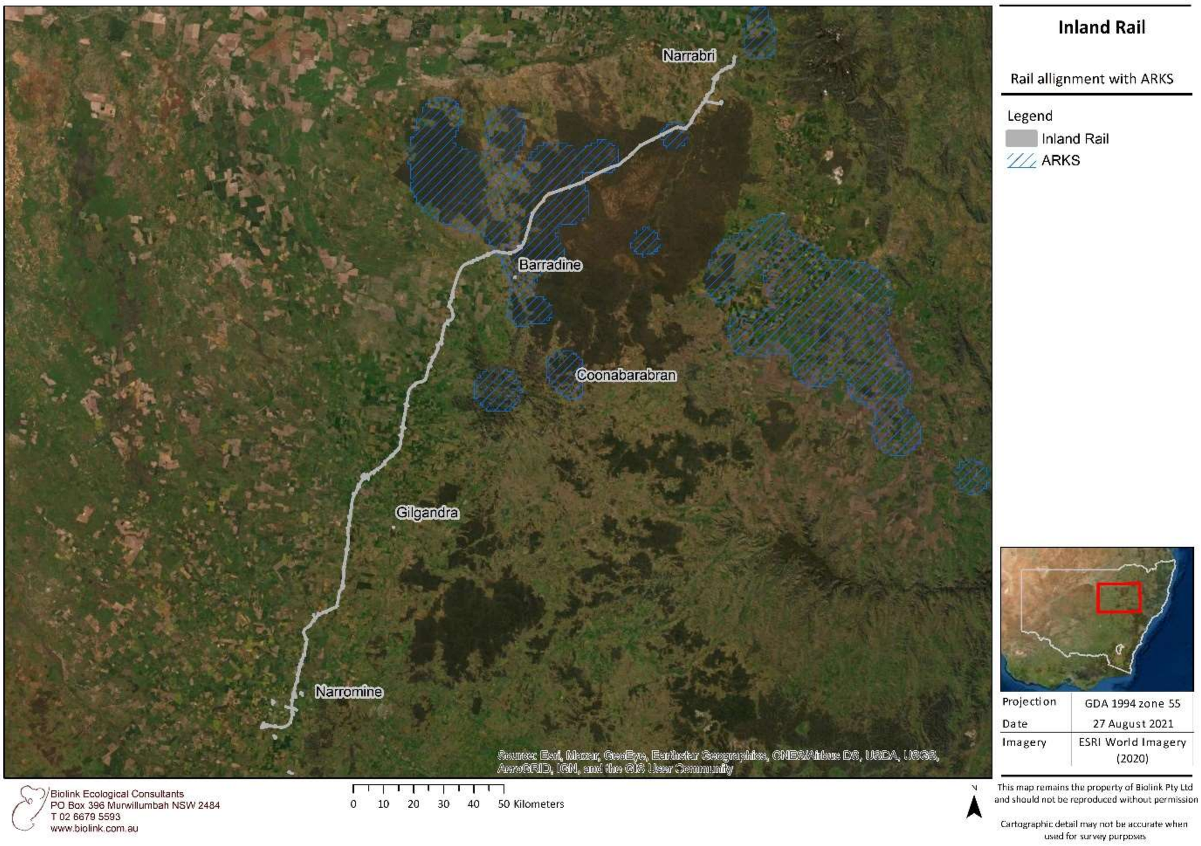


Figure 1. The N2N Inland Rail alignment, and ancillary areas (grey line/polygons). The locations of Areas of Regional Koala Significance (ARKS) identified by Rennison and Fisher (2019) are indicated with blue diagonal hatching.

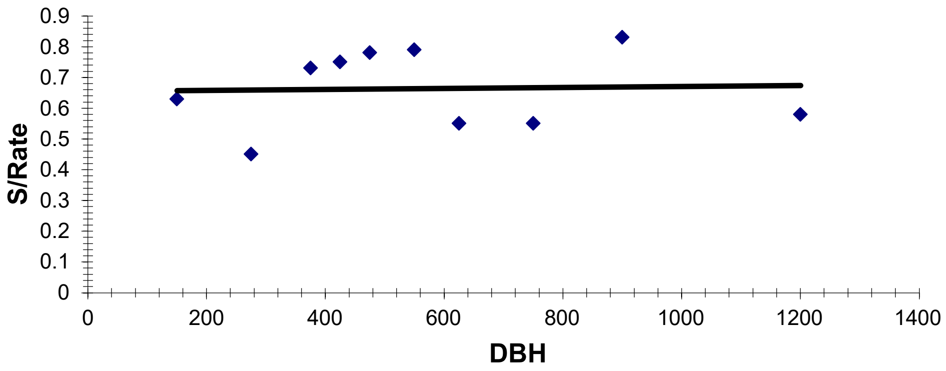
Methodology

Prior knowledge / assumptions

1. Vegetation mapping for the N2N alignment as supplied by JacobsGHD was accepted without prejudice.
2. Habitat use by koalas in the north-western slopes and plains of NSW focuses on the preferential utilisation of 'Primary' and/or 'Secondary' food trees[2] in the form of 'red gums'

[2] As illustrated in Figure 2, a 'Primary' food tree requires preferential use by koalas to be significantly higher than other congeners with a measure of utilisation that is independent of size class (Phillips *et al*. (2000) refers) whereas a 'Secondary' food tree also requires a level of use that is significantly higher than other congeners but with a mode of utilization that is typically size-class dependent (Phillips and Callaghan (2000) refers).

and 'boxes' respectively (hereafter referred to as Preferred Koala Food Trees or PKFTs). The various species in these two groups collectively constitute a critical ecological resource for koalas, with all other tree species being either browsed opportunistically and/or utilised for purposes such as shelter. **Figure 2** illustrates the different modes of use of PKFTs by koalas which distinguish between Primary and Secondary categorisations.



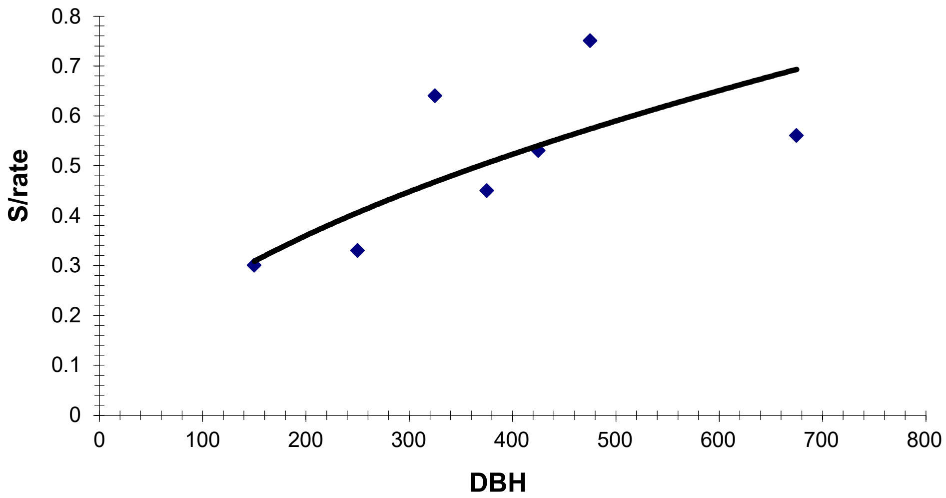


Figure 2. Simplified logit models illustrating the differences in use by koalas of a 'Primary' PKFT such as the red gum *E. camaldulensis* (top image), and a 'Secondary' PKFT such as the box E. *albens* (lower image). The y-axis title 'S/rate' refers the pooled proportion of trees beneath which koala faecal pellets were recorded from sites being actively utilised by koalas using SAT sampling protocols (Image source: Greenloaning Biostudies 2013).

Approach to assessment

Identifying suitable habitat for assessment purposes

The presence and extent of suitable koala habitat in the landscape can be most reliably estimated by reference to descriptions of mapped Vegetation / PCTs, the detail of which insofar as the relative abundance / dominance of PKFTs is concerned enables identification for assessment purposes of suitable koala habitat as outlined in **Table 1** below.

Table 1. Five-tiered koala habitat classification hierarchy.

Koala habitat type	Classification criteria
Primary koala habitat (1)	Forest and/or woodland PCTs occurring on soils of medium to high nutrient value whereupon Primary PKFTs are dominant or co-dominant components of the tallest stratum.
Secondary (Class A) koala habitat (2A)	Forest and/or woodland PCTs occurring on soils of medium to high nutrient value whereupon Primary PKFTs are sub-dominant components of the tallest stratum.
Secondary (Class B) koala habitat (2B)	Forest and/or woodland PCTs occurring on soils of low to medium nutrient value whereupon primary PKFTs are absent, the tallest stratum instead dominated or co-dominated by Secondary food tree species only.
Secondary (Class C) / marginal koala habitat (2C)	Forest and/or woodland PCTs occurring on soils of low to medium nutrient value whereupon primary food tree species are absent and Secondary food tree species are homogeneously distributed but otherwise sub-dominant components of the tallest stratum.
Other	PCTs wherein PKFTs do not typically occur and/or are at sufficiently low densities (< 0.05 PKFTs ha^{-1}) as to be capable of sustaining transient use only.

Each of the classifications in Table 1 above reflect differing koala carrying capacities, areas of ‘Primary’ Koala Habitat being capable of sustaining high density populations (*i.e.* > 0.5 koalas ha^{-1}), whereas ‘Secondary (Class C) / Marginal’ Koala Habitat can only sustain low-density populations (*i.e.* < 0.1 koalas ha^{-1}), this latter category additionally presumptive of a condition that also requires PKFTs to be uniformly distributed therein. Applying this understanding of the relationship between the relative abundance of PKFTs and the ability of a landscape to support resident koalas thus provides the basis for an effective and ecologically meaningful koala habitat classification process which also functions to assist identification of suitable habitat. Collectively, all four of the preceding categories constitute suitable koala habitat for assessment purposes. This approach to the classification and ranking of koala habitat differs to that which might otherwise be derived by using the tree use rankings promulgated by a recent review of tree use by koalas in NSW (NSWDPE 2018) but is the superior approach because it is based on a quantitative partitioning of data relating to tree use by koalas rather than the qualitatively and statistically unsupported approach of the alternative.

Examination of contemporaneous koala records

The N2N alignment was configured into a series of 5 km x 5 km cells in the area between Baradine and Narrabri, and 10 km x 10 km cells between Baradine and Narromine, the differing spatial scales concordant with the approach developed by the NSW Government's Koala Likelihood model (Predavec *et al.*, 2016) and refined ARKS approach (Biolink 2021). These varying scales of resolution reflect the intensity of historical sampling and/or extent of habitat fragmentation respectively. The cells were created by buffering the alignment on both sides by 2.5 km and 5 km accordingly, and thereafter partitioning the resulting polygon into 5 km and 10 km segments respectively.

Koala records occurring within the resulting grid-cell series for the 3 consecutive koala generations 2003 – 2020 were obtained from the NSW BioNet Atlas, and thereafter coded by koala generation as follows: Gen 1: 2020 – 2015; Gen 2: 2014 -2009 and Gen 3: 2008 – 2003. Areas of koala generational persistence (*visive* habitat supporting breeding populations / Core Koala Habitat) were then identified based on koala records being present in each grid cell for each of koala generations 1 & 3. This approach is a departure from the more typical requirement for records to be present for each of the immediately preceding 3 consecutive koala generations because it presumes the presence of generation 2 records, and thus reflects application of the precautionary principle in areas where reporting rate is infrequent and/or koala population status is uncertain. Because the records themselves are the result of field survey, albeit over a longer and ecologically relevant time frame for koalas, their use in the context of contemporary occupancy assessments such as that required for BAM purposes is considered valid.

Field survey

a) Vegetation

A point-based assessment of tallest-stratum cover at each sampling point was undertaken by firstly recording all observable species within a radius of 25 m – 50 m of the sampling point. Relative abundance data for each tree species was then enumerated by scoring which of the observed species were detected by sighting along lines concordant with cardinal and intermediate compass points (*i.e.*, typically 8 samples / site). This approach functions to provide point-based data that can be intersected with PCT mapping to verify accuracy, and/or assist in understanding matters of PKFT dominance at PCT level for associated classifications of koala habitat.

b) Habitat use by koalas

An unbiased field survey design for the N2N alignment was not possible because of access constraints. Other parts of the northern alignment between Baradine and Narrabri (*i.e.,* the Pilliga Scrub) had also been previously covered by an earlier field survey work undertaken by JacobsGHD (2022) and an independent thermal drone survey targeting koalas along a 70 km transect (Saunders Havill Group 2021). Because of these considerations, and additional to ancillary desktop analyses (as described in preceding section), the field survey program was directed by JacobsGHD personnel to opportunistically focus on selected private properties, larger habitat patches, travelling stock and road reserves traversed by the alignment that were not constrained by access considerations and/or had not been covered by drone survey. This approach mandates the need for caution in interpretation of the overall point-based outcomes obtained by field survey (see below), such that results cannot be extrapolated beyond ~ 250 m surrounding a given survey point[3]. Depending on how the field survey data is used, the lack of systematic survey may also result in over / underestimates of measures of occupancy by koalas.

Sampling points were also assessed for use by koalas using the Rapid Spot Assessment Technique (Rapid-SAT), a naïve koala occupancy determination tool which focuses on the presence/absence of koala faecal pellets within a prescribed search area of 1 m around the bases of PKFTs ≥ 300 mm Diameter at Breast Height (DBH) utilising the same search protocols (1 m search area; maximum 2-person minute search for scats) as those underpinning the SAT methodology of Phillips and Callaghan (2011). Originally, developed from a dataset of 12,470 individual trees from 702 NSW north-coast field sites known to have been utilised by koalas, Rapid-SAT offers a resource-effective survey technique predicated by knowledge derived from the Koala_SAT database[4] that in areas being utilised by koalas, there is a discrete probability of koala faecal pellets occurring within 1 m of the base of any Primary or Secondary PKFT ≥ 300 mm DBH (Phillips and Wallis 2016). Given this knowledge, the associated probability of faecal pellets not being present thus becomes an important metric for assessment purposes because it enables determination of how many PKFTs <u>without</u> faecal pellets need to be searched at a given sampling point to prescribe a measure of statistical confidence that koalas are <u>not</u> using the habitat in the immediate area.

[3] This estimate is a rounding up of the 211 m otherwise obtained using the square root of (median female koala home range size in sq meters/2) approach described in Phillips (2016).
[4] A database maintained by AustIcon/Biolink Ecological Consultants

Koala faecal pellets persist for significantly longer time periods in western areas of the species range (Phillips 1999; Phillips and Callaghan 2011) and because of this the probability of finding pellets beneath PKFTs in areas being used by koalas is significantly higher than on the north-coast (Koala_SAT: percentage equivalent probability of faecal pellet presence beneath PKFTs in western areas = 57%; range: 55.5% - 66%). Informed by the probability modelling of McArdle (1990), Kéry (2002) and Murn & Holloway (2016), **Figure 3** illustrates the probability function curve based on the corresponding 43% failure rate (*i.e.*, probability of faecal pellets NOT being present). This function and associated graph demonstrate that the absence of koala faecal pellets from within the prescribed 1 m radial search area around the bases of a minimum of 6 and a maximum of 9 PKFTs ≥ 300 mm DBH is sufficient to be 95% – 99% confident respectively that koalas are not using habitat in the immediate area. For Rapid-SAT purposes, assessment at a given sampling point ceases when one or more koala faecal pellets have been detected; this is because the objective of the assessment – confirming koala presence - has been achieved, whereas the minimum numbers of trees without pellets to be surveyed has been standardised at 7 for State-wide assessment purposes, thus ensuring that for any given site the absence of koala faecal pellets from beneath this number of PKFTs > 300 mm DBH at a given site falls within a measure of 95% – 99% confidence.

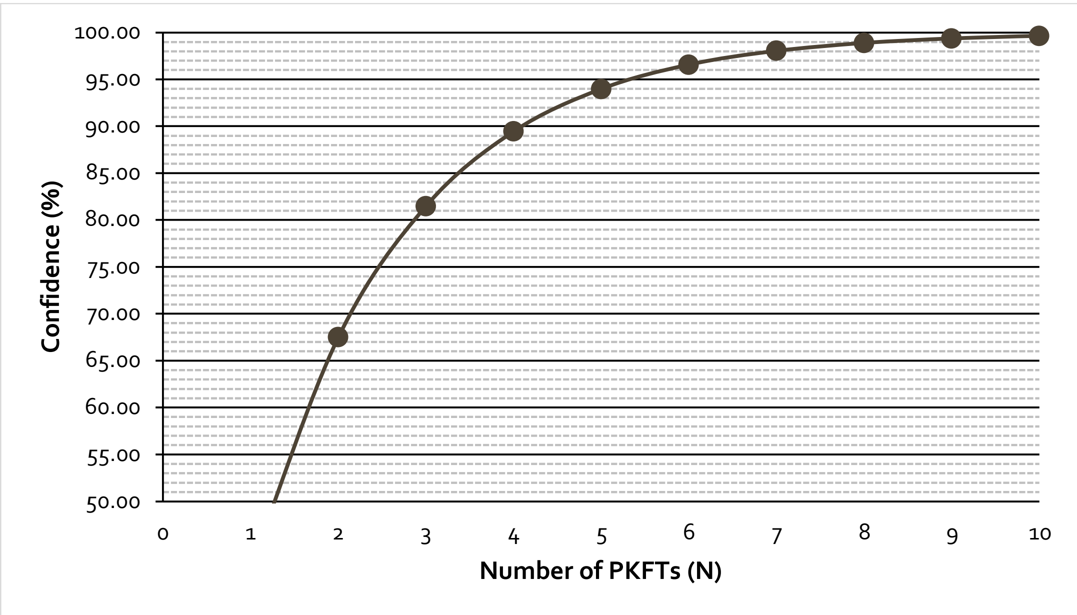


Figure 3: Statistical confidence in the probability of non-occurrence of koalas at an individual Rapid-SAT site based on a 43% probability of failure and the associated numbers of sampled PKFTs ≥ 300 mm DBH beneath which no koala faecal pellets have been detected. Note the intersections of the x and y axes around the 95% - 99% Confidence measure.

In addition to site assessments that were undertaken using Rapid-SAT protocols, PKFTs > 300 mm dbh that were opportunistically encountered during foot-based traverses enroute to and/or between sampling points were also inspected for the presence of koala faecal pellets.

The field survey program was terminated on the 12/08/2021 due to the reported presence and proximity of community-transmitted Covid-19 in the adjoining Gilgandra and Narromine LGAs to the south.

Identifying the species credit polygon

Results from the generational persistence assessment, coupled with and/or refined by the estimated extent of suitable habitat and field survey outcomes, were used to estimate the size of the species credit polygon. This was done by calculating the total area of potentially suitable habitat that occurred within the boundaries of the identified areas of contemporaneous generational persistence that occurred within the N2N corridor, refined as required by the field survey outcomes.

Results

Identification of potentially suitable koala habitat

At least thirty-six PCTs are mapped as occurring along the N2N alignment. **Table 2** provides a breakdown of known PCTs in terms of the areal extent of their representation along the alignment, as well as their corresponding koala habitat classifications. Collectively, this results in an estimated area within the N2N alignment of **1,422.63 ha** of habitat that is potentially suitable for koalas, a summary of which is provided in **Table 3**. Derived Native Grasslands associated with former woodland PCTs that otherwise contained PKFTs were excluded from this calculation on a presumption that distances between individual PKFTs were too great to independently sustain resident koala populations.

Table 2. Plant Community Types (PCTs) present along the N2N alignment, and their associate Koala Habitat Classification based on the criteria detailed in Table 1 (Note: PCTs are listed in alphabetical order).

PCT Code	PCT Long Name	Area (ha)	Koala Habitat Code
55	Belah woodland on alluvial plains and low rises in the central NSW wheatbelt to Pilliga and Liverpool Plains regions	3.99	2C
599	Blakely's Red Gum - Yellow Box grassy tall woodland on flats and hills in the Brigalow Belt South and Nandewar bioregion	3.04	2B
35	Brigalow - Belah open forests / woodland on alluvial often gilgaied clay from pilliga scrub to Goondiwindi, Brigalow Belt South Bioregion	7.28	2C
141	Broombush - wattle very tall shrubland of the Pilliga to Goonoo regions, Brigalow Belt South Bioregion	30.92	Other
746	Brown Bloodwood - cypress - ironbark heathy woodland in the Pilliga region of the Brigalow Belt South Bioregion / 2C	2.12	2C
0	Crop and/or introduced grassland	1637.71	Other
168	Derived Copper burr shrubland of the NSW northern inland alluvial floodplains	7.34	Other
409	Dirty (Baradine) Gum - White Bloodwood - White Cypress Pine - Motherumbah shrubby woodland on sandy soils in the Pilliga Scrub and surrounding region, Brigalow Belt South Bioregion	0.76	2C
148	Dirty Gum - Buloke - White cypress pine - ironbark shrubby woodland of the deep sandy soils on the Liverpool Plains Region of the Brigalow Belt South Bioregion	141.67	2C
206	Dirty Gum - White Cypress Pine tall woodland of alluvial sand (sand monkeys) in the Darling Riverine Plains Bioregion and Brigalow Belt South Bioregion	10.13	2C

PCT Code	PCT Long Name	Area (ha)	Koala Habitat Code
185	Dwyer's Red Gum - White Cypress Pine - Currawang shrubby woodland	13.46	2C
202	Fuzzy Box woodland on colluvium and alluvial flats in the Brigalow Belt South and Nandewar Bioregion (including Pilliga)	3.59	2B
256	Green Mallee tall mallee woodland on rises in the Pilliga - Goonoo regions, southern Brigalow Belt South Bioregion	0.27	2C
248	Mixed box eucalypt woodland on low sandy loam rises on alluvial plains in central western NSW	16.28	2B
255	Mugga Ironbark - Buloke - Pillga Box - White Cypress Pine shrubby woodland	12.15	2C
398	Narrow-leaved Ironbark - White Cypress Pine - Buloke tall open forest on lower slopes and flats in the Pilliga Scrub and surrounding forests in the central north Brigalow Belt South Bioregion	382.30	2C
394	Narrow-leaved Ironbark - White Cypress pine woodland on slopes and flats in the Coonabarabran - Pilliga Scrub regions	81.07	2C
49	Partly derived Windmill Grass – Copper burr alluvial plains shrubby grassland of the Darling Riverine Plains Bioregion and Brigalow Belt South Bioregion	330.11	Other
88	Pilliga Box - White Cypress Pine - Buloke shrubby woodland in the Brigalow Belt South Bioregion	402.07	2B
56	Poplar Box - Belah woodland on clay-loam soils on alluvial plains in north central NSW	38.19	2B
397	Poplar Box - White Cypress Pine shrub grass tall woodland of the Pilliga - Warialda region, Brigalow Belt South Bioregion	17.79	2B

PCT Code	PCT Long Name	Area (ha)	Koala Habitat Code
244	Poplar Box grassy woodland on alluvial clay-loam soils mainly in the temperate (hot summer) climate zone of central NSW (wheatbelt)	43.95	2B
473	Red gum - Rough-barked Apple - Narrow-leaved Ironbark - cypress pine grassy open forest on flats and drainage lines in the Goonoo and surrounding forests, southern Brigalow Belt South Bioregion	20.08	2A
399	Red gum - Rough-barked Apple +/- tea tree sandy creek woodland (wetland) in the Pilliga - Goonoo sandstone forests, Brigalow Belt South Bioregion	54.83	2A
404	Red Ironbark - White Bloodwood +/- Burrows Wattle heathy woodland on sandy soil in the Pilliga forests	25.09	2C
78	River Red Gum riparian tall woodland / open forest wetland in the Nandewar Bioregion and Brigalow Belt South Bioregion	30.75	2A
36	River Red Gum tall to very tall open forest/woodland wetland on rivers on floodplains mainly in the Darling Riverine Plains Bioregion	5.77	1
444	Silver-leaved Ironbark grassy tall woodland on clay-loam soils on plains in the Brigalow Belt South Bioregion	1.75	2C
27	Weeping Myall open woodland of the Darling Riverine Plains Bioregion and Brigalow Belt South Bioregion	6.49	2C
81	Western Grey Box - cypress pine shrub grass shrub tall woodland in the Brigalow Belt South Bioregion	0.91	2C
145	Western Rosewood - Wilga - Wild Orange - Belah low woodland of the Brigalow Belt South Bioregion and eastern Darling Riverine Plains Bioregion	70.90	2C
	This row is deliberately left blank		

PCT Code	PCT Long Name	Area (ha)	Koala Habitat Code
406	White Bloodwood - Motherumbah - Red Ironbark shrubby sandstone hill woodland / open forest mainly in east Pilliga forests	2.40	2C
589	White Box - White Cypress Pine - Silver-leaved Ironbark grassy woodland on mainly clay loam soils on hills mainly in the Nandewar Bioregion	1.05	2C
435	White Box – White Cypress Pine shrub grass hills woodland in the Brigalow Belt South bioregion and Nandewar bioregion	5.38	2B
1384	White Cypress Pine - Bulloak - ironbark woodland of the Pilliga area of the Brigalow Belt South Bioregion	8.85	2C
469	White Cypress Pine - Narrow-leaved Ironbark - Buloke grassy open forest of the Dubbo region, southern Brigalow Belt South Bioregion	0.98	2C
414	White Mallee - Dwyer's Red Gum mallee heath on sands in the Goonoo - Pilliga region, Brigalow Belt South Bioregion	7.31	2C
	Total Area	**3428.71**	

Table 3. Areas of mapped PCT along the N2N alignment and associated koala habitat classifications informing the identification of potentially suitable koala habitat.

Koala Habitat Type	Area (ha)
Primary	5.77
Secondary (Class A)	105.66
Secondary (Class B)	530.28
Secondary (Class C) / Marginal	780.92
Total Suitable Koala Habitat	**1422.63**
Other	2006.08
Total	**3428.71**

Examination of contemporaneous koala records

One hundred and eighteen koala records comprising the 3-generational data set 2003 – 2020 occurred within the buffered areas on either side of the N2N alignment, the results of which continue to imply a strong downward trend in the koala reporting rate / koala distribution and abundance (**Table 4**).

Table 4. Generational chronology and associated numbers of koala records within buffered area of N2N alignment utilised to identify areas of generational persistence. The implied population decline is reflected in the downward trend in reporting rate for each of the three contributing koala generations from 2003 – 2020.

Generation	Time Period	*n*
1	2015 - 2020	8
2	2009 - 2014	12
3	2003 - 2008	98

Based on the presence of records relating to koala generations 1 and 3 only, three areas of koala generational persistence along the alignment were apparent, two of which were approximately 5.7 and 9.1 km in length and located around the area of Baradine and Etoo Creeks, the third approximately 5.5 km in length located to the southwest of Narrabri. **Figure 4** illustrates the locations of koala generational persistence along the N2N alignment.

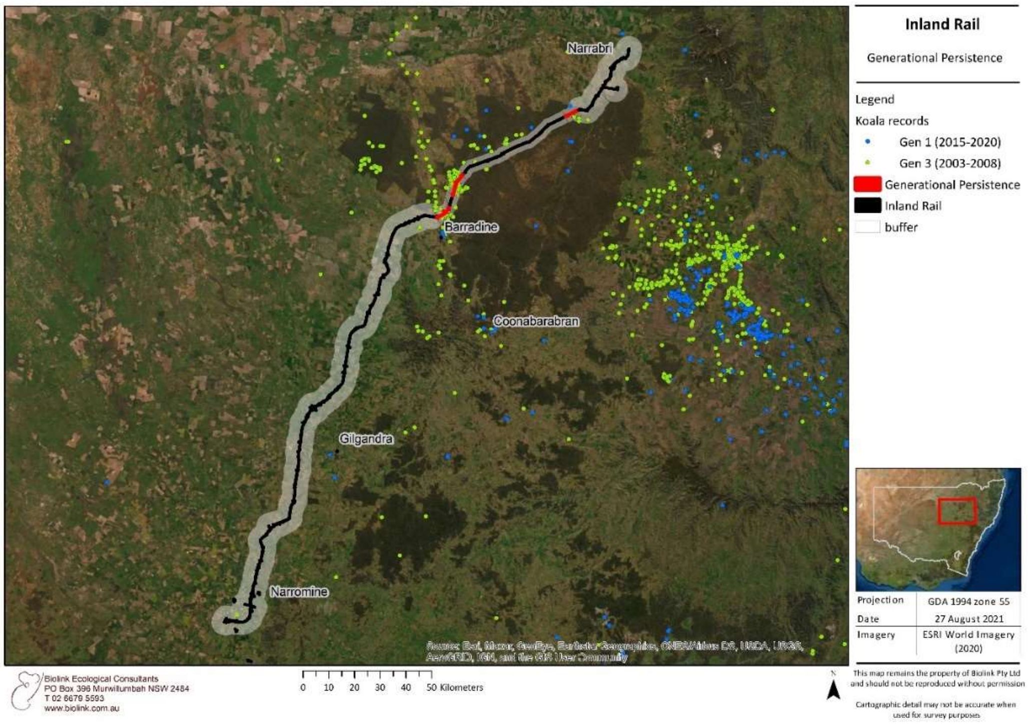


Figure 4. Identified areas of koala generational persistence (red areas) along the N2N alignment between Baradine and Narrabri.

Field survey

Field survey was undertaken over a four-day period 9/08/2021 – 12/08/2021, during which time 34 field sites were assessed. No substantive differences were detected between field site outcomes and PCT mapping. However, survey data from some sites (e.g., N2N_17 and N2N_21) implies the often-localised occurrence of a further PCT within the N2N alignment, one wherein Yellow Box *E. melliodora* is the dominant / co-dominant overstorey species; this knowledge does not affect considerations of the amount of potentially suitable koala habitat that is present along the alignment.

Evidence of habitat use by koalas in the form of diagnostic koala faecal pellets or part thereof was detected in 1 of the 20 sites that were sampled in the area between the Oxley and Castlereagh Highways northwest of Gilgandra. Because the area could not be systematically surveyed, this result arguably implies that 5% of preferred / potential koala habitat in this area may currently be supporting koalas. However, given the paucity of records in the N2N alignment between Narromine and Baradine, this is likely to be a substantive overestimate. No evidence of habitat use was recorded at the 14 sites between Baradine and Narrabri. A summary of the site data is included in **Appendix II**. **Figure 5** illustrates the distribution of survey effort along the N2N alignment that was completed during the truncated survey period.

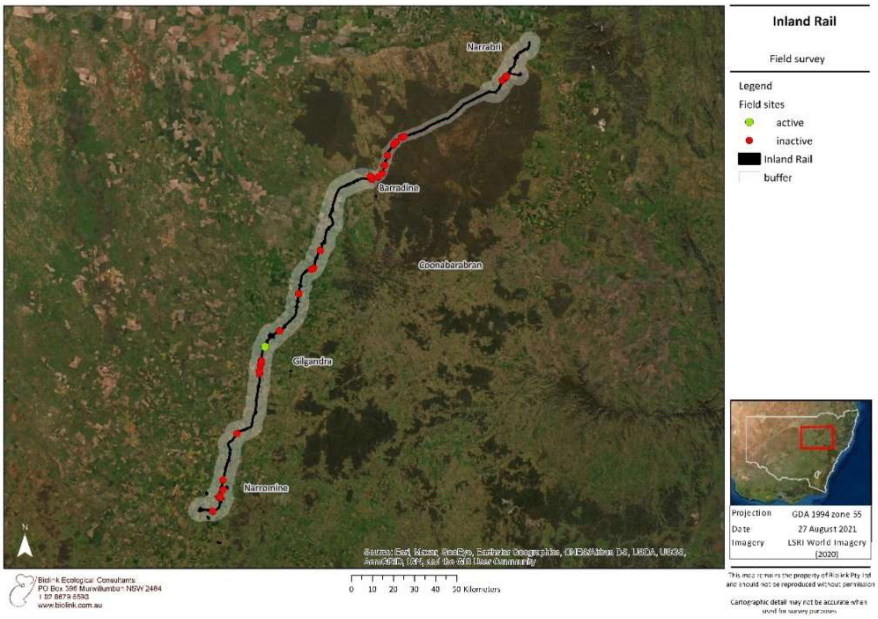


Figure 5. Distribution of N2N Rapid-SAT assessment sites. Note positive site to northwest of Gilgandra.

As illustrated in **Figure 6**, there was strong concordance between the results of the generational persistence assessment, the earlier survey work undertaken by JacobsGHD (2022) and the drone survey by Saunders Havill Group (2021).

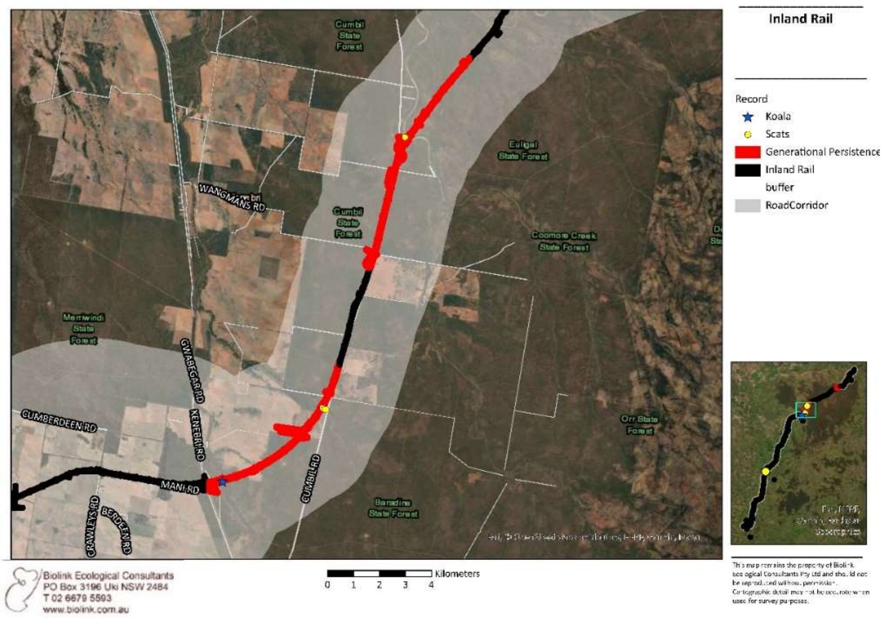


Figure 6. Locations of koala survey work by JacobsGHD (2022) and result of drone survey by Saunders Havill Group (2021) in context of identified areas of koala generational persistence identified by this study.

The species credit polygon

Consideration of outcomes from records analysis and field survey and based on an assumption that the alignment will be unfenced and thus not impede the east-west movement of koalas, results in an unrefined species credit polygon of **349.16** ha being identified, an outcome that includes the positive site to the northwest of Gilgandra. **Table 5** summarises the amount of potentially suitable koala habitat occurring within this area, the sum of which when adjusted for the presence of otherwise unsuitable habitat results in an estimated species credit polygon of **260.44 ha** occurring within the N2N alignment.

Table 5. Areas of preferred / potential koala habitat contained within areas identified as being used by koalas along the N2N alignment.

PCT ID	PCT Long name	Area (ha)
56	Poplar Box - Belah woodland on clay-loam soils on alluvial plains on north central NSW	2.92
88	Pilliga Box - White Cypress Pine - Buloke shrubby woodland in the Brigalow Belt South Bioregion	52.01
148	Dirty Gum - Buloke - White cypress pine - ironbark shrubby woodland of the deep sandy soils on the Liverpool Plains Region of the Brigalow Belt South Bioregion	15.53
394	Narrow-leaved Ironbark - White Cypress pine woodland on slopes and flats in the Coonabarabran - Pilliga Scrub regions	27.28
397	Poplar Box - White Cypress Pine shrub grass tall woodland of the Pilliga - Warialda region, Brigalow Belt South Bioregion	14.55
398	Narrow-leaved Ironbark - White Cypress Pine - Buloke tall open forest on lower slopes and flats in the Pilliga Scrub and surrounding forests in the central north Brigalow Belt South Bioregion	102.83
399	Red gum - Rough-barked Apple +/- tea tree sandy creek woodland (wetland) in the Pilliga - Goonoo sandstone forests, Brigalow Belt South Bioregion	24.73
435	White Box – White Cypress Pine shrub grass hills woodland in the Brigalow Belt South bioregion and Nandewar bioregion	0.32
473	Red gum - Rough-barked Apple - Narrow-leaved Ironbark - cypress pine grassy open forest on flats and drainage lines in the Goonoo and surrounding forests, southern Brigalow Belt South Bioregion	19.22
589	White Box - White Cypress Pine - Silver-leaved Ironbark grassy woodland on mainly clay loam soils on hills mainly in the Nandewar Bioregion	1.05

Area of Occupied habitat / Species Credit Polygon	**349.16**
Other veg	88.72
Total area	**260.44**

Summary/Conclusion

- The N2N alignment is approximately 300 kms in length and encompasses a land surface area of approximately 3,216 ha. Based on available PCT mapping and excluding areas of derived native grassland and lands dedicated to crop production, **1,422.63 ha** of vegetation cover within the N2N alignment qualifies as potentially suitable koala habitat.
- Analysis of contemporaneous koala records to identify areas of generational persistence identified approximately 20.8 km of the N2N alignment as currently supporting resident koala populations; the identified areas independently capture those localities at which evidence of koalas was detected by earlier project-related work by JacobsGHD (field survey) and the thermal drone survey undertaken by the Saunders Havill Group.
- The veracity and utility of an ancillary generational persistence assessment as part of the field assessment process is validated by the strong concordance between areas identified by the generational persistence assessment and those wherein evidence of koalas has been obtained using other methods.
- Field survey identified a further area of use by koalas at a single site to the northwest of Gilgandra.
- Consideration of outcomes from records analysis and field survey and based on an assumption that the alignment will be unfenced and thus not impede the east-west movement of koalas, results in a species credit polygon of **260.44 ha** being identified.

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Appendix I

BAM Expert Credentials - Dr. Stephen Phillips

(a) *expert's qualifications such as relevant degrees, post graduate qualifications,*

Dr. Phillips has a B.Sc. (Hons) from the University of New England and a Ph.D. in Science from Southern Cross University. His Ph.D. Thesis was entitled '*Habitat Utilisation by the Koala – towards more effective conservation and management*' and focused on the development of probability-based methodologies to determine the tree species preferences of koalas, niche partitioning / socio-biology and landscape-scale koala habitat modelling.

(b) history of experience in the ecological research and survey method, for the relevant species,

Dr. Phillips has more than 40 years of demonstrable experience in koala conservation management, commencing in the early 1970s as a founding member of the NSW Koala Preservation Society (now Koala Conservation Australia Ltd.); he is the developer of the Spot Assessment Technique (SAT) (Phillips & Callaghan 2011) and companion survey techniques RG-bSAT and Rapid-SAT, all of which are recognised by Commonwealth, State & Local Government Authorities as the best practice standard for koala habitat and population assessment studies.

(c) *a resume detailing projects pertaining to the survey of the relevant species (including the locations and dates of the work) over the previous 10 years,*

A <u>selected</u> list of consultancy work on koalas that has been completed over the last 10 years include:

2011

- *Tweed Coast koala habitat study*. Final report to Tweed Shire Council, NSW.

2012

- *Byron Coast koala habitat study*. Report to Byron Shire Council, NSW
- *Koala habitat assessment: Ashby, Woombah and Iluka*. Report to Clarence Valley Council, NSW.

2013

- *Port Macquarie Hastings koala habitat & population assessment*. Report to Port Macquarie Hastings Council, NSW.
- *Koala management study for part of the Gunnedah Shire Council Local Government Area.* Report to Gunnedah Shire Council, NSW.
- *Koala habitat and population assessment: Ballina Shire Council LGA*. Report to Ballina Shire Council, NSW.

2014

- *A review of road-kill data and issues relating to underpass use by koalas: Pacific Highway upgrades between Clothiers Creek to Ewingsdale, NSW*. Report to NSW Roads and Maritime Services.
- *Strzelecki Ranges koala survey. Corridors and Core Habitat for Koalas Project*. Report to NSW OEH.
- *Ocean Drive Road corridor koala management framework*. Report to Roadnet/Port Macquarie Hastings Council.

2015

- *Aspects of koala distribution and abundance in the Coffs Harbour LGA with a focus on the Northern Management Precinct*. Report to Coffs Harbour Council / NSW OEH.
- *Koala habitat and population assessment*: *Richmond Valley Council LGA*. Report to Richmond Valley Council, NSW.
- *Koala population survey: Woolgoolga to Ballina Pacific Highway upgrade - Section 10 (Wardell to Coolgardie).* Report to NSW Roads and Maritime Services.

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- *Byron Coast koala population monitoring 2016 – Byron LGA (part)*. Report to Byron Shire Council.
- *Koala Likelihood Mapping: baseline koala survey analysis and reporting*. Report to NSW Environmental Protection Authority.
- *Analysing the historical record: aspects of the distribution and abundance of koalas in the Campbelltown City Council Local Government Area 1900 – 2012.* Report to Campbelltown City Council, NSW.
- *Campbelltown Comprehensive Koala Plan of Management*. Prepared for Campbelltown City Council.
- *Habitat utilisation by koalas in the Gippsland region*. Report to South Gippsland Landcare, Vic.

2017

- *Koala habitat and population assessment: Lismore LGA (part)*. Report to Lismore City Council, NSW.
- *Saving our Species: managing koala populations for the future, Port Stephens LGA*. Report to DPIE & Port Stephens Council, NSW.

2018

- *South Campbelltown koala habitat connectivity study*. Report to Campbelltown City Council.
- *Identifying least-cost dispersal pathways for koalas within the Campbelltown City Council Local Government Area*. Report to Campbelltown City Council.
- *Review of koala generational persistence across the Campbelltown City Council LGA 2012 – 2017*. Report to Campbelltown City Council.
- *The Southern Clarence ARKS: aspects of the distribution and abundance of koalas 1952 – 2017*. Report to Clarence Valley Council, NSW.

2019

- *The Kiwarrak and Khappinghat ARKS: aspects of the distribution and abundance of koalas*. Report to MidCoast Council, NSW.

- *Redlands Coast koala population and habitat assessment*. Report to Redlands City Council, Qld.
- *City-wide koala monitoring: habitat mapping and monitoring program*. Report to City of Gold Coast Council, Qld.

2020

- *Ipswich City Council Koala Assessment*. Report to Ipswich City Council, Qld.
- *A Review of the Conservation Status of NSW Populations of the Koala (Phascolarctos cinereus) leading up to and including part of the 2019/20 Fire Event* (Version 3). Report to International Fund for Animal Welfare.
- *A Review of the Conservation Status of the Queensland Population of the Koala (Phascolarctos cinereus) leading up to and including part of the 2019 Fire Event*s. Report to WWF – Australia.

(d) *employer's name and period of employment (where relevant)*

Dr. Phillips has been self-employed since 2005 as the Managing Director of Biolink Pty. Ltd. t/a Biolink Ecological Consultants, a specialist, koala habitat population assessment consultancy based in northern NSW. In 2020 he gifted his trading name to his staff and now assists them in the capacity of professional mentor/Principal Research Associate.

Biolink Pty. Ltd. now trades as a separate entity *AustIcon Consulting* which and in addition to specialist koala work, works exclusively on threatened species management issues including the design of effective survey and monitoring methodologies, data analysis and impact / recovery assessment.

(e) *relevant peer reviewed publications*

Dr. Phillips' professional CV has been provided as a separate attachment, elements of which include book chapters and ongoing series of peer-reviewed papers amongst which are many addressing various aspects of koala ecology, conservation, and management.

(f) *evidence that the person is a well-known authority on the relevant species to which the survey relates.*

Dr. Phillips is a former member (independent scientist) of both the NSW Koala Recovery Team and the Commonwealth Government's Expert Working Group on koala distribution and abundance. He is a Laureate of the USA-based Smithsonian Institute in recognition of his contributions to koala conservation and management, an Honorary Life Member of Koala Conservation Australia Ltd. and is listed on the Lismore-based Friends of the Koala 'Tree of Fame'.

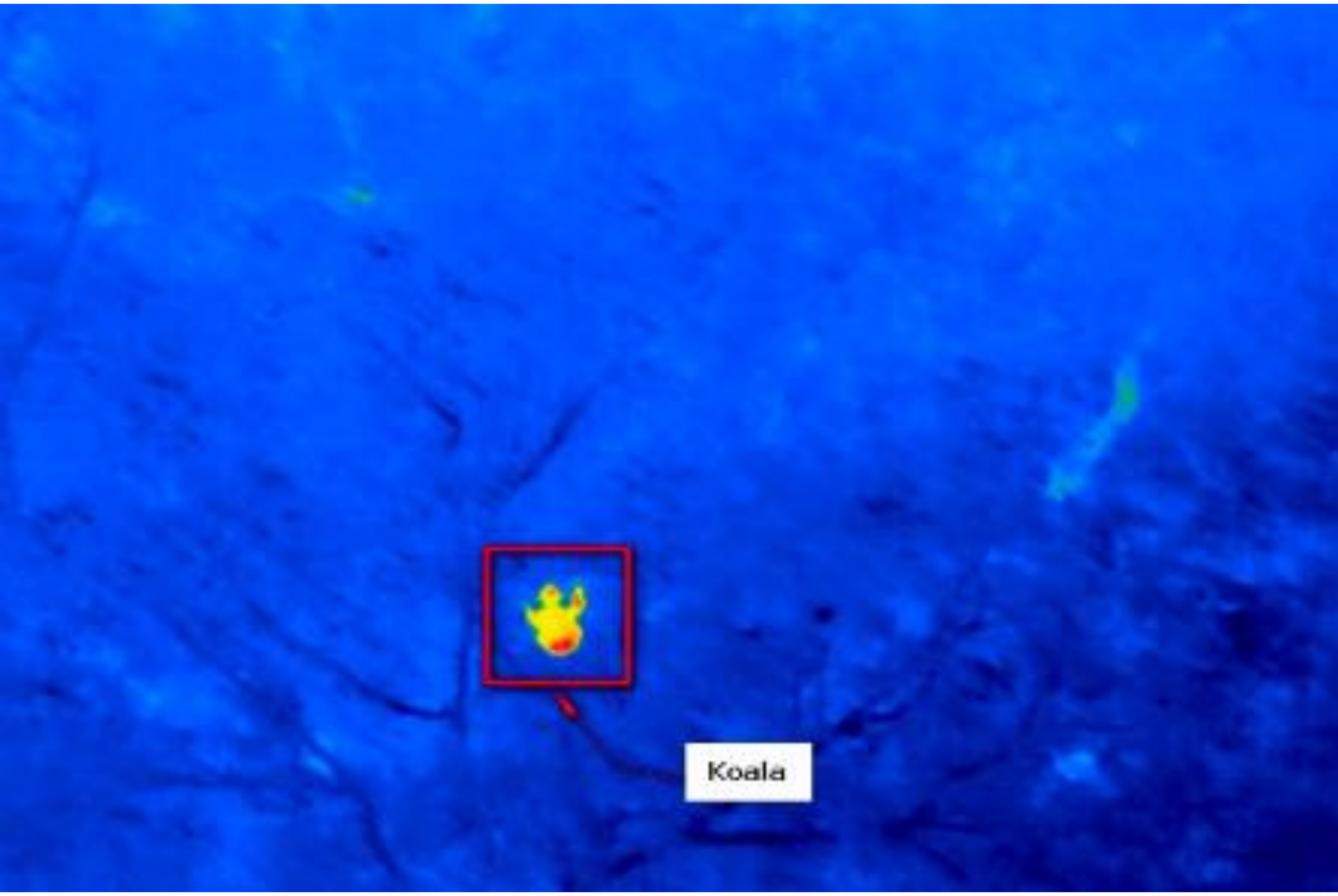
Appendix II

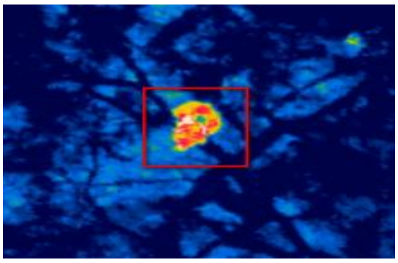
Field Survey Data

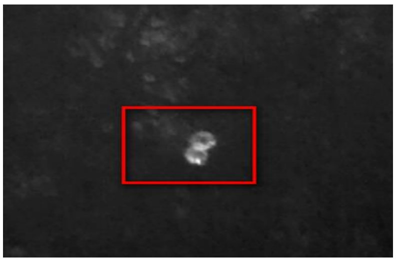
Date	Site_Code	Easting	Northing	R_VEG	Aflo	Cgla	Cleu	Ealb	Ecam	Echl	Econ	Ecre	Emel	Emic	Epop	Ewoo	Esid	R_SAT	Hab_Code
9/08/2021	N2N_01	623531	6439493			1										6		N	2B
9/08/2021	N2N_02	640966	6490733				4								2	2		N	2B
9/08/2021	N2N_03	641080	6491480			1	2								2			N	2C
9/08/2021	N2N_04	641420	6493704			4				2					1			N	2B
9/08/2021	N2N_05	641502	6494340			4				4								N	2A
9/08/2021	N2N_06	630267	6461551						4				1		1			N	2A
9/08/2021	N2N_07	623613	6434822														8	N	2C
9/08/2021	N2N_08	618729	6424700						3				2		1	2		N	2A
9/08/2021	N2N_09	622140	6431898						8									N	1
9/08/2021	N2N_10	621719	6431377								3					5		N	2B
9/08/2021	N2N_11	622223	6431274								1				3	4		N	2B
10/08/2021	N2N_12	643586	6502843			1	1							2	1	3		Y	2B
10/08/2021	N2N_13	641795	6496136			5			3									N	1
10/08/2021	N2N_14	641885	6495875						2						5	1		N	2A
10/08/2021	N2N_15	650449	6510389			1			3						2	1		N	2A
10/08/2021	N2N_16	659609	6528072			1			5						1			N	1
10/08/2021	N2N_17	666668	6540152			1							3		1			N	2B
10/08/2021	N2N_18	665742	6539663			1		2							5			N	2B
10/08/2021	N2N_19	669816	6548623			3									4			N	2B
11/08/2021	N2N_20	701710	6593826			4	y					2				2		N	2C
11/08/2021	N2N_21	704630	6598777		y	2	2						3					N	2B
11/08/2021	N2N_22	705644	6600099						6	1			y					N	1
11/08/2021	N2N_23	708384	6602248			y						2				6		N	2B

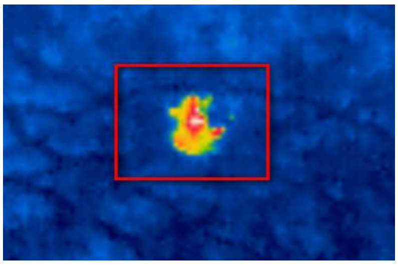
Date	Site_Code	Easting	Northing	R_VEG	Aflo	Cgla	Cleu	Ealb	Ecam	Echl	Econ	Ecre	Emel	Emic	Epop	Ewoo	Esid	R_SAT	Hab_Code
11/08/2021	N2N_24	709645	6602664													8		N	2B
11/08/2021	N2N_25	694211	6582293			6				1						y		N	2C
11/08/2021	N2N_26	694186	6583219			4	1			2				1				N	2C
11/08/2021	N2N_27	693509	6583856			5				1		2						N	2C
11/08/2021	N2N_28	697305	6583581			1	1					y				5		N	2B
11/08/2021	N2N_29	699180	6585230			1	1		3			y						N	2B
11/08/2021	N2N_30	700389	6589132		1	4	1			1		1						N	2C
12/08/2021	N2N_31	756275	6629455		1	3				4								N	2B
12/08/2021	N2N_32	757676	6630631		6	2				y								N	2C
12/08/2021	N2N_33	757943	6631036		1	4				3								N	2C
12/08/2021	N2N_34	758223	6631437			3	4			1								N	2C

Note: Tree species codes as follows: Aflo = *Angophora floribunda*; Cgla = *Callitris glaucophylla*; Cleu = *Casuarina leuhmanii*; Ealb = *Eucalyptus albens*; E. cam = *E. camaldulensis*; Echl = *E. chloroclada*; Econ = *E. conica*; Ecre = *E. crebra*; E. mel = *E. melliodora*; Emic = *E. microcarpa*; Ewoo= *E. woollsiana*; Epop = *E. populnea*; Esid – *E. sideroxylon*.









N2N CIZ Field Study Koala Survey GHD – Thermal RPA

Prepared for Wildlife Drones & GHD

Job 10723

Document Control

Title:	10723 N2N_CIZ_Field Study_GHD_Report(1)
Address:	Pilliga (Baradine to Narrabri)
Job Number:	10723
Client:	Wildlife Drones & GHD

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2. Methodology **2**

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Figures

No table of figures entries found.

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1. Introduction

Wildlife Drones & Saunders Havill Group are tasked with spotting Phascolarctos cinereus (Koala), using RPA (remotely piloted aircraft) equipped with a DJI XTR thermal sensor.

1.1. Project summary

Table 1: Property Summary

Address	Greater Pilliga Area
Area	70km corridor
Topography	Flat/Hilly/River steep slope areas
Land access by client	Granted
Land access by landholder	Granted
Site manager/contractor	GHD
Site stage	Greenfield
Species to be detected	Phascolarctos cinereus (Koala)

2. Methodology

A detailed site assessment was conducted across the project area to identify suitability for Phascolarctos cinereus (Koala) thermal sensor spotting. Items include airspace, landfall and vegetation mass to determine suitability. Additional elements of influence regarding safe and successful flight also included risk management factors, CASA air law generally and RPA standard operating procedures that may influence outcomes. The following stages were undertaken:

1. Desktop Research
   - Existing environmental studies undertaken on the surrounding lots by Saunders Havill Group
   - Existing vegetation species identified
   - Watercourse and drainage areas of influence
2. Review of Historical Aerial Photography
3. Aerial survey
   a. Flights were conducted during the night from the 19-23rd July 2021 using a grid survey pattern (or lawn mower pattern) within the defined transect study area, as illustrated in the attached survey flight line maps.
   b. Surveys were undertaken between 10pm and 6.30am each night, except for the final night when flights were ceased at 2am due to WHS restrictions.
   c. Flights were undertaken with a DJI Matrice 200 series drone with a 19mm XT thermal camera at an altitude of 60m for sensing wildlife in the canopy of the forest which reached up to approximately 30m.
   d. Further flight specifications are provided in section 3.1 flight Information.
4. Imagery where suspected and/or confirmed koalas were observed were then examined in more detail following completion of the flights using Flir post-processing tools to confirm results.
5. Report generation

3. Survey Results

Saunders Havill Group traversed the site 19/07/2021 – 23/07/2021 undertaking a fauna detection assessment.

Weather conditions were stable and suitable for drone flight operations throughout the detection process, with the exception of intermittent rain on nights 4 & 5 (22/07/21 & 23/07/2021) where some minor delays occurred. Night 5 23/07/2021 operations ended earlier due to fatigue management requirements (GHD).

3.1. Flight information

Table 2: Flight Information

Flight line direction	NNW/SSE (adjusted to corridor angle & site specific heliotropic angle corrections)
Flight line overlap (side)	40%
Survey altitude (AGL)	60m AGL (adjusted to flight base area)
Inspection altitude (AGL)	30m AGL
Detection method (a)	Hot spot alert
Detection method (b)	Shape detection
Detection method (c)	Characteristic trait
Total flight area (ha)	996
Total Koalas detected	1
Unknown but possible Koala	0
Total Dogs detected	0
Total Flights	113

Mapped flight lines across the study site

- Figure 1: 10723 E 01 N2N CIZ Field Study GHD Key A
- Figure 2: 10723 E 02 N2N CIZ Field Study GHD N1 A
- Figure 3: 10723 E 03 N2N CIZ Field Study GHD N2 A
- Figure 4: 10723 E 04 N2N CIZ Field Study GHD N3 A
- Figure 5: 10723 E 05 N2N CIZ Field Study GHD N4 A
- Figure 6: 10723 E 06 N2N CIZ Field Study GHD N5 A
- Figure 7: 10723 E 07 N2N CIZ Field Study GHD A

4. Detection evidence

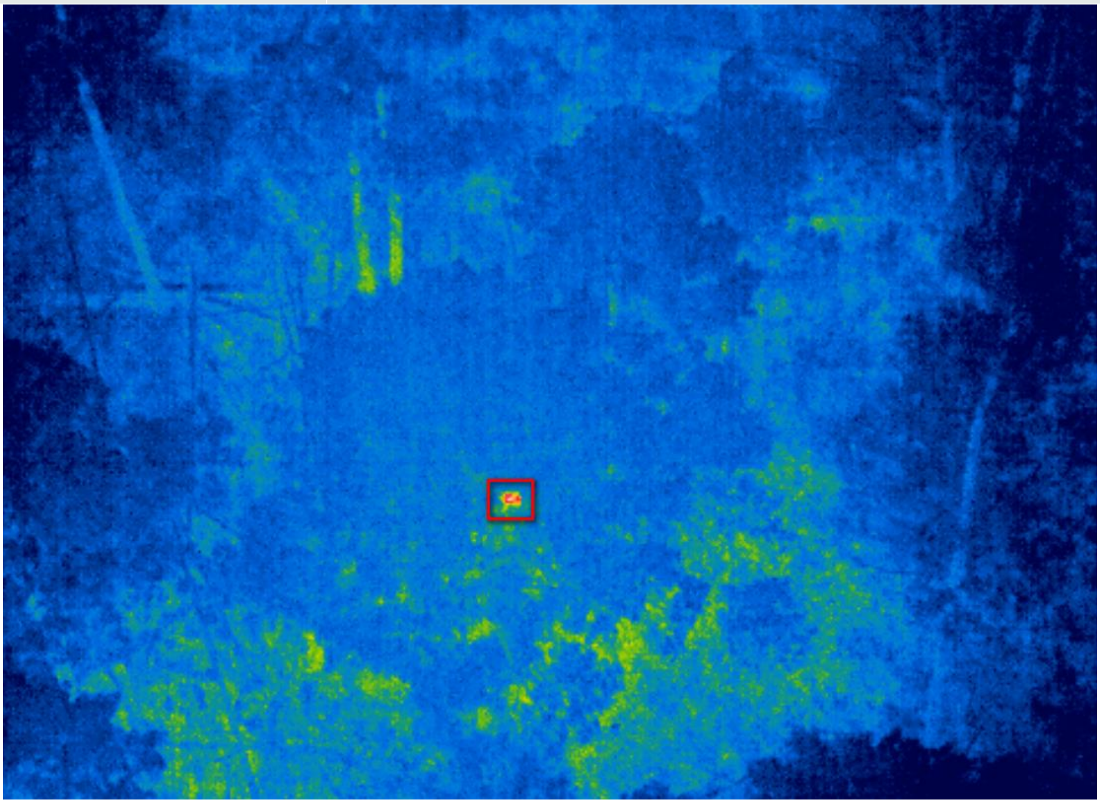
Table 3: Detection Evidence

Species	Koala K1 DJI_0065_R
	In flight characteristic traits, size based on altitude (pixel size) and position confirm as high likelihood/confidence of Koala detection. Traits observed in flight were the size of object, position in tree and the images were logged for post-processing desktop assessment. Desktop assessment characteristics used for koala identification: 1) the position of the subject in the canopy top of the tree 2) the size of the pixel signature was consistent with koalas at the specified survey altitude 3) the size of the subject relative to the tree 4) thermal isolation features observed included ears, head and body temperature aspects including a warm hind area with cool central pelt which are all attributes providing high confidence that this was a koala. The third zoomed in image shows this temperature isolation.
GPS	30.8747959 S , 149.0415802 E
As spotted by SHG staff at confirmed RPA location	Field spotting was performed with spotlight to detect Koala by eye shine or visual, however no koala was sighted. Time between in-flight spotting and ground spotting was 30-40 minutes given the need to drive to the sighting location given no direct access from drone launch site and the time taken for additional navigation to the exact sighting location.

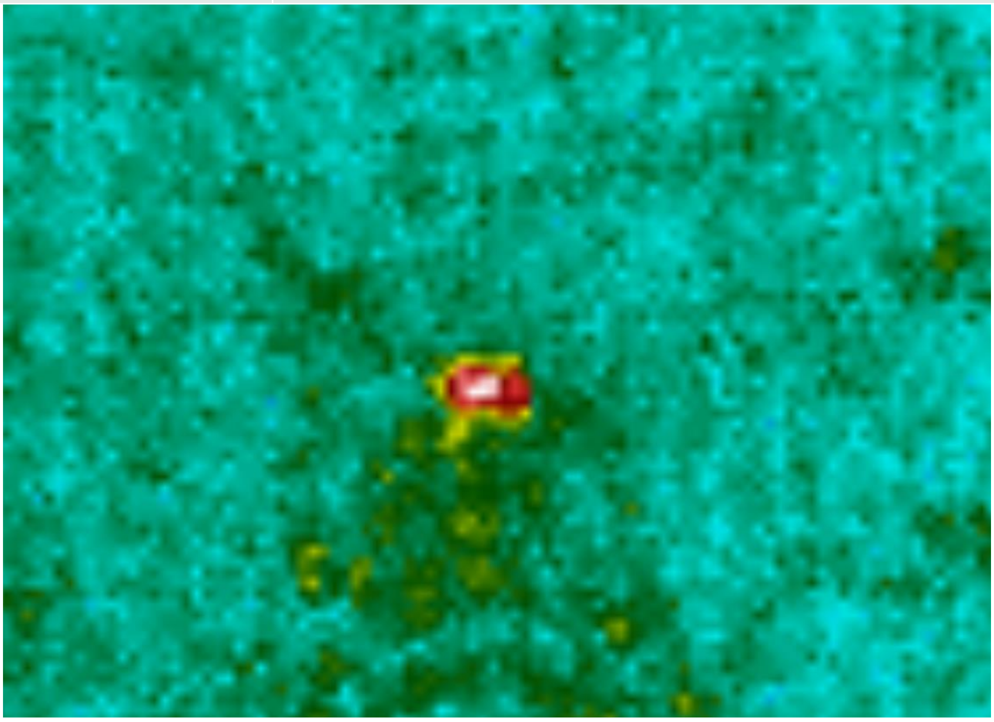
Appendix A list Night 1 2316 image – koala sighting confirmed during post-processing

Thermal image type	<Raw or by heat comparison>

Thermal image type	<Raw or by heat comparison>

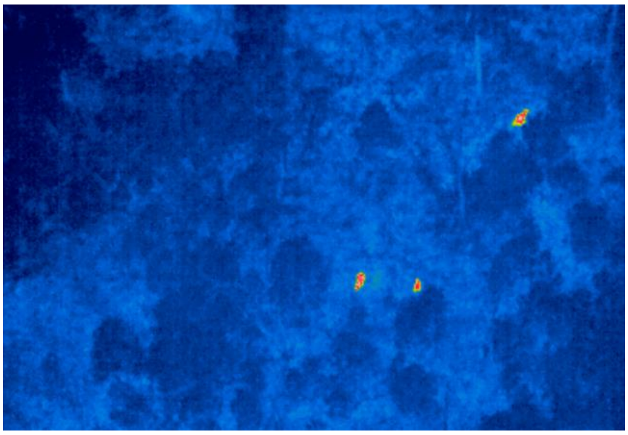


Thermal image type	<Raw or by heat comparison zoom>

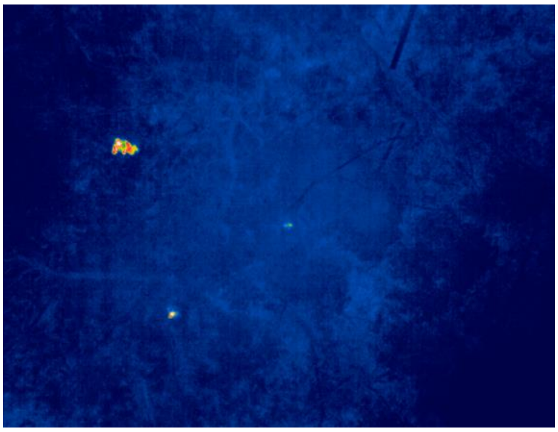


Other fauna detection examples

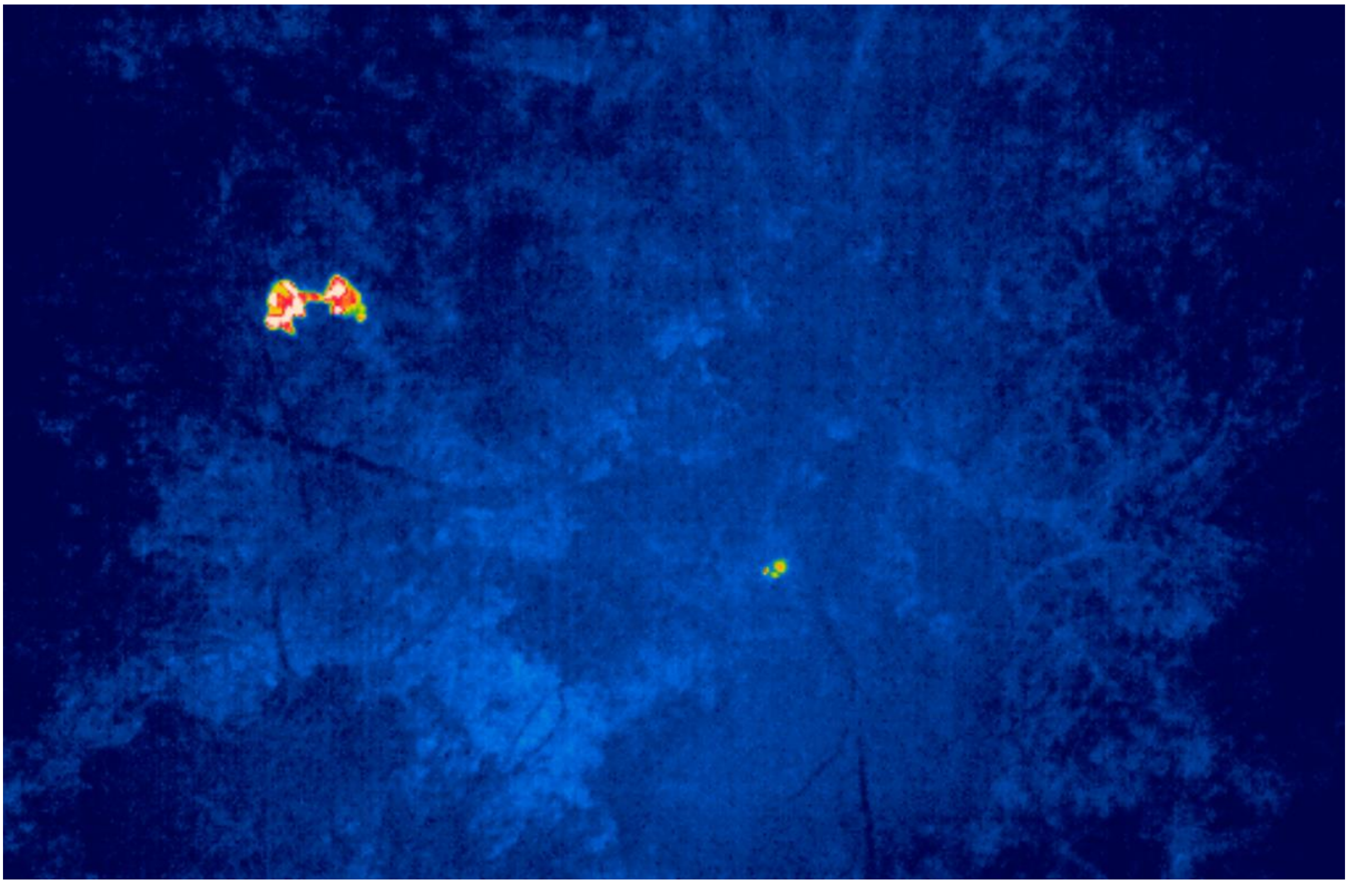
Macropods:



Roosting birds:

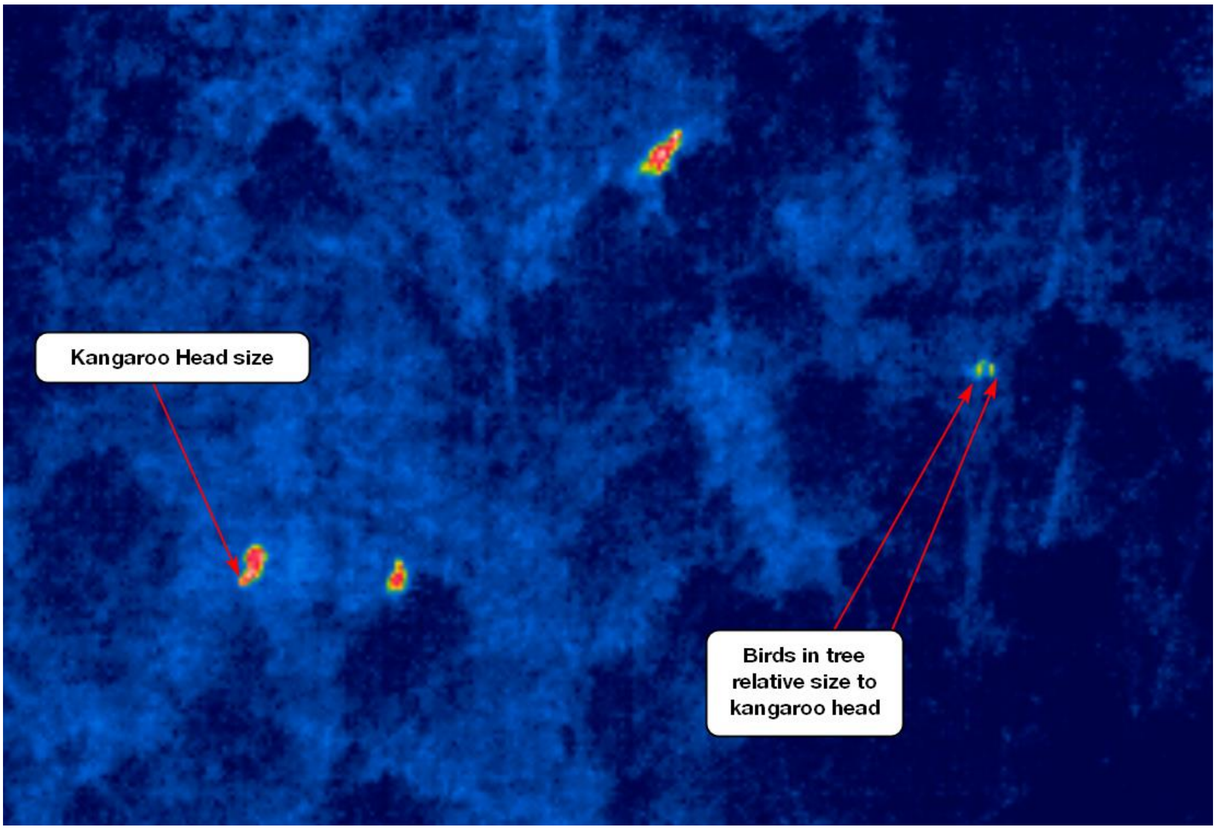


Ground spotting crew with possum:



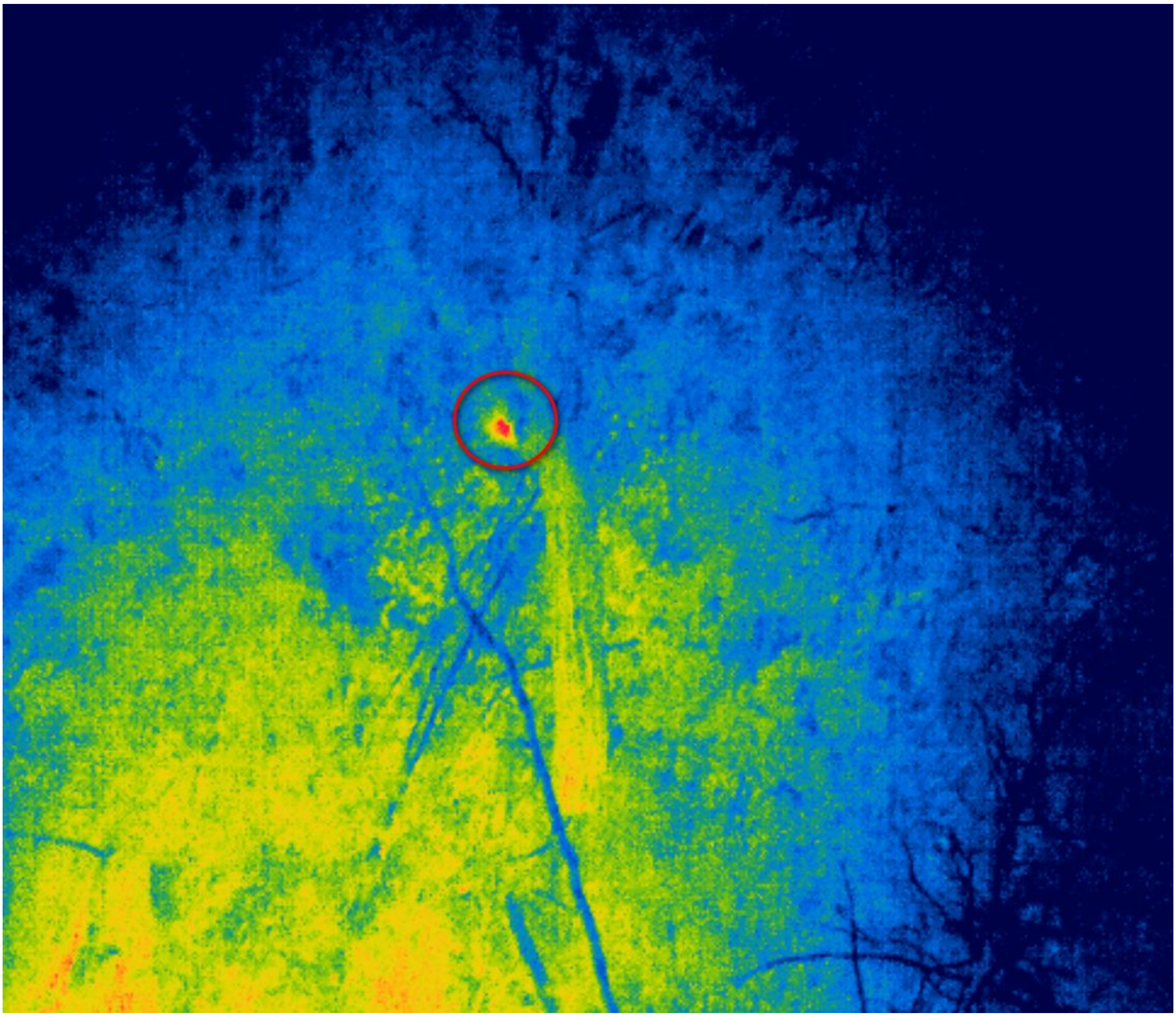
Appendix A list 2253 image – bird sighting confirmed by field crew and during post-processing

This was the first potential koala sighting noted, however it was confirmed to not be a koala upon further investigation. That is, field staff did go in and ground spot most items seen, and in this case birds were observed in this location. Desktop investigation also shows the size of a kangaroo head vs the size of the two birds in the tree roosted do not match from a pixel size aspect to be a koala in tree. There was also no movement characteristics or shape definition was shown to be commensurate with a koala. Finally, the heat distribution shown in this image is not consistent with a thermal koala example.



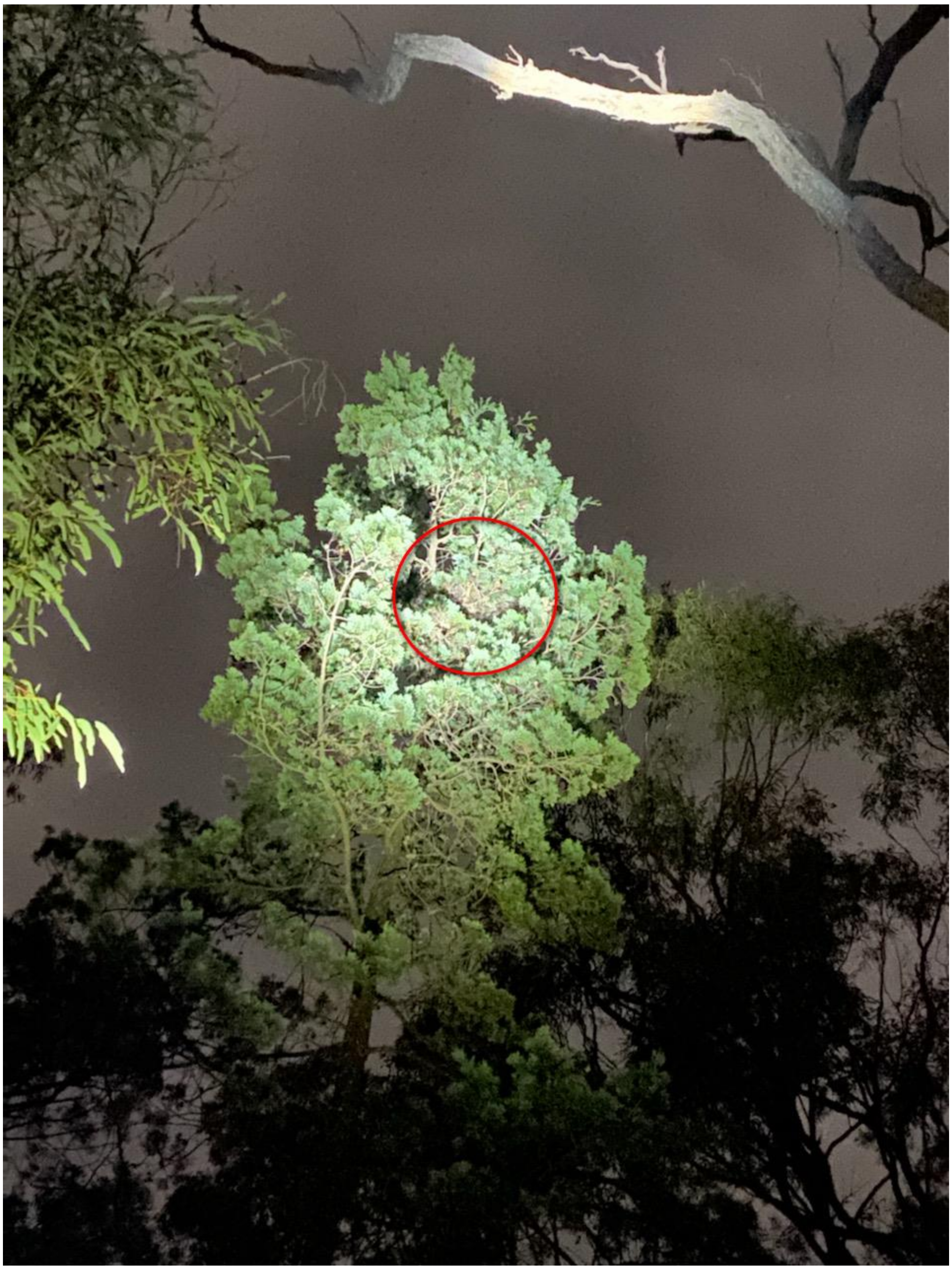
Tree Hollow observed in flight (Lat, Long) -30.728886, 149.134521

When a heat signature is detected radiating from a hollow it is likely to be occupied, but the identity of the occupant/s remains unknown unless further targeted surveys are conducted by the ground team. A number of hollows were detected during the flights and each of them were inspected by the ground team. The ground team were responsible for documenting their observations, including recording coordinates of these extra habitat features of interest. All of the imagery collected during the surveys are available for further exploration by GHD staff should further investigation be needed on additional habitat features and species of interest.



Bird nest spotted during drive between drone operations bases in the area (Lat, Long) -30.606960, 149.405950

Thermal spotting in the area showed the nest with no heat and assumed that not birds were roosted at the time of survey.



Echidna spotted on ground during other search efforts at (Lat, Long) -30.586916, 149.43223

5. Conclusion

The aerial survey found 1 (Koala) total over the survey area. Other species were detected, identified through site-based methods and post flight analysis using FLIR thermal investigation software. Whilst not spotted in the field, this survey detection of the koala displayed strong attributes that would indicate potential koala through thermal post flight software analysis.

Thermal detection total:

Koala	1

Location is confirmed whilst airborne using several techniques including statistical temperature evaluation/alert, characteristic behavioural traits and flora type investigation methods. Whilst every effort is made to confirm species and location, as will be noted Koalas can be difficult to identify due to position in vegetation and uncharacteristic behaviour.

An in-flight log sheet was also taken down regarding other species observed during flight operations, this sheet is attached as Appendix A 10723 Field Sightings List

Please use the below email addresses to obtain relevant google or shape-files (.shp) for use in this assessment.

Please use the following contact details in relation to further questions and/or site visit arrangements

Jamie Holyoak, Thermal Fauna Export
Mapping Manager
Saunders Havill Group
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Facsimile: (07) 3251 9455
Mobile: 0419 723 436
Email: **jamieholyoak@saundershavill.com**

Dr Debbie Saunders
CEO, Conservation Ecologist & Chief Remote Pilot
Wildlife Drones
Mobile: 0487 902 204
Email: **debbie@wildlifedrones.net**

10723 – Field Sightings List

This list consists of the brief notes taken by the pilot whenever a potential subject of interest were found. Given the project brief to focus on the target species (koalas) and to cover hundreds of hectares within the project period, detailed information and imagery were collected by the pilot whenever there were any potential sightings of the target species.

Where other objects were detected, the field team were responsible for locating, collecting coordinates, photographing and documenting any further information about these additional objects/features. All imagery collected in this project will be provided so that any additional features of interest can be fruther explored by the GHD team.

Night 1   19/2/2021

2240- Macropods 2+4

2250- Macropod

2253- ? Bird in tree, Koala ? (post-processing and field crew confirmed as birds, not a koala)

2316- Macropod, Koala ? (post-processing confirmed a macropod and a koala sighting)

0113- Macropods

0120- 2 x Brushtail Possum

0145- Macropods

0242- Fox?

0248- Macropods

0319- Macropod

0325- 2 x Sulpher Crested Cockatoo 0350- Possums

0204- Unknown on ground Rabbit?

0208- Macropods

0212- Pig ground sighted confirmed

0229- Pig

0252- Pig/Macropod?

0313- Macropods

0328- small unknown on ground

0330- Macropod

0353- Macropod

0354- Macropod

0356- Macropods X 5

0405- Tree Hollow

0421- Macropods

0430- Macropods

0435- Unknown on ground Mac?

0459- Macropod

0536- Macropod?

0614- Macropod

Night 3   21/07/2021

2235- Macropods x 2

0303- Bird in tree

0412- Stump/Hollow

0429- Unknown in tree, not koala

0525- Pigs

Night 4 22/07/2021

Rain Delays throughout early part of night

2236- Macropod

2241- Ground based unknown

2246- Ground based unknown

2252- Macropod

2259- Ground Based Unknown

2304- Macropods x 3

2308- Macropods x 3

2328- Object in tree- confirmed birdsnest

0040- Object on ground- confirmed Echidna

0107- Tree Hollow

0142- Macropod

0247- 2 x unknown

Rain Delay

0338- Quails x 3

0354- Quails x 3

0414- Macropod

0416- Birds x 2

0444- Macropod

0518- Macropod

0535- Macropods x 2

0620- Macropod

Night 5 23/07/2021

Some rain delays

1000- Brushtail Possum

1017- Brushtail Possum

1025- Brushtail Possum

1035- Ground based unknown Macropod?

1105- Brushtail Possum

1130- Brushtail Possum

1140- Brushtail Possum x 3

1156- Ground based unknown Macropod?

1158- Ground based unknown Macropod?

1204- 5-6 White Winged Choughs

1215- Unknown Possum?

1216- Bird

1225- Brushtail Possum

1230- Macropods x 3

1240- Brushtail Possums x 6

1247- Macropods x 3

0100- Brushtail Possums x 6

0101- Cat?

0127- Macropod

0130- Ground based unknown Macropod?

0132- Macropods x 3

0133- Fox?

0133- Macropod

0138- Tree Hollow

0139- Macropod x 3

0143- Brushtail Possum

0145- Macropod

0148- Macropod

0150- Macropods x 2

0152- Macropods x 6

0153- Macropod

0154- Macropods x 2

0155- Macropod

0200- Macropods x 4

0210- Brushtail Possum

0215- Macropods x 3

0216- Brushtail possums x 2

0217- Macropods x 2

0225- Macropods x 2

0227- Macropod

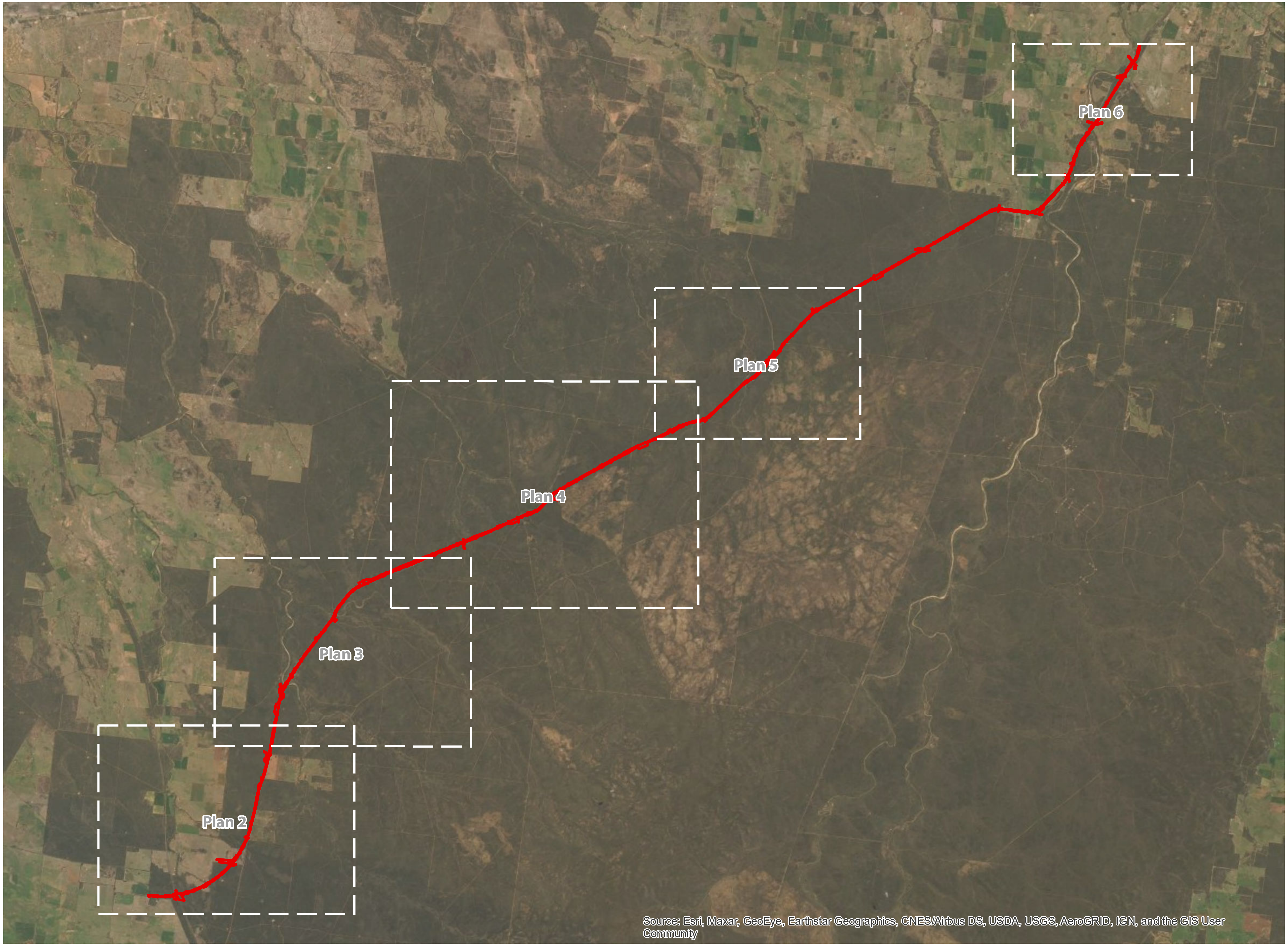
0229- Macropod

0230- Macropod

0231- Macropod

Early finish due to GHD health and safety

1. N2N CIZ Field Study GHD July 2021



Notes:
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Legend

Project Area

Plan context

Survey Details
- Matrice 200 series Drone capture
- DJI XT2 13mm Thermal sensor
- Average flying height 60m AGL
- 40% side overlap per run flown
- Date of survey 19/07/21 - 23/07/21

PIC: Mark Phillips (Ripper Corp)
Project coordinator: Debbie Saunders (Wildlife Drones)
Project RPAS Thermal Detection Expert & Reporting:
Jamie Holyoak (Saunders Havill Group)

Issue	Date	Description	Drawn	Checked
A	30/07/2021	Preliminary	MP	JH

0 1 2 3 4 5 6 7 8 Kilometers

Transverse Mercator | GDA 2020 | Zone 56 | 1:249,030 @ A3

saunders havill group

Wildlife Drones

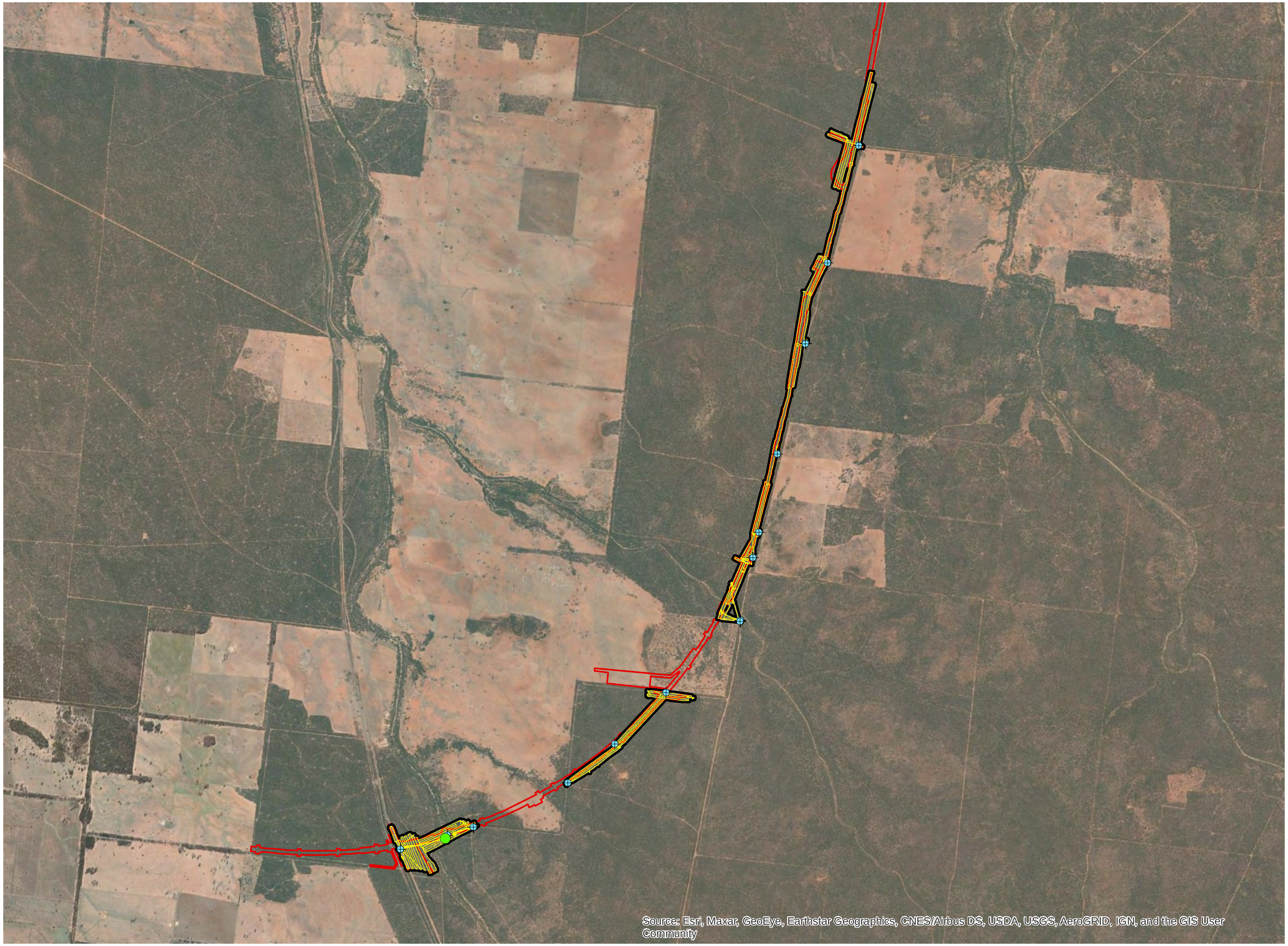
GHD

Pilliga, NSW

Address / RPD: Pilliga, NSW

30/07/2021 | 10723 E 01 N2N CIZ Field Study GHD Key A

2. N2N CIZ Field Study GHD July 2021 - Night 1 Operations 19/07/2021



Legend

- Project Area
- Flight Coverage
- Flight Lines
- Base of operations
- Koala

Survey Details
- Matrice 200 series Drone capture
- DJI XT2 13mm Thermal sensor
- Average flying height 60m AGL
- 40% side overlap per run flown
- Date of survey 19/07/21 - 23/07/21

PIC: Mark Phillips (Ripper Corp)
Project coordinator: Debbie Saunders (Wildlife Drones)
Project RPAS Thermal Detection Expert & Reporting:
Jamie Holyoak (Saunders Havill Group)

Issue	Date	Description	Drawn	Checked
A	30/07/2021	Preliminary	MP	JH

0 500 1,000 1,500 Meters

Transverse Mercator | GDA 2020 | Zone 56 | 1:50,000 @ A3

saunders havill group

Wildlife Drones

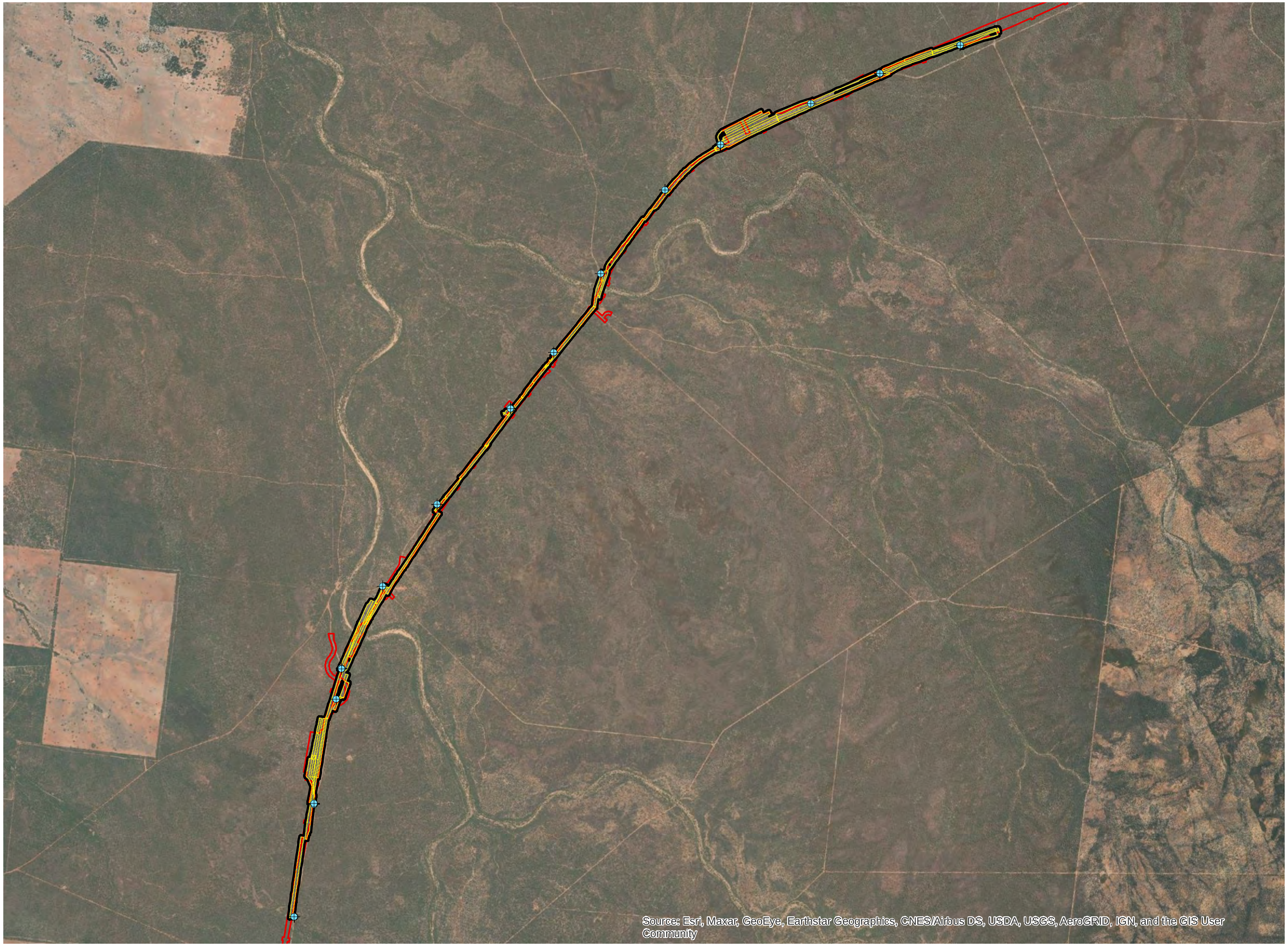
GHD

Pilliga, NSW

Address / RPD: Pilliga, NSW

30/07/2021 | 10723 E 02 N2N CIZ Field Study GHD N1 A

3. N2N CIZ Field Study GHD July 2021 - Night 2 Operations 20/07/2021



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Legend

- Project Area
- Flight Coverage
- Flight Lines
- Base of operations

Survey Details

- Matrice 200 series Drone capture
- DJI XT2 13mm Thermal sensor
- Average flying height 60m AGL
- 40% side overlap per run flown
- Date of survey 19/07/21 - 23/07/21

PIC: Mark Phillips (Ripper Corp)
Project coordinator: Debbie Saunders (Wildlife Drones)
Project RPAS Thermal Detection Expert & Reporting:
Jamie Holyoak (Saunders Havill Group)

Issue	Date	Description	Drawn	Checked
A	30/07/2021	Preliminary	MP	JH

0 500 1,000 1,500 Meters

Transverse Mercator | GDA 2020 | Zone 56 | 1:50,000 @ A3

Pilliga, NSW

Address / RPD: Pilliga, NSW

30/07/2021 | 10723 E 03 N2N CIZ Field Study GHD N2 A

4. N2N CIZ Field Study GHD July 2021 - Night 3 Operations 21/07/2021

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Legend

- Project Area
- Flight Coverage
- Flight Lines
- Base of operations

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Issue	Date	Description	Drawn	Checked
A	30/07/2021	Preliminary	MP	JH

0 500 1,000 1,500 Meters

Transverse Mercator | GDA 2020 | Zone 56 | 1:60,000 @ A3

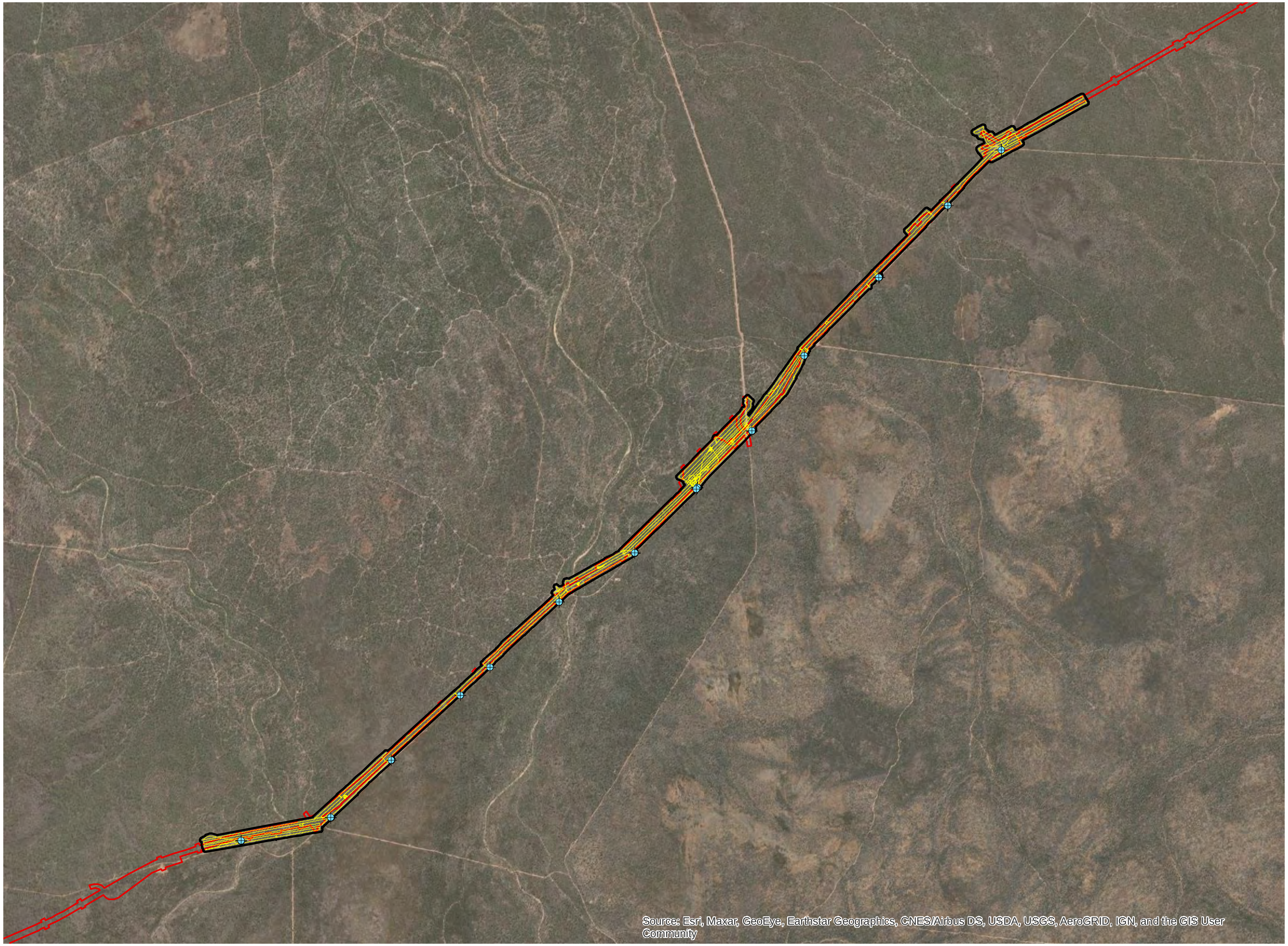
saunders havill group | Wildlife Drones | GHD

Pilliga, NSW

Address / RPD: Pilliga, NSW

30/07/2021 | 10723 E 04 N2N CIZ Field Study GHD N3 A

5. N2N CIZ Field Study GHD July 2021 - Night 4 Operations 22/07/2021



Legend

- Project Area
- Flight Coverage
- Flight Lines
- Base of operations

Survey Details

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- DJI XT2 13mm Thermal sensor
- Average flying height 60m AGL
- 40% side overlap per run flown
- Date of survey 19/07/21 - 23/07/21

PIC: Mark Phillips (Ripper Corp)
Project coordinator: Debbie Saunders (Wildlife Drones)
Project RPAS Thermal Detection Expert & Reporting: Jamie Holyoak (Saunders Havill Group)

Issue	Date	Description	Drawn	Checked
A	30/07/2021	Preliminary	MP	JH

0 500 1,000 1,500 Meters

Transverse Mercator | GDA 2020 | Zone 56 | 1:40,000 @ A3

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6. N2N CIZ Field Study GHD July 2021 - Night 5 Operations 23/07/20221

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Legend

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PIC: Mark Phillips (Ripper Corp)
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Project RPAS Thermal Detection Expert & Reporting:
Jamie Holyoak (Saunders Havill Group)

Issue	Date	Description	Drawn	Checked
A	30/07/2021	Preliminary	MP	JH

0 500 1,000 Meters

Transverse Mercator | GDA 2020 | Zone 56 | 1:35,000 @ A3

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GHD

Pilliga, NSW

Address / RPD: Pilliga, NSW

30/07/2021 | 10723 E 06 N2N CIZ Field Study GHD N5 A

Kirsten Crosby

From: Renee Shepherd <Renee.Shepherd@environment.nsw.gov.au>
Sent: Wednesday, 4 August 2021 10:54 AM
To: Steve Phillips (InTouch)
Cc: OEH ROD North West Mailbox; Sharon Ziko; Lucian McElwain; Kirsten Crosby; Ben Ellis
Subject: Application to be a BAM species expert - application number BE 21 15 - Steve PHILLIPS

Hi Steve,

Thank you for your application (received on 26 July 2021) to be considered as an expert within the meaning of the Biodiversity Assessment Method, and to prepare an expert report on the koala for the following project:

Project Name: Inland Rail – Narromine to Narrabri
Project Type: Major Project
Local Government Areas: Narromine Shire Council, Gilgandra Shire Council, Warrumbungle Shire Council, Coonamble Shire Council and Narrabri Shire Council

The Biodiversity, Conservation and Science Directorate, North West Branch, has reviewed your application against your state-wide approval to prepare expert reports for the koala.

Your state-wide expert status has been considered **valid and acceptable** for the purposes of preparing an expert report for the Inland Rail Narromine to Narrabri project.

Please note that any expert report prepared for this project must demonstrate your expert status by addressing the criteria in section 6.5.2.3 of the BAM (BAM 2017) within the BDAR.

Regards,
Renee.

Renee Shepherd
Acting Senior Team Leader Planning, North West

Biodiversity, Conservation and Science Directorate | Department of Planning, Industry and Environment
T 02 6883 5355 | **M** 0488 444 953 | **E** renee.shepherd@environment.nsw.gov.au
48-52 Wingewarra Street, Dubbo NSW 2830
www.dpie.nsw.gov.au

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Our Vision: Together, we create thriving environments, communities and economies.

We work flexibly. *I'm sending this message now because it's a good time for me. I don't expect that you will read, respond to, or action this message outside of your own regular hours.*

Strategic Assessment

for the

Little Eagle *Hieraaetus morphnoides*

in the

Narromine to Narrabri

Inland Rail

Alignment

Report prepared for JacobsGHD

Prepared by Dr Tony Saunders and Dr Stephen Debus
Merops Services Pty Ltd

Prepared December 2021

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1. Justification for the Experts' Report

ARTC proposes to construct the Narromine to Narrabri (N2N) section of Inland Rail (the proposal). Due to the large area of land that requires assessment for the proposal, and access constraints generally relating to denied access to private landholdings and distance from access points in forested areas, it is not feasible to conduct targeted threatened species surveys across the entire assessment area. As such, in accordance with Section 6 of the Biodiversity Assessment Method (BAM) 2017 (OEH 2017), a species expert report was required to assess the impacts on the Little Eagle (*Hieraaetus morphnoides*). This report was updated in December 2021 due to changes to the Construction Impact Zone (CIZ) to allow for flood mitigation, and to meet the requirements of BAM 2020 (DPIE 2020), following completion of the transition period.

The presence of suitable habitat for foraging and breeding for the Little Eagle in the inland rail alignment and ancillary areas, combined with the low density for this species and the difficulties with gaining sufficient access for surveys to establish the presence and habitat use by the Little Eagle within the alignment, has meant that what survey effort has been possible has not been sufficient to establish the level of importance of the area for the Little Eagle.

An expert in the breeding and foraging ecology of the Little Eagle was required to assess the importance of the habitat remnants in mostly cleared areas, and in forested areas occurring along the alignment, and the likelihood of occurrence within the rail alignment. The Little Eagle is a forest and woodland specialist whose major food in its breeding season is mainly ground foraging mammals, birds, and reptiles, although it also takes birds from the tree canopy. Therefore, an expert would also need to also be expert on the avifauna species occurring in forest and woodland in New South Wales.

The Little Eagle is listed in New South Wales as vulnerable under the *Biodiversity Conservation Act* 2016 and is an uncommon species found in open forests and woodlands. It shows a preference for areas containing a mosaic of open woodland and open grasslands with scattered trees but can also be found along timbered watercourses and the edges of forest remnants as well as in larger forest patches. Records for this species exist in and around the area to be impacted by the rail alignment. However, the species is encountered infrequently in this area and its interactions with local habitat are not well known.

The existence of potential habitat for the Little Eagle and of records for the species within the area has meant that a more detailed assessment of the likelihood of impacts from the development in the area is required, particularly of the species' potential for foraging and breeding in the area. Targeted surveys could gather this information, but the survey effort required to collect sufficient data would be great and in the order of hundreds of hours in the appropriate seasons over several years, assuming access across the whole footprint was possible. This would also require tracking of individual birds to gather information on foraging, breeding locations and behaviour at nests etc. In particular, the whole 300-kilometre length of the alignment would need to be searched to a width of between 650 and 700 metres allowing for a buffer of 300 metre radius around active nests. All emergent trees would need to be searched for raptor stick nests and each found nest would need its position recorded so that it could be checked over several consecutive breeding seasons for nesting activity. Knowledge of the habitat structure and plant community types (PCTs) that the Eagle has been recorded in within the Narromine to Narrabri area and of the ecology of the species can be used as a surrogate for the paucity of fieldwork.

2. Description and Ecology of the Little Eagle

Species Description

The Little Eagle is a smaller bird than the Wedge-tailed Eagle (*Aquila audax*) and about the same size as the Whistling Kite (*Haliastur sphenurus*). However, it is more robust than the Whistling Kite with shorter wings and a shorter square-edged tail. It glides and soars on flat wings or slightly raised wings when gaining height. The head is short and broad compared with the Whistling Kite. There is a light morph which is light and dark brown with light rufous underparts. The underwings have a distinctive pale 'M' pattern, and the tail is barred (Debus 2019). When observed from underneath they appear to have dark leading and trailing edges to the underwing, compared with the Whistling Kite which only has dark trailing edges to the wing (pers. obs.). The dark morph has a rufous body with slightly darker brown wings, which from the underside appear all dark except for pale inner primaries (Debus 2019).

Life Cycle

Little Eagles will form pairs in breeding territory but are solitary outside the breeding season (Debus 1993). Nesting behaviour has been observed from late July and into February (Rae *et al.* 2019). In New South Wales, nest building, or renovation occurs in August, egg laying from August to September, incubation lasts from 37-39 days with hatching from October to December, fledging occurs from December to January and post-fledglings are dependent on adults for 2 or more months after that (Olsen 2014, Olsen *et al.* 2017, Debus *et al.* 2007, Debus and Ley 2009, Debus 2011). Banded individuals have been recovered up to 26 years after banding and banding data suggest that birds occupy a home range or wintering range for at least 6-10 years (Debus 2015). Nests can be occupied for up to 7-10 years (Russell and Franklin 2018; Larkin *et al.* 2020)

Breeding success may be low in very dry years due to a shortage of prey (Rae *et al.* 2019) and can be disrupted by competition for prey and displacement from nests by Wedge-tailed Eagles (Rae *et al.* 2019, Debus *et al.* 2021).

Distribution and Abundance

The Little Eagle is endemic to Australia but is not found in Tasmania (Olsen *et al.* 1993). The New Guinea form is now classed as a separate species (Debus 2017). The global population is estimated to be a maximum of 80,000 (Debus 2017). It is considered to be resident for at least several consecutive years at nesting sites (Debus *et al.* 2007, Debus and Ley 2009). It may also be a partial migrant with some movement north in the non-breeding period (Olsen 1995). It can traverse the continent (>2000 km: Debus 2015), and a satellite-tracked breeding male near Canberra wintered in the Top End of the Northern Territory before returning (approximately 3300 km Brawata *et al.* 2018, Dabb 2018). Others wintered in the Gulf of Carpentaria (Qld.), approximately 2,000 km away, and in central-coastal Queensland (Rae *et al.* 2019).

The Little Eagle was considered moderately common and a partial nomad in New South Wales (Morris *et al.* 1981). They are found throughout New South Wales but are more common in the western two-thirds of the state (Cooper *et al.* 2014). It was rarely noted in lightly timbered country of the Cumberland County prior to the 1950s (Hindwood and McGill 1958) but had become a frequent visitor over the next 30 years (Hoskin 1991). It is often recorded from western Sydney in lightly timbered country away from areas of dense urbanisation (Patrick 2016).

Little Eagles have declined by 14% nationally between the two national bird atlases over an approximately 20-year period (Barrett *et al.* 2003) and declined by 39% in New South Wales over the same period (Barrett *et al.* 2007). The reporting rates in the NSW Bird Atlas declined by 70% since the mid-1980s (Cooper *et al.* 2014).

The declines are thought to be due to loss of woodland habitat (Cooper *et al.* 2014), disturbance to nests, loss of breeding habitat, urbanisation and high-density rural subdivision and subsequent competition for remaining habitat by Wedge-tailed Eagles (Debus *et al.* 2007, Debus and Ley 2009, Debus 2011, Dabb 2018, Rae *et al.* 2020, Debus *et al.* 2021). Declines in the ACT and NSW may also be due to control of rabbits, which are a major prey item, and the use of Pindone for rabbit control, which possibly affects the predator as well through secondary poisoning from eating baited rabbits (Olsen *et al.* 2013). Urban encroachment not only affects nesting woodland habitat but also the surrounding open areas used for foraging (Walsh and Beranek 2017, Olsen 2019) and nesting and foraging areas may become disjunct (ACT Government 2008). They are easily disturbed while nesting (Cupper and Cupper 1981) and will flush from the nest when approached to within 50 to 140 metres (Debus *et al.* 2007, Saunders pers. obs. 2020).

Breeding density in eastern NSW has been estimated at 1 pair per 1600 hectares in the early 1980s (Debus 1984) and one pair per 2100-3000 hectares since 2000 (Debus 2017). Active nests in eastern NSW are between 2 and 5 kilometres apart and birds will forage up to at least 1.8 kilometres from the nest (Debus 1984, Debus and Ley 2009); average inter-nest distance in contiguous wooded habitat is 3.6 km (Larkin *et al.* 2020). Walsh and Beranek (2017) found that the Eagles will forage up to 3 kilometres from the nest, which gives a minimum breeding/ foraging territory of 2800 hectares. In the ACT, active nests were on average 5 km apart (Rae *et al.* 2018), and one post-breeding adult male had an elongated foraging range of 6500 hectares, with foraging journeys of 10-20 km, around the outer edge of Canberra (Brawata and Gruber 2016). Other breeding males ranged 2-5 km from the nest, occasionally up to 10 km, with one return excursion of 40 km (Rae et al. 2019), in home ranges of up to approximately 8000 hectares.

Habitat Requirements

Little Eagles prefer open woodland, but are also found along forest edges, timbered watercourses through open country and open grazing country (Hollands 1984, Taylor and Canberra Ornithologists Group 1992, Olsen *et al.* 1993). They hunt over most open habitats and will seek areas where there is a mosaic of treed habitat and open country (Debus 1993, Cooper e*t al.* 2014). They can also be found in woodland associated with wetlands (Debus 1993). They have also been observed nesting in forested areas with open tall grassy forest and woodland (Saunders pers. obs.). Breeding has also been reported during October and November in forested areas in the Royal National Park and at Warriewood on the northern beaches of Sydney (CBOC Atlas accessed 28-04-2021).

They will nest in tall living eucalypts between 5 and 30 metres tall in open forest, woodland, and remnant woodland in farmland (Debus 1993, Debus *et al.* 2007, Debus and Ley 2009). Nests are generally between 13 and 20 metres above ground (Debus 1993, Debus and Ley 2009, Saunders pers. obs.). They prefer to nest in dense woodland adjacent to open habitat, e.g. grassy woodland for foraging (Debus 1993, Debus and Ley 2009, Debus 2011). Nests are typically in an emergent eucalypt, the tallest in the stand and often with the largest girth, in woodland patches at least 4.8 hectares in size (average 75 ha); mostly within 200 m of an edge; more distant from sealed roads (average 838 m) than gravel roads (average 546 m) than tracks (average 304 m), at least 38 m from the nearest dwelling (average 457 m), and at least 1 km from suburbia (Larkin *et al.* 2020). Near Canberra, nests were at least 215 m from a dwelling, at least 122 m from an urban edge, and farther from sealed roads (average 710 m) than gravel roads (260 m) or footpaths (average 90 m) (Rae *et al.* 2018). The minimum nesting requirements as per a review of the literature are provided in Tables 1 and 2 below.

Table 1. Minimum distances of active Little Eagle nests from developments in 2 studies:

Parameter	Armidale (Larkin *et al.* 2020)	Canberra (Rae *et al.* 2018)
Dwelling	38 m	215 m
Urban area	1 km	122 m
Industrial building#	–	65 m
Sealed road	65 m	31 m
Unsealed road	135 m	29 m
Track/path	34 m	24 m

Included in the 'urban area' category for Armidale.

Table 2. Minimum criteria for active Little Eagle nest-site characteristics (Armidale, Larkin *et al.* 2020):

Parameter	Measurement
Woodland patch size	4.8 ha
Nest-tree height	20.5 m
Reference tree height*	14.6 m
Nest-tree DBH**	37 cm
Reference tree DBH*	54 cm
Nest height	14 m

*Reference trees are other trees > 30 cm DBH within the nest stand (within 25 m of the eagle's nest tree)
**Diameter at breast height

Foraging requires open woodland areas and open grasslands adjacent to woodlands because the preferred prey includes mainly ground foraging prey species. These are across a broad range of prey species and include insects, reptiles, birds, mammals, and carrion. The prey types that have been recorded for the Little Eagle are listed as follows:

Insects	grasshoppers, beetles, cicadas (Debus 1993, 2017, Debus *et al.* 2021)
Reptiles	Bearded Dragon, Eastern Blue-tongue, Cunningham's Skink, goannas (Debus 1993, Debus *et al.* 2007, Debus 2017, Rae *et al.* 2020, 2021a,b, Debus *et al.* 2021)
Birds	Crimson and Eastern Rosellas and other parrots, Galah, Australian Magpie-lark, Peaceful Dove, other pigeons, Common Starling, ducks, pigeons, small to large passerines (Debus 1993, Debus *et al.* 2007, Olsen *et al.* 2010, Debus 2017, Rae *et al.* 2018, 2020, 2021 a,b, Debus *et al.* 2021)
Mammals	Rabbit, Hare, Mouse, Rat, Cat, *Antechinus*, bandicoot, possums (Debus 1993, Debus *et al.* 2007, Walsh & Beranek 2017, Rae *et al.* 2020, 2021a,b, Debus *et al.* 2021)
Carrion	macropods, Rabbit, Hare, Sheep, Fox (Debus 1993, Olsen *et al.* 2010, Debus 2017, Debus *et al.* 2021, Rae et al. 2021a,b)

The NSW Threatened Biodiversity Data Collection indicates that the Little Eagle has the potential to inhabit the plant communities listed in Table 3 that are found within the N2N alignment.

Table 3. List of Plant Community Types (PCT) found along the inland rail alignment that are utilised by the Little Eagle

PCT No.	PCT Type (abbreviated)
36	River Red Gum tall to very tall open forest/woodland
55	Belah Woodland
56	Poplar Box - Belah woodland
78	River Red Gum riparian tall woodland/open forest
81	Western Grey Box - cypress pine shrub grass shrub tall woodland in the Brigalow Belt South Bioregion
88	Pilliga Box - White Cypress Pine - Buloke shrubby woodland
141	Broombush - Wattle very tall shrubland
145	Western Rosewood- Wilga - Wild Orange - Belah low woodland
148	Dirty Gum - Buloke - White Cypress Pine
202	Fuzzy Box woodland
206	Dirty Gum - White Cypress Pine - Buloke shrubby woodland
244	Poplar Box grassy woodland
248	Mixed Box eucalypt woodland
255	Mugga Ironbark - Buloke - Pillaga Box - White Cypress Pine
256	Green Mallee tall woodland
394	Narrow-leaved Ironbark - White Cypress Pine woodland
397	Poplar Box - White Cypress Pine tall woodland
398	Narrow-leaved Ironbark - White Cypress Pine - Buloke
399	Red Gum - Rough-barked Apple sandy creek woodland
404	Red Ironbark - White Bloodwood heathy woodland
406	White Bloodwood - Motherumbah - Red Ironbark woodland
409	Dirty Gum - White Bloodwood - White Cypress Pine woodland
411	Buloke - White Cypress Pine woodland
414	White Mallee - Dwyer's Red Gum mallee heath
469	White Cypress Pine - Narrow-leaved Ironbark - Buloke grassy open forest of the Dubbo region, southern Brigalow Belt South Bioregion
473	Red Gum - Rough-barked Apple - Narrow-leaved Ironbark
589	White Box - White Cypress Pine - Silver-leaved Ironbark
599	Blakely's Red Gum - Yellow Box tall woodland
746	Brown Bloodwood - Cypress - Ironbark heathy woodland
1384	White Cypress Pine - Buloke - Ironbark woodland

The habitat requirements discussed above have been used in this report to identify important habitat areas. They have been grouped into the habitat criteria listed below. If at least criteria 1, 7 and 8 are met then the habitat area is potential breeding habitat. The greater the number of criteria that are met the more likely it is that the habitat area will provide breeding habitat for Little Eagle.

1. Site contains tall open forest or woodland (> 15 m tall, DBH 0.3->1 m).
2. Site is near or along a timbered watercourse (particularly where forest or woodland is confined to riparian zone where surrounding area is mostly very open).
3. Site contains one or more of the following PCTs: -
   36, 55, 56, 78, 88, 141, 145, 148, 202, 206, 244, 248, 255, 256, 394, 397, 398, 399, 404, 406, 409, 411, 414, 473, 589, 599, 746, 1384.
4. Site contains a mosaic of open grazing land and woodland.
5. Site contains ground foraging prey species
   e.g., rabbits, hares, mice, passerines, parrots and pigeons, reptiles, and carrion.
6. Site has open grassy areas around the edges of remnants, timbered corridors and watercourses.
7. Site has tall or emergent trees suitable for nesting (often > 20 m).
8. Site is within a habitat remnant equal to or larger than 5 ha.

3. Methods Used in the Preparation of the Report

Field Methods

Breeding habitat surveys were undertaken over 4 days from the 9th to the 12th of August 2021. Fifty aerial map sites out of 111 aerial maps were accessed. Thirty-three map sections were not visited because there were no potential habitat areas present on those sections. Any woodland appeared to be very sparse, or too low, or contained patches smaller than 5 hectares. The remaining 28 map sections were not visited because in many cases access to private lands along the rail alignment was denied (this affected 16 of the map sections), points of access in forest sites were too difficult to access and some of the other sites were not visited because Covid restrictions meant that the fieldwork was terminated one day short of the proposed survey period. The degree of access and survey effort for each aerial section map is described in Table 4 below.

Table 4. Site access and survey status for Little Eagle potential breeding habitat.
Accessed and Surveyed (n=50): Aerial map area reached and surveyed at one or more points (see Methods for more details)
Habitat Inferred (n=28): Access not achieved, and habitat inferred from aerial photo (see Methods for more details)
No Suitable Habitat (n=33): No open forest or woodland providing suitable habitat, so area not surveyed.

Aerial Photo No.	Access		Aerial Photo No.	Access
1	No Suitable Habitat		57	Habitat Inferred
2	No Suitable Habitat		58	Habitat Inferred
3	No Suitable Habitat		59	Habitat Inferred
4	Accessed & Surveyed		60	Habitat Inferred
5	Accessed & Surveyed		61	Habitat Inferred
6	Habitat Inferred		62	No Suitable Habitat
7	Accessed & Surveyed		63	No Suitable Habitat
8	Accessed & Surveyed		64	Accessed & Surveyed
9	Accessed & Surveyed		65	Accessed & Surveyed
10	No Suitable Habitat		66	Accessed & Surveyed
11	No Suitable Habitat		67	Accessed & Surveyed
12	Habitat Inferred		68	Accessed & Surveyed
13	Accessed & Surveyed		69	Accessed & Surveyed
14	Accessed & Surveyed		70	Accessed & Surveyed
15	No Suitable Habitat		71	Accessed & Surveyed
16	Accessed & Surveyed		72	Accessed & Surveyed
17	Accessed & Surveyed		73	Accessed & Surveyed
18	Habitat Inferred		74	Accessed & Surveyed
19	Habitat Inferred		75	Accessed & Surveyed
20	Habitat Inferred		76	Accessed & Surveyed
21	Habitat Inferred		77	Accessed & Surveyed
22	Habitat Inferred		78	Accessed & Surveyed
23	Habitat Inferred		79	Habitat Inferred
24	Habitat Inferred		80	Accessed & Surveyed
25	Accessed & Surveyed		81	Accessed & Surveyed
26	No Suitable Habitat		82	Accessed & Surveyed
27	Accessed & Surveyed		83	Accessed & Surveyed
28	Accessed & Surveyed		84	Accessed & Surveyed
29	Accessed & Surveyed		85	Accessed & Surveyed
30	No Suitable Habitat		86	Accessed & Surveyed
31	Accessed & Surveyed		87	Accessed & Surveyed
32	No Suitable Habitat		88	Accessed & Surveyed
33	No Suitable Habitat		89	Accessed & Surveyed
34	No Suitable Habitat		90	Habitat Inferred
35	Accessed & Surveyed		91	Accessed & Surveyed
36	Habitat Inferred		92	No Suitable Habitat
37	Habitat Inferred		93	Accessed & Surveyed
38	Habitat Inferred		94	No Suitable Habitat

Aerial Photo No.	Access		Aerial Photo No.	Access
39	Habitat Inferred		95	Accessed & Surveyed
40	No Suitable Habitat		96	Accessed & Surveyed
41	Accessed & Surveyed		97	No Suitable Habitat
42	No Suitable Habitat		98	No Suitable Habitat
43	No Suitable Habitat		99	Habitat Inferred
44	Habitat Inferred		100	Habitat Inferred
45	Accessed & Surveyed		101	No Suitable Habitat
46	Accessed & Surveyed		102	No Suitable Habitat
47	No Suitable Habitat		103	Habitat Inferred
48	Accessed & Surveyed		104	No Suitable Habitat
49	Accessed & Surveyed		105	No Suitable Habitat
50	No Suitable Habitat		106	No Suitable Habitat
51	No Suitable Habitat		107	Accessed & Surveyed
52	No Suitable Habitat		108	No Suitable Habitat
53	Habitat Inferred		109	No Suitable Habitat
54	Habitat Inferred		110	Habitat Inferred
55	No Suitable Habitat		111	Habitat Inferred
56	No Suitable Habitat			

For the 50 map sections that could be surveyed, 15 to 30 minutes was spent at least at one access point along the rail alignment if the habitat appeared to be uniform along the alignment in that map section. If the habitat varied along the map section, then several points were visited and surveyed where possible.

At each survey point a transect of about 100 to 200 metres was traversed to assess the habitat quality along the rail alignment section that could be accessed. The plant community type (PCT), dominant tree species, forest height and diameter at breast height (DBH) range, presence, height and DBH of any emergent trees, presence of a nearby watercourse, shrub cover density, ground cover density and type of cover, presence of ground prey and tree canopy prey species and the existence of any potential raptor nests were recorded during each survey.

For any potential nest observed the location's latitude and longitude were recorded and the position plotted on the relevant section map. The tree species, tree height and DBH, nest size and position in the tree were also recorded.

Criteria used for the Determination of Potential Habitat Areas

Habitat data collected from each site were then used to assess the level of suitability of the habitat remnant for either breeding or foraging for the Little Eagle and how well each remnant satisfied the list of eight criteria characterising quality breeding habitat (see Habitat Requirements above). If at least criteria 1, 7 and 8 were met then the habitat area was potential breeding habitat. The greater the number of criteria that were met the more likely it was that the habitat area would provide breeding habitat for Little Eagle. Some areas were identified as potential foraging areas when some of the criteria but not 1, 7 and 8 were met. Such areas may be more important if they are also within a breeding territory as their loss would reduce the foraging area close to a nest and thus impact nesting success. There is also the potential for the development to reduce the size of a remnant to below the minimum requirements of 5 hectares. This is relevant if parts of the remnant are both within and adjacent to the transport alignment.

Visiting many of the sites allowed habitat remnants to be checked for plant community type and vegetation structure. This was then compared with what was shown in the aerial photographs of the alignment sections for those same sites. Hence the plant community type and vegetation structure could be reasonably well determined from the aerial photographs for sites that could not be reached. and for areas of section maps that had only limited access where the habitat polygon could be extended by extrapolating to include similar habitat area along the rail alignment. If a remnant could not be approached because of limited access, then the structure and suitability of the habitat remnant was inferred from the aerial photographs.

The size of each potential habitat area was determined by drawing polygons around each area within the rail alignment and calculating the area within each polygon in the Avenza Maps app in the aerial photographs of each map section. The position of each remnant was determined from the geo-referenced aerial photographs of each section of the rail alignment.

Data Collection to Determine the Status of the Local Population of the Little Eagle

The Atlas of Living Australia was accessed on the 17-08-2021 to search for all records of the Little Eagle within 50 km either side of the rail alignment. The Atlas of Living Australia also collects data from eBird, BirdLife Australia, NSW Bionet Atlas and NSW Bird Atlas. The combination of all datasets means that most of the available data is accessed. The records were tabulated, analysed for seasonality, and plotted onto a map of the greater area to show their distribution. Where 2 or more birds were counted on a survey, they are assumed to be a breeding pair as the Eagles are generally solitary outside the breeding season. These survey points are coded differently on the map with the other records to highlight the position of likely breeding territories. However, a record of a single bird could still represent a breeding pair as one bird may have been foraging when observed while the other bird was attending the nest and may have been missed during the survey. The number of breeding territories is calculated for the length of the rail alignment, based on the presence of suitable breeding habitat and 5 kilometres between adjacent pairs of nesting Eagles (see paragraph on breeding density in section on Distribution and Abundance).

4. Location and Patch Size of Potential Habitat Areas

Habitat patch position, size, criteria met, status for each map section are listed in Appendix 1. Each habitat patch is numbered consecutively from south to north. The patch number, status and area in hectares are also shown as maps in Appendix 2 for the inland rail alignment based on the supplied aerial photo map sections.

The rail alignment and borrow pits were divided into 111 map sections for the field surveys. Fifty of the map sections were visited out of the 78 that appeared to have suitable habitat. The other 33 map sections either contained no suitable woodland habitat, or the remnant was too low and/or sparse, or the remnant intersected by the rail alignment was smaller than 5 hectares. Suitable breeding habitat was inferred from the aerial map sections of the 28 map sections that could not be reached (see Field Methods above for reasons) by comparing the structure to other maps where similar vegetation structure had been identified during ground surveys of the map sections that were visited and these were identified as containing potential breeding habitat. Seventy-five of the aerial map sections contained potential breeding habitat while another 3 contained potential foraging habitat. Outside of the forested areas, where remnants were relatively small and narrow, the rail alignment footprint did not reduce the size of any habitat areas to less than 5 hectares. This means that the rest of the remnant was still large enough to be potential breeding habitat. This was also not an issue in the forested areas where contiguous habitat exists either side of the rail alignment.

The total area of potential breeding habitat for the inland rail alignment was 822.99 hectares while the potential additional foraging habitat was 17.97 hectares.

One probable nest was found near Bohena Creek at -30.458509 149.660993 in a 25 m tall Pilliga Box *Eucalyptus pilligaensis* with a DBH of > 0.8 m. The nest was between 0.5 and 0.7 m wide and 0.4 m deep and was located about 23 m above the ground and 4 m in from the foliage edge in a near vertical fork with one branch nearly horizontal. The sticks comprising the nest appeared to be about 10 to 15 mm in diameter. The nest structure, position in the tree, tree height and habitat area strongly suggest that this is a nest of a Little Eagle.

Note that habitat mapping has been updated to take into account flood mitigation. The updated habitat maps are those provided in Appendix 2. A comparison with the original assessment is provided in Appendix 1.

5. Status of the Local Population of the Little Eagle

Distribution of Records along the N2N Alignment

There were 354 records of Little Eagles within 50 km of the inland rail alignment in the records from the Atlas of Living Australia (accessed 17-08-2021). These records for the rail alignment are shown in Appendix 3. The distribution of those records is shown in Figure 1 and those records which are likely to represent breeding pairs are indicated as a different colour (n=15). Many of the survey points for records represent sightings made over several years or months from the same location and so one dot on the map may represent 2 to 10 records from the combined atlas data.

Of the 354 records approximately 25 records are within 5 km of the rail alignment and 2 of those are likely to represent breeding pairs. The data show that many of the records are in areas of fragmented woodland and forest, as well as within contiguous forest areas. Considering that much of the rail alignment is on private lands or goes through areas of forest where access is very difficult, and that many of the surveys in the data set were contributed by volunteer bird watchers, it is very likely that the distribution of surveys under-estimates the actual population occurring along the rail alignment.

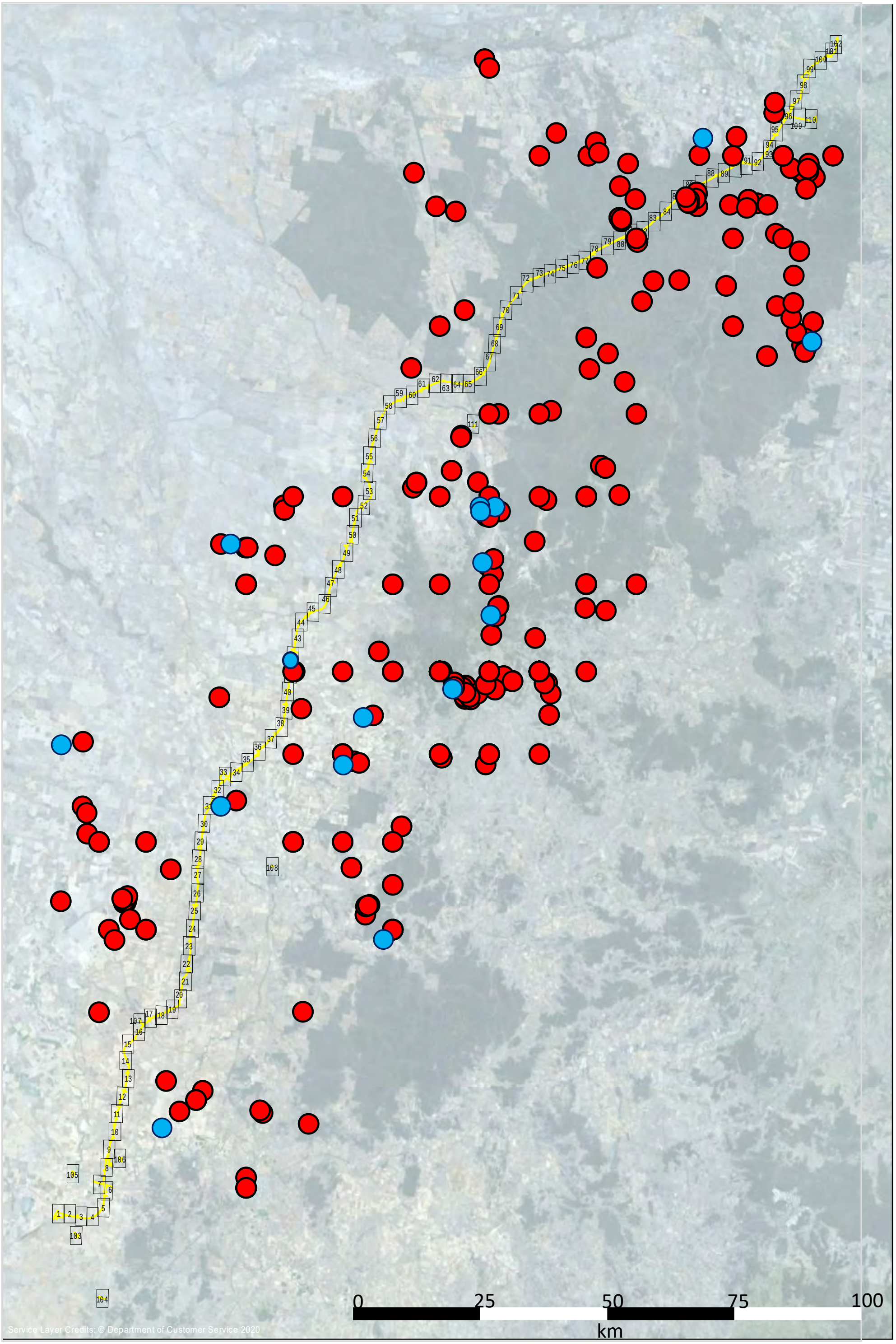

Figure 1. Distribution of Little Eagle records along N2N Rail Alignment (n=354, blue markers indicate where 2 birds were recorded in survey (n=15), red markers are all other records of single birds or where number of individuals not recorded in the survey).

No Eagles or evidence of breeding were detected during the 4 days of the survey period. This was to be expected as the surveys were conducted just before the commencement of the breeding season and before they are likely to arrive in the area from further north. The seasonal distribution of 237 of the local records is shown in Figure 2. Although there are records all year round the majority of records peak during spring when the birds would arrive and commence breeding. The spike in January could just reflect the time available to bird watchers during annual leave or fledgling young that are now able to fly and so represent a post breeding increase in the population, followed by dispersal of young Eagles. A pair of Little Eagles were recorded in November 2020 during surveys for the project by JacobsGHD at -31.334254 148.683454 and this record has been included in the data analysis.

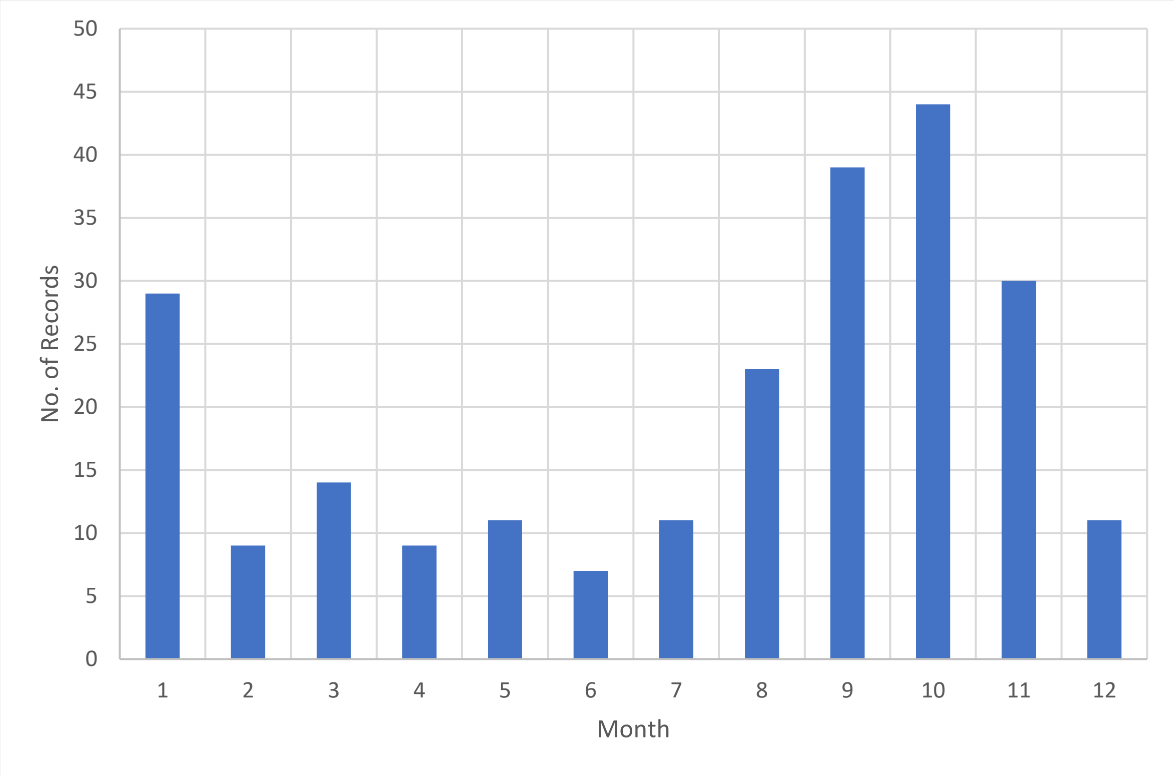

Figure 2. Monthly distribution of Little Eagle records for those records which have dates recorded with the observation (n=237).

Species Polygon

Based on the locations of potential breeding habitat along the rail alignment and the distance between adjacent breeding pairs found in the literature, it is estimated that up to 61 breeding pairs of Little Eagle may occur along the rail alignment. At least sixteen of these are likely to occur within the 80 km long Pilliga forests section of the rail alignment, but there may be more as some adjacent nests can be less than 5 km from each other (see paragraph on breeding density in section on Distribution and Abundance). In order to create the species polygon in areas where potential habitat is relatively continuous, a buffer of 1 km radius within the potential territories has been created over the potential breeding habitat. The Threatened Biodiversity Data Collection recommends a 300 m buffer for this species, however given the linear nature of the alignment, this has been increased to a 1km buffer for the purposes of this assessment. The total species polygon for the Little Eagle was determined to be 465.40 hectares of which 277.01 hectares are within the Pilliga forests. The distribution of potential breeding/foraging territories, indicative nest tree buffers and the species polygon are shown in the maps in Appendix 4. The species polygon calculations for each PCT and the total polygon area are shown in Appendix 5.

6. Recommendations for Impact Minimisation and Mitigation Measures

Of the 823 hectares of potential breeding habitat along the inland rail alignment 576 hectares are within the Pilliga state forests. These forests are critically important for the Little Eagle and many other threatened bird species that were encountered during the short visits to each map section through the forest. It is recommended that another route for the rail alignment be found outside the state forest areas. A route through grazing and or cropping areas would reduce the impact on important wildlife refuge areas in an already greatly fragmented landscape and reduce the potential breeding habitat impacts by 576 hectares.

Other sections of the proposed rail alignment overlap remnant vegetation along road easements and vegetation corridors between open grazed areas. Many of these areas are potential breeding habitat for the Little Eagle and several other threatened bird species were also recorded within some of these patches. It is recommended that the route be shifted to pass alongside instead of through these areas wherever possible. The relevant map sections are numbers 6, 22, 23, 27, 28, 45, 46, 48, 49, 53 and 54. This would remove another 114 hectares from the potential impacted breeding habitat area.

These recommendations combined would reduce the impacted habitat area for the Little Eagle by around 700 hectares. Another route will have impacts on habitat areas along it, but if the principles relating to the above recommendations are implemented along an alternative route any impacts could be kept to a minimum.

The status of the probable Little Eagle nest in map section 93 at -30.458509 149.660993 is unknown. It is recommended that the nest be monitored during the coming breeding season to see if it is an active nest.

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8. Credentials of the Experts Providing this Report

Credentials and Relevant Publications

Dr. Tony Saunders
BSc University of Sydney 1976, PhD University of Western Sydney 2005.
Company Director and Avian Ecologist, Merops Services Pty Ltd 1995 to present.

Relevant experience in surveys and the study of woodland birds including the Little Eagle:

- Woodland bird surveys throughout NSW for the NSW Bird Atlas and then for BirdLife Australia from 1982 to the present.
- Cumberland Plain woodland bird surveys on the UWS Hawkesbury Campus 1998 to 2005.
- Woodland bird surveys for managed reserves and bushland remnants in rural and peri-urban landscapes.
- Survey for threatened woodland birds in proposed urban expansion areas, rural subdivisions and mine developments
- Avifauna surveys of sites for development applications and assessment of status of threatened bird species with recommendations for minimising impact of development on these species within New South Wales. (22 years)
- Bird habitat assessment of managed landscapes and natural habitat areas and recommendations for habitat enhancement and rehabilitation for birds. (22 years)
-
- Opportunistic monitoring of nests of the Little Eagle and contributing collected data to BirdLife Australia's Nest Record Scheme.

Relevant publications relating to woodland birds and the Little Eagle:

- Saunders, T. (2016). Birds of the Cumberland Plain. What was there? What have we lost? Abstract from 'Birds of the Cumberland Plain: Past distributions, present studies and the outlook for their future' Australian Bird Study Association Conference - 23 January 2016. *Corella* **40**: 46.
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Adjunct associate lecturer/research associate, Zoology University of New England, Armidale. 2004 to present
Senior Ecologist (casual) Eco Logical Australia 2014 to 2019

Relevant experience in surveys and the study of the Little Eagle *Hieraaetus morphnoides* and of woodland birds:

- Birds of Prey Monitoring project: nest sites and productivity of threatened raptors on the tablelands – field survey and report (Northern Tablelands Local Land Services 2017-21); 19 Little Eagle nests as at 2021
- Regent Honeyeater, Swift Parrot, raptor and woodland bird surveys and reporting (North West Local Land Services 2015-21)
- Co-supervising, and finding all 13 Little Eagle nests and sharing the fieldwork for, a UNE Zoology student Honours project near Armidale in 2017 on the breeding habitat and nest-site characteristics of the Eagle (Candice Larkin, B Zool. Hons thesis duly submitted and awarded)

Relevant publications relating to foraging and breeding biology of the Little Eagle *Hieraaetus morphnoides*:

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Curriculum Vitae

Dr Tony Saunders:

Academic Qualifications:

BSc University of Sydney 1976
Dip Ed Sydney Teachers College 1977
PhD University of Western Sydney 2005

Other Qualifications:

LR Drivers Licence
Work Health & Safety General Construction Induction (White Card)
Chemical Use and Handling Certificate
Resuscitation Certificate
Emergency Care Certificate
Anaphylaxis Training Certificate
Drone Essentials Certificate

Fields of expertise:

Bird habitat assessment on reserves, lands in production and potential offset property.
Bird monitoring in natural, modified, and managed habitats.
Assessment of likelihood of threatened woodland bird species occurrence on development sites.
Coordinating projects between government and non-government organisations.
Coordination of volunteers collecting wildlife data.
Ecotourism: guiding general interest and specialists' groups in flora and fauna.
Environmental and science education at high school, TAFE, and university levels.
Habitat management for terrestrial woodland birds and other wildlife.
Presentations on ecology to public interest groups and at professional workshops.
Remote area wildlife atlassing.
Wildlife database design and management.
Land for Wildlife assessments and habitat enhancement planning.

Professional positions held:

2010 - 2021	Merops Services Pty Ltd (director, avifaunal ecologist). Environmental and landscape consultant and contractor, flora and fauna surveys, habitat enhancement plans.
2013 - 2021	Land for Wildlife Assessor for Community Environment Network
1995 - 2010	Merops Services (avifaunal ecologist). Environmental and landscape consultant and contractor.

2006 - 2017	Part-time teacher, mainly Science, but also Industrial Arts, English and Maths, Crookwell High School, Goulburn High School and Trinity Grammar School.
1997 - 2005	Part-time bird guide and ecotourism bus driver.
1993 - 2004	Part-time lecturer, supervisor and demonstrator, University of Western Sydney (biology, ecology and field survey techniques).
2001 - 2004	Atlas Facilitator, Birds Australia (organising remote atlassing, facilitating data exchange and communication between Birds Australia, state government organizations and other non-government organisations).
1997	Field Technical Officer, Birds Australia (monitoring breeding success of the endangered Regent Honeyeater).
1996	Field Technical Officer, University of Western Sydney (reptile, bird and plant survey techniques and data analysis).
1978 - 1994	High School Science Teacher at Marsden, Heathcote, Penrith and Kingswood High Schools.

Other volunteer positions held:

2014 - 2017	Assistant to Co-ordinator of the Sydney Bird Fair.
2015 – 2021	President - Crookwell Native Flora and Fauna Club.
2013 - 2021	Secretary - Grabine/Foggs Crossing Landcare Group
2001 - 2020	Avifaunal Advisor and Education Officer for Oolong Sanctuary, Dalton.
1997 - 2010	Project Manager for Atlas of Birds of the County of Cumberland.
2010 - 2021	Technical advisor to the Cumberland Bird Observer's Club's Atlas Databasae Management Committee.
1996 - 2009	Committee Member (Records Officer & Bird Database Manager)- CBOC (Cumberland Bird Observers Club Inc.).
1998 – 2014	CBOC representative to Bird Interest Group Network (BIGnet).
1997 - 2002	Faunal Advisor for the Hawkesbury Rainforest Network.
1999 - 2002	Member of Steering Committee of Birds in Backyards for Birds Australia.
1998 - 1999	Consultant to Birds Australia Birds for Birds in Backyards Project.
1998 - 2003	Regional Organiser for Sydney and the Blue Mountains, NSW facilitator and NSW/ACT representative on the Steering Committee for the National Bird Atlas for Birds Australia.
2002	Representative on NSW NPWS Wildlife Issues Advisory Panel for Birds Australia.

Relevant experience:

Co-ordination, facilitation and organization of exhibits and presentations at field-day events and indoor venues. This has involved allocating space, providing necessary facilities and setting-up audio-visual equipment for exhibitors and presenters (18 years)

Co-ordinator of volunteers for the CBOC Inc. and the Birds Australia national birds atlas. (13 years)

Facilitated the BIGnet data exchange agreement between Birds Australia, NSW Bird Atlassers, Canberra Ornithologists Group and the Cumberland Bird Observers Club. Facilitated bird data exchanges between Birds Australia, NSW State Forests and NSW DECC. (4 years)

Presenter at seminars for Bushcare, Landcare, Greening Australia, Wires and local councils, conservation societies and garden clubs on habitat management for birds and bird survey techniques. (33 years)

Educator at public, tertiary and secondary levels in the area of bird habitat management and bird survey methodology. (25 years)

Ecotourism and bird guiding (23 years).

Undertaking avifauna surveys of sites for development applications and assessment of status of threatened bird species on sites and making recommendations for minimising impact of development on these species. (23 years)

Bird habitat assessment of managed landscapes and natural habitat areas and recommendations for habitat enhancement and rehabilitation for birds. (23 years)

Design, building and management of the bird database for the birds of the County of Cumberland on behalf of CBOC Inc. (17years)

Critical assessment of habitat and population status for Little Eagle *Hieraaetus morphnoides* and Square-tailed Kite *Lophoictinia isura* (Listed as an expert in the DPIE website for site assessments (4years)

Membership and professional affiliations:

Australian Bird Study Association
Birdlife Australia
Crookwell Native Flora and Fauna Society
Cumberland Bird Observers Club (Life Member)
Ecological Consultants Association of NSW
Grabine/Foggs Crossing Landcare Group
NSW Bird Atlassers
Royal Zoological Society (Scientific member)

Papers, Articles and Reports:

Saunders, T. 1985. Common Bronzewings at Round Hill Nature Reserve.
CBOC Newsletter Vol. 6 No. 6 : 5

Saunders, T. 1986. Eastern Bristlebird at Ku-Ring-Gai Chase National Park.
CBOC Newsletter Vol. 8 No. 2 : 1

Saunders, T. 1990. Bird watching on North Stradbroke Island.
SIMO Newsletter

Saunders, T. 1990. Sooty Oystercatcher. *CBOC Newsletter* Vol. 11 No. 3 : 3

Saunders, T. 1991. Keeping Records of Bird Observations. *CBOC Newsletter* Vol. 12 No. 5 : 6-7.

Saunders, T. 1997. Birdscaping Gardens *CBOC Newsletter* Vol. 18 No. 4 : 6

Saunders, A.S.J. 1993. Seasonal variation in the distribution of the Noisy Friarbird *Philemon corniculatus* and the Red Wattlebird *Anthochaera carunculata* in eastern New South Wales. *Australian Bird Watcher* 15: 49-59.

Saunders, A.S.J., Ambrose, S.J. & Burgin, S. 1995. Gape width and prey selectivity in the Noisy Friarbird *Philemon corniculatus* and Red Wattlebird *Anthochaera carunculata*. *Emu* 95: 297-300.

Whelan, H. (ed.) 1997. *Australian Geographic Birdwatcher's Journal.* Australian Geographic. Chapters 'How to Watch Birds' and 'Bringing Birds into Your Garden'.

Healey, J. (ed.) 1997. *Encyclopaedia of Australian Wildlife.* Reader's Digest, Sydney. Chapters on Honeyeaters and Chats.

Saunders, A.S.J. & Burgin, S. 2001. Selective foliage foraging by Red Wattlebirds, *Anthochaera carunculata*, and Noisy Friarbirds, *Philemon corniculatus*. *Emu* 101: 163-166.

Saunders, T. 2002 *Bird Monitoring of Federal Park and White's Creek Valley Park, Annandale*. Leichhardt Council, Unpublished Report.

Saunders, T. 2002 Bird Habitat Issues and Management of Urban Bushland. *Caring For Our Bushland and Waterways: Forum Proceedings*. 2002 Wollondilly Catchment Landcare Forum.

Saunders, A.S.J., Burgin, S. & Jones, H. 2003 The importance of eucalypt nectar in the diet of large honeyeaters. *Corella* 27: 1-12.

Saunders, T. 2003 *Managing Avian Biodiversity in the Leichhardt Local Government Area.* Leichhardt Council, Unpublished Report.

Saunders, T. 2003 *Breeding Waterbird Study at Sydney Olympic Park.* Sydney Olympic Park Authority, Unpublished Report.

Saunders, T. 2004 *Bush Bird Status at Sydney Olympic Park.* Sydney Olympic Park Authority, Unpublished Report.

Saunders, T. 2005 *Bush Bird Project at Sydney Olympic Park.* Sydney Olympic Park Authority, Unpublished Report.

Saunders, T. 2005 *Habitat Survey of Sydney Olympic Park.* Sydney Olympic Park Authority, Unpublished Report.

Darcovich, K., Saunders, T. & O'Meara, J. 2005. *Revegetation on an Olympic scale - case studies in building fauna habitat on constructed parkland landscapes.* Sydney Olympic Park Authority, Conference poster.

Saunders, T. 2006 *Flora and Fauna Assessment of Badgerys Creek.* Unpublished Report.

Saunders, T. 2007 *Bird Habitat Management within Holroyd Local Government Area.* Holroyd City Council, Unpublished Interim Report.

Burgin, S. & Saunders, T. 2007 Parrots of the Sydney region: population changes over 100 years. Pp. 185-194 in *Pest or Guest; The Zoology of Overabundance*, edited by Lunney, D., Eby, P., Hutchings, P. & Burgin, S. Royal Zoological Society of NSW, Mosman.

Saunders, T. 2008 *Avian Biodiversity Monitoring and Bird Habitat Management within the Leichhardt LGA.* Leichhardt Council, Unpublished Report.

Saunders, T. 2009 *Bird Habitat Management within Holroyd Local Government Area.* Holroyd City Council, Unpublished Report.

Saunders, T. 2009 *Sydney Olympic Park Bush Bird Survey* Sydney Olympic Park Authority, Unpublished Report.

Saunders, T. 2010 *Bird Habitat Monitoring in Holroyd LGA* Holroyd City Council, Unpublished Interim Report.

Saunders, T. 2010 *Bird Monitoring at Sydney Olympic Park 1999 to 2009* Sydney Olympic Park Authority, Unpublished Report.

Saunders, T. 2011 *Bird Habitat Monitoring in Holroyd LGA* Holroyd City Council, Unpublished Interim Report.

Saunders, T. 2011 *Habitat Enhancement Plan for 'Heathfield' Cowra*, Unpublished Report.

Saunders, T. 2011 *Habitat Enhancement Plan for 'Girragirra' Cowra*, Unpublished Report.

Saunders, T. 2011 *Habitat Enhancement Plan for 'Garrallan' Cowra*, Unpublished Report.

Saunders, T. 2011 *Habitat Enhancement Plan for 'Garraroo' Binda*, Unpublished Report.

Saunders, T. 2011 *Habitat Enhancement Plan for 'Watervale' Boorowa*, Unpublished Report.

Saunders, T. 2011 *Habitat Enhancement Plan for 'Wookie Hills' Cowra*, Unpublished Report.

Saunders, T. 2011 *Habitat Enhancement Plan for 'Orchre Arch' Cowra*, Unpublished Report.

Saunders, T. 2011 *Habitat Enhancement Plan for 'Raintree-Marra' Cowra*, Unpublished Report.

Saunders, T. 2011 *Criteria for Ranking Priorities for Habitat Enhancement for Lachlan Catchment Management Authority,* Unpublished Report.

Saunders, T. 2012 *Bird Habitat Monitoring in Holroyd LGA* Holroyd City Council, Unpublished Final Report.

Saunders, T. 2013 Birdscaping Gardens. p 16 *Our Gardens* Volume 55, The Garden Clubs of Australia.

Saunders, T. 2014 *Habitat Survey of Sydney Olympic Park.* Sydney Olympic Park Authority, Unpublished Report.

Saunders, T. 2015 *Land for Wildlife Assessment for 'Mitchell' Binda*, Unpublished Report.

Saunders, T. 2015 *Land for Wildlife Assessment for 'Douglass' Binda*, Unpublished Report.

Saunders, T. 2015 *Land for Wildlife Assessment for 'Holmes' Peelwood*, Unpublished Report.

Saunders, T. 2015 *Habitat Assessment and Enhancement Plan for 'Ollis' Bigga*, Unpublished Report.

Saunders, T. 2015 *Habitat Assessment and Enhancement Plan for 'Flat Rocks' Bigga*, Unpublished Report.

Saunders, T. 2015 *Land for Wildlife Assessment for 'Gunthori' Yass*, Unpublished Report.

Saunders, T. 2015 *Land for Wildlife Assessment for Lot3 DP 789337 Taralga*, Unpublished Report.

Saunders, T. 2015 *Land for Wildlife Assessment for Lot 57 Bevendale*, Unpublished Report.

Saunders, T. 2015 *Flora and Fauna Assessment of DP 48541Abercrombie for Pejar Aboriginal Land Council*, Unpublished Report.

Saunders, T. 2015 *Flora and Fauna Assessment of DP 48016 Abercrombie for Pejar Aboriginal Land Council*, Unpublished Report.

Saunders, T. 2015 *Flora and Fauna Assessment of DP 823525 Binda for Pejar Aboriginal Land Council*, Unpublished Report.

Saunders, T. 2015 *Flora and Fauna Assessment of DP 753055 Binda for Pejar Aboriginal Land Council*, Unpublished Report.

Saunders, T. 2016 *Land for Wildlife Assessment for DP 1217631 Reids Flat*, Unpublished Report.

Saunders, T. 2016 *Land for Wildlife Assessment for 'Callarah' Reids Flat*, Unpublished Report.

Saunders, T. 2016 *Land for Wildlife Assessment for 'The Angle' Reids Flat*, Unpublished Report.

Saunders, T. 2016 *Land for Wildlife Assessment for 'Bobbins' Reids Flat*, Unpublished Report.

Saunders, T. 2016 Birds of the Cumberland Plain. What was there? What have we lost? Abstract from 'Birds of the Cumberland Plain: Past distributions, present studies and the outlook for their future.' Australian Bird Study Association Conference - 23 January 2016. *Corella* 40: 46

Saunders, T. 2016 *Bird surveys, likelihhood for threatened birds and habitat description for Syerston Mine Project, Fifield,* Unpublished Report.

Saunders, T. 2017 *Land for Wildlife Assessment for 'Tanjenong' Abercrombie*, Unpublished Report.

Saunders, T. 2017 *Land for Wildlife Assessment for 'Bohara' Breadalbane*, Unpublished Report.

Saunders, T. 2017 *Land for Wildlife Assessment for 'Greendale' Breadalbane*, Unpublished Report.

Saunders, T. 2017 *Land for Wildlife Assessment for 'Bunduluk' Laggan*, Unpublished Report.

Saunders, T. 2017 *Flora and Fauna Assessment of DP 48618 Windellama for Pejar Aboriginal Land Council*, Unpublished Report.

Saunders, T. 2017 *Flora and Fauna Assessment of DP 1185604 Windellama for Pejar Aboriginal Land Council*, Unpublished Report.

Saunders, T. 2017 *Flora and Fauna Assessment of DP 823489 Cullulla for Pejar Aboriginal Land Council*, Unpublished Report.

Saunders, T. 2017 *Bird surveys, likelihhood for threatened birds and habitat description for Vickery Mine Project, Boggabri,* Unpublished Report.

Saunders, T. 2017 *Land for Wildlife Assessment for 'Bimbimbie' Bigga*, Unpublished Report.

Saunders, T. 2017 *Habitat Assessment and Enhancement Plan for 'Tanjenong' Abercrombie*, Unpublished Report.

Saunders, T. 2017 *Habitat Assessment and Enhancement Plan for DP 1162296 Crookwell*, Unpublished Report.

Saunders, T. 2017 *Habitat Assessment and Enhancement Plan for 1206394 Red Ground*, Unpublished Report.

Saunders, T. & Debus, S. 2018 *Strategic Assessment for the Square-tailed Kite Lophoictinia isura in the Greater Macarthur Growth Area and the Wilton Growth Area* Unpublished Report. Department of Planning and the Environment

Saunders, T. & Debus, S. 2018 *Strategic Assessment for the Little Eagle Hieraaetus morphnoides in the Greater Macarthur Growth Area and the Wilton Growth Area* Unpublished Report. Department of Planning and the Environment

Saunders, T. 2018 *Bird surveys, likelihhood for threatened birds and habitat description for Maxwell Mine Project, Jerrys Plains,* Unpublished Report.

Saunders, T. 2018 *Bird surveys, likelihhood for threatened birds and habitat description for Mount Pleasant Mine Project, Muswellbrook,* Unpublished Report.

Saunders, T. 2018 *Preliminary habitat description for Mount Thorley/Warkworth Mine Project, Warkworth,* Unpublished Report.

Saunders, T. 2018 Trends in woodland bird populations on the Cumberland Plain, New South Wales, from long-term datasets. *Australian Zoologist* 38(4): 675-697. Royal Zoological Society of NSW, Mosman.

Saunders, T. 2019 Wombat Tunnel Under a Fence: A Solution to Damaged Fences. *WIRES Southern Tablelands Branch Newsletter* No. 50 p 10.

Saunders, T. 2019 *Assessment of Breeding Habitat and Potential Nests for either the Little Eagle or the Square-Tailed Kite at 7 Kyte Place Tumbi Umbi*. Unpublished Report.

Saunders, T. 2019 *Assessment of Potential Breeding and Foraging Habitat for the Little Eagle at DP 2944 and DP 1229317, Colo Vale.* Unpublished Report.

Saunders, T. 2019 *Habitat trends 2004 to 2019: Woodland birds project.* Sydney Olympic Park. Unpublished Report.

Saunders, T. 2019 *Bird and habitat trends 2004 to 2019: Woodland birds project.* Sydney Olympic Park. Unpublished Report.

Saunders, T. 2019 Changes in the flora and fauna of the Upper Lachlan Shire over the last 40 years. Crookwell Native Flora and Fauna Club Newsletter.

Saunders, T. 2019 Woodland Birds of the Cumberland Plain. CBOC Newsletter Vol. 40-6. pp 1-5.

Saunders, T. 2019 Impact Assessment on Nesting Australian Pied Oystercatcher *Haematopus longirostris* at Crooked River Inlet, Gerroa, NSW.

Saunders, T. 2019 Test of Significance as applied to nesting Australian Pied Oystercatcher *Haematopus longirostris* at Crooked River Inlet, Gerroa, NSW.

Saunders, T. 2020 The Cumberland County Bird Database. CBOC Newsletter Vol. 41-6. pp 8-9.

Saunders, T. 2020 Review of updates to the development footprints of the Greater Macarthur and Wilton urban growth areas in relation to strategic assessments on the Little Eagle and the Square-tailed Kite. Report prepared for Biosis Pty Ltd.

O'Meara, J. & Saunders, T. 2020. Restoring the restoration: Bringing back woodland birds. pp 188-213 in: 20 years of healing: Delivering the ecological legacy of the Green Games. Sydney Olympic Park Authority.

Saunders, T. 2020 Scarlet Robin population and habitat monitoring on private lands within the Bigga region: initial habitat monitoring and spring surveys. Report prepared for the Foundation of National Parks of NSW.

Saunders, T. 2021 Birdscaping Gardens. CBOC Newsletter Vol. 42-5. pp 1-5.

Saunders, T. 2021 Habitat Enhancement Plan for 15 Turkey Hill Road Limerick NSW. Report prepared for the Foundation of National Parks of NSW, Saving Our Species, K2W Glideways Project.

Saunders, T. 2021 Habitat Enhancement Plan for 2617 Rugby Rd Rugby NSW. Report prepared for the Foundation of National Parks of NSW, Saving Our Species, K2W Glideways Project.

Saunders, T. & Debus, S. 2021 Strategic Assessment for the Square-tailed Kite *Lophoictinia isura* within the proposed Western Sydney Transport Corridors. Report prepared for Transport NSW.

Saunders, T. & Debus, S. 2021 Strategic Assessment for the Little Eagle *Hieraaetus morphnoides* within the proposed Western Sydney Transport Corridors. Report prepared for Transport NSW.

Dr Stephen Debus:

Abridged CV: Stephen John Stewart DEBUS

BA (Biol./Behav. Sc.) Macquarie Uni 1978, Dip. Natural Resources (Wildlife) Uni of New England 1981, Dip. Ed. (Sci.) UNE 1983, MSc. (Zool.) UNE 1994, PhD (Zool.) UNE 2004

Contact details:

Ph: 02 6773 2510 (BH), mobile: 0409 779 766

Addresses: Zoology, University of New England, Armidale NSW 2351 (business) PO Box 1015 (6 Holloway St), Armidale NSW 2350 (private)

Website www.une.edu.au/staff-profiles/ers/sdebus

Professional capacities:

Vertebrate fauna surveys. Research and survey of threatened forest and woodland birds, particularly raptors and owls. Ecology/biology/behaviour of birds, especially predatory species. Conservation and management of threatened bird species. Distribution, status and biology/ecology of NSW birds. Reviews and biological profiles of bird species. Editing ornithological papers. Peer review of ornithological documents/EISs/species impact statements. Impact assessment (avifauna). Review of conservation status of NSW fauna.

Computer skills:

Proficient in Word and Excel, limited experience with GIS and ArcView

Employment:

Eco Logical Australia 2011-19 (casual; senior ecologist: fauna survey and report)

EA Systems (now EnviroAg Australia) 2000-14 (casual; ecologist: fauna survey and assessment)

Research assistant, Zoology, UNE, casual 1984-2014 (field ornithology: bird banding, bird surveys/censusing, ecological studies)

Tutor/demonstrator, Zoology UNE (casual), 2007-13

NSW Dept Environment & Climate Change, 2008-09 (temporary) (threatened species officer: Project Officer, NSW Scientific Committee)

Research Assistant, Ecosystem Management UNE (casual), 2008-09 (bird survey)

Post-doctoral research fellow, Zoology, UNE, 2005-07 (ecology of woodland birds)

Junior research fellow, Zoology, University of New England, 1990-1993, 1998-2004 (ecology of rare forest owls in relation to habitat and forest management; ecology and management of birds)

Technical officer, University Partnerships Pty Ltd (UNE), 1995-1996 (fauna survey and report, Eastlink EIS)

Casual assistant demonstrator, Depts Zoology and Ecosystem Management, UNE, 1988-2002 (field practical classes on population ecology and behavioural ecology of birds)

Casual teacher, New England Institute of TAFE, 1987-1993 (bird biology: including laboratory and field practical classes on classification, identification, and ecology)

Field technician, National Parks & Wildlife Service Armidale, 1986 (fauna inventory, vegetation sampling and analysis)

Research assistant, Department of Ecosystem Management, University of New England, casual 1986-1987 (field survey of vegetation and fauna)

Honorary position:

Adjunct associate lecturer/research associate, Zoology UNE, 2004-2021 (includes collaborative research and publication, co-supervision of Honours/Masters/PhD students)

Consultant biologist (selected recent clients):

Northern Tablelands Local land Services 2017-21 (Birds of Prey Monitoring project: nest sites and productivity of threatened raptors on the tablelands – field survey and report)

North West Local Land Services 2015-2021 (Regent Honeyeater, Painted Honeyeater, Swift Parrot, raptor and woodland bird surveys and reporting)

University of New England 2019-2021 (Murray-Darling Basin waterbird monitoring)

Brisbane City Council 2020 (revision and updating of Conservation Action Statements for large forest owls, including Masked and Barking Owl, and Eastern Grass Owl)

BirdLife Australia – Northern NSW (for Bundarra-Barraba Operations Group of the Regent Honeyeater Recovery Team), 2007-20 (Regent Honeyeater/woodland bird survey and monitoring)

Minter Ellison 2019–2021 (White-bellied Sea-Eagle expert reports)

28 South Environmental 2013-2020 (threatened fauna survey/assessment and report)

ERM 2020 (Masked Owl and Barking Owl BioBanking assessment expert report)

Eco Logical Australia 2010-2011 (threatened bird research, fauna database compilation); 2019- 2020 (Regent Honeyeater BioBanking assessment expert reports)

Fenner School of Environment and Society, Australian National, University 2016-19 (Regent Honeyeater surveys and data submission; habitat assessment)

NSW OEH/NPWS 2019 (fauna inventory in Service estate; expert workshop on Red Goshawk)

Greencap Pty Ltd 2019 (BioBanking assessment expert report: threatened raptors and Regent Honeyeater)

NSW Department of Planning and Environment 2018 (biodiversity assessment expert report: Square-tailed Kite and Little Eagle)

Whitehaven Coal 2018 (field survey, assessment and expert report on potential BioBank site for Regent Honeyeater)

Cumberland Ecology 2004-2012, 2018 (fauna survey and report; Regent Honeyeater BioBanking assessment expert report)

Central Coast Council 2017 (expert report: White-bellied Sea-Eagle)

Southern New England Landcare 2014-16 (fauna surveys on farms, data submission, landholder workshop, report review)

Ecotone Environmental Services 2012-13 (peer review of threatened fauna assessment; targeted fauna survey: federally listed birds)

NSW National Parks & Wildlife Service/Dept Environment & Conservation/DECC 1987-2013 (fauna survey, review of avifaunal component of environmental impact statements/ fauna impact statements/fauna reports, preparation of recovery plans and species profiles for threatened species)

Australian Museum, 1995, 2012 (review of fauna impact statement, avifauna; feather sampling of wild-caught birds for DNA analysis)

State Forests of NSW 1987-2009 (fauna survey, review of avifaunal component of environmental impact statements/fauna impact statements/fauna reports, fauna survey worskhop)

ACT Planning & Land Authority 2005-06 (fauna survey and assessment) ANCA 1995-1996 (fauna survey, Jervis Bay National Park)
SA National Parks & Wildlife Service, 1995 (fauna survey, Strzelecki Desert)

Grants and awards:

Search for Red Goshawk in NSW: $1,000 from the Australian Bird Environment Fund (Bird Observers Club of Aust.), 1987.

Distribution, status and habitat requirements of the Sooty Owl in northern NSW: $2,000 as a Cayley Memorial Scholarship (Gould League of NSW) 1990-93; with Associate Professors Hugh Ford & Harry Recher (UNE), $34,280 from WWF Australia and $64,835 from ANPWS (Endangered Species Program) 1990-93.

Will wildlife corridors work for sedentary birds?: with Professor Hugh Ford, $42,565 from the NSW Environmental Trust 2005, $43,359 in 2006-07.

Bird Observers Club of Australia: Distinguished Service Award, 2005 (editing the *Australian Bird Watcher*/*Australian Field Ornithology* for 21 years 1984-2005).

Royal Zoological Society of NSW Whitley Award, 2013 (*Birds of Prey of Australia: A Field Guide*, 2nd edn, best vertebrate guide in 2012)

BirdLife Australia's D.L. Serventy Medal for publication in ornithology, 2015

Voluntary work:

Editor: *Australasian Raptor Association News* 1980-1989 and *Boobook* (re-named) 2004-19 (biannual journal for bird-of-prey enthusiasts); *Australian Field Ornithology* 1984-2015 (quarterly journal)

Sub-editor: *Corella* Wedge-tailed Eagle special issue, 2007; White-bellied Sea-Eagle special issue, 2009; rare raptors special issue, 2011

Committee member: Australian Bird Study Association 1981-1988, 2005-17; Birds Australia Northern NSW Group 1996-99, 2004-12, 2015-17; Australasian Ornithological Conference 2009 organising committee 2008-09; ABSA/BirdLife Southern NSW conference organising committee 2013-14

Regent Honeyeater Recovery Team: Bundarra-Barraba Operations Group rep, 2008-21 Red Goshawk National Recovery Team 2014-21

Publications:

~150 refereed papers (selection appended), books and book contributions, theses: see following list

Refereed publications (selected titles):

Debus, S.J.S. 1984. Biology of the Little Eagle on the Northern Tablelands of New South Wales. *Emu* 84: 87-92.

_____, Ley, A.J., Trémont, S. & Trémont, R. 1991. Breeding behaviour and diet of the Australian Hobby *Falco longipennis* in northern New South Wales. *Aust. Bird Watcher* 14: 123-137.

Debus, S.J.S. 1992. A survey of diurnal raptors in north-east New South Wales, 1987-1990. *Aust. Birds* 25: 67-77.

Debus, S.J.S. 1993a. The mainland Masked Owl *Tyto novaehollandiae*: a review. *Aust. Bird Watcher* 15: 168-191.

_____ 1993b. The status of the Red Goshawk *Erythrotriorchis radiatus* in New South Wales, in Olsen, P.D. (Ed.), *Australian Raptor Studies*, pp. 182-191. Australasian Raptor Association, RAOU, Melbourne.

Debus, S.J.S., Ley, A.J., Trémont, S.M., Trémont, R.M. & Collins, J.L. 1993. Breeding behaviour and diet of the Collared Sparrowhawk *Accipiter cirrhocephalus* in northern New South Wales. *Aust. Bird Watcher* 15: 68-91.

Debus, S.J.S., McAllan, I.A.W. & Mead, D.A. 1993a,b. Museum specimens of the Red Goshawk *Erythrotriorchis radiatus*. I. Annotated list of specimens; II. Morphology, biology and conservation status in eastern Australia. *Sunbird* 23: 5-28; 75-89.

Debus, S.J.S., McAllan, I.A.W. & Morris, A.K. 1993. The Square-tailed Kite *Lophoictinia isura* in New South Wales. *Aust. Birds* 26: 104-118.

Peake, P., Conole, L.E., Debus, S.J.S., McIntyre, A. & Bramwell, M. 1993. The Masked Owl *Tyto novaehollandiae* in Victoria. *Aust. Bird Watcher* 15: 124-136.

Ford, H.A., Davis, W.E., Debus, S., Ley, A., Recher, H. & Williams, B. 1993. Foraging and aggressive behaviour of the Regent Honeyeater *Xanthomyza phrygia* in northern New South Wales. *Emu* 93: 277-281.

Debus, S.J.S. 1994. The Sooty Owl *Tyto tenebricosa* in New South Wales. *Aust. Birds* 28 supplement: 4-19.

_____ & Chafer, C.J. 1994. The Powerful Owl *Ninox strenua* in New South Wales. *Aust. Birds* 28 supplement: 21-38.

_____ & Rose, A.B. 1994. The Masked Owl *Tyto novaehollandiae* in New South Wales. *Aust. Birds* 28 supplement: 40-64.

Debus, S.J.S. 1995. Surveys of large forest owls in northern New South Wales: methodology, calling behaviour and owl responses. *Corella* 19: 38-50.

Kavanagh, R.P., Debus, S., Tweedie, T. & Webster, R. 1995. Distribution of nocturnal forest birds and mammals in north-eastern New South Wales: relationships with environmental variables and management history. *Wildlife Research* 22: 359-377.

Debus, S.J.S. 1997a. A survey of the raptors of Jervis Bay National Park. *Aust. Birds* 30: 29- 44.

_____ 1997b. The Barking Owl in New South Wales. *Aust. Birds* 30: 53-80.

_____ 1997c. Aspects of the biology of captive-bred, hack-released Masked Owls *Tyto novaehollandiae*. In Czechura, G. & Debus, S. (Eds), *Australian Raptor Studies II*, pp. 14- 33. Birds Australia Monograph 3, Birds Australia, Melbourne.

_____ 1997d. Vocal behaviour of the Southern Boobook *Ninox novaeseelandiae* and other nocturnal birds. In Czechura, G. & Debus, S. (Eds), *Australian Raptor Studies II*, pp. 71- 85. Birds Australia Monograph 3, Birds Australia, Melbourne.

Mathieson, M.T., Debus, S.J.S., Rose, A.B., McConnell, P.J. & Watson, K.M. 1997. Breeding diet of the Letter-winged Kite *Elanus scriptus* and Black-shouldered Kite *Elanus axillaris* during a House Mouse plague. *Sunbird* 27: 65-71.

Debus, S.J.S., Maciejewski, S.E. & McAllan, I.A.W. 1998. The Grass Owl in New South Wales. *Aust. Birds* 31: 29-45.

Brigham, R.M., Debus, S.J.S. & Geiser, F. 1998. Cavity selection for roosting, and roosting ecology of forest-dwelling Australian Owlet-nightjars (*Aegotheles cristatus*). *Aust. J. Ecol.* 23: 424-429.

Bischoff, T., Lutter, H. & Debus, S. 2000. Square-tailed Kites breeding on the mid-north coast of New South Wales. *Aust. Bird Watcher* 18: 233-240.

Brown, B., Brown, F. & Debus, S.J.S. 2000. Further observations on a pair of Square-tailed Kites nesting near Grafton, New South Wales. *Aust. Bird Watcher* 18: 270-273.

Debus, S.J.S. & Rose, A.B. 2000. Diet of Grey Falcons *Falco hypoleucos* breeding extralimitally in New South Wales. *Aust. Bird Watcher* 18: 280-281.

Harrington, G.N. & Debus, S.J.S. 2000. Dietary items of the Rufous Owl *Ninox rufa* on the Atherton Tableland, north Queensland. *Aust. Bird Watcher* 18: 251-252.

Debus, S.J.S. 2001. Surveys of the Barking Owl and Masked Owl on the North-west Slopes of New South Wales. *Corella* 25: 5-11.

Barnes, C.P., Zillmann, E.E., Rose, A.B. & Debus, S.J.S. 2001. Diet and biology of the Square- tailed Kite *Lophoictinia isura* in south-eastern Queensland: nest-building to post-fledging. *Aust. Bird Watcher* 19: 28-43.

Debus, S.J.S., Agnew, L.R. & Schulz, M. 2001. Surveys of the Grass Owl *Tyto capensis* in coastal New South Wales. *Aust. Bird Watcher* 19: 94-102.

Debus, S.J.S. 2002. Distribution, taxonomy, status and major threatening processes of owls of the Australasian Region. In Newton, I., Kavanagh, R., Olsen, J. & Taylor, I. (Eds), *Ecology and Conservation of Owls*, pp. 355-363. CSIRO, Melbourne.

Griffiths, H., Lutter, H., Rose, A.B. & Debus, S.J.S. 2002. Breeding and diet of a pair of Square- tailed Kites *Lophoictinia isura* on the mid-north coast of New South Wales. *Aust. Bird Watcher* 19: 184-193.

Debus, S.J.S. & Rose, A.B. 2003. Diet of a Barking Owl *Ninox connivens* in the channel country of south-west Queensland. *Corella* 27: 18-19.

Lutter, H., Dinnie, R. & Debus, S.J.S. 2003. Square-tailed Kites breeding in northern coastal New South Wales: post-fledging diet and behaviour. *Aust. Field Ornithology* 20: 94-104.

Debus, S.J.S., Olsen, J. & Rose, A.B. 2004. Diet of the Barn Owl *Tyto alba* near Lake Frome in arid South Australia. *Corella* 28: 40-42.

Debus, S.J.S. & Rose, A.B. 2004. Diet of the Barn Owl *Tyto alba* near Tamworth, New South Wales. *Corella* 28: 95.

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Appendix 1. Habitat patch position, size, criteria met and status

Aerial Photo No.	Patch No.	Location of Patch	Updated map page	Updated area ID	Patch size (ha)	Criteria Met	Patch Status
1	-	-	-	-	-	nil	No likely foraging or breeding habitat
2	-	-	-	-	-	nil	No likely foraging or breeding habitat
3	-	-	-	-	-	nil	No likely foraging or breeding habitat
4	1	-32.304133 148.275800	1	1	0.37	1,3,4,5,6,7,8	Potential breeding habitat
5	1	-32.282196 148.296023	2		2.6	3,4,5,6	Potential foraging habitat
6	1	-32.249567 148.298424	3	2	9.59	1,2,3,4,5,6,7,8	Potential breeding habitat
7	1	-32.243128 148.296847	4	Part of patch above		1,2,3,4,5,6,7,8	Potential breeding habitat
8	1	-32.214903 148.311744	5		8.23	1,3,4,5,6,8	Potential foraging habitat
9	1	-32.175076 148.301389	6	3	2.26	1,3,4,5,6,7,8	Potential breeding habitat
10	-	-	-	-	-	nil	No likely foraging or breeding habitat
11	-	-	-	-	-	nil	No likely foraging or breeding habitat
12	1	-32.092719 148.336277	8	4	1.03	1,3,4,5,6,7,8	Potential breeding habitat
13	1	-32.065674 148.343204	9	5	0.61	1,3,4,5,6,7,8	Potential breeding habitat
14	1	-32.045983 148.346025	10		7.14	3,4,5,8	Potential foraging habitat
15	-	-	-	-	-	nil	No likely foraging or breeding habitat
16	1	-31.976173 148.376090	11	6	2.5	1,3,4,5,6,7,8	Potential breeding habitat
17	1	-31.973991 148.380779	12	7	2.09	1,2,3,4,5,6,7,8	Potential breeding habitat

Appendix 1. Habitat patch position, size, criteria met and status

Aerial Photo No.	Patch No.	Location of Patch	Updated map page	Updated area ID	Patch size (ha)	Criteria Met	Patch Status
18	1	-31.957344 148.414566	13	8	3.36	1,2,3,4,5,6,7,8	Potential breeding habitat
19	1	-31.948363 148.438759	14	9	0.73	1,3,4,5,6,7,8	Potential breeding habitat
20	1	-31.941729 148.450777	14	10	3.41	1,2,3,4,5,6,7,8	Potential breeding habitat
21	1	-31.908958 148.457322	16	11	0.19	1,3,4,5,6,7,8	Potential breeding habitat
21	2	-31.904089 148.458163	16	12	0.62	1,2,3,4,5,6,7,8	Potential breeding habitat
21	3	-31.890718 148.465629	16	13	0.47	1,2,3,4,5,6,7,8	Potential breeding habitat
21	4	-31.887410 148.467535	16	14	0.25	1,3,4,5,6,7,8	Potential breeding habitat
22	1	-31.87548 148.470628	17	15	31.64	1,2,3,4,5,6,7,8	Potential breeding habitat
23	1	-31.845306 148.473905	18	15	6.06	1,3,4,5,6,7,8	Potential breeding habitat
23	2	-31.832405 148.473188	19	15	3.53	1,3,4,5,6,7,8	Potential breeding habitat
24	1	-31.822013 148.474848	19	16	1.84	1,2,3,4,5,6,7,8	Potential breeding habitat
24	2	-31.799522 148.478893	20	17	3.62	1,3,4,5,6,7,8	Potential breeding habitat
25	1	-31.789838 148.480655	20	18	0.70	1,3,4,5,6,7,8	Potential breeding habitat
25	2	-31.785313 148.481435	20	19	0.64	1,3,4,5,6,7,8	Potential breeding habitat
25	3	-31.779168 148.482582	21	20	0.48	1,3,4,5,6,7,8	Potential breeding habitat
25	4	-31.775948 148.483051	21	21	1.49	1,3,4,5,6,7,8	Potential breeding habitat
25	5	-31.769950 148.484260	21	22	8.21	1,3,4,5,6,7,8	Potential breeding habitat
26	-	-	-	-	-	nil	No likely foraging or breeding habitat

Appendix 1. Habitat patch position, size, criteria met and status

Aerial Photo No.	Patch No.	Location of Patch	Updated map page	Updated area ID	Patch size (ha)	Criteria Met	Patch Status
27	1	-31.712812 148.487350	22	23	13.27	1,3,4,5,6,7,8	Potential breeding habitat
28	1	-31.692157 148.490669	23	24	10.33	1,3,4,5,6,7,8	Potential breeding habitat
29	1	-31.675190 148.493440		Part of patch above		1,3,4,5,6,7,8	Potential breeding habitat
29	2	-31.667279 148.494819	24	25	0.58	1,2,3,4,5,6,7,8	Potential breeding habitat
29	3	-31.662347 148.494927	24	26	1.77	1,2,3,4,5,6,7,8	Potential breeding habitat
30	-	-	-	-	-	nil	No likely foraging or breeding habitat
31	1	-31.599568 148.512363	25	27	4.12	1,3,4,5,6,7,8	Potential breeding habitat
31	2	-31.600878 148.513350	25	28	0.76	1,3,4,5,6,7,8	Potential breeding habitat
32	-	-	-	-	-	nil	No likely foraging or breeding habitat
33	-	-	-	-	-	nil	No likely foraging or breeding habitat
34	-	-	-	-	-	nil	No likely foraging or breeding habitat
35	1	-31.531581 148.583707	26	29	2.42	1,2,3,4,5,6,7,8	Potential breeding habitat
36	1	-31.511593 148.613129	27	30	0.26	1,3,4,5,6,7,8	Potential breeding habitat
37	1	-31.491457 148.633418	28	31	2.16	1,3,4,5,6,7,8	Potential breeding habitat
38	1	-31.462253 148.663325	29	32	0.29	1,3,4,5,6,7,8	Potential breeding habitat
39	1	-31.425821 148.669603	30	33	2.20	1,3,4,5,6,7,8	Potential breeding habitat
40	-	-	-	-	-	nil	No likely foraging or breeding habitat
41	1	-31.377517 148.677182	31	34	1.74	1,3,4,5,6,7,8	Potential breeding habitat

Appendix 1. Habitat patch position, size, criteria met and status

Aerial Photo No.	Patch No.	Location of Patch	Updated map page	Updated area ID	Patch size (ha)	Criteria Met	Patch Status
41	2	-31.371657 148.678119	31	34	5.20	1,2,3,4,5,6,7,8	Potential breeding habitat
42	-	-	-	-	-	nil	No likely foraging or breeding habitat
43	-	-	-	-	-	nil	No likely foraging or breeding habitat
44	1	-31.289016 148.695574	32	35	1.21	1,2,3,4,5,6,7,8	Potential breeding habitat
45	1	-31.268259 148.724047	33	36	16.52	1,3,4,5,6,7,8	Potential breeding habitat
46	1	-31.265165 148.739048	34	Part of patch above		1,3,4,5,6,7,8	Potential breeding habitat
47	-	-	-	-	-	nil	No likely foraging or breeding habitat
48	1	-31.199721 148.771820	35	37	1.84	1,3,4,5,6,7,8	Potential breeding habitat
48	2	-31.191433 148.775858	35	38	0.95	1,3,4,5,6,7,8	Potential breeding habitat
48	3	-31.185299 148.780388	35	39	21.07	1,3,4,5,6,7,8	Potential breeding habitat
49	1	-31.173910 148.787053	35	Part of patch above		1,3,4,5,6,7,8	Potential breeding habitat
49	2	-31.163197 148.791262	35	40	0.5	1,3,4,5,6,7,8	Potential breeding habitat
49	3	-31.154104 148.794150	37	41	6.3	1,3,4,5,6,7,8	Potential breeding habitat
50	-	-	-	-	-	nil	No likely foraging or breeding habitat
51	-	-	-	-	-	nil	No likely foraging or breeding habitat
52	-	-	-	-	-	nil	No likely foraging or breeding habitat
53	1	-31.072579 148.841200	38	42	4.56	1,3,4,5,6,7,8	Potential breeding habitat
54	1	-31.042216 148.831482	40	43	1.32	1,3,4,5,6,7,8	Potential breeding habitat

Appendix 1. Habitat patch position, size, criteria met and status

Aerial Photo No.	Patch No.	Location of Patch	Updated map page	Updated area ID	Patch size (ha)	Criteria Met	Patch Status
55	-	-	-	-	-	nil	No likely foraging or breeding habitat
56	-	-	-	-	-	nil	No likely foraging or breeding habitat
57	1	-30.951540 148.853930	41	44	1.41	1,3,4,5,6,7,8	Potential breeding habitat
58	1	-30.917447 148.873355	42	45	0.92	1,2,3,4,5,6,7,8	Potential breeding habitat
58	2	-30.911198 148.884592	42	46	0.26	1,3,4,5,6,7,8	Potential breeding habitat
59	1	-30.900628 148.909499	43	47	4.79	1,3,4,5,6,7,8	Potential breeding habitat
60	1	-30.900409 148.912896		Part of patch above		1,3,4,5,6,7,8	Potential breeding habitat
61	1	-30.889991 148.938040	44	48	0.27	1,3,4,5,6,7,8	Potential breeding habitat
61	2	-30.881580 148.958973	45	49	0.69	1,3,4,5,6,7,8	Potential breeding habitat
62	-	-	-	-	-	nil	No likely foraging or breeding habitat
63	-	-	-	-	-	nil	No likely foraging or breeding habitat
64	1	-30.876062 149.022922	47	50	9.17	1,3,5,6,7,8	Potential breeding habitat
65	1	-30.874562 149.041210	48	51	24.24	1,2,3,5,6,7,8	Potential breeding habitat
66	1	-30.862915 149.067378	48	52, 53	24.93	1,2,3,5,6,7,8	Potential breeding habitat
67	1	-30.837387 149.086388	50	54	20.34	1,2,3,5,6,7,8	Potential breeding habitat
68	1	-30.812828 149.093674	51	55	26.44	1,2,3,5,6,7,8	Potential breeding habitat
69	1	-30.778468 149.105288	52	56	28.81	1,3,5,7,8	Potential breeding habitat
70	1	-30.754347 149.113782	53	57	24.35	1,2,3,5,7,8	Potential breeding habitat

Appendix 1. Habitat patch position, size, criteria met and status

Aerial Photo No.	Patch No.	Location of Patch	Updated map page	Updated area ID	Patch size (ha)	Criteria Met	Patch Status
71	1	-30.723579 149.140754	54	58	21.42	1,2,3,5,7,8	Potential breeding habitat
72	1	-30.704949 149.156471	55	59	10.42	1,2,3,5,7,8	Potential breeding habitat
72	2	-30.696075 149.169399	56	60	9.69	1,2,3,5,7,8	Potential breeding habitat
73	1	-30.694509 149.175992	56	61	3.5	1,3,5,7,8	Potential breeding habitat
73	2	-30.689606 149.190317	56	62	19.34	1,3,5,7,8	Potential breeding habitat
74	1	-30.683187 149.210205	57	63	28.36	1,3,5,7,8	Potential breeding habitat
75	1	-30.678579 149.224593	58	64	6.42	1,3,5,7,8	Potential breeding habitat
75	2	-30.674234 149.238098	58	65	13.44	1,3,5,7,8	Potential breeding habitat
76	1	-30.668046 149.257415	59	66	17.4	1,2,3,5,7,8	Potential breeding habitat
77	1	-30.662830 149.273206	59	67	7.69	1,2,3,5,7,8	Potential breeding habitat
77	2	-30.658163 149.286298	60	68	12.76	1,2,3,5,7,8	Potential breeding habitat
78	1	-30.652881 149.293912	60	69	1.77	1,3,5,7,8	Potential breeding habitat
78	2	-30.645048 149.305746	61	70	21.24	1,2,3,5,7,8	Potential breeding habitat
78	3	-30.640835 149.314939	61	71	1.22	1,2,3,5,7,8	Potential breeding habitat
79	1	-30.639164 149.318731	62	72	4.44	1,3,5,7,8	Potential breeding habitat
79	2	-30.632739 149.332859	62	73	14.81	1,2,3,5,7,8	Potential breeding habitat
80	1	-30.623081 149.354288	63	74	33.16	1,3,5,7,8	Potential breeding habitat
81	1	-30.617404 149.370727	64	75	8.56	1,3,5,7,8	Potential breeding habitat

Appendix 1. Habitat patch position, size, criteria met and status

Aerial Photo No.	Patch No.	Location of Patch	Updated map page	Updated area ID	Patch size (ha)	Criteria Met	Patch Status
81	2	-30.612430 149.38474	64	76	12.46	1,3,5,7,8	Potential breeding habitat
82	1	-30.607744 149.401239	65	77	16.4	1,2,3,5,7,8	Potential breeding habitat
83	1	-30.585897 149.433199	66	78	15.38	1,2,3,5,7,8	Potential breeding habitat
84	1	-30.580969 149.441241	67	79	11.3	1,2,3,5,7,8	Potential breeding habitat
84	2	-30.566848 149.457054	67	80	16.9	1,2,3,5,7,8	Potential breeding habitat
85	1	-30.552309 149.472990	68	81	18.71	1,3,5,7,8	Potential breeding habitat
86	1	-30.539541 149.494699	69	82	18.17	1,2,3,5,7,8	Potential breeding habitat
87	1	-30.526693 149.524278	70	83	23.82	1,3,5,7,8	Potential breeding habitat
88	1	-30.516533 149.544715	71	84	17.62	1,3,5,7,8	Potential breeding habitat
89	1	-30.505174 149.569551	72	85	15.6	1,3,5,7,8	Potential breeding habitat
89	2	-30.512284 149.558253	73	86	17.23	1,3,5,7,8	Potential breeding habitat
90	1	-30.494550 149.592623		Part of patch above		1,3,5,7,8	Potential breeding habitat
91	1	-30.489432 149.605107	73	87	6.78	1,3,5,6,7,8	Potential breeding habitat
92	-	-	-	-	-	nil	No likely foraging or breeding habitat
93	1	-30.463028 149.658864	75	88	6.44	1,3,4,5,6,7,8	Potential breeding habitat
93	2	-30.453765 149.663193	75	89	1.58	1,3,4,5,6,7,8	Potential breeding habitat
94				This map is a repeat of map 93.			
95	1	-30.445227 149.670391	76	90	22.13	1,2,3,4,5,6,7,8	Potential breeding habitat

Appendix 1. Habitat patch position, size, criteria met and status

Aerial Photo No.	Patch No.	Location of Patch	Updated map page	Updated area ID	Patch size (ha)	Criteria Met	Patch Status
96	1	-30.405518 149.701346	77	91	9.00	1,2,3,4,5,6,7,8	Potential breeding habitat
97	-	-	-	-	-	nil	No likely foraging or breeding habitat
98	-	-	-	-	-	nil	No likely foraging or breeding habitat
99	1	-30.327447 149.742093	78	92	0.29	1,2,3,4,5,6,7,8	Potential breeding habitat
100	1	-30.309597 149.767481	79	93	0.17	1,2,3,4,5,6,7,8	Potential breeding habitat
101	-	-	-	-	-	nil	No likely foraging or breeding habitat
102	-	-	-	-	-	nil	No likely foraging or breeding habitat
103	1	-32.338373 148.240096	80	94	3.26	1,3,4,5,6,7,8	Potential breeding habitat
104	-	-	-	-	-	nil	No likely foraging or breeding habitat
105	-	-	-	-	-	nil	No likely foraging or breeding habitat
106	-	-	-	-	-	nil	No likely foraging or breeding habitat
107	1	-31.976108 148.376053		Repeat of page 11		1,3,4,5,6,7,8	Potential breeding habitat
108	-	-	-	-	-	nil	No likely foraging or breeding habitat
109	-	-	-	-	-	nil	No likely foraging or breeding habitat
110	1	-30.411686 149.756024	81	95	2.12*	1,3,4,5,6,7,8	Potential breeding habitat
111	1	-30.946724 149.055913	82	96	0.31	1,3,4,5,6,7,8	Potential breeding habitat
			-	-	-		
TOTAL POTENTIAL FORAGING HABITAT					**17.97**		
TOTAL POTENTIAL BREEDING HABITAT					**822.99**		

* Note: This patch (Borrow Pit D) has been cleared, however, it is still showing as vegetated on aerial photos.

Appendix 2. Habitat maps

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NARROMINE TO NARRABRI

Appendix 2

Habitat areas and status

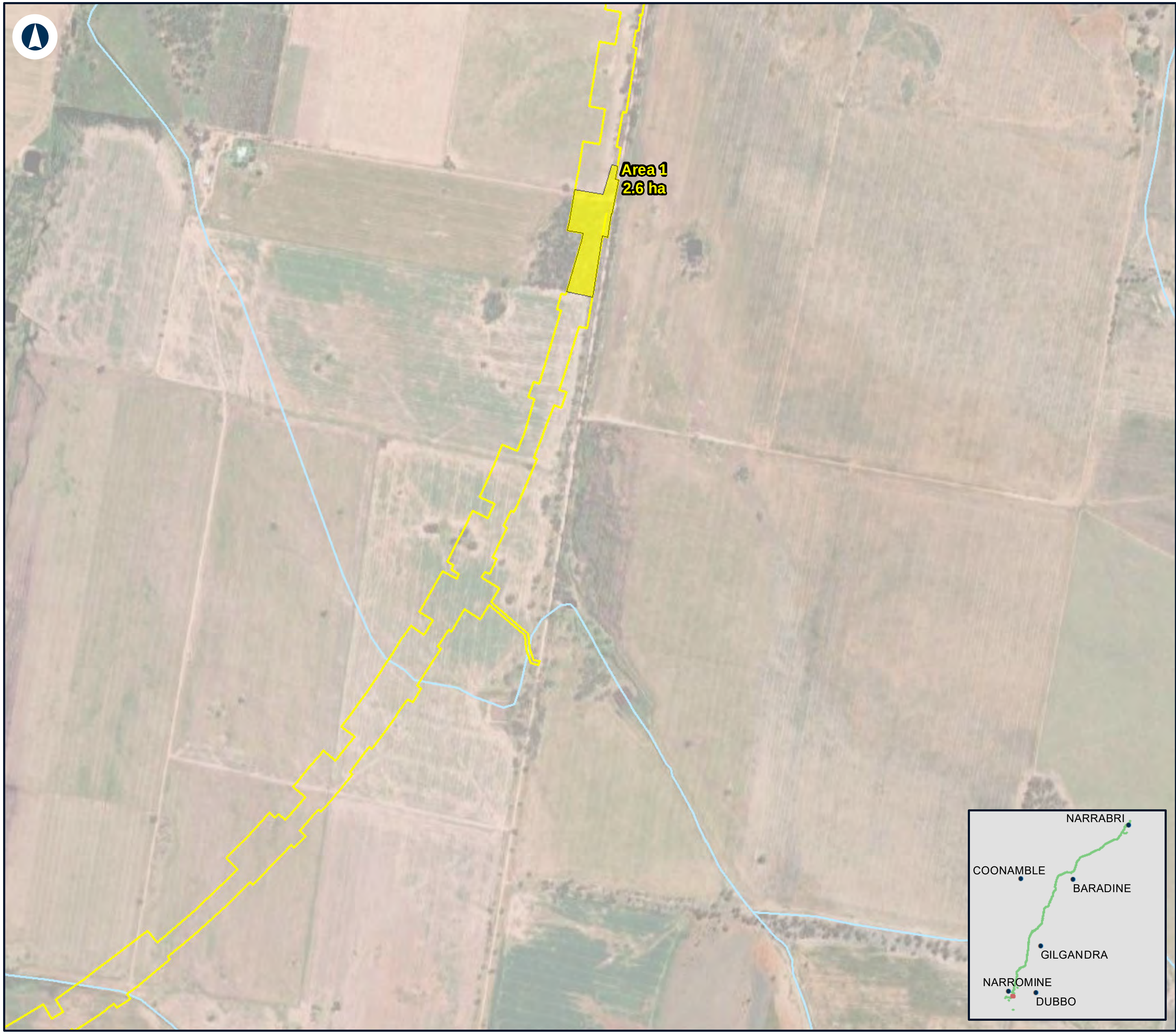
LEGEND

- Construction impact zone
- Little Eagle potential breeding habitat

0 250 500 Metres

Coordinate System: GDA 1994 MGA Zone 55

Date: 2021-11-30
Paper: A4
Author: JacobsGHD
Scale: 1:15,000
Data Sources: Basemap layers: NSWSS, esri;



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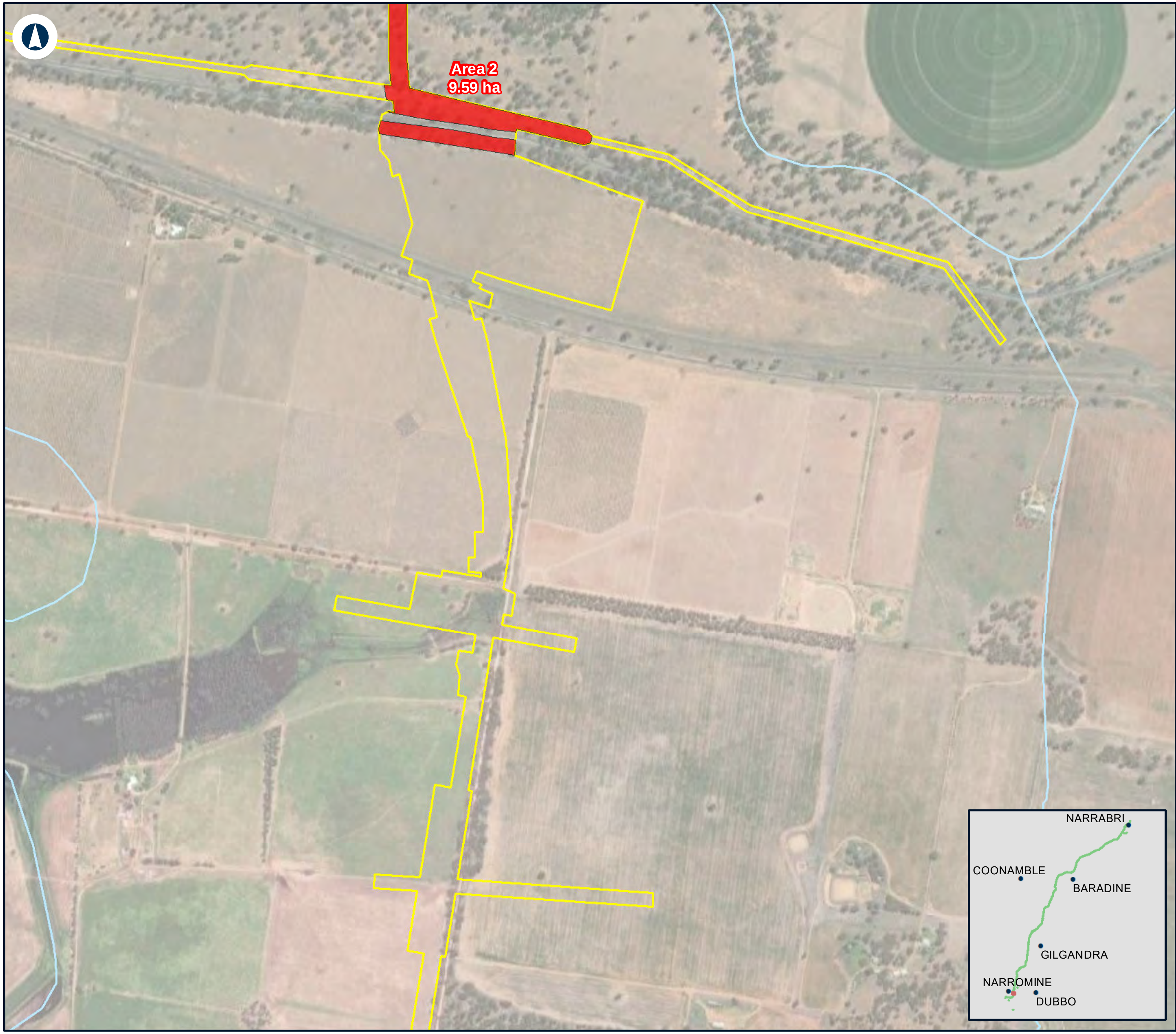

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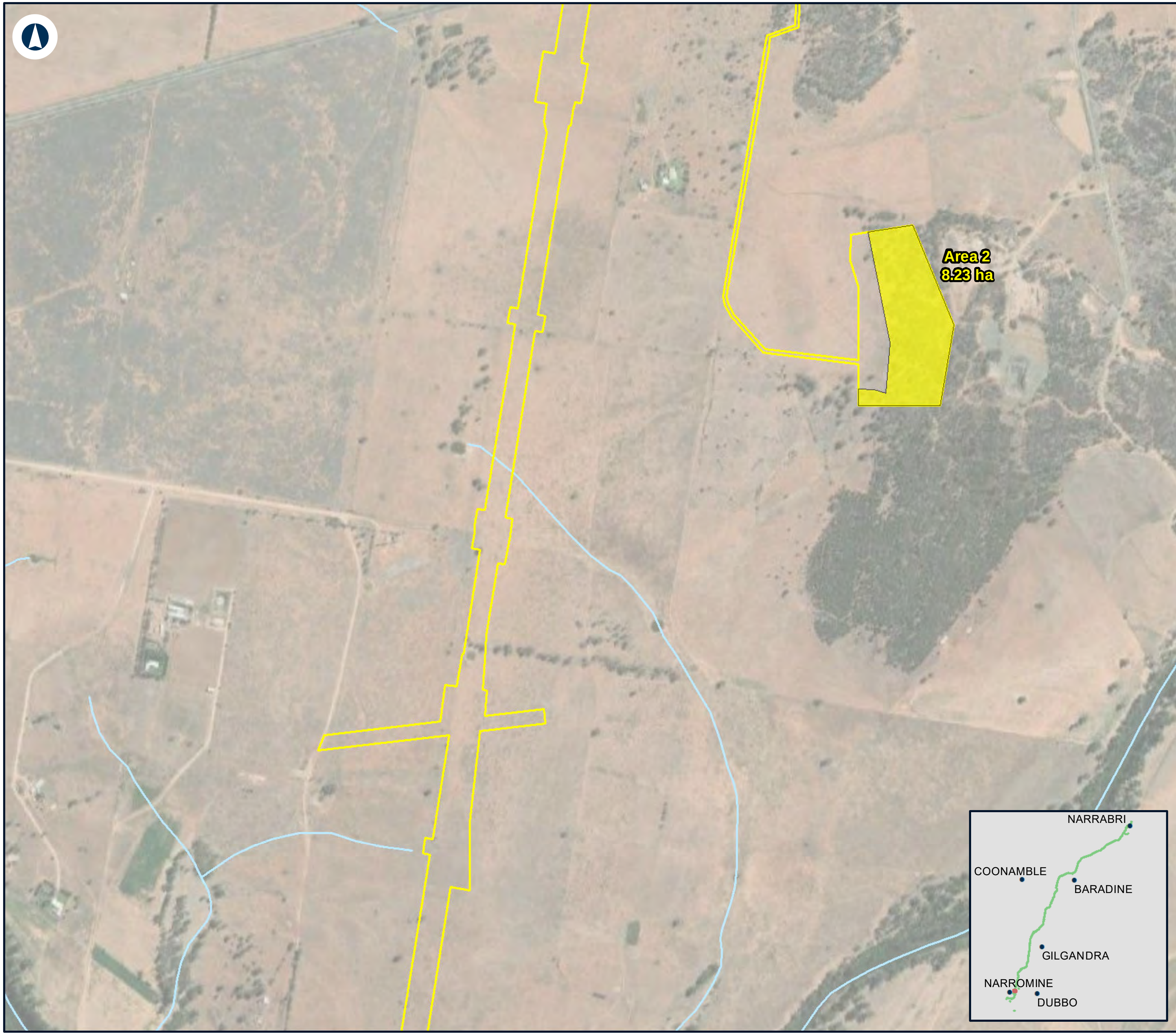

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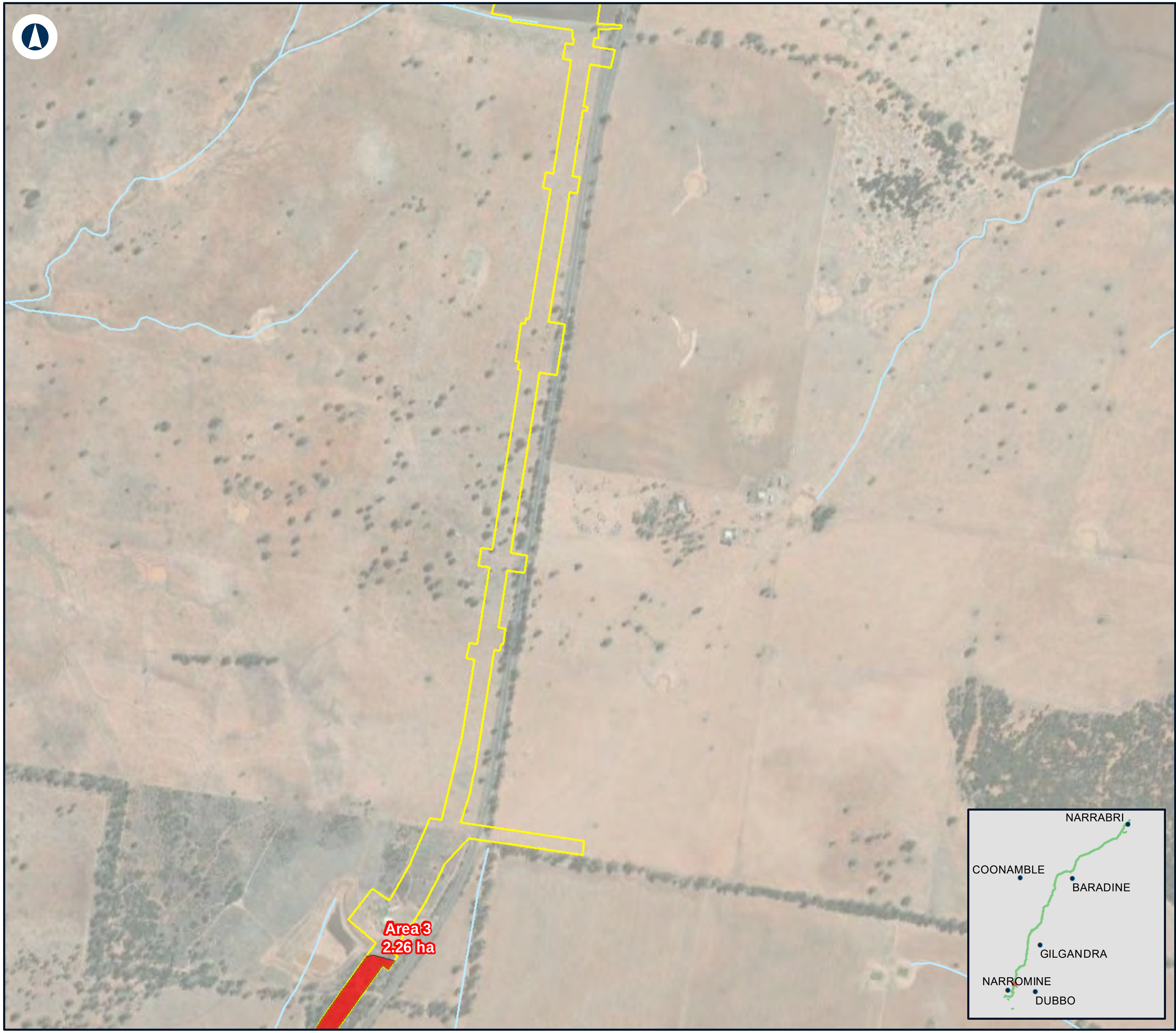

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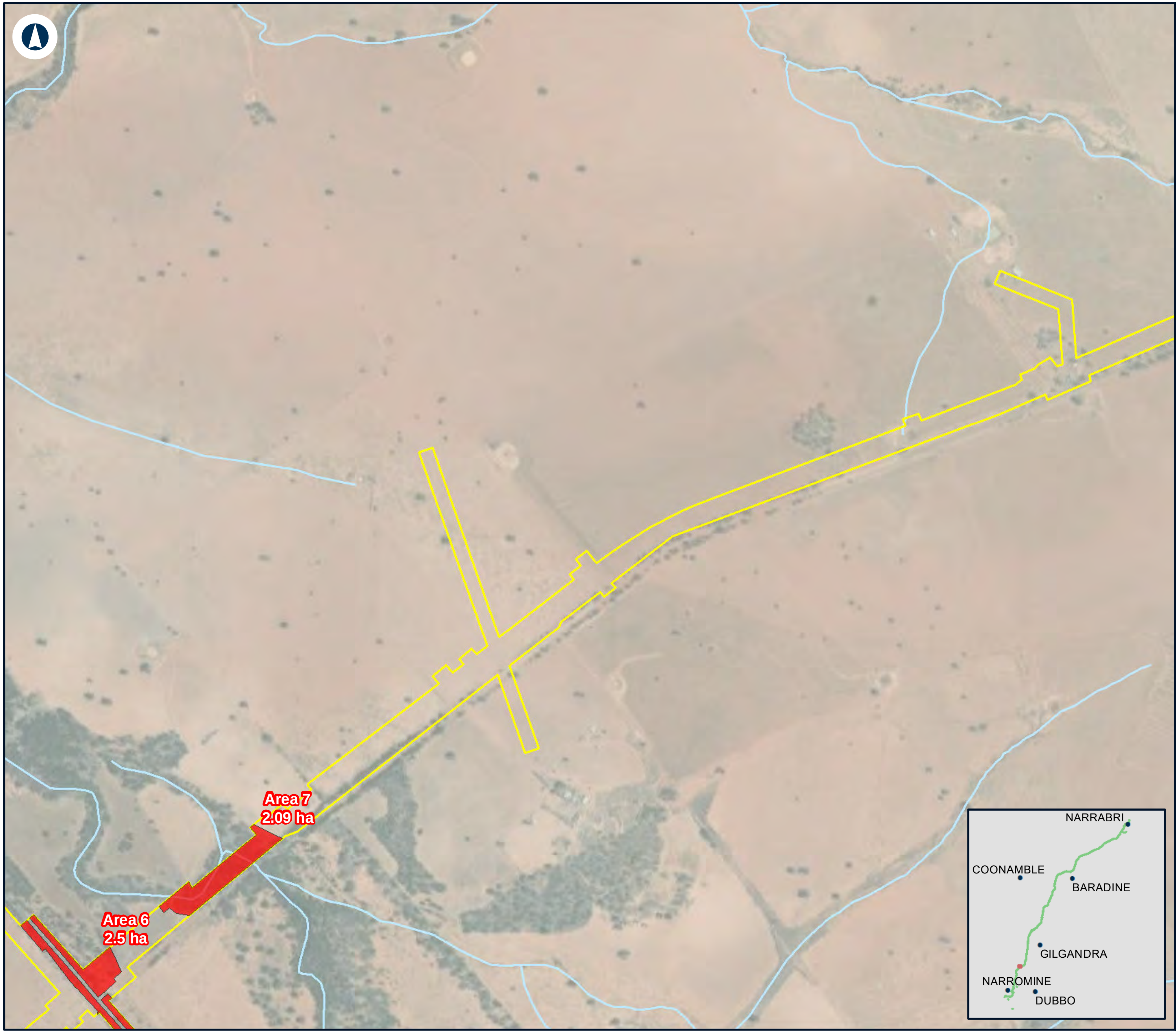

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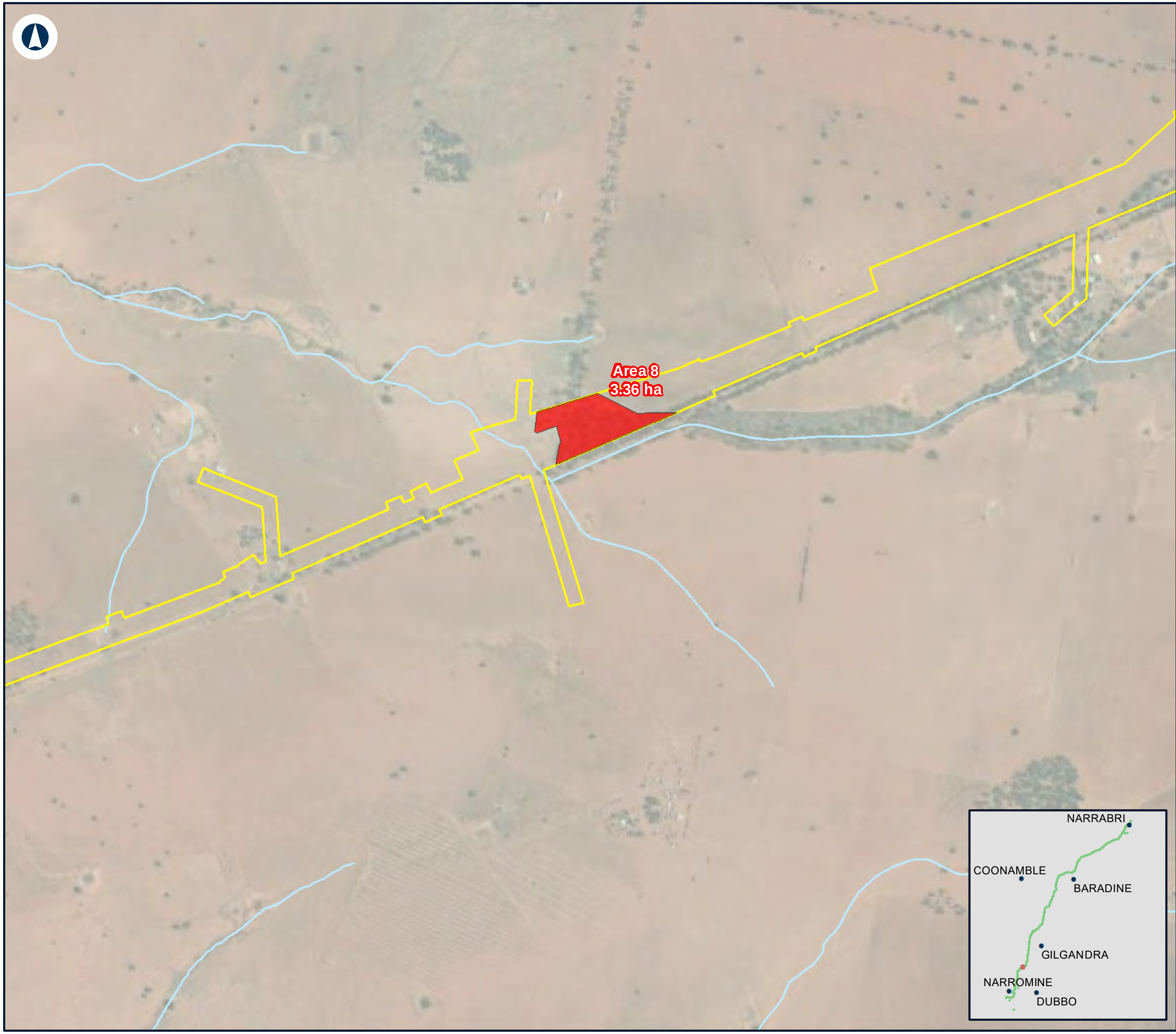

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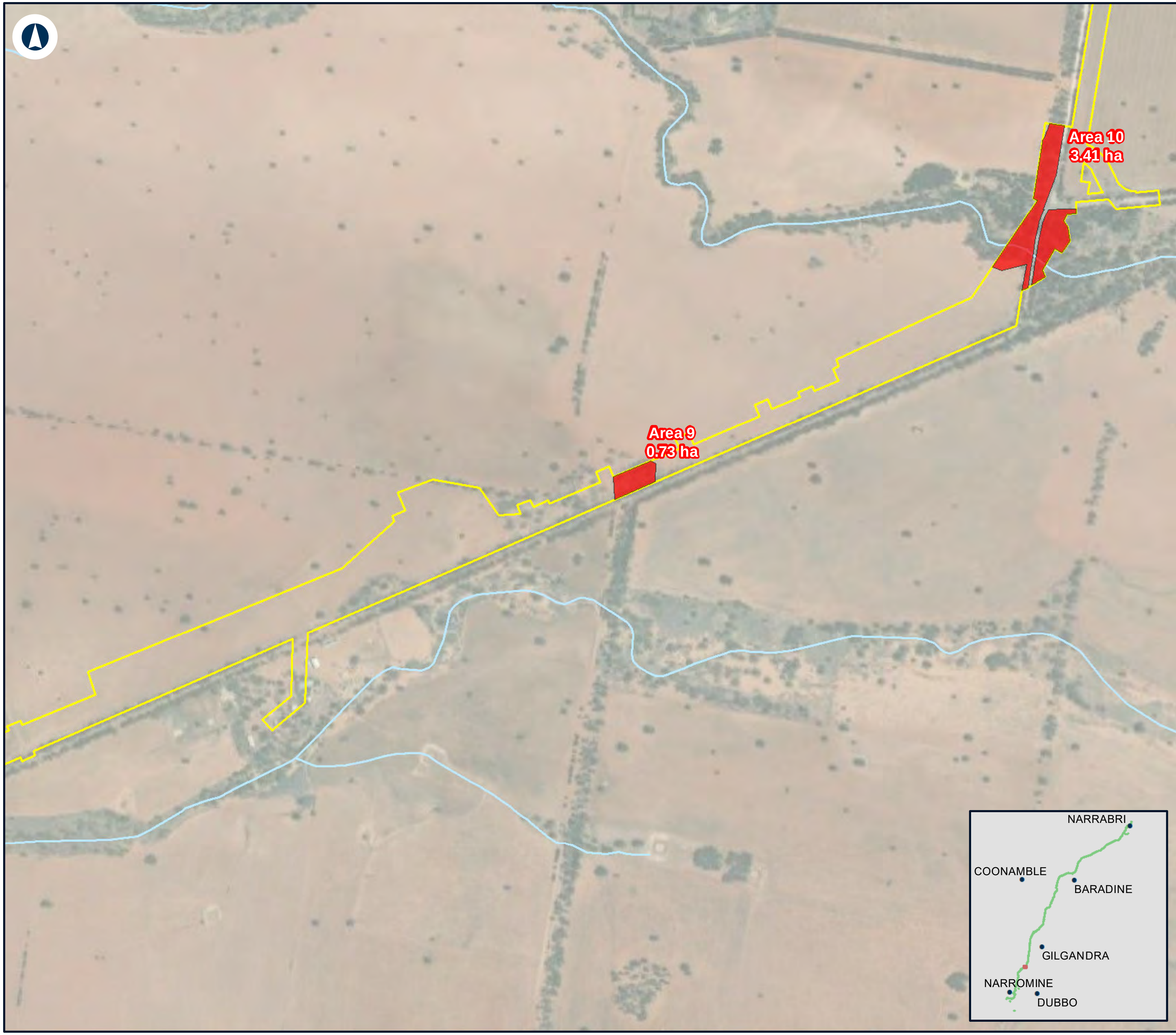

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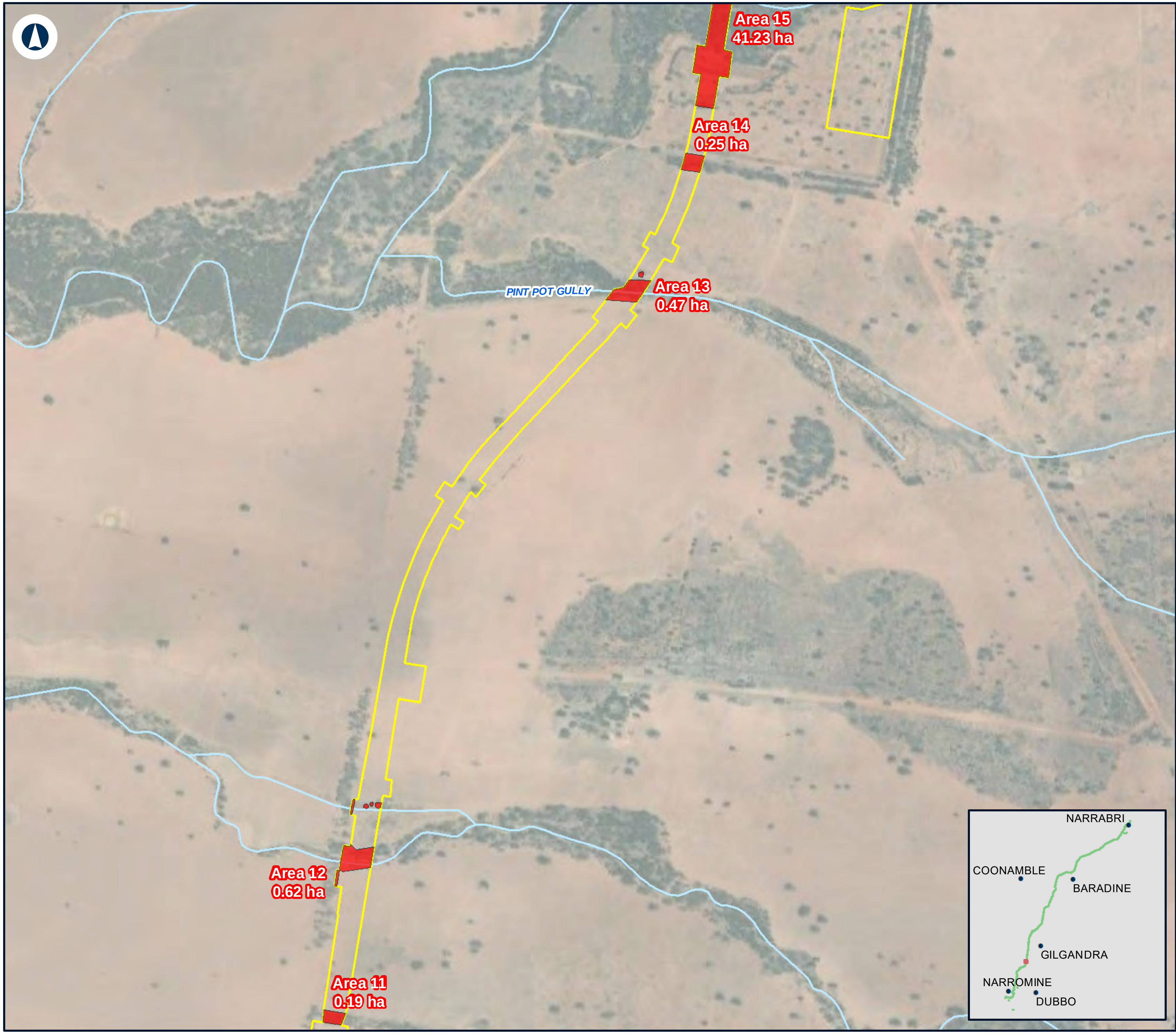

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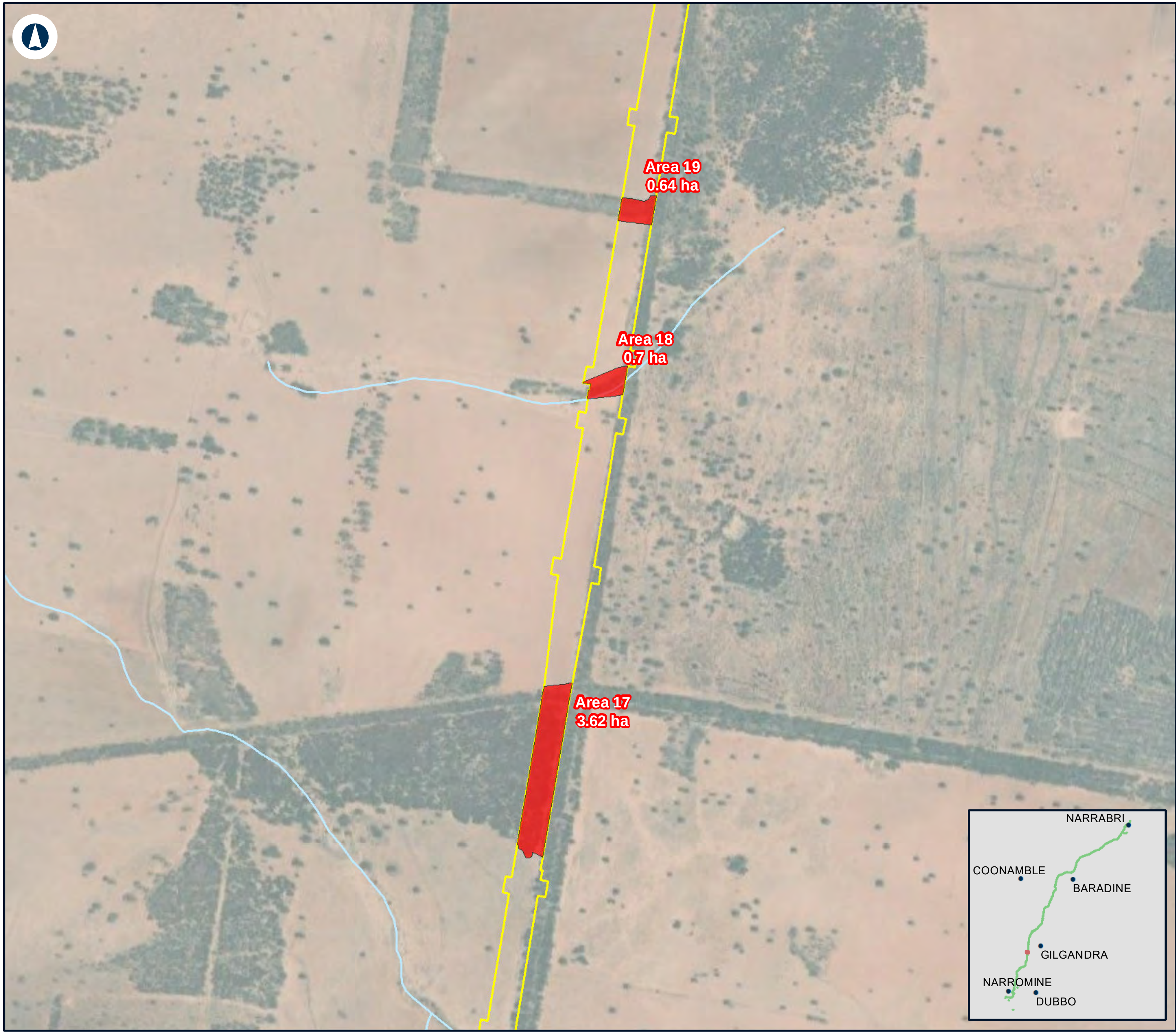

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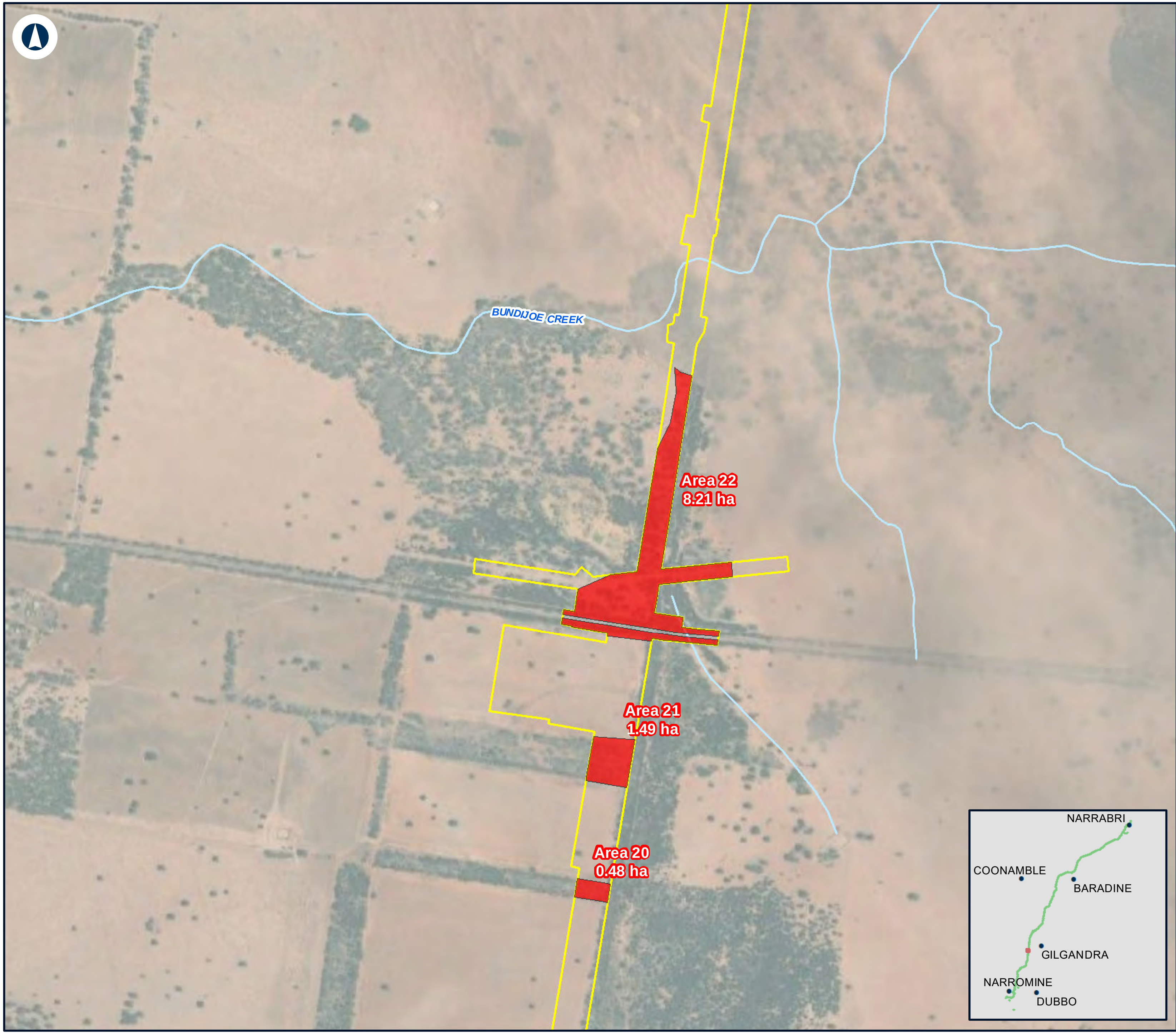

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NARROMINE TO NARRABRI

Appendix 2

Habitat areas and status

LEGEND

- Construction impact zone
- Little Eagle potential breeding habitat

0 250 500 Metres

Coordinate System: GDA 1994 MGA Zone 55

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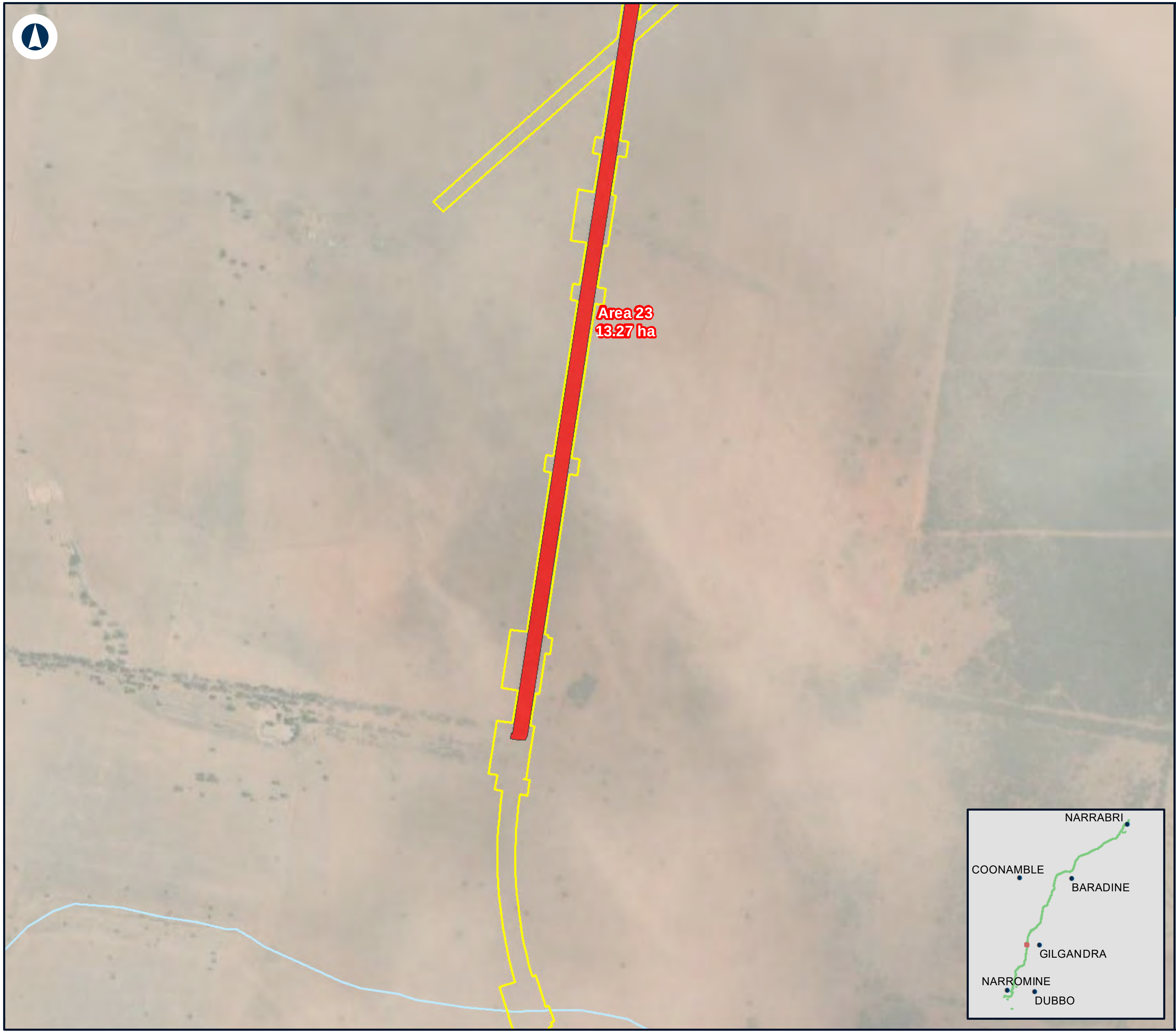

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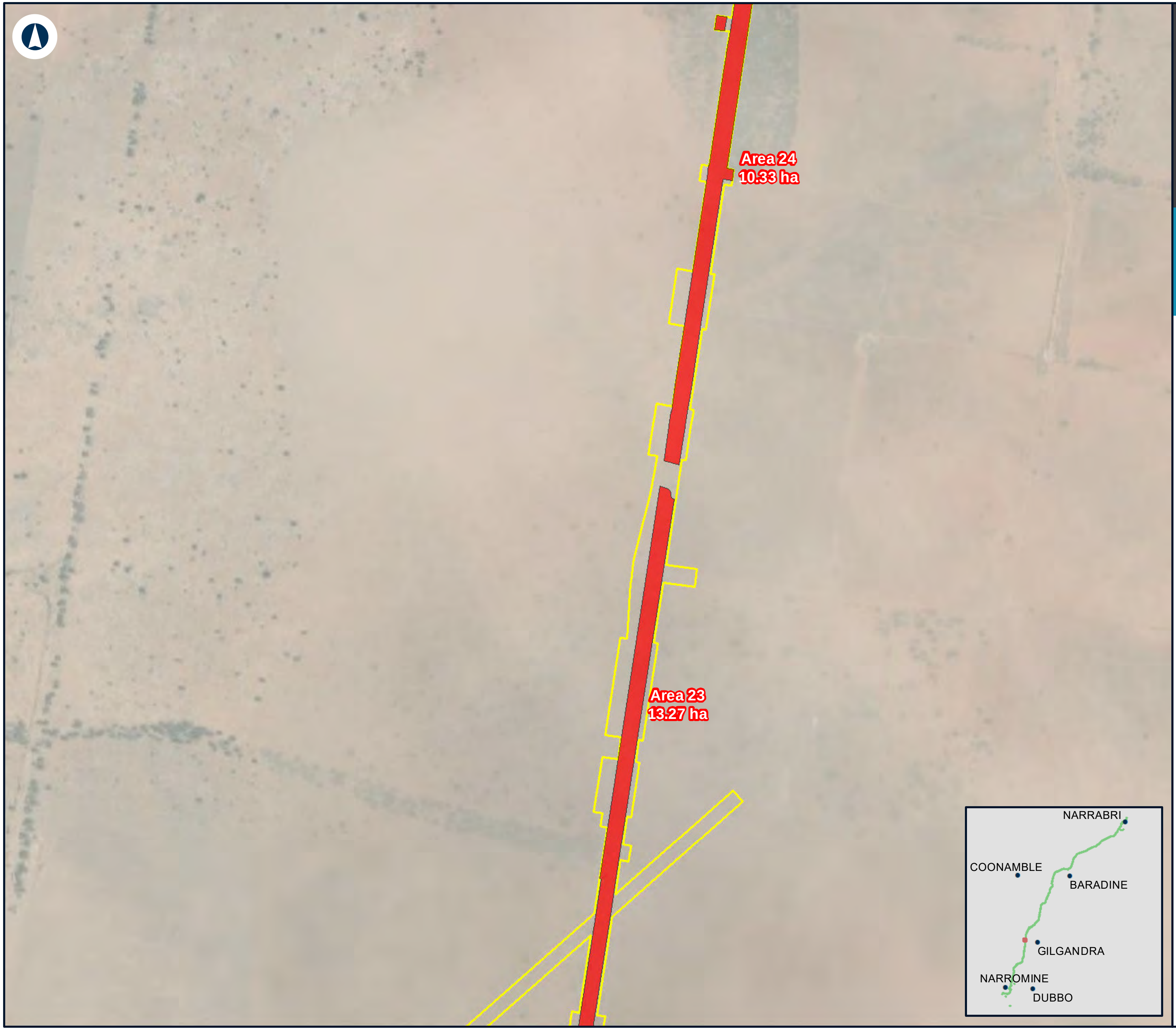

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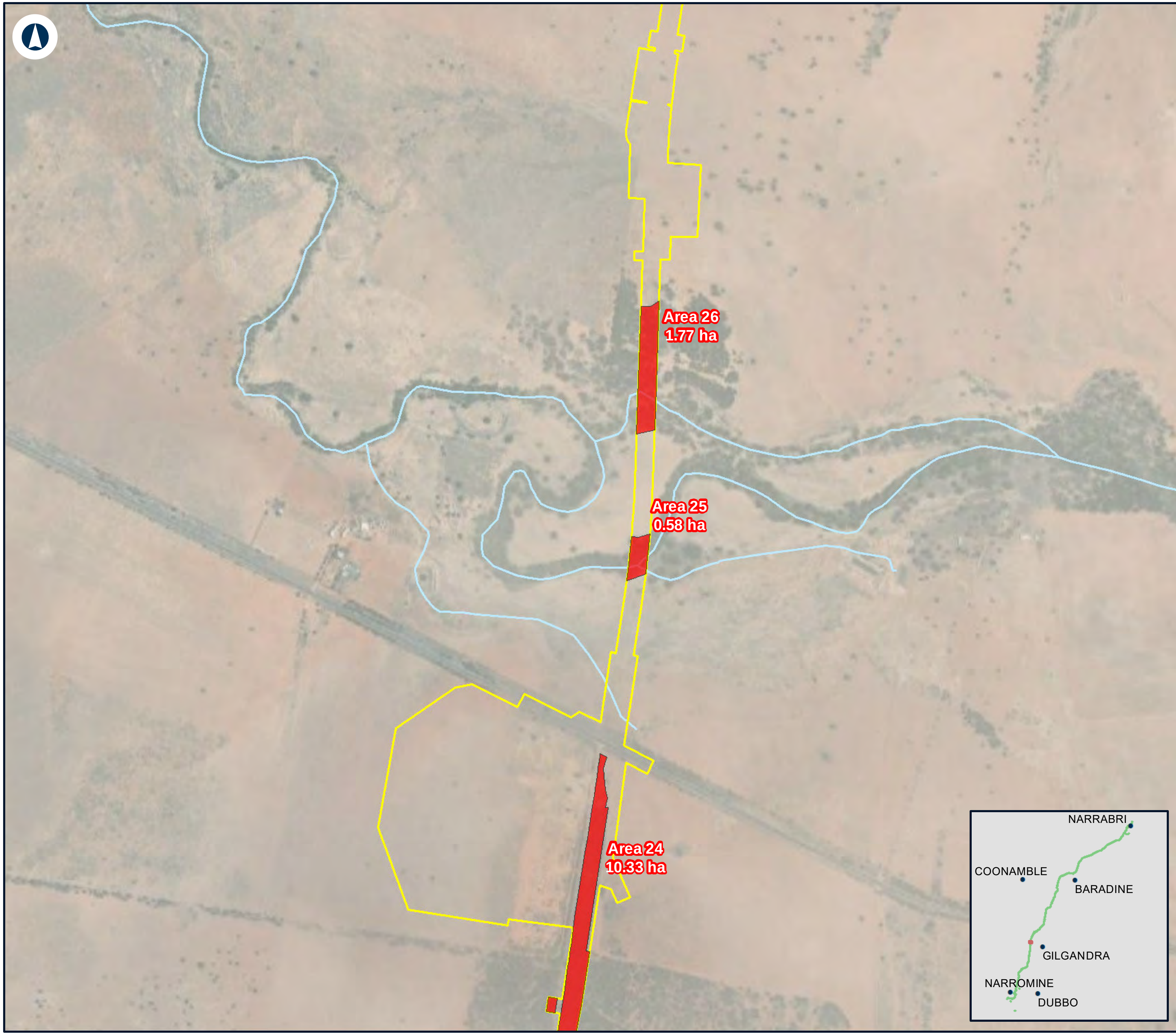

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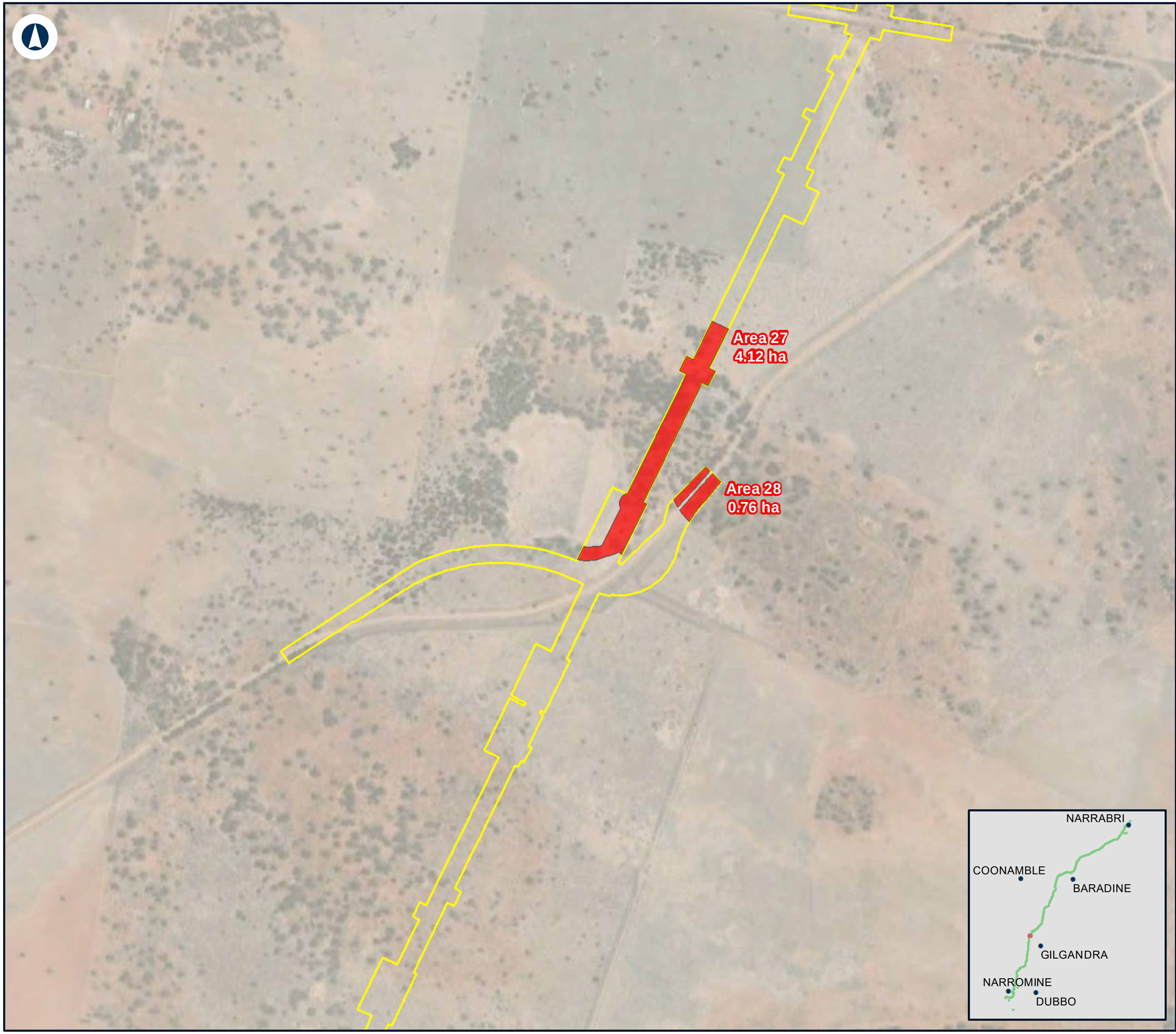

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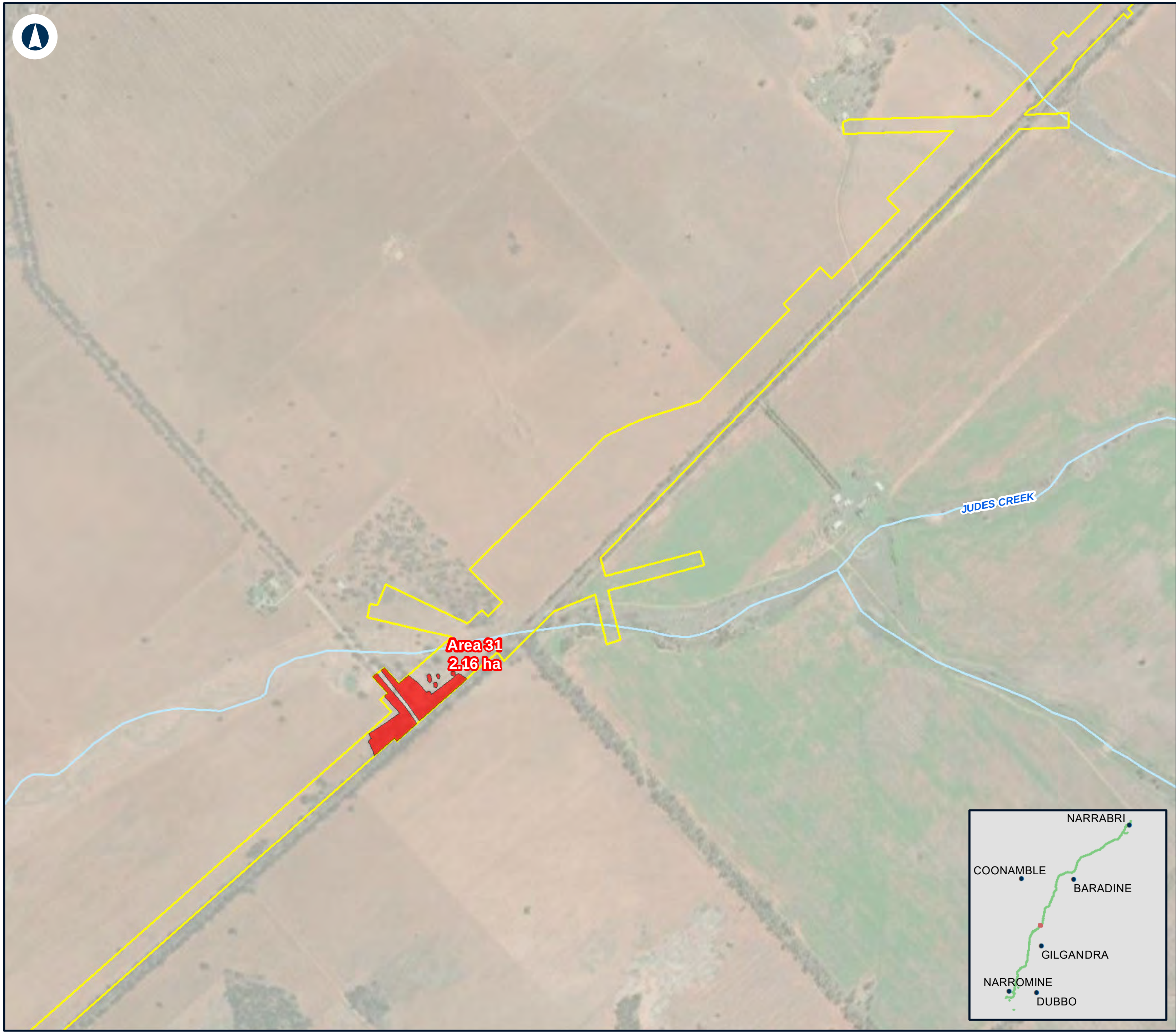

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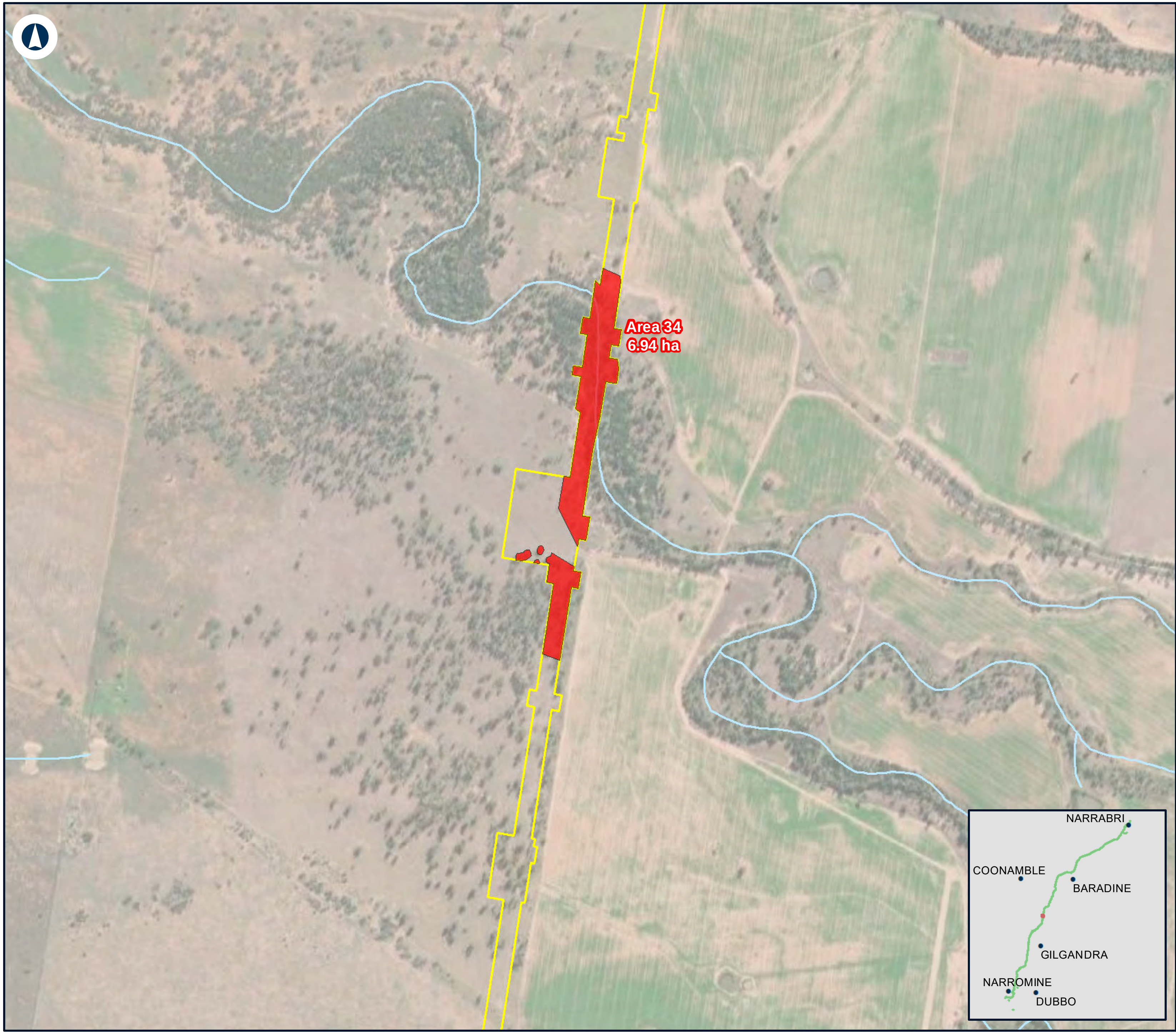

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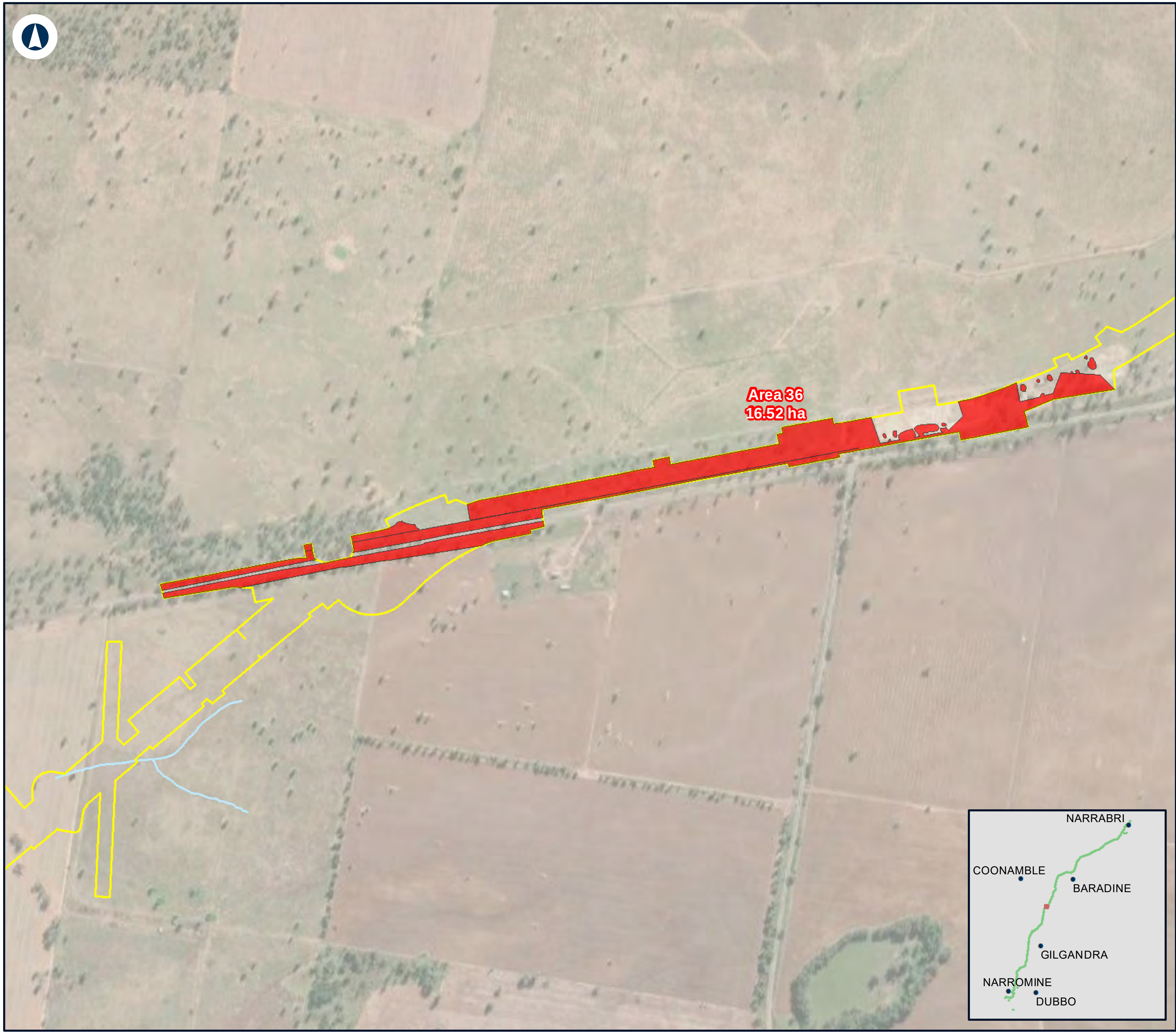

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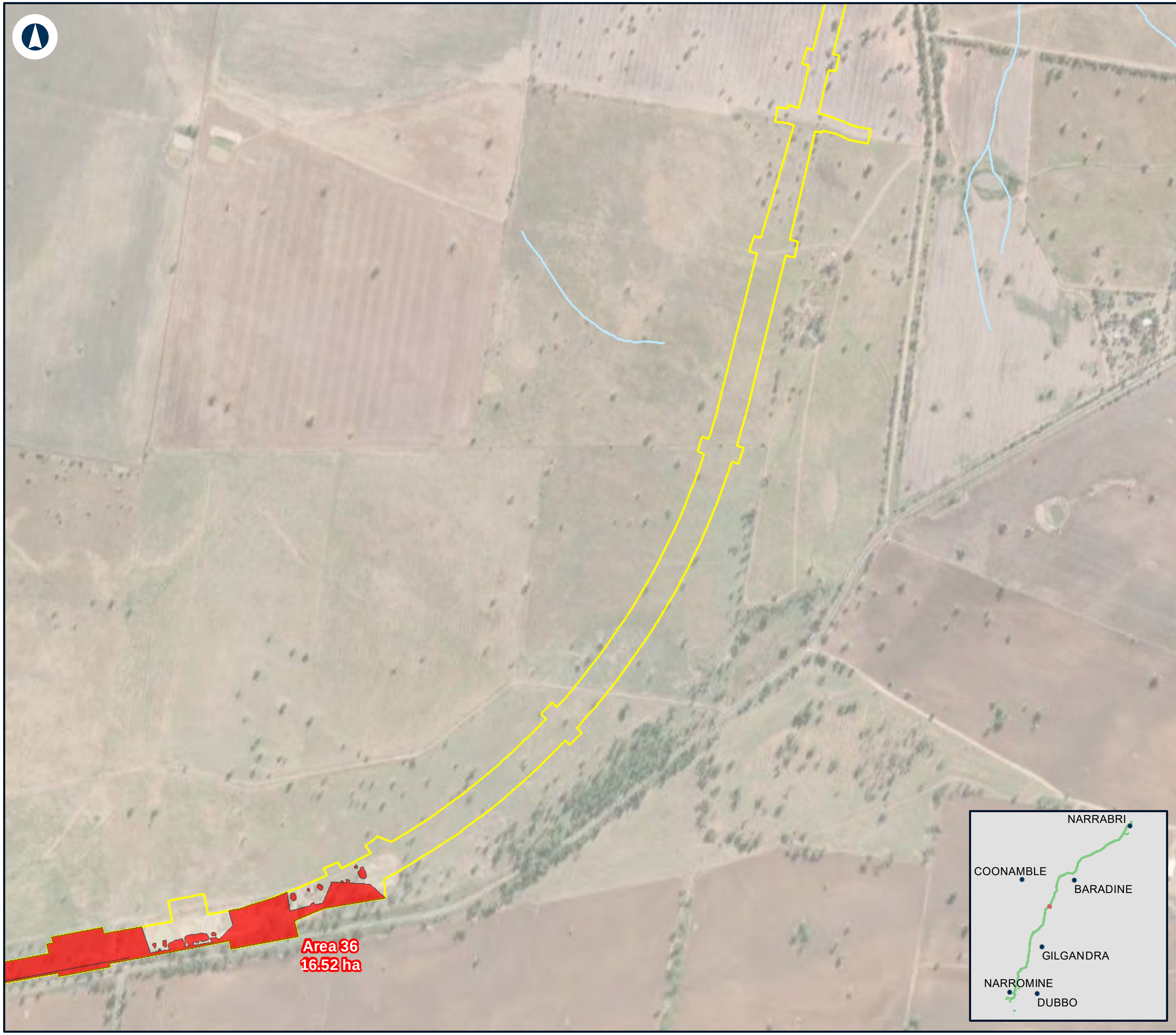

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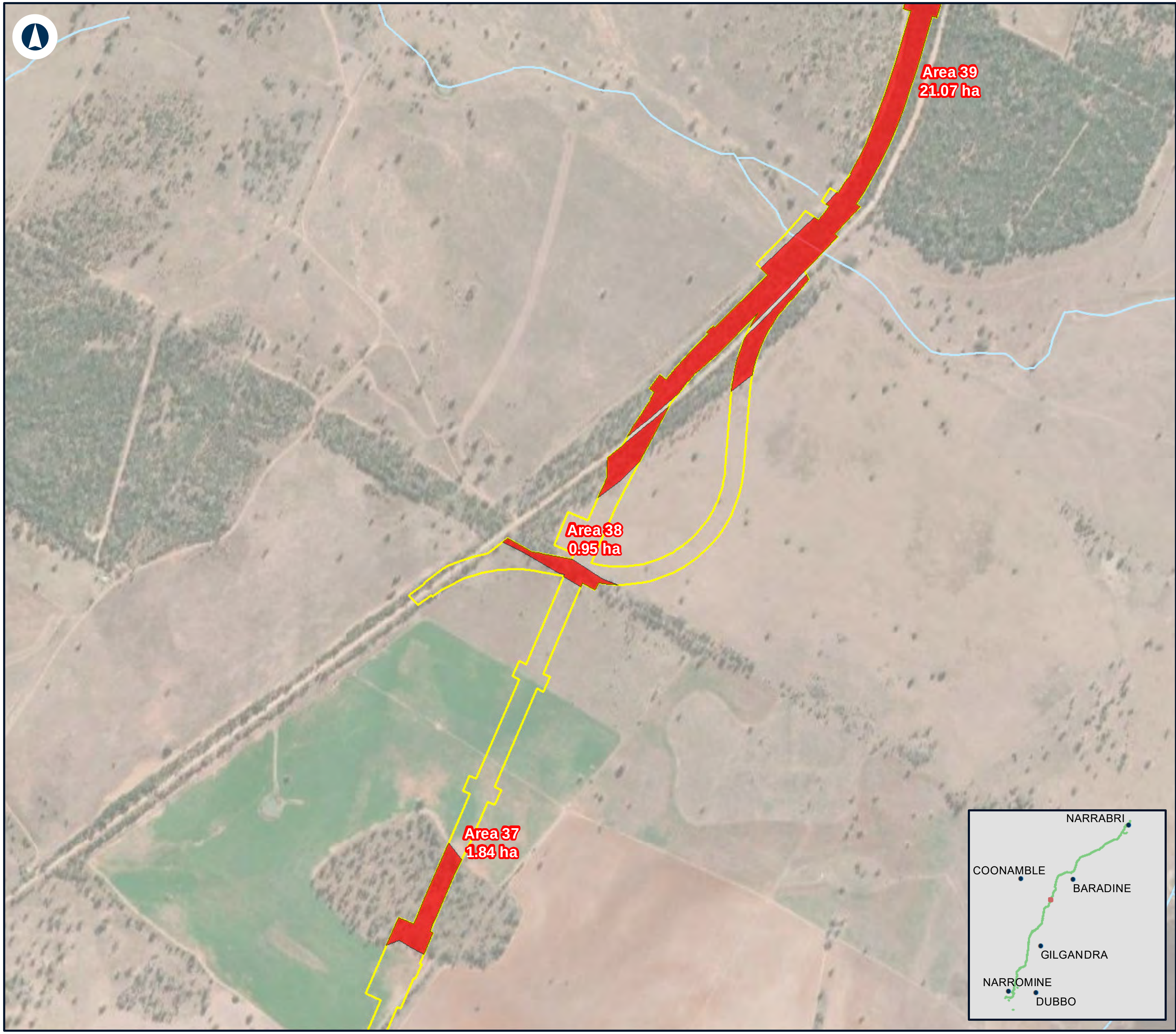

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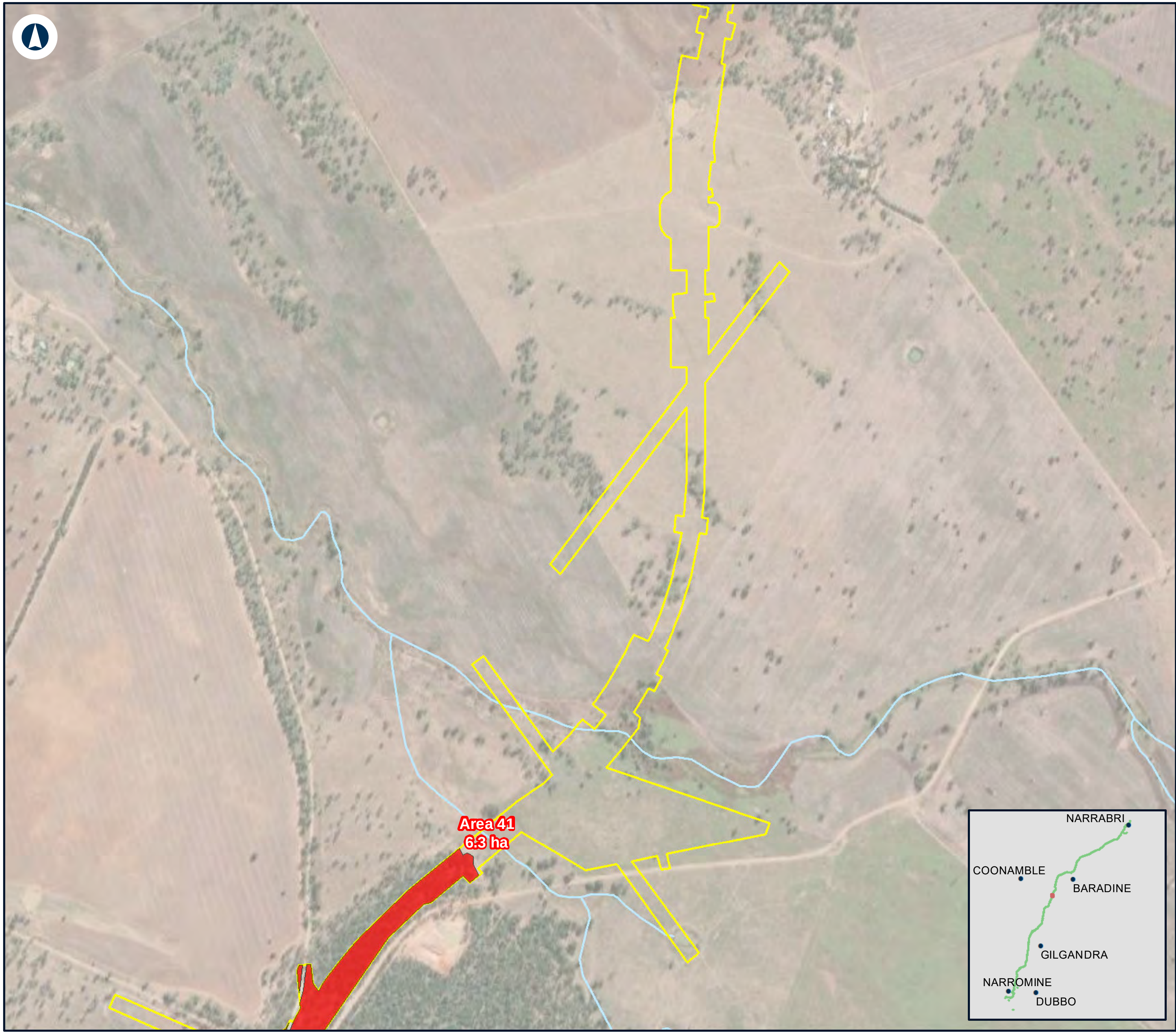

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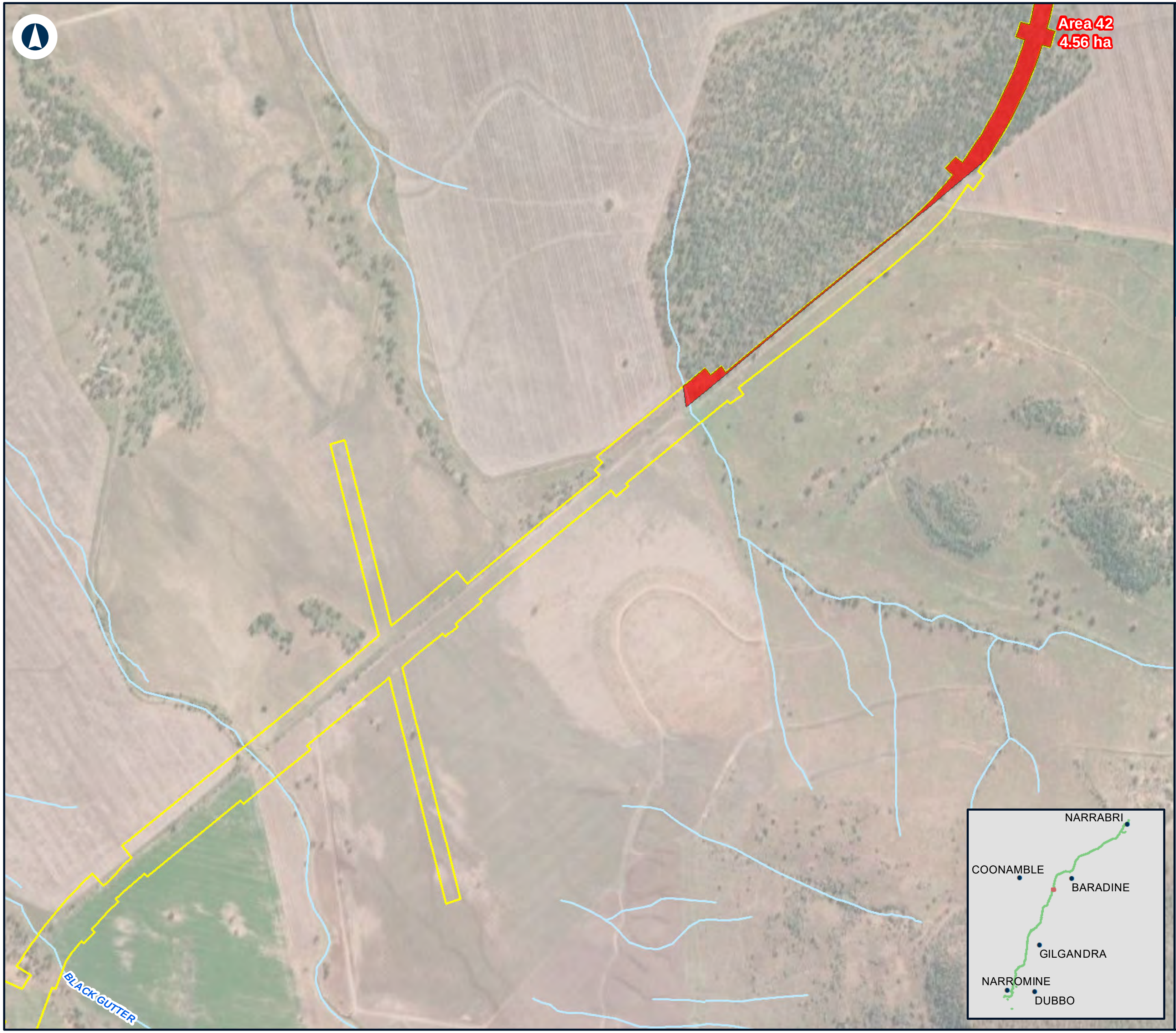

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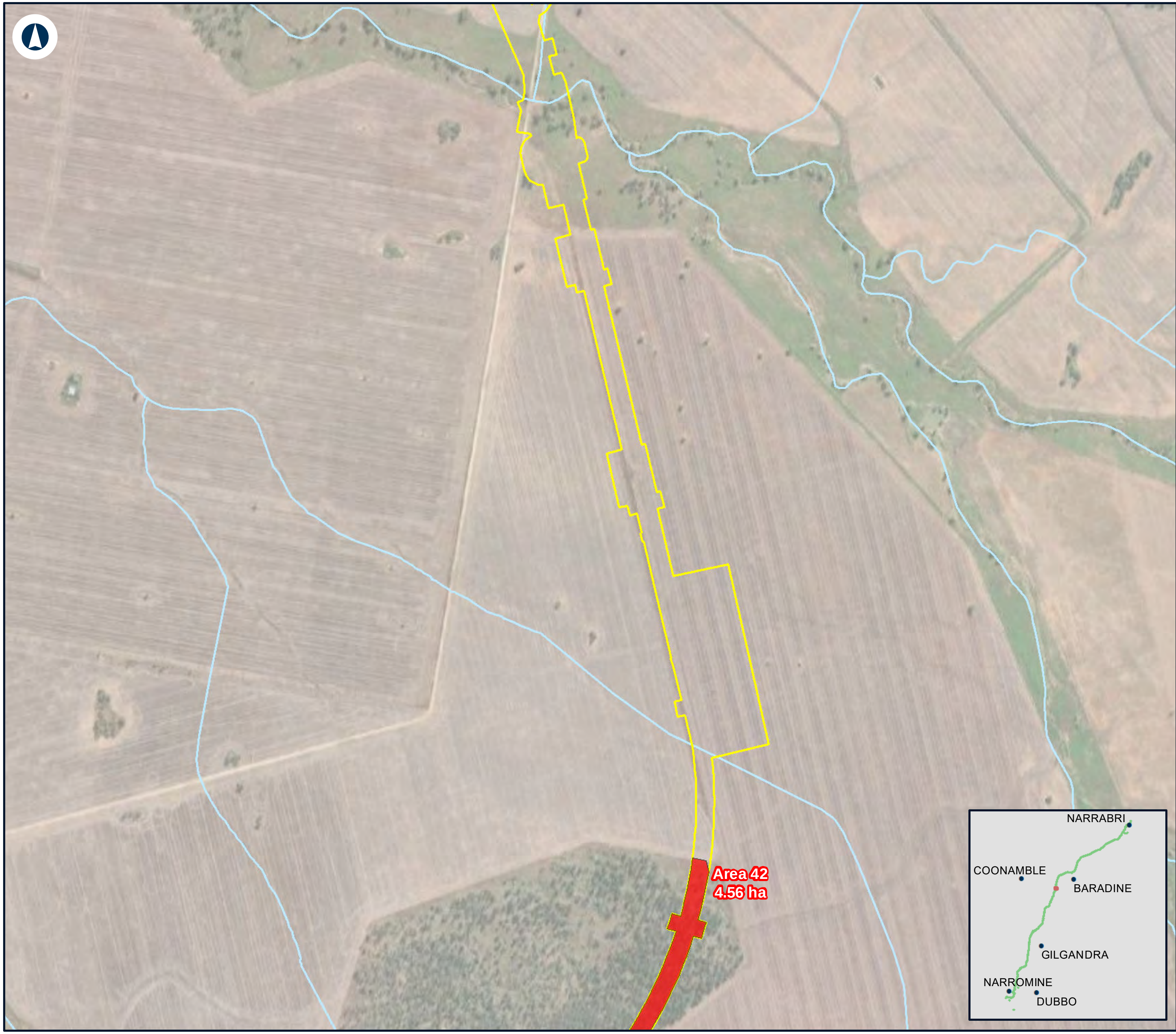

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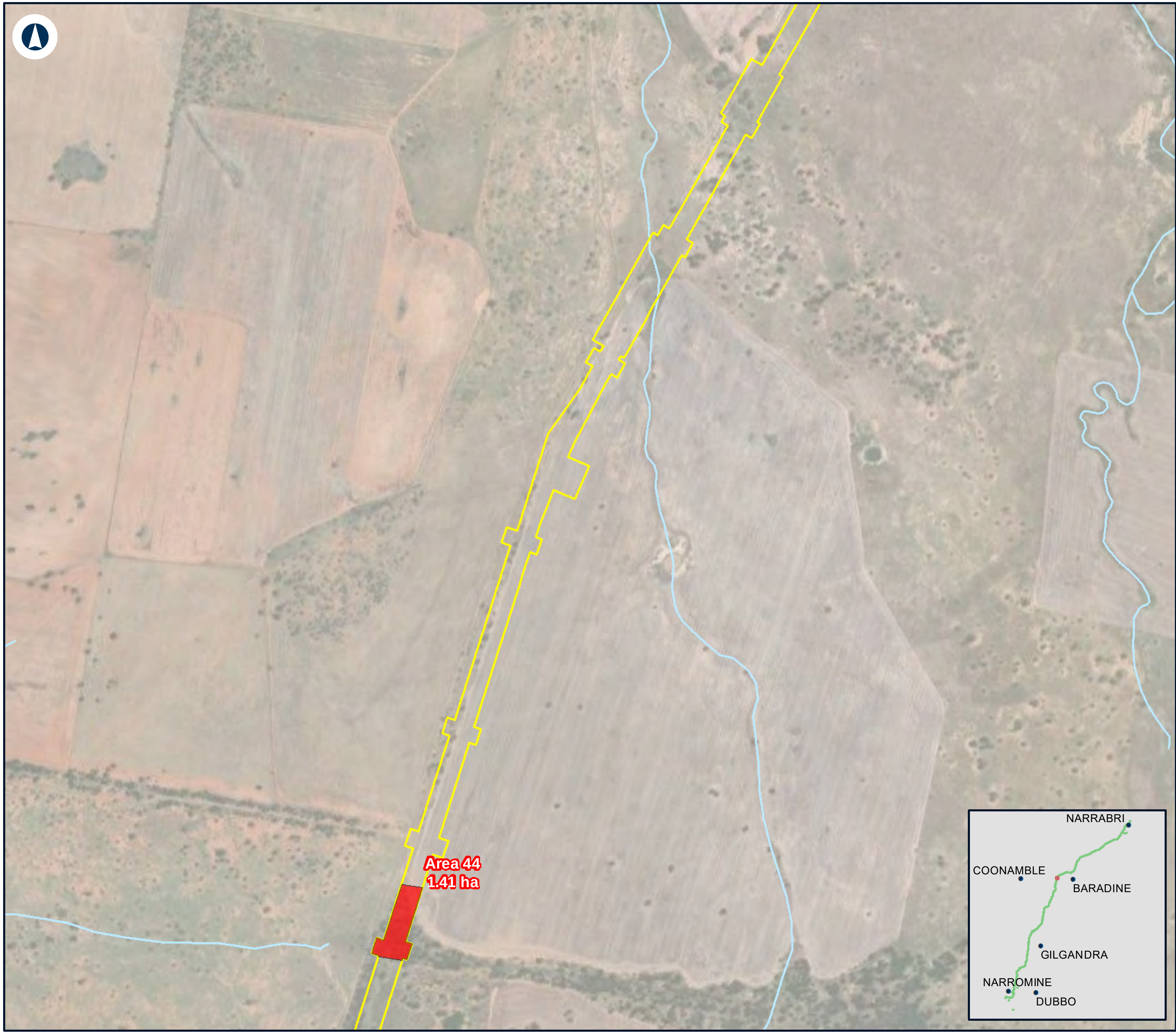

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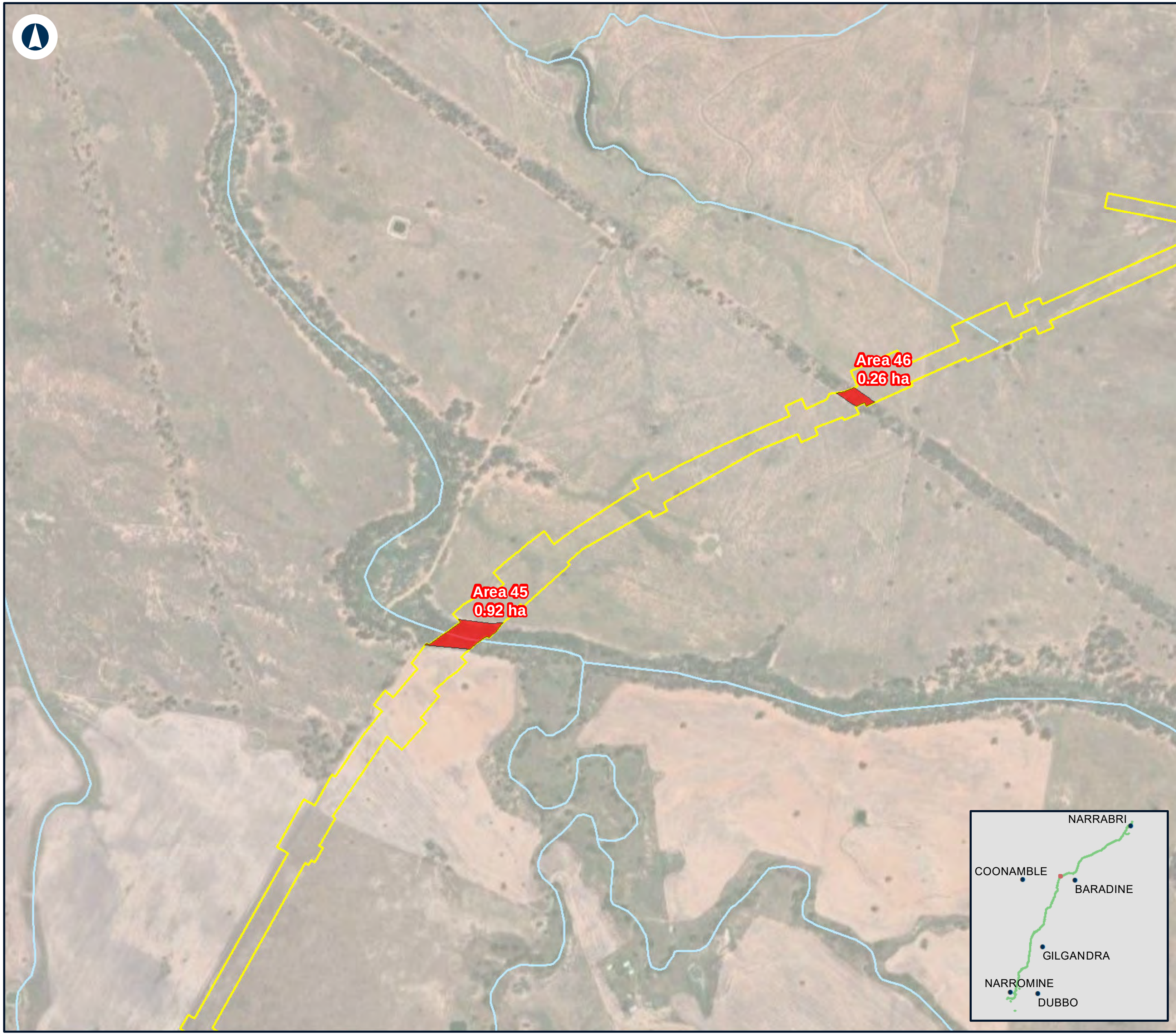

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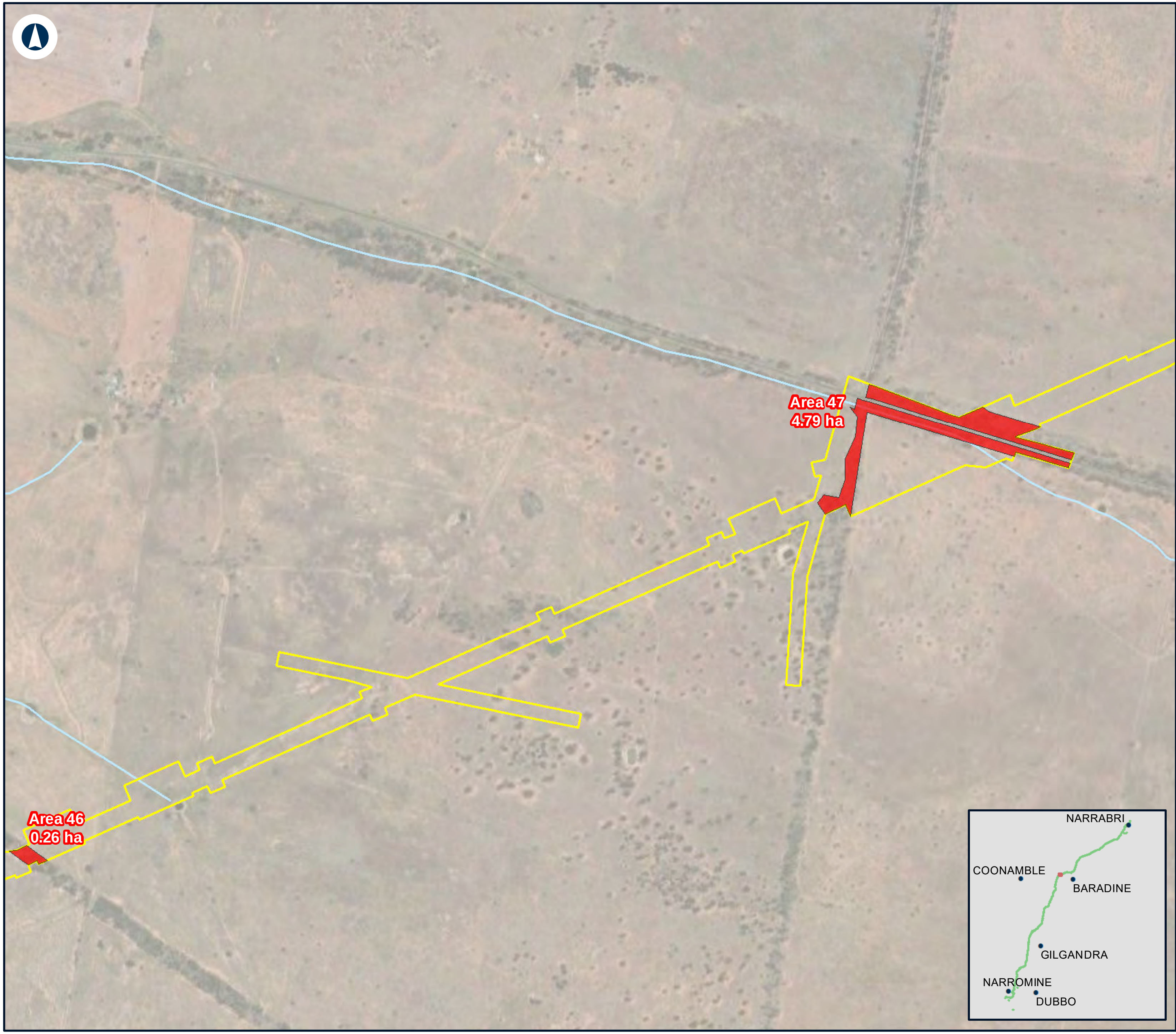

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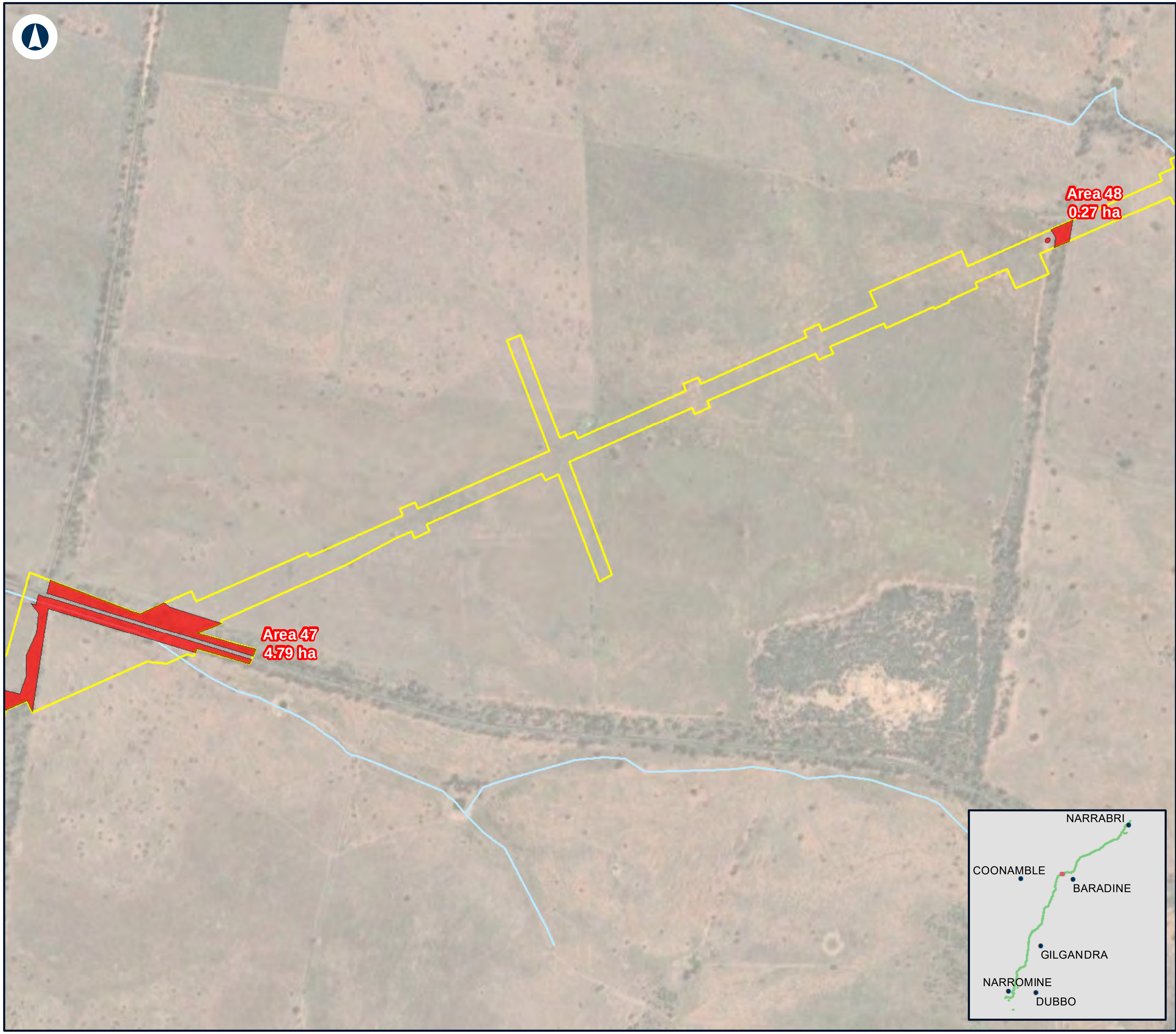

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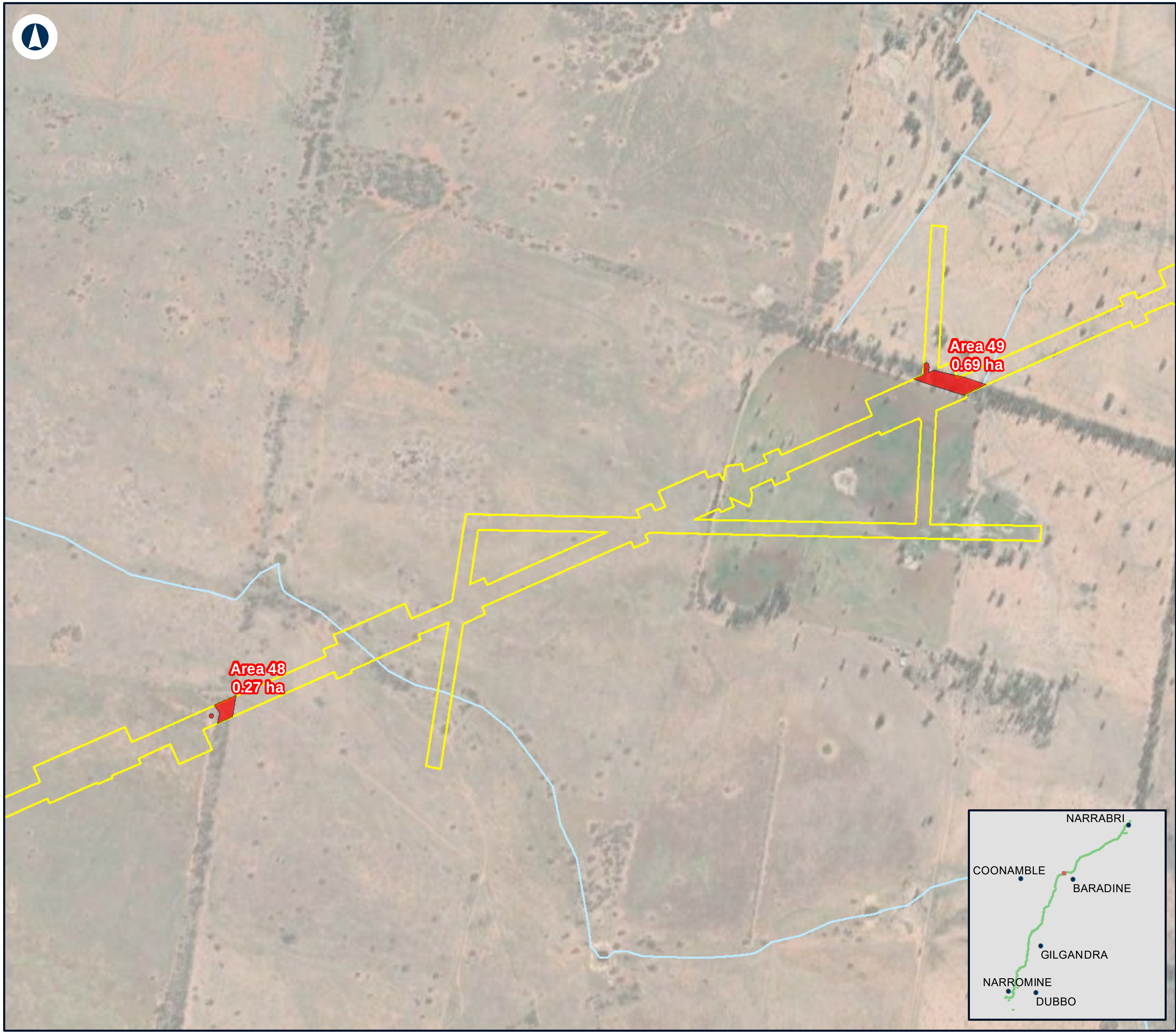

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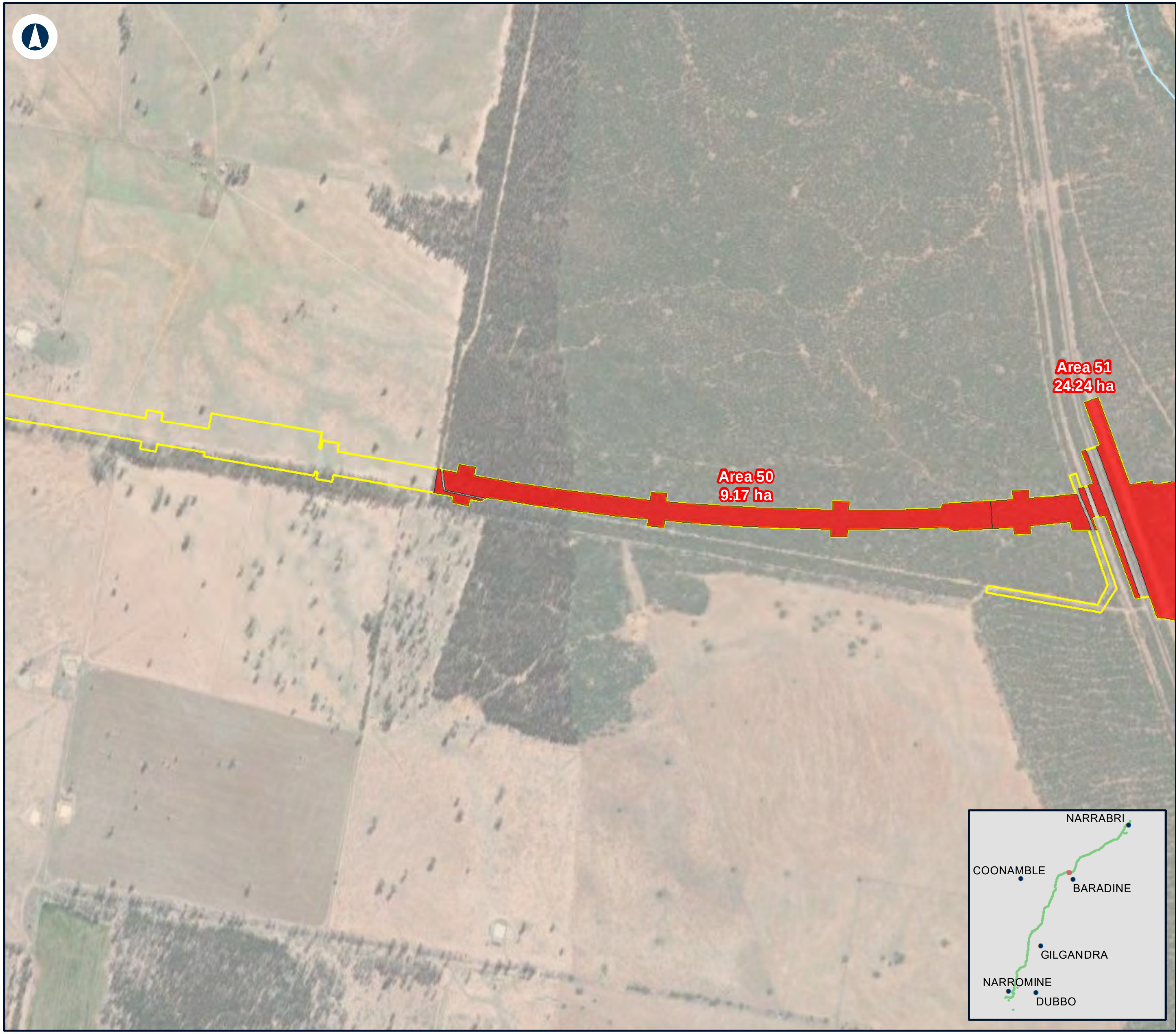

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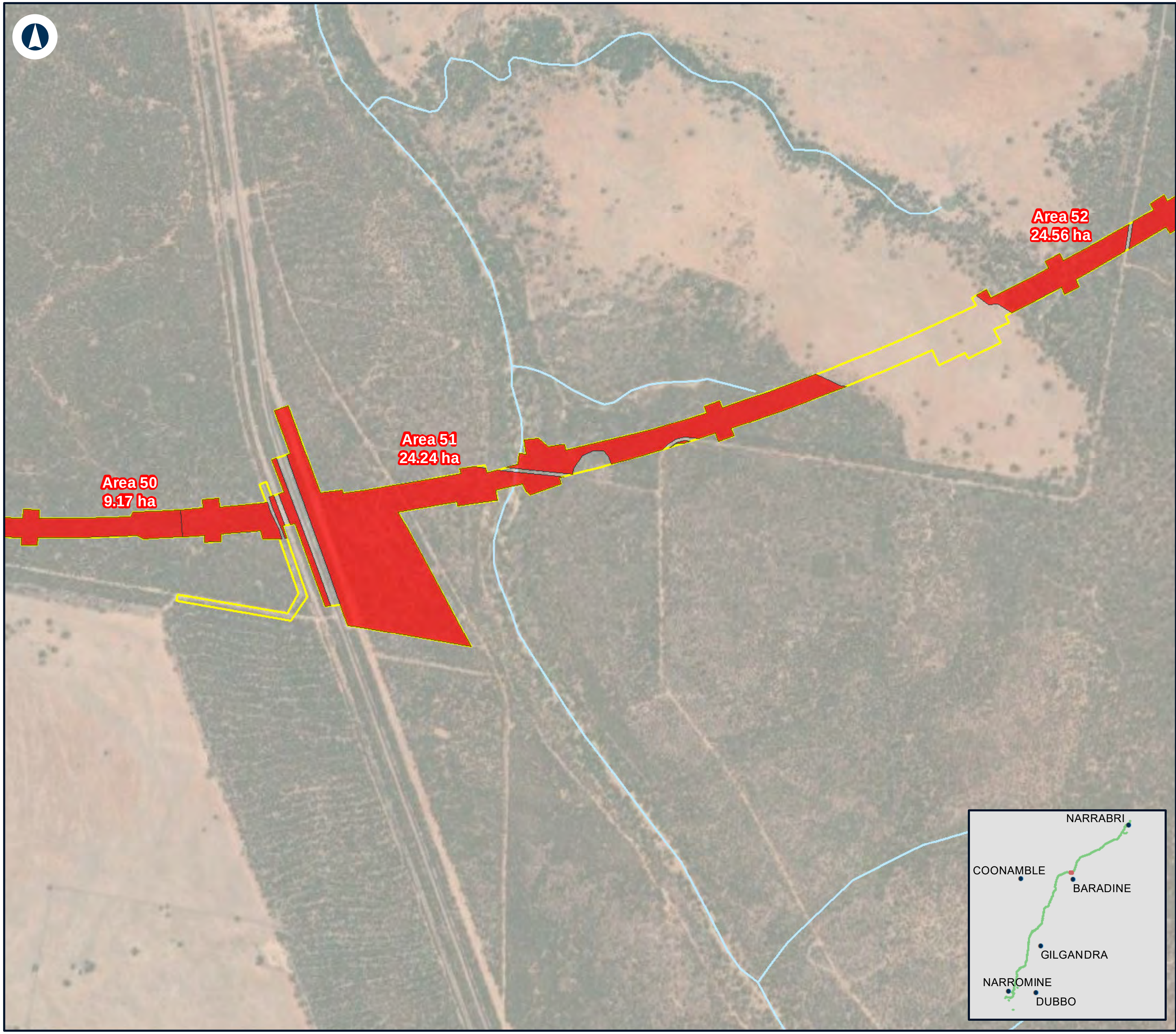

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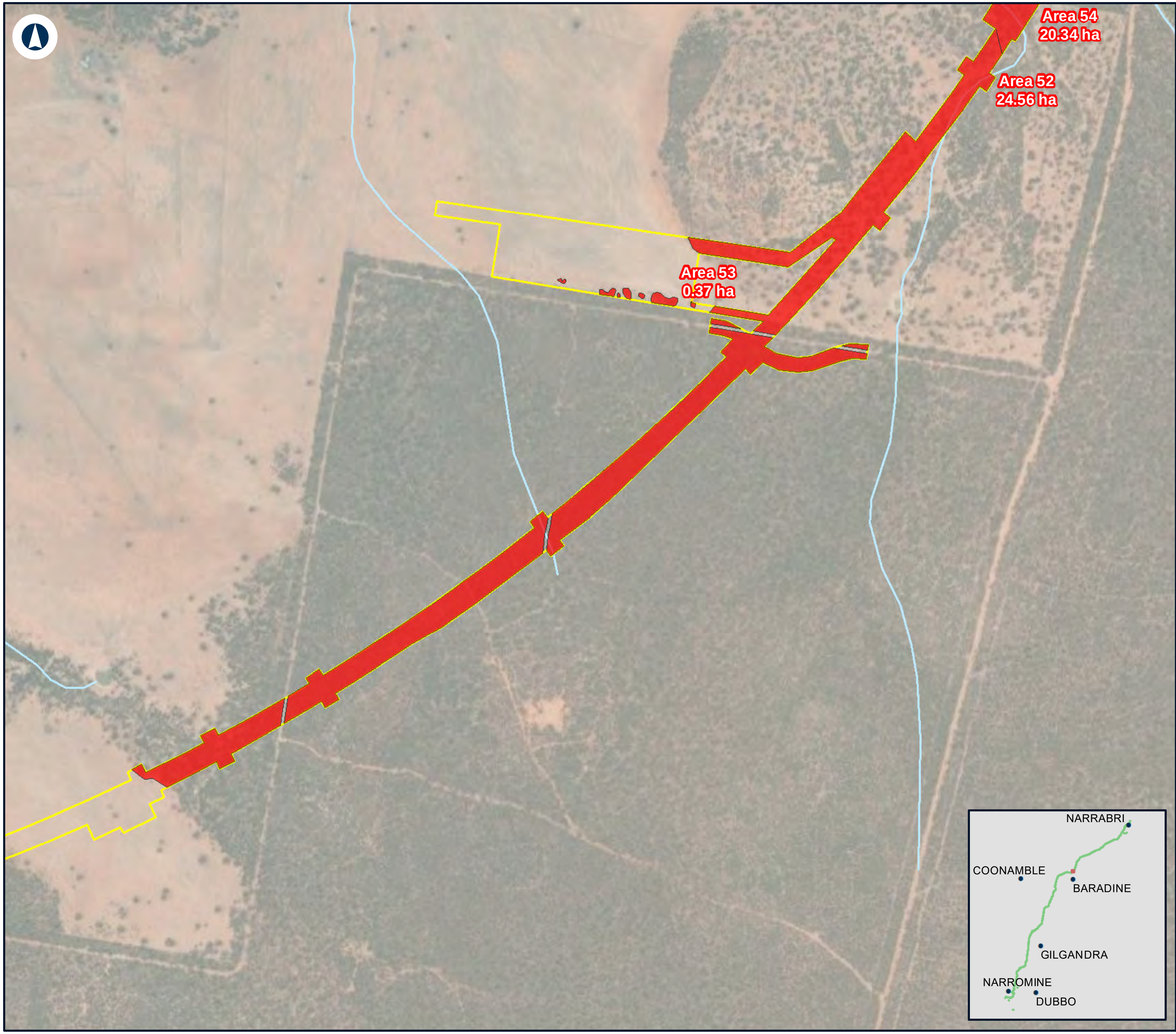

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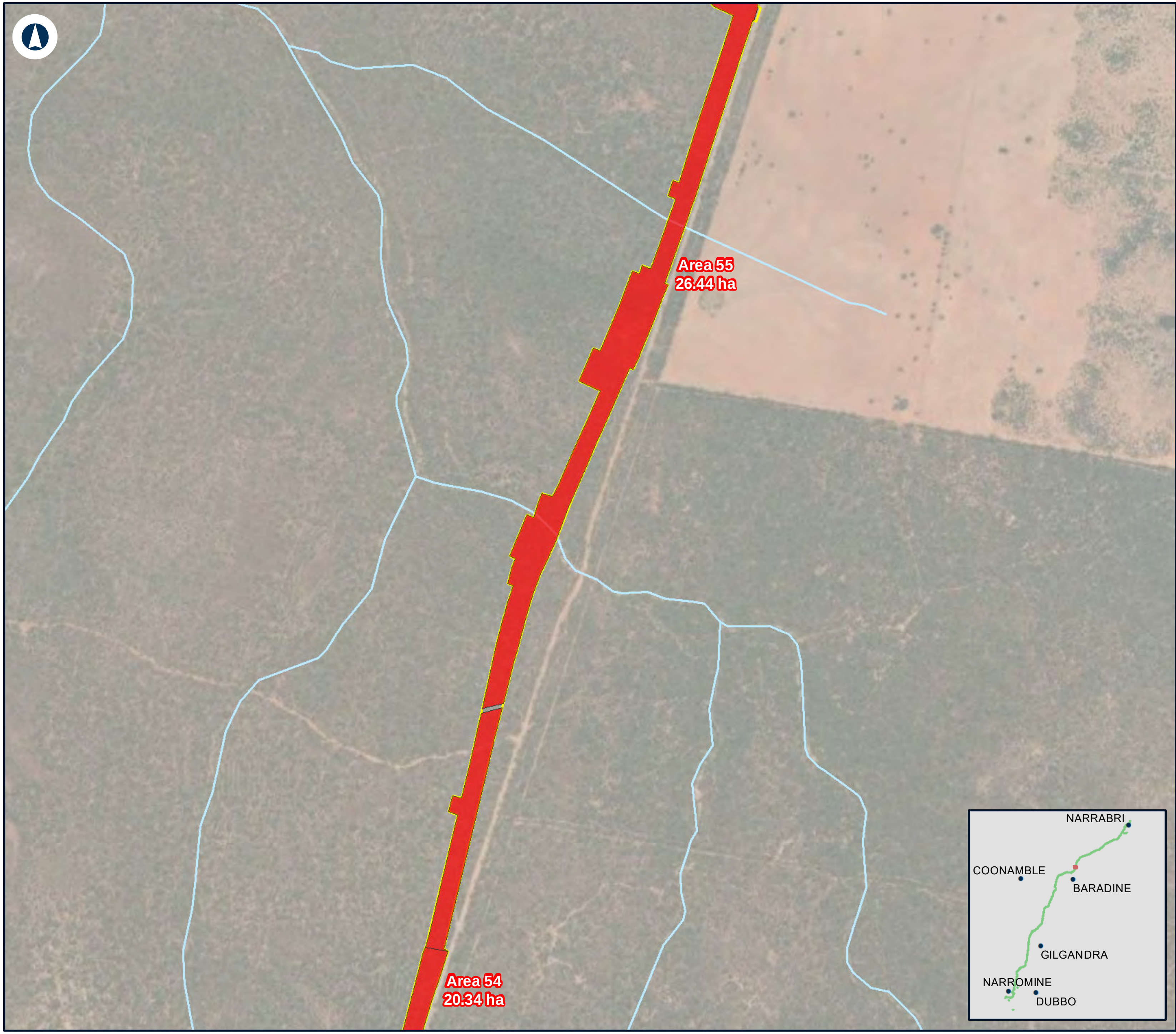

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NARROMINE TO NARRABRI

Appendix 2

Habitat areas and status

LEGEND

Construction impact zone

Little Eagle potential breeding habitat

0 250 500 Metres

Coordinate System: GDA 1994 MGA Zone 55

Date: 2021-11-30 Paper: A4

Author: JacobsGHD Scale: 1:15,000

Data Sources: Basemap layers: NSWSS, esri;

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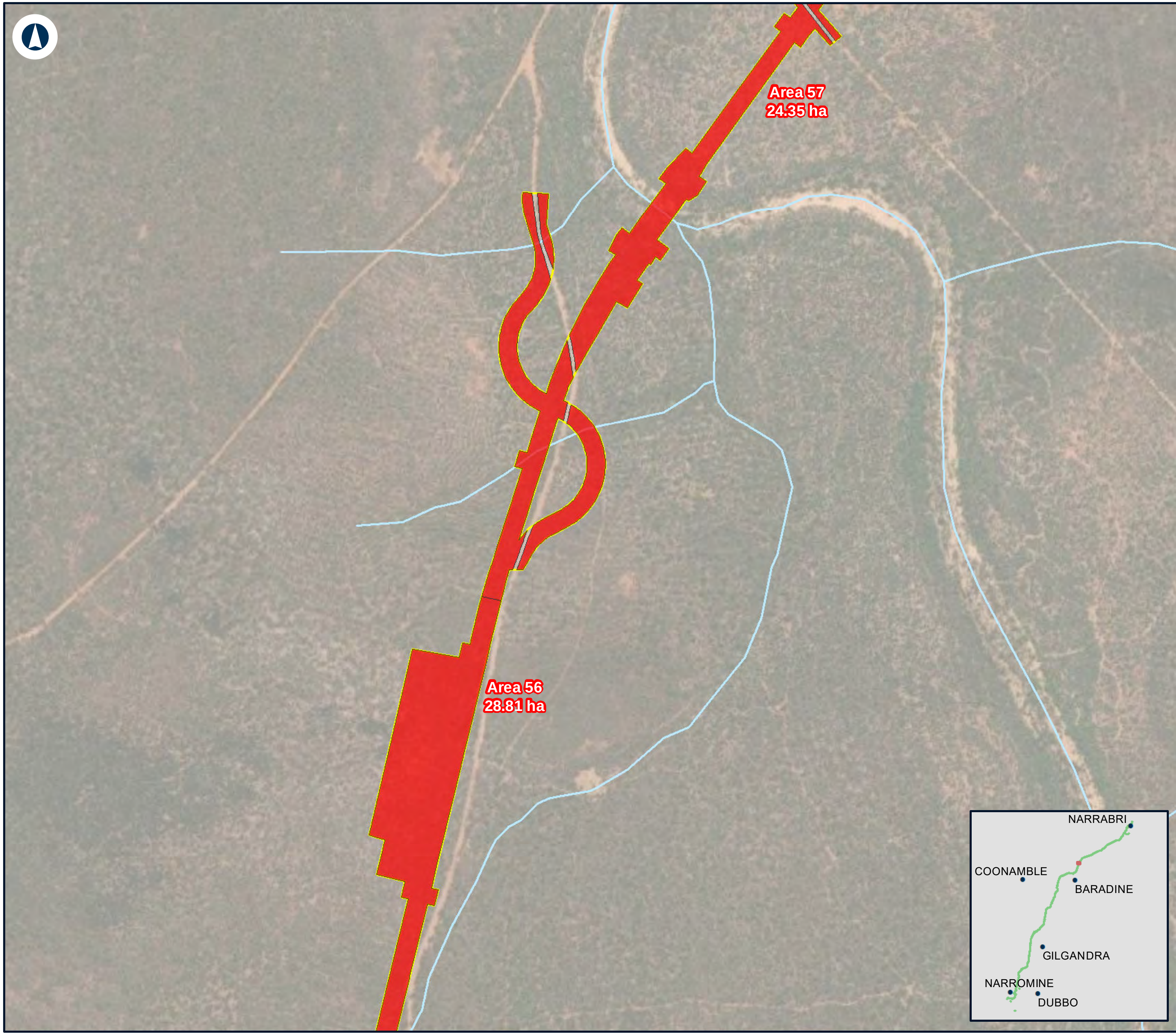

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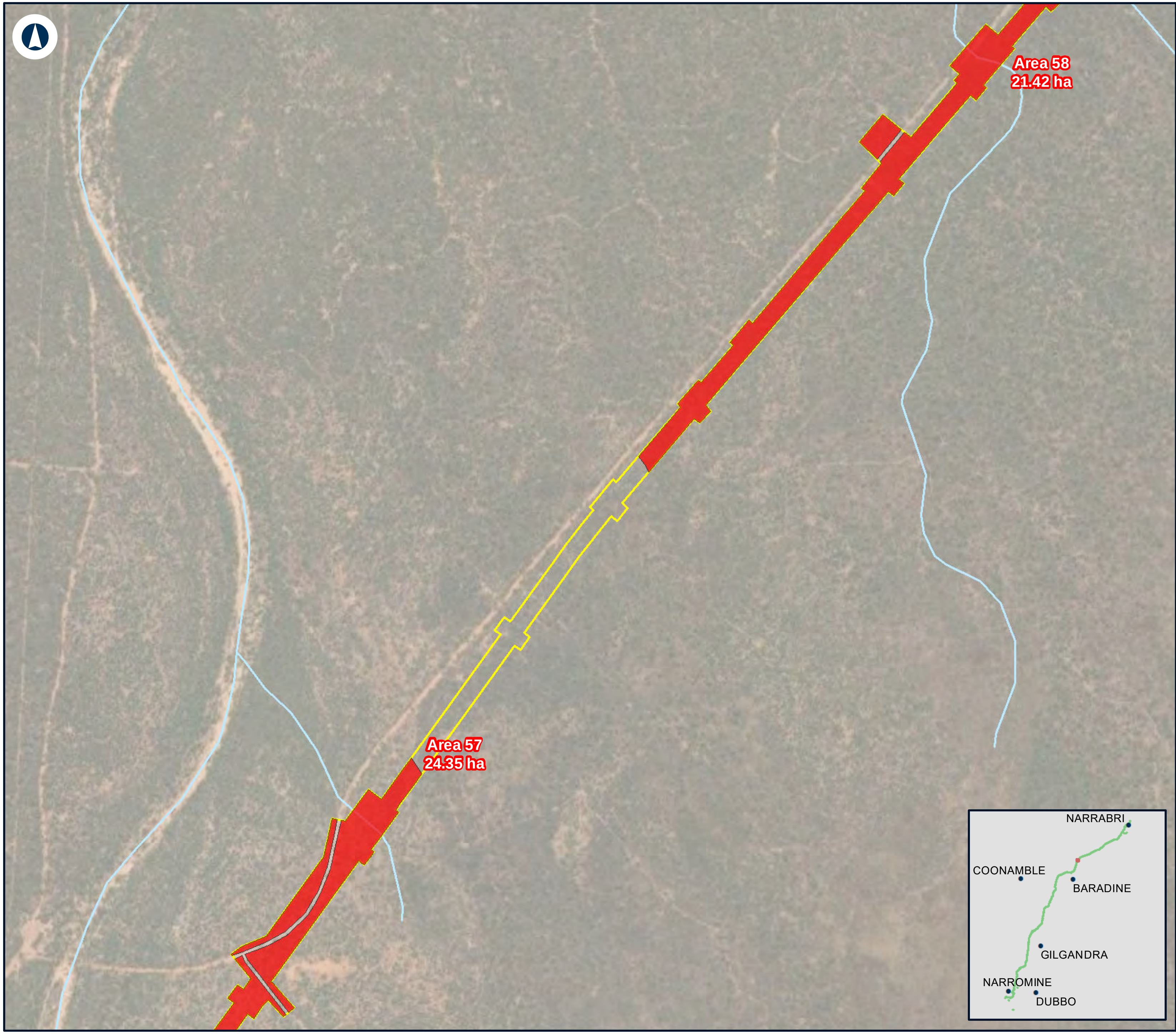

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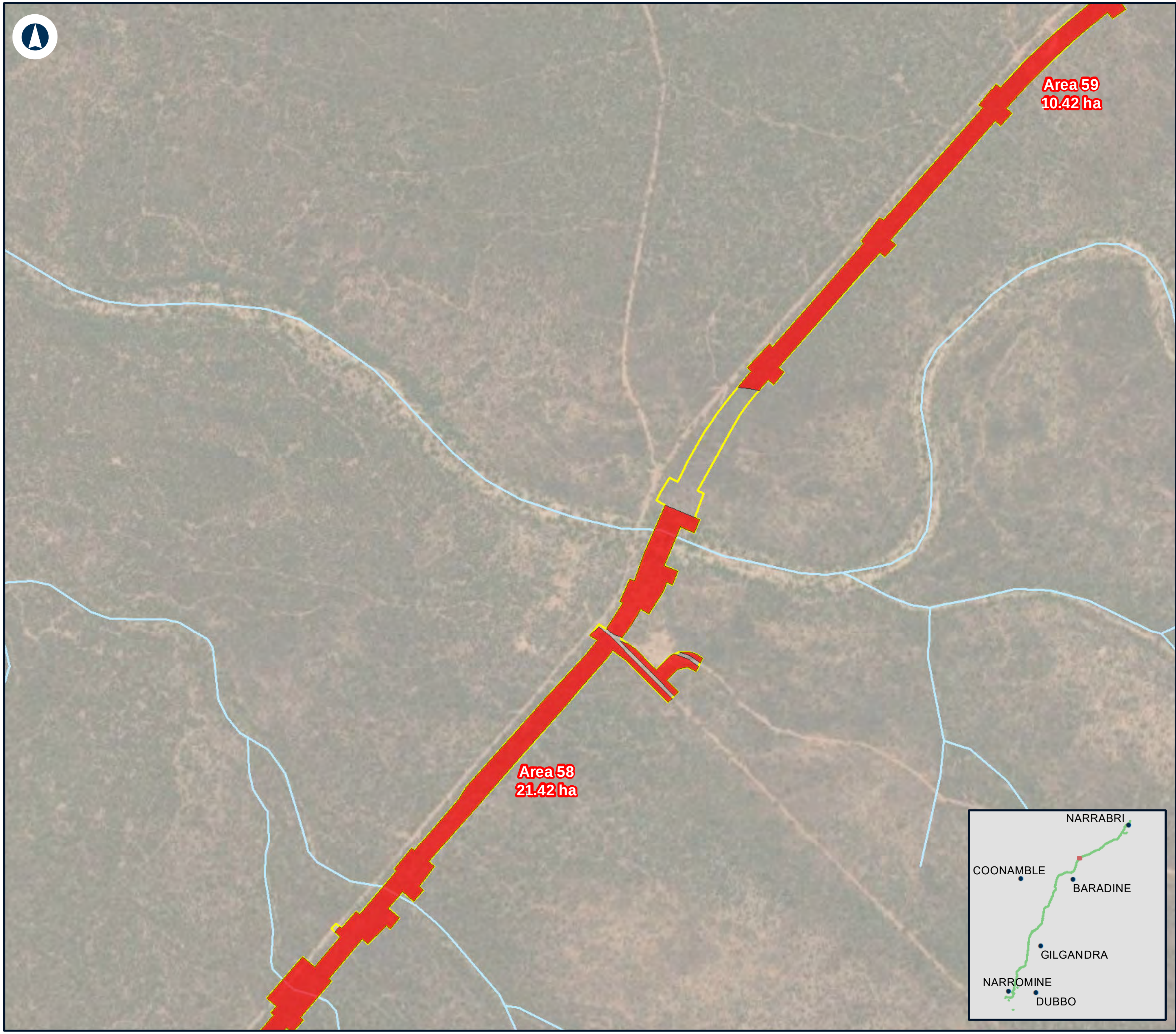

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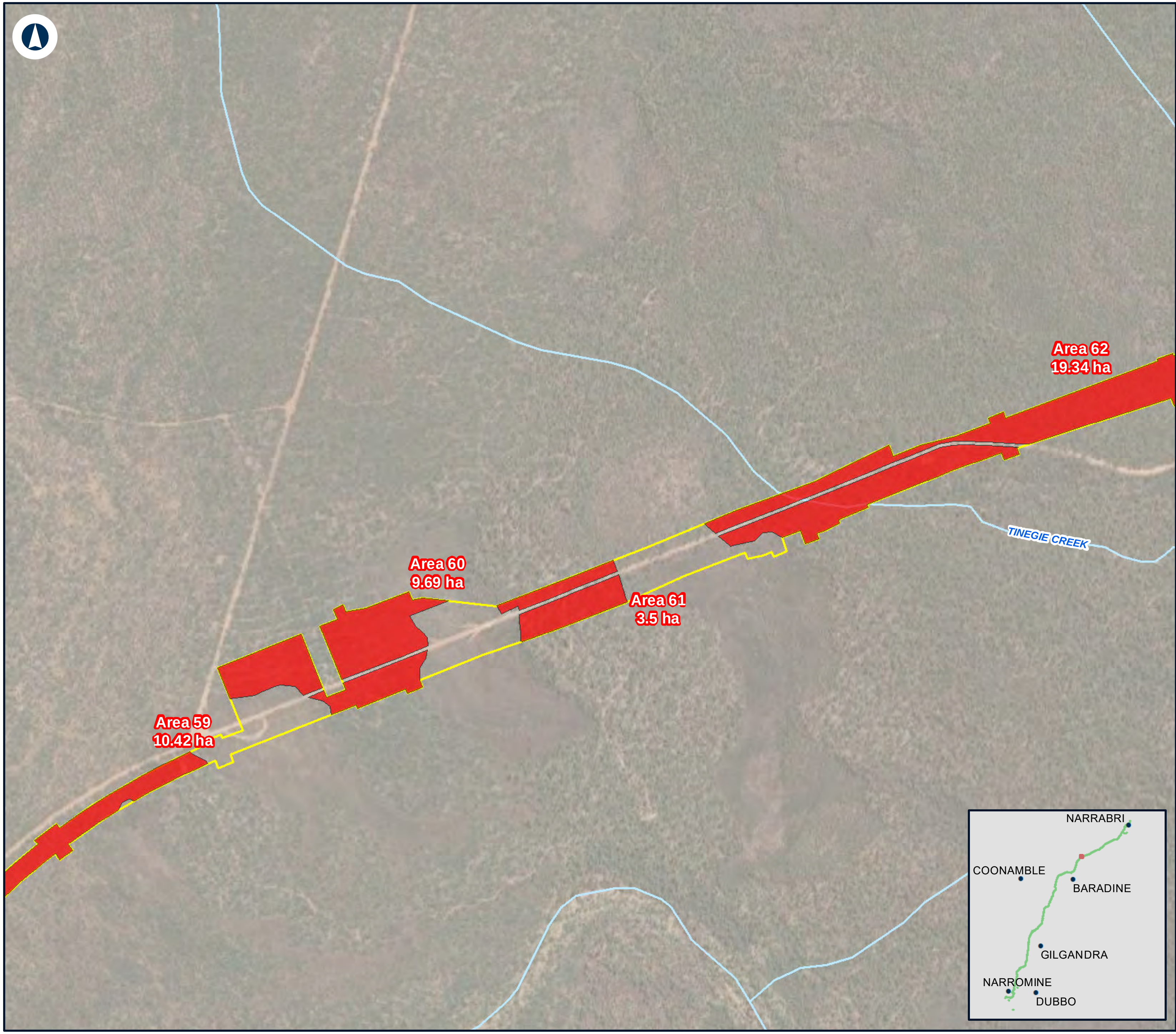

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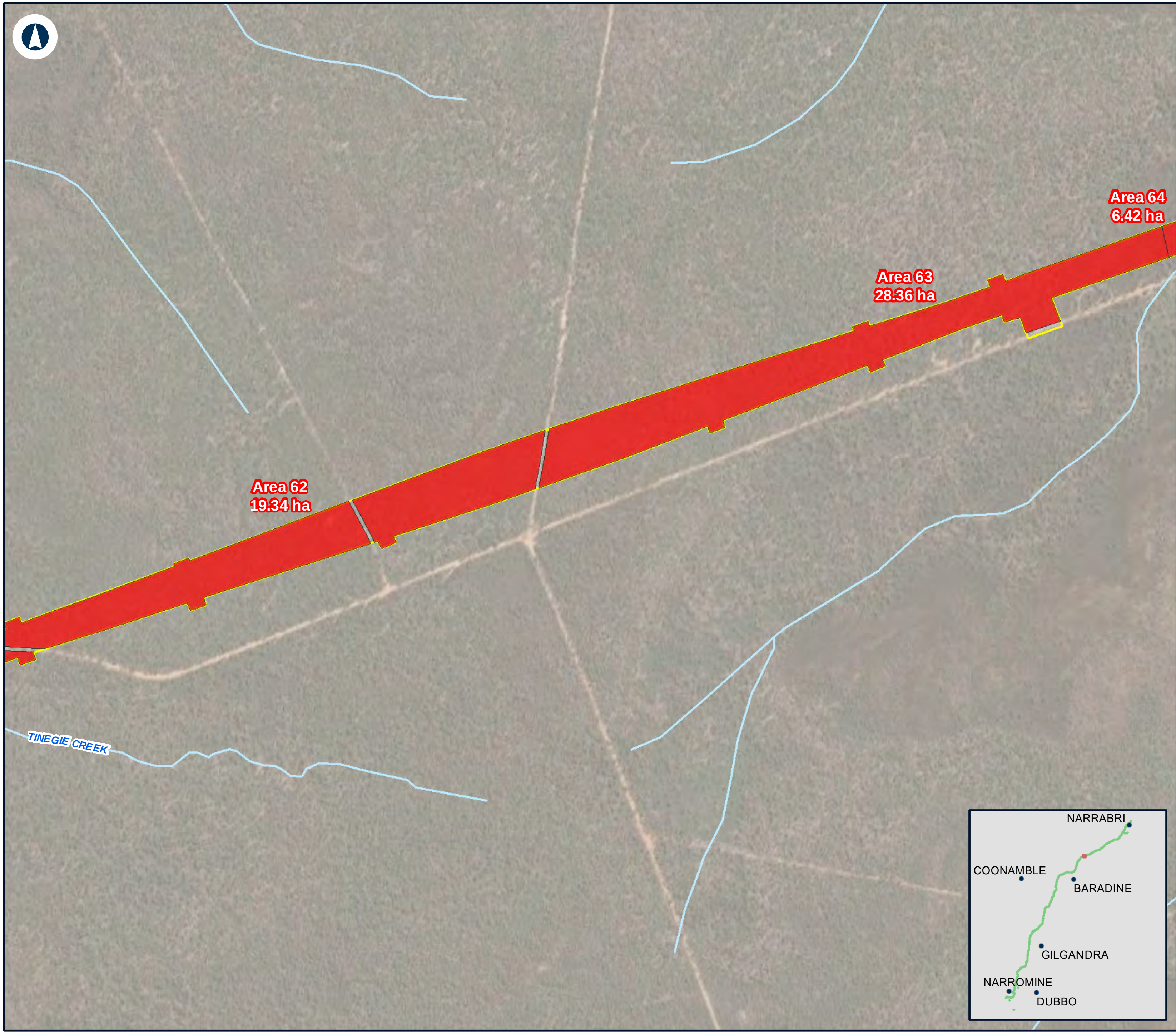

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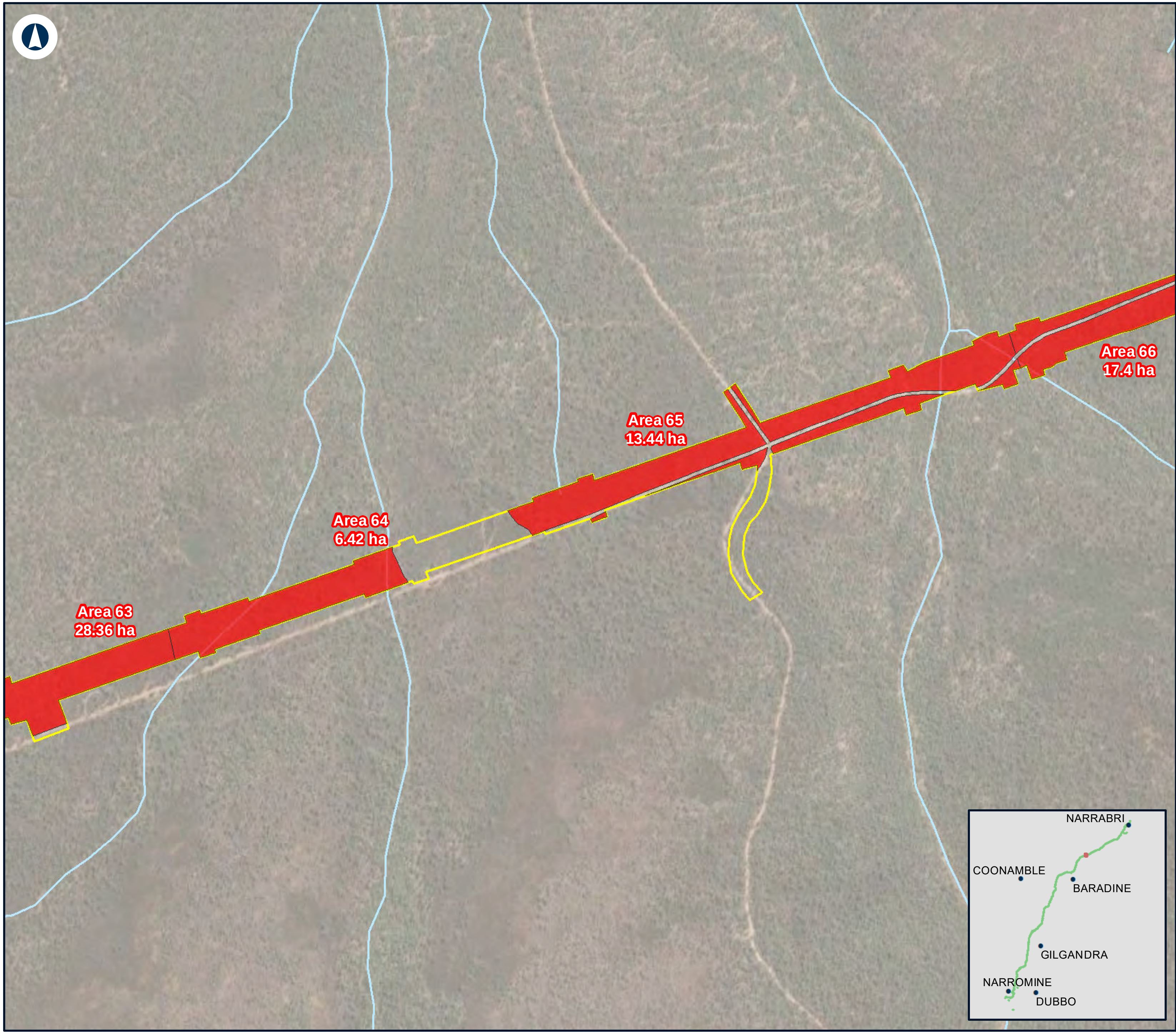

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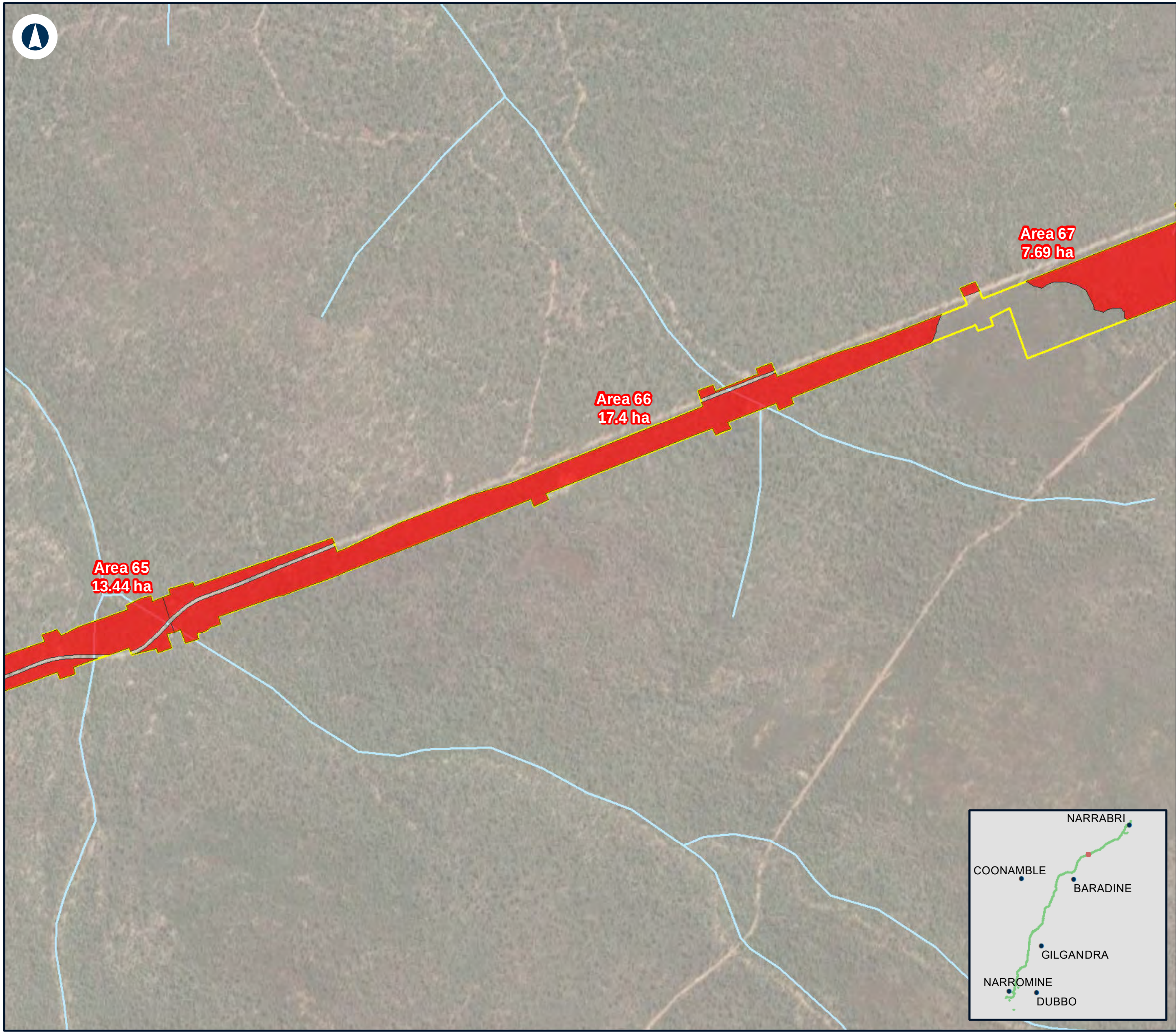

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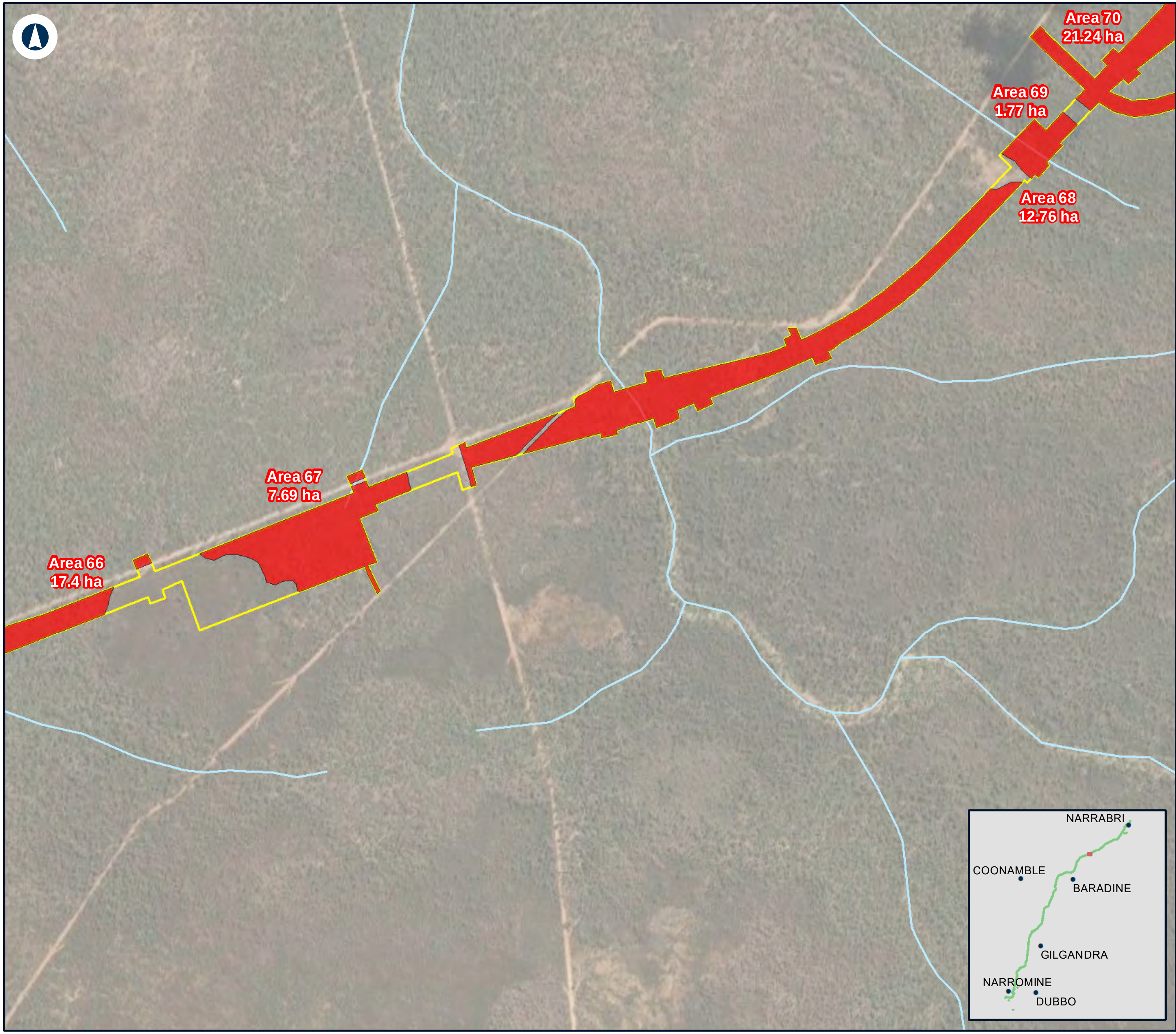

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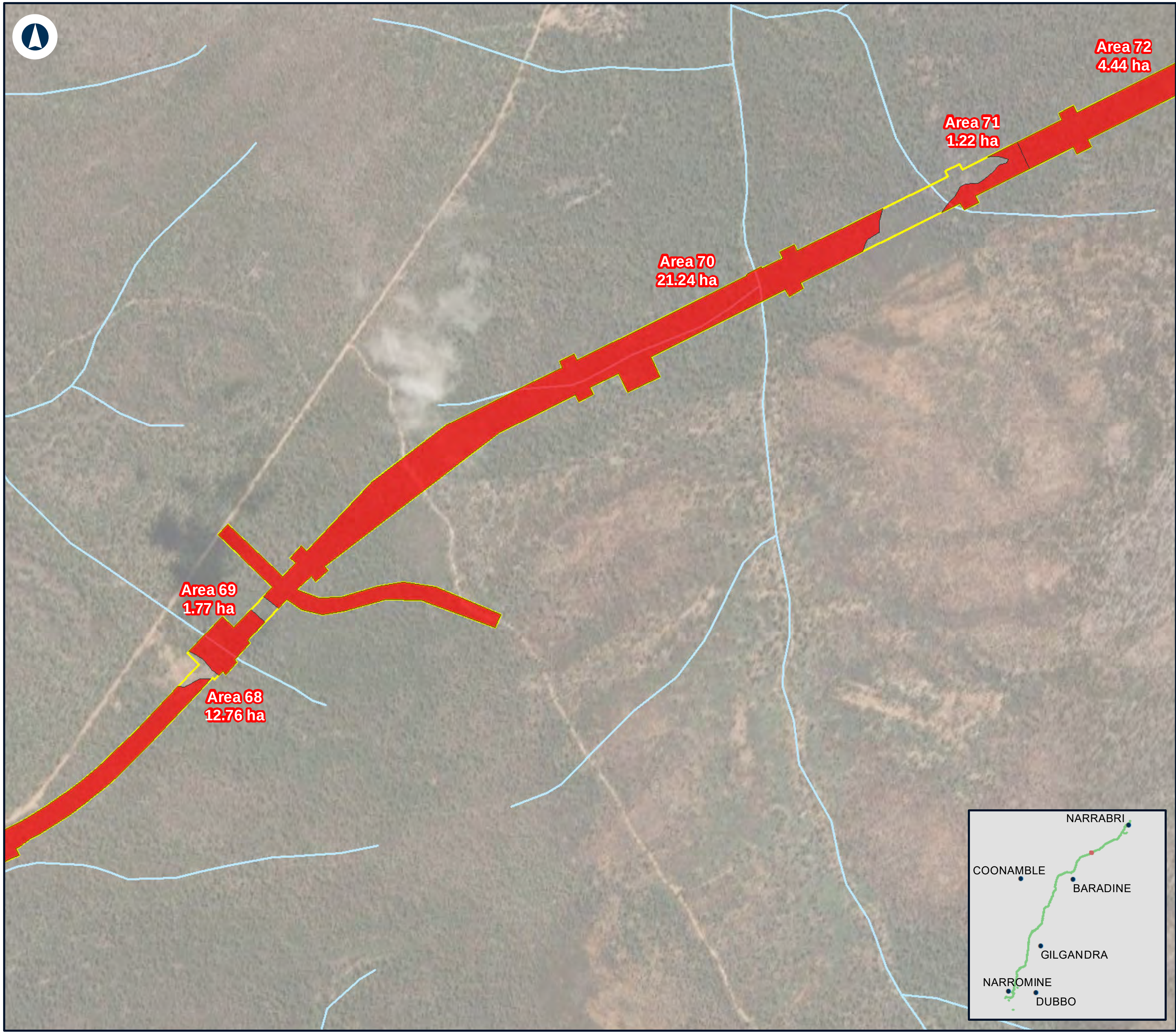

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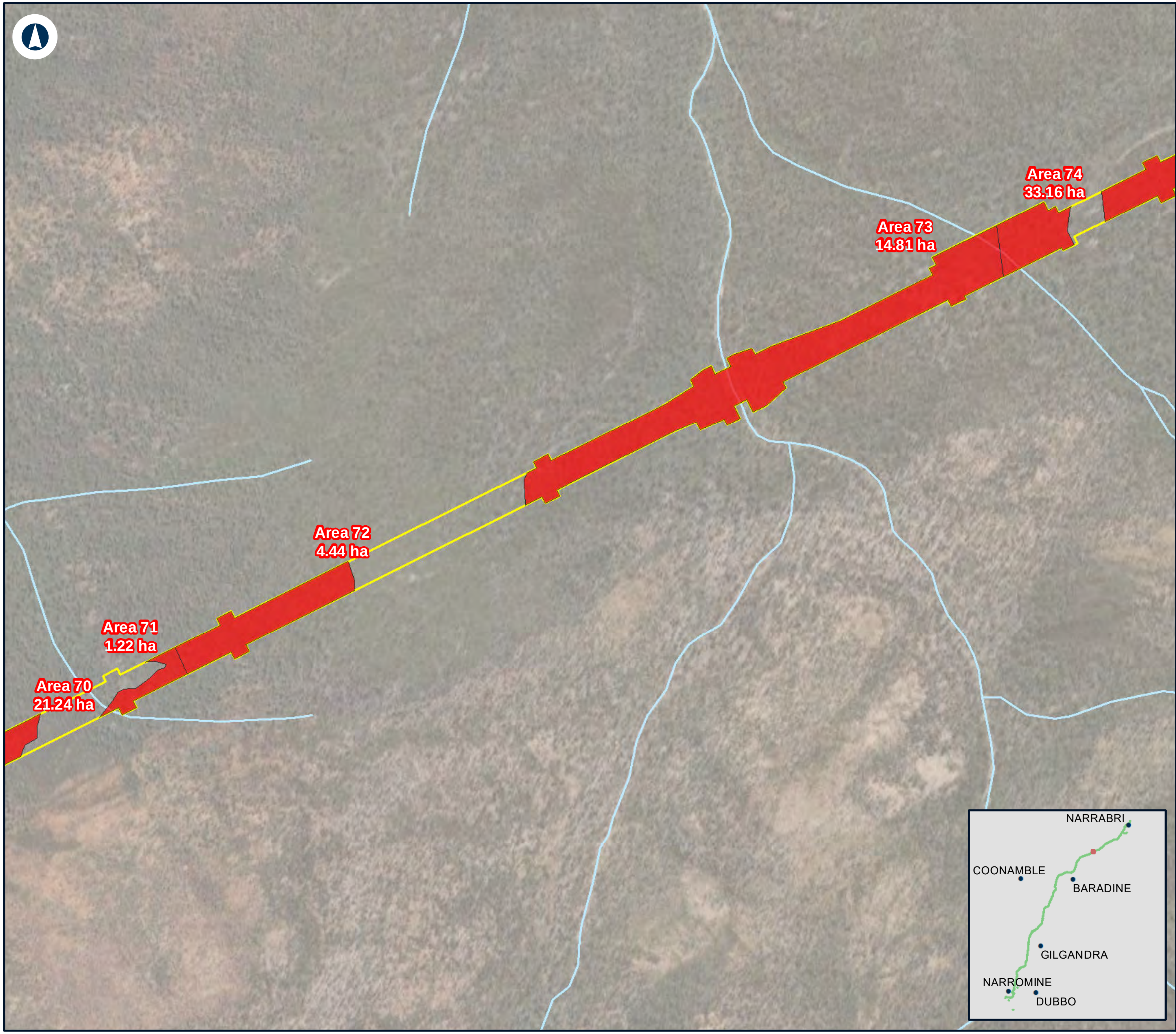

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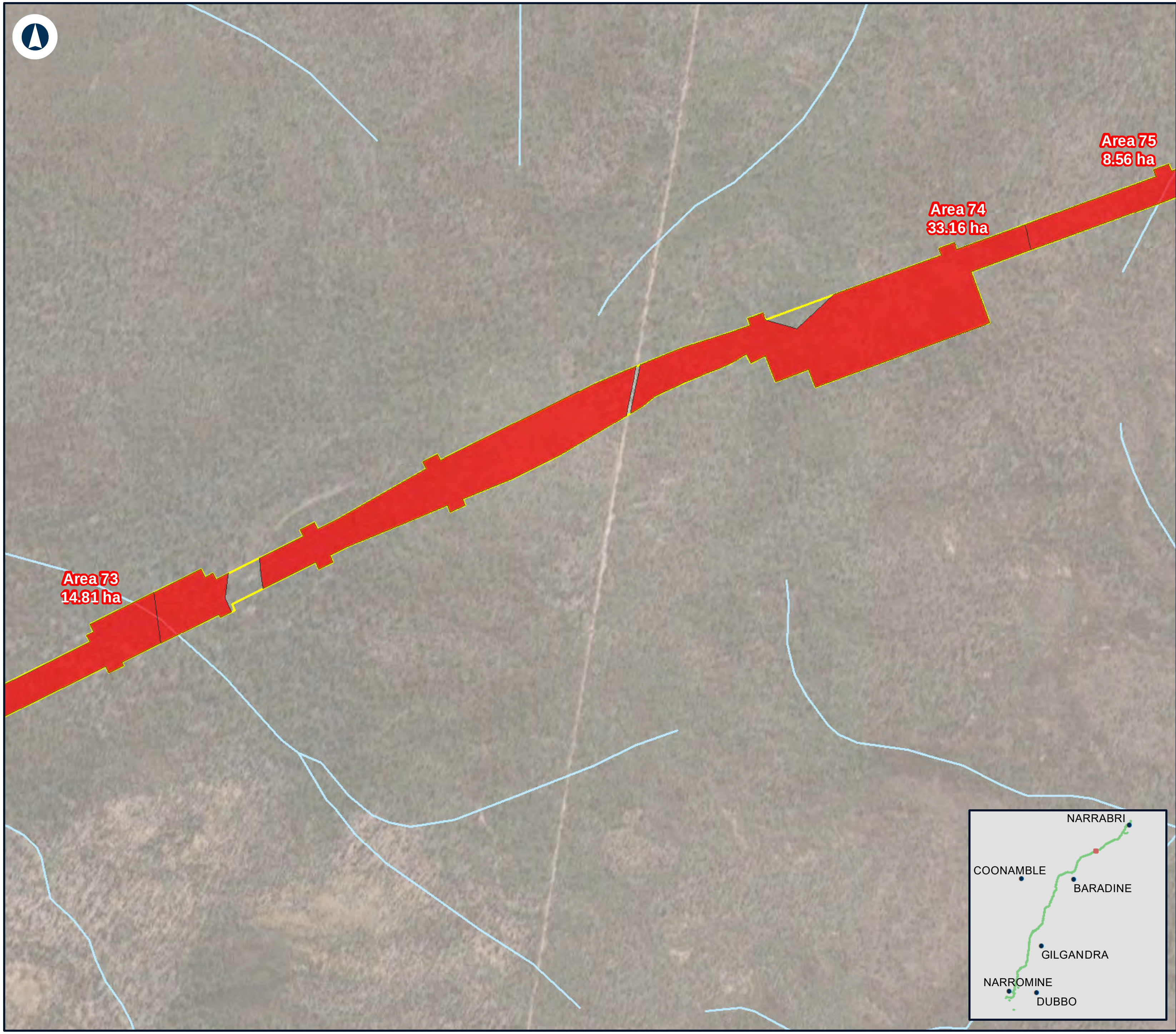

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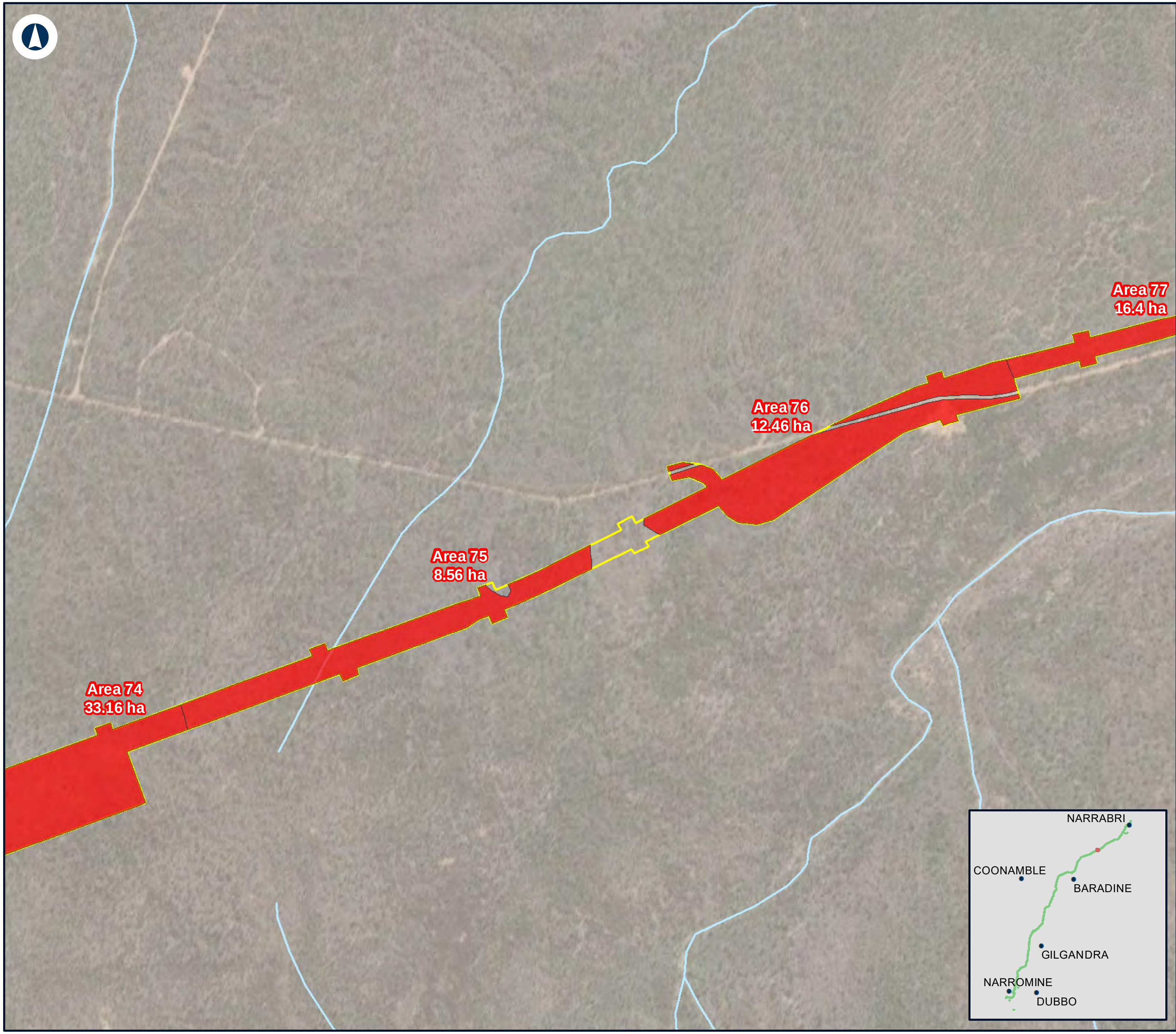

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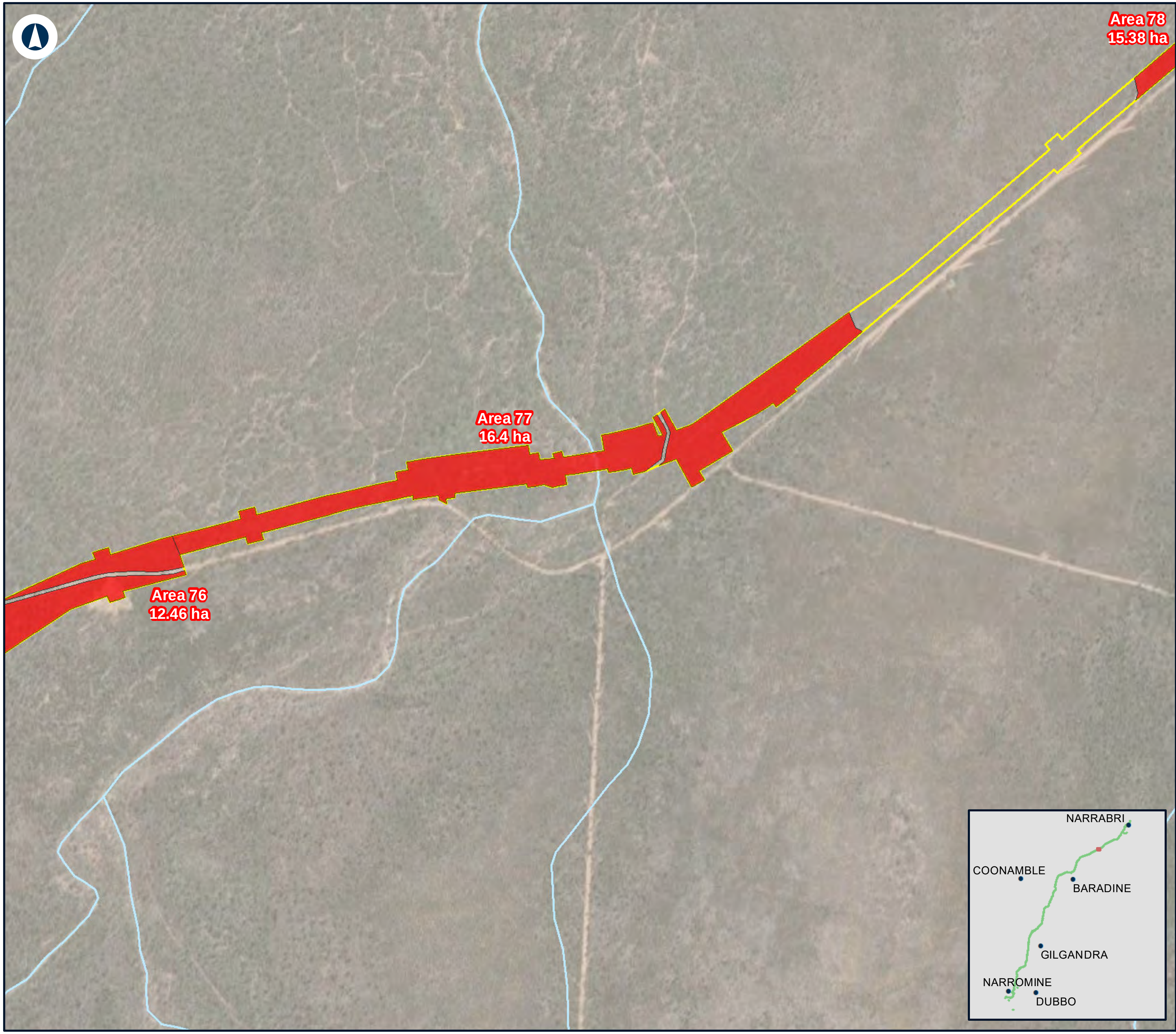

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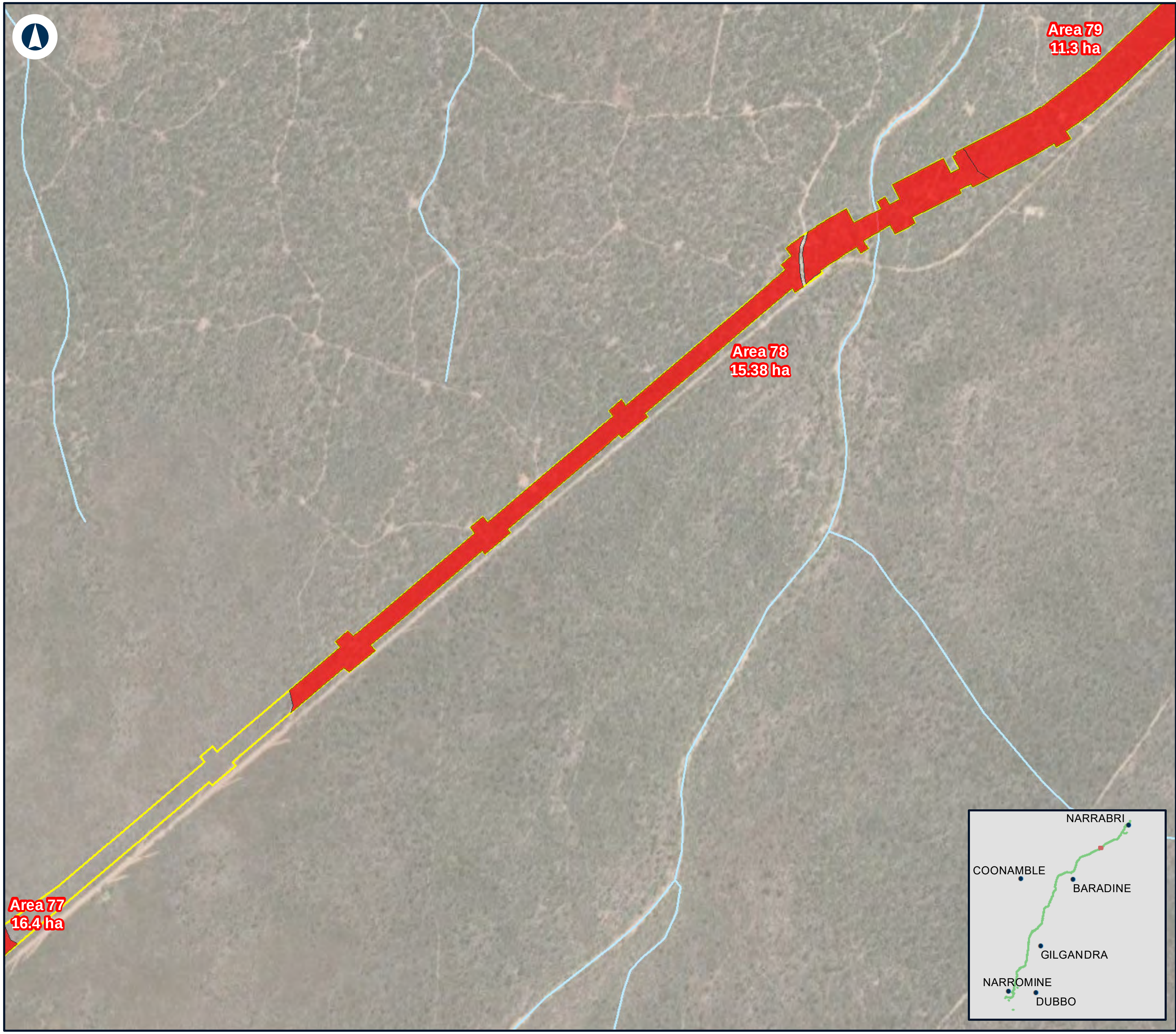

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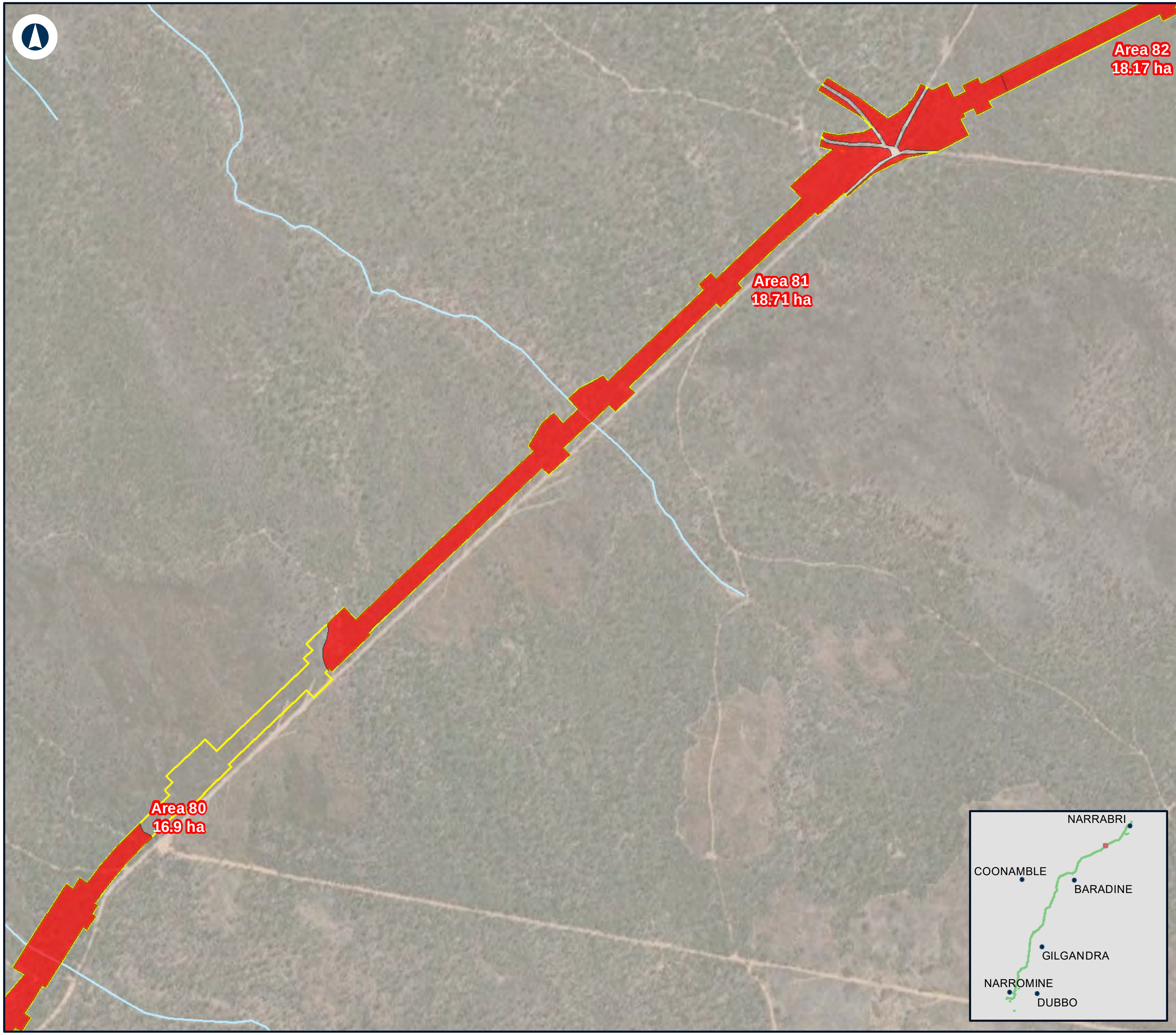

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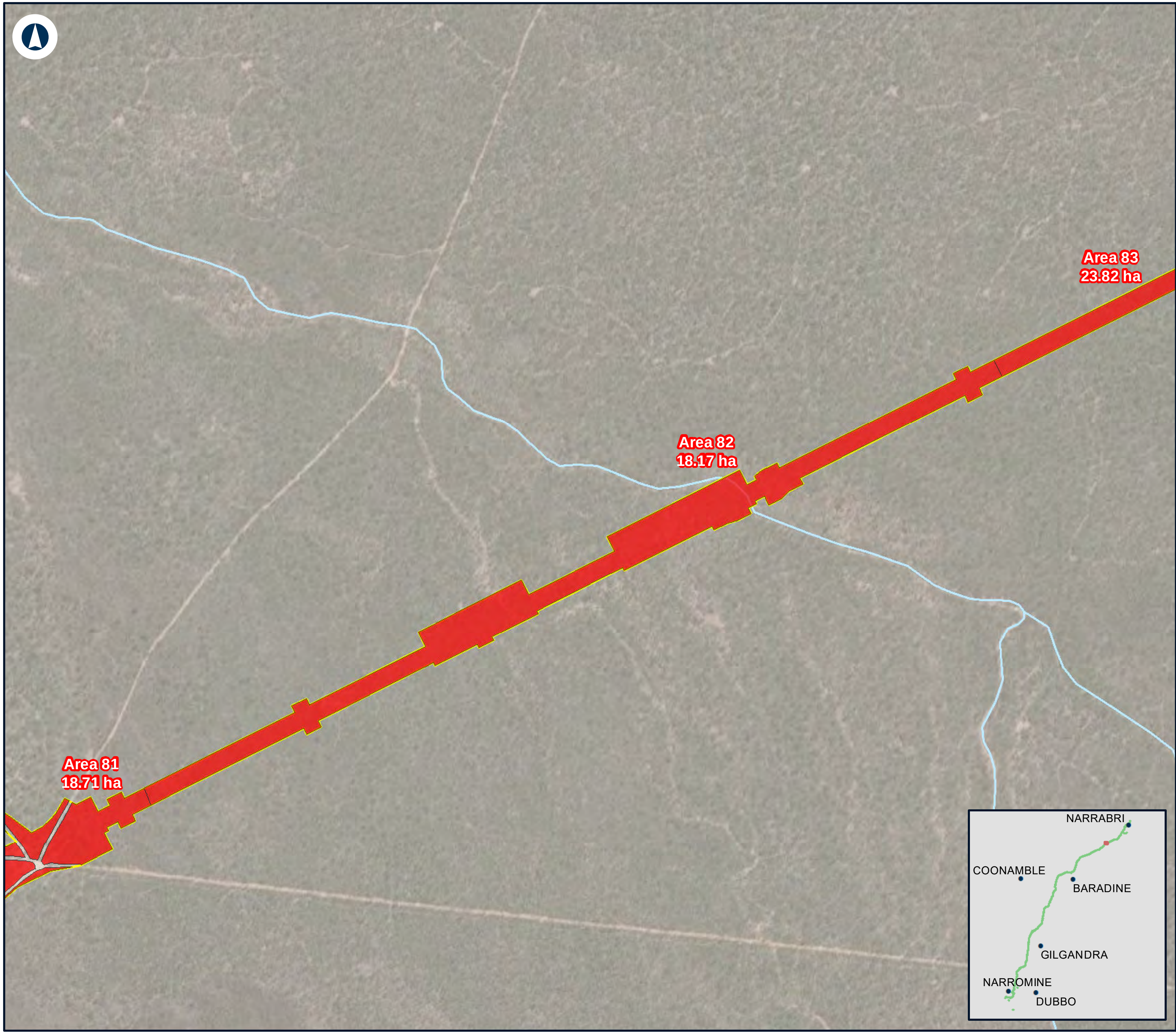

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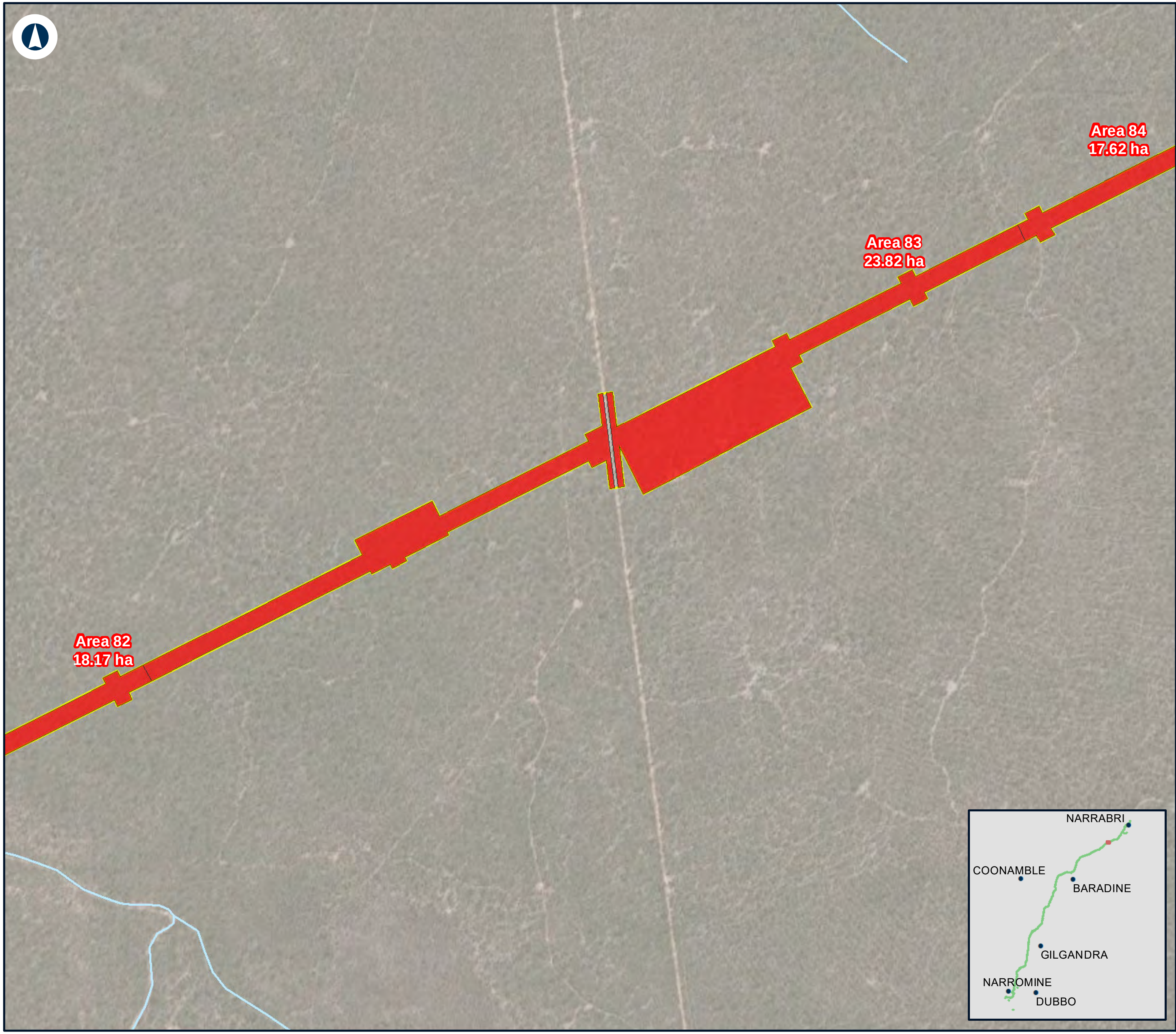

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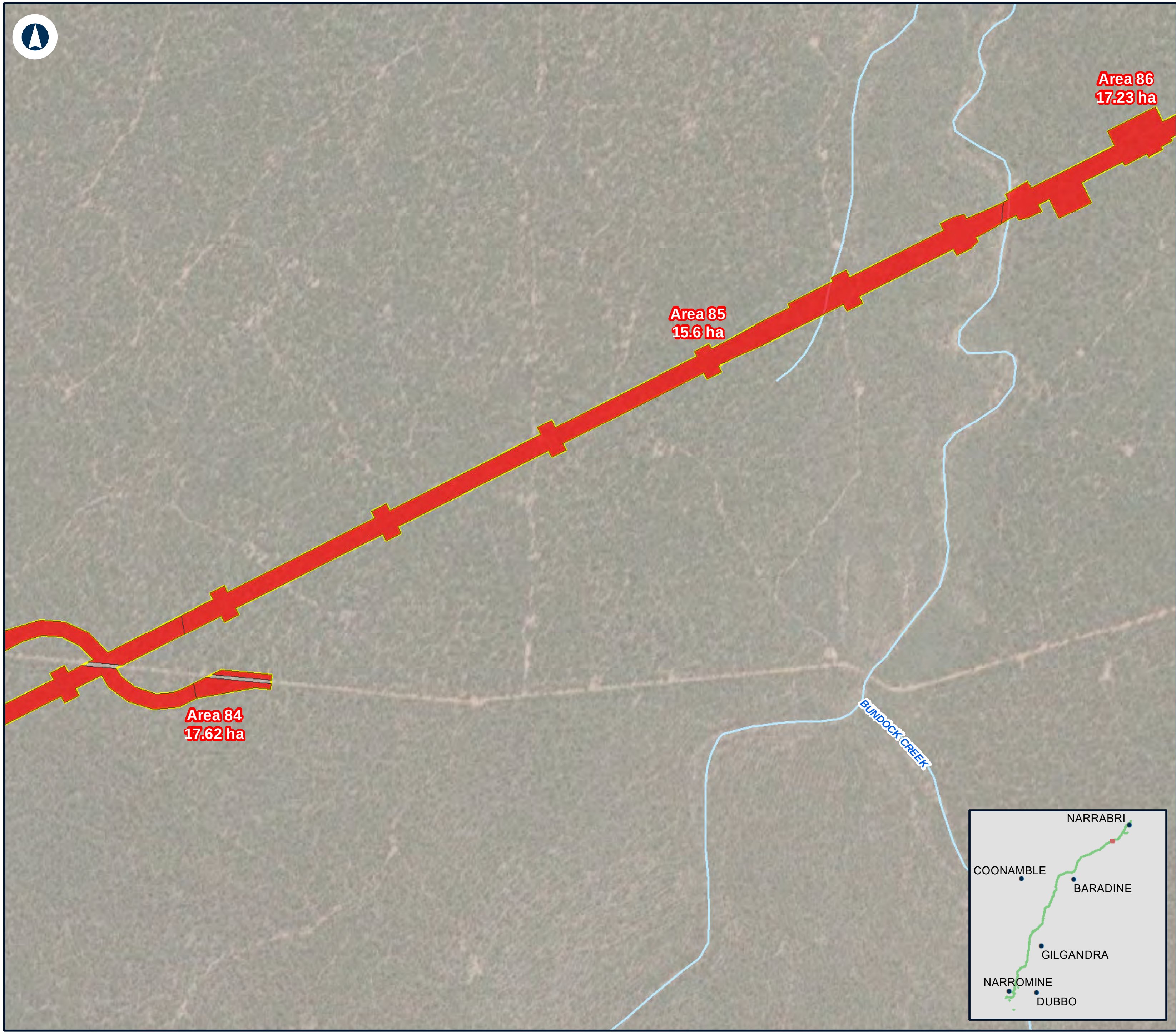

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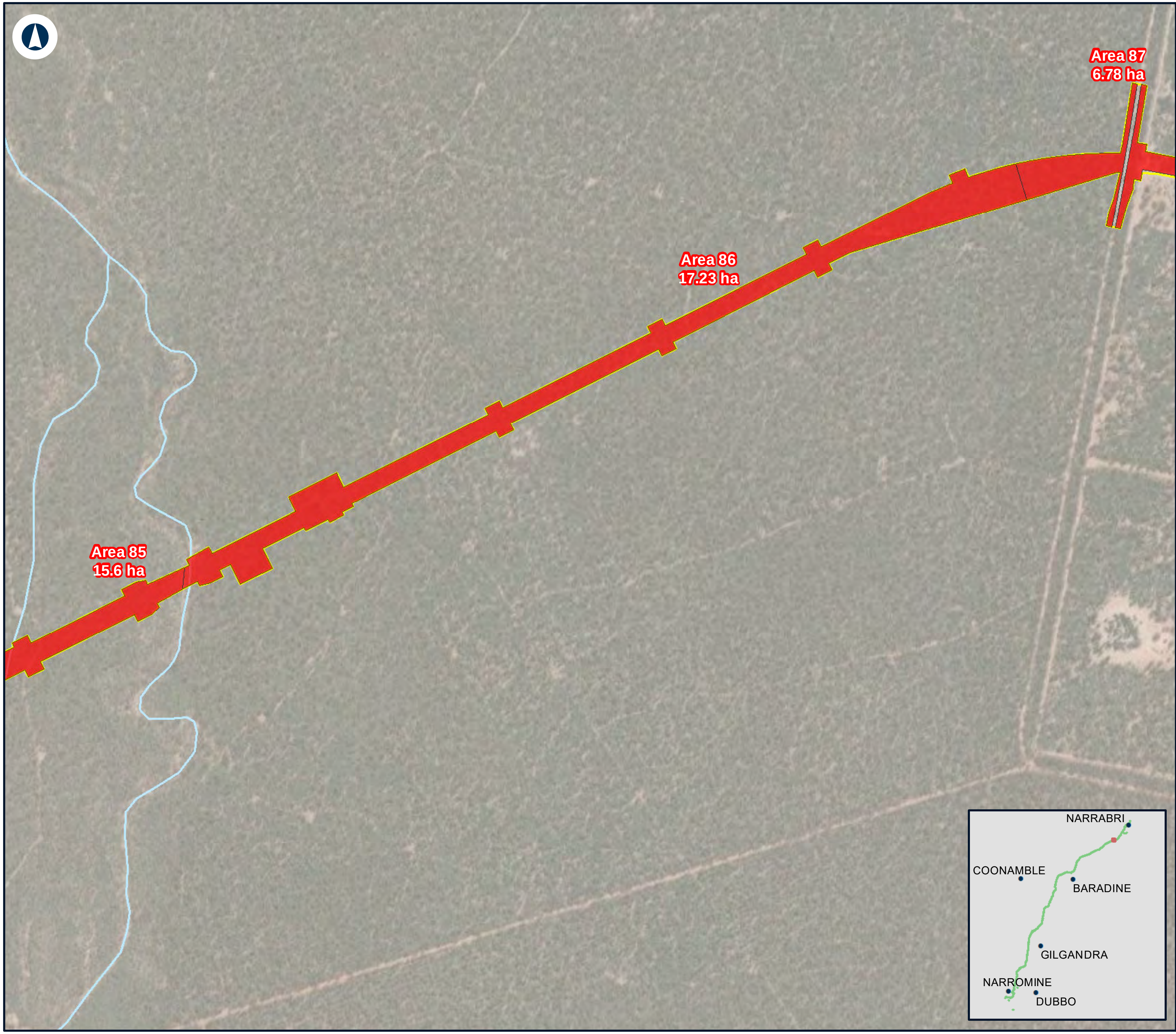

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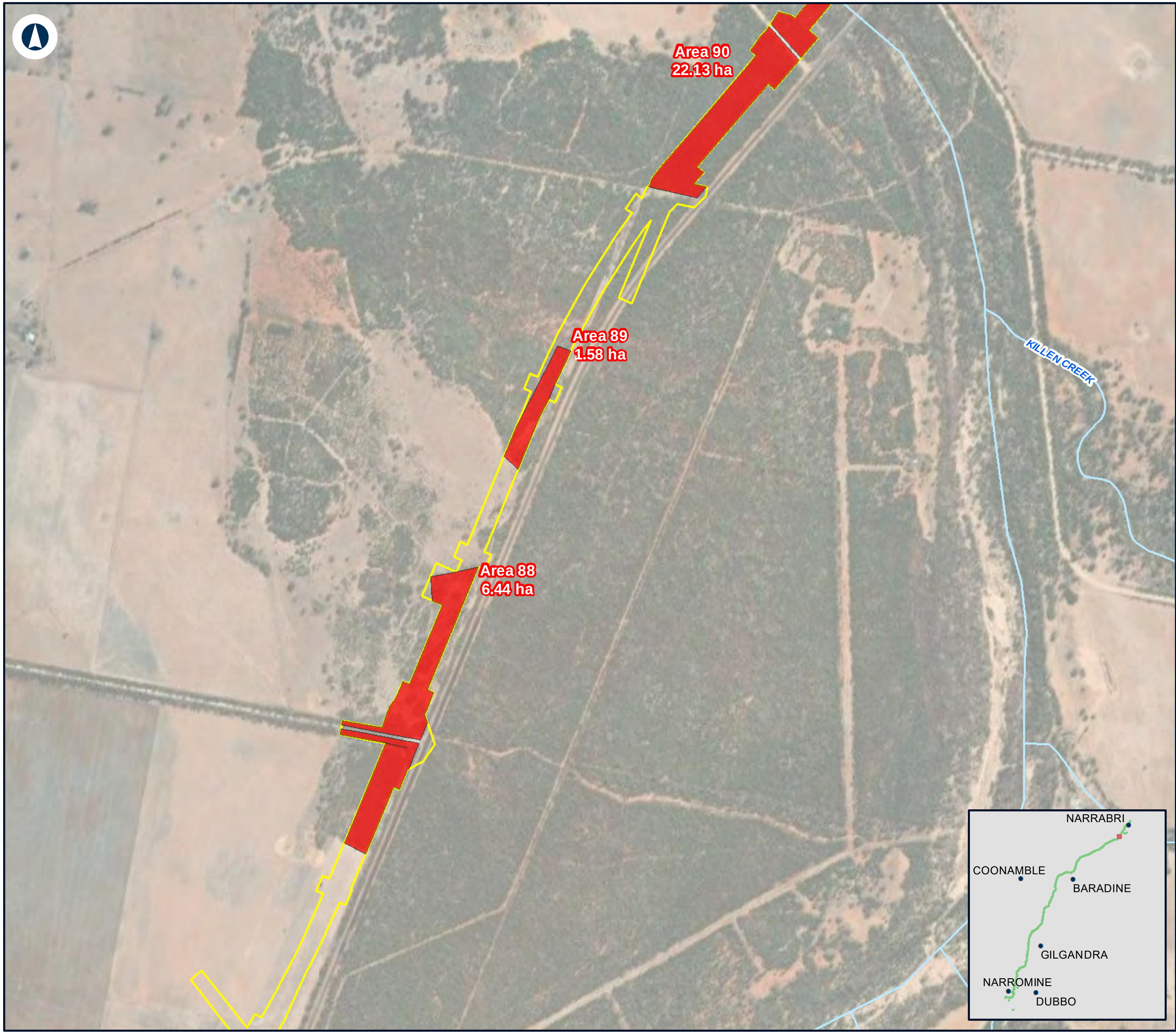

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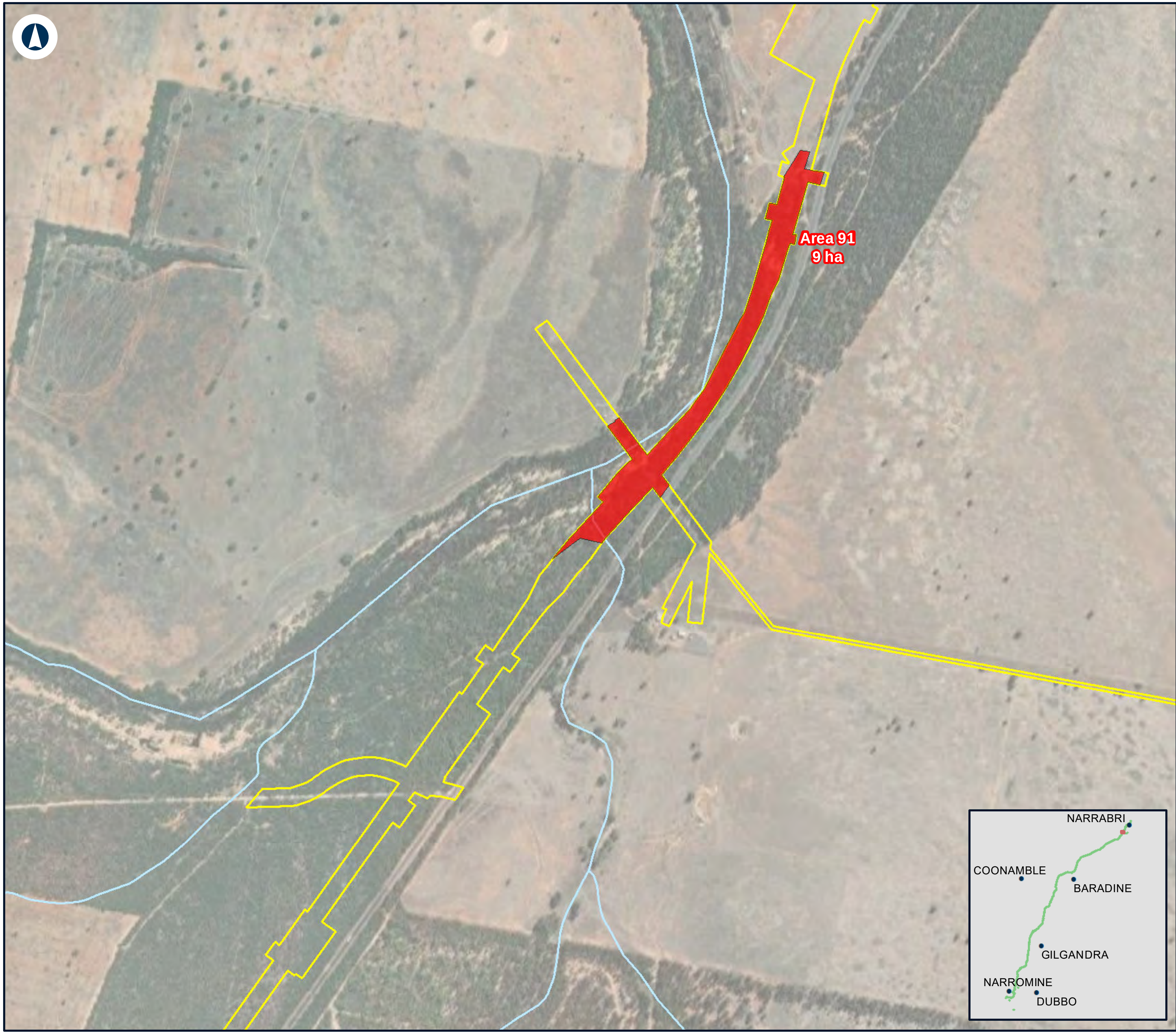

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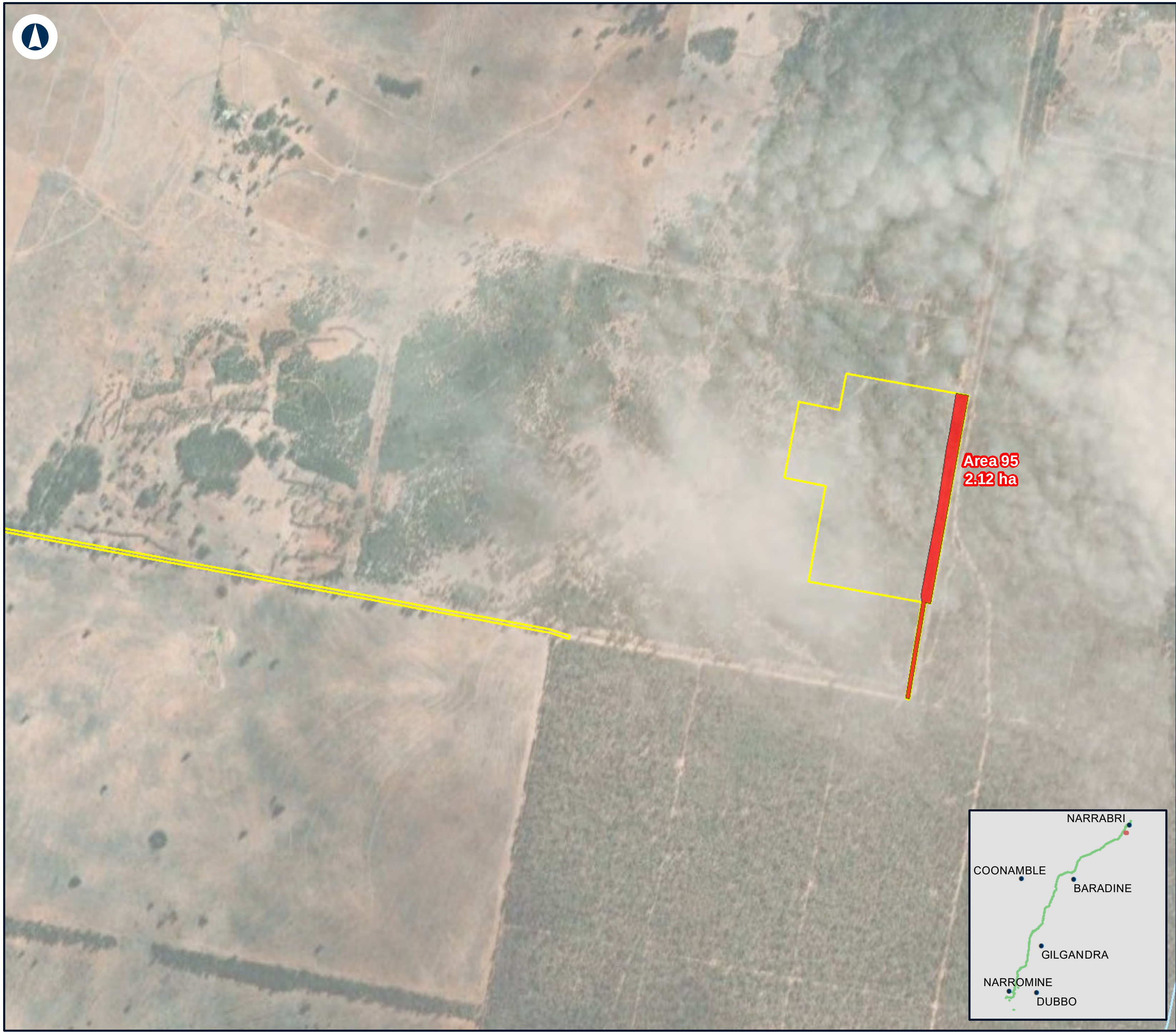

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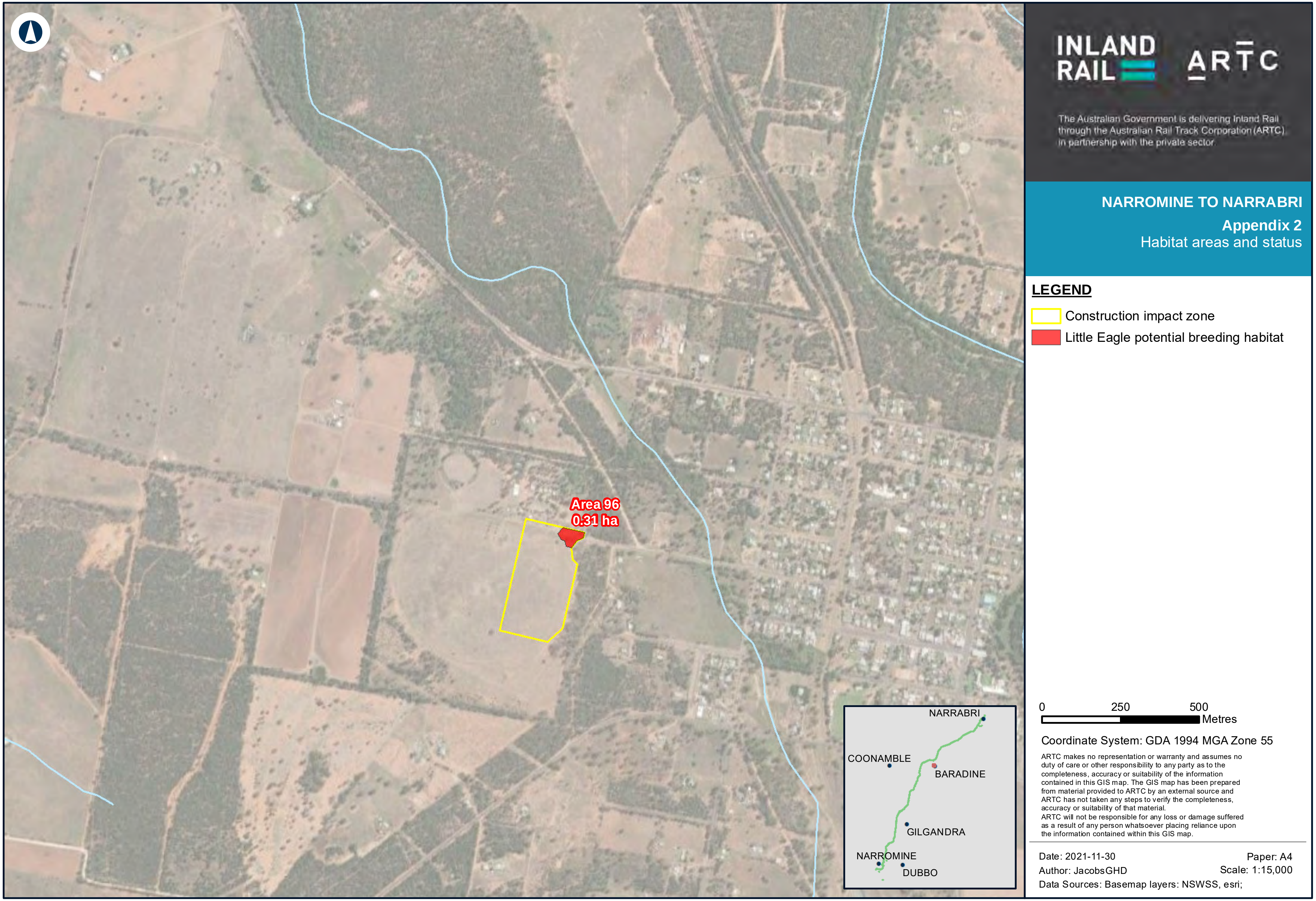


N:\AU\Newcastle\Projects\22\19593\GIS\GIS_2500_N2N_v2\Maps\Working\Biodiversity\2219593_N2N_HabitatAreasAndStatus_LittleEagle.mxd

Appendix 3. Records of Little Eagle along the N2N rail corridor

Year	Month	Day	Latitude	Longitude	Source
1900	11	2	-32.23	148.25	BirdLife Australia
1915	9	26	-30.333	149.783	EBird Australia
1969	9	3	-31.52330403	147.706892	BioNet Atlas of NSW Wildlife
1972	8	1	-31.25	149.08	BirdLife Australia
1974	11	14	-30.88207003	149.041081	BioNet Atlas of NSW Wildlife
1975	1	19	-31.29046203	148.998363	BioNet Atlas of NSW Wildlife
1976	1	1	-30.86	148.95	BirdLife Australia
1976	8	18	-31.27135	148.95917	EBird Australia
1976	8	20	-31.27135	148.95917	EBird Australia
1976	10	24	-31.25	148.91	BirdLife Australia
1976	11	28	-30.41	149.91	BirdLife Australia
1977	1	1	-30.91	148.41	BirdLife Australia
1977	1	4	-31.25	148.91	BirdLife Australia
1977	1	4	-31.25	149.25	BirdLife Australia
1977	1	4	-30.91	149.41	BirdLife Australia
1977	1	10	-31.25	149.08	BirdLife Australia
1977	3	1	-30.91	148.91	BirdLife Australia
1977	6	1	-31.25	148.91	BirdLife Australia
1977	6	1	-31.25	149.25	BirdLife Australia
1977	6	1	-30.91	148.91	BirdLife Australia
1977	7	1	-31.08	149.58	BirdLife Australia
1977	7	1	-31.58	148.75	BirdLife Australia
1977	8	22	-31.25	149.08	BirdLife Australia
1977	8	22	-31.25	148.91	BirdLife Australia
1977	8	31	-31.25	148.91	BirdLife Australia
1977	9	12	-31.25	148.91	BirdLife Australia
1977	11	2	-31.41	148.91	BirdLife Australia
1977	11	5	-30.26468503	150.167716	BioNet Atlas of NSW Wildlife
1977	12	25	-31.41	148.91	BirdLife Australia
1977	12	25	-32.25	148.25	BirdLife Australia
1977	12	26	-31.08	148.25	BirdLife Australia
1977	12	26	-31.25	148.75	BirdLife Australia
1977	12	27	-30.75	149.58	BirdLife Australia
1977	12	27	-30.75	149.25	BirdLife Australia
1977	12	27	-30.41	149.58	BirdLife Australia
1977	12	28	-30.41	150.08	BirdLife Australia
1978	1	5	-31.25	148.91	BirdLife Australia
1979	3	10	-31.41	148.41	BirdLife Australia
1979	4	12	-31.58	148.58	BirdLife Australia
1980	5	8	-31.25	148.91	BirdLife Australia
1980	7	24	-31.25	148.41	BirdLife Australia
1980	8	29	-31.429462	149.06705	EBird Australia

Appendix 3. Records of Little Eagle along the N2N rail corridor

Year	Month	Day	Latitude	Longitude	Source
1980	8	29	-30.91	149.25	BirdLife Australia
1980	8	29	-31.41	149.08	BirdLife Australia
1980	10	5	-31.277414	148.99855	EBird Australia
1980	11	22	-30.27453203	150.164316	BioNet Atlas of NSW Wildlife
1981	5	20	-30.08	149.08	BirdLife Australia
1981	8	9	-30.93950903	149.115556	BioNet Atlas of NSW Wildlife
1981	8	11	-31.41	148.91	BirdLife Australia
1981	8	29	-31.277414	148.99855	EBird Australia
1981	8	30	-31.25	148.9167	EBird Australia
1981	9	14	-30.75	149.58	BirdLife Australia
1982	5	18	-30.63259603	149.484363	BioNet Atlas of NSW Wildlife
1982	5	18	-30.46734303	149.446835	BioNet Atlas of NSW Wildlife
1982	5	18	-30.60243503	149.409559	BioNet Atlas of NSW Wildlife
1982	9	24	-31.27135	148.95917	EBird Australia
1982	9	26	-31.303818	149.01599	EBird Australia
1984	10	9	-31.27676	148.99747	EBird Australia
1985	1	1	-31.90950803	148.444842	BioNet Atlas of NSW Wildlife
1987	10	30	-30.27416003	150.10614	BioNet Atlas of NSW Wildlife
1989	12	4	-30.27416003	150.10614	BioNet Atlas of NSW Wildlife
1990	8	10	-31.27032003	148.959082	BioNet Atlas of NSW Wildlife
1990	8	11	-31.27032003	148.959082	BioNet Atlas of NSW Wildlife
1990	9	9	-31.27032003	148.959082	BioNet Atlas of NSW Wildlife
1992	7	1	-31.2715	149.27605	EBird Australia
1992	10	9	-30.93083303	149.066184	BioNet Atlas of NSW Wildlife
1992	11	4	-30.93940003	149.066369	BioNet Atlas of NSW Wildlife
1992	11	12	-30.94843303	149.067819	BioNet Atlas of NSW Wildlife
1993	9	29	-31.277414	148.99855	EBird Australia
1993	11	17	-31.277414	148.99855	EBird Australia
1995	2	27	-32.06178303	148.10296	BioNet Atlas of NSW Wildlife
1995	9	17	-31.277414	148.99855	EBird Australia
1996	1	16	-31.27495503	149.0663	BioNet Atlas of NSW Wildlife
1996	2	7	-31.27495503	149.0663	BioNet Atlas of NSW Wildlife
1996	11	19	-32.12577803	148.464139	BioNet Atlas of NSW Wildlife
1997	1	1	-31.25805	149.12805	EBird Australia
1998	9	30	-31.266397	149.13963	EBird Australia
1998	9	30	-31.267132	149.15843	EBird Australia
1998	9	30	-31.26833	149.1578	BirdLife Australia
1998	10	1	-31.06028	149.0911	BirdLife Australia
1998	10	1	-31.12361	149.1086	BirdLife Australia
1998	10	3	-31.302425	148.99652	EBird Australia
1998	10	3	-31.009314	148.24948	EBird Australia
1998	10	3	-31.00283	148.16542	EBird Australia

Appendix 3. Records of Little Eagle along the N2N rail corridor

Year	Month	Day	Latitude	Longitude	Source
1998	10	3	-30.927637	148.37976	EBird Australia
1998	10	3	-31.00889	148.2569	BirdLife Australia
1998	10	3	-31.2975	148.9933	BirdLife Australia
1998	10	3	-30.93611	148.3806	BirdLife Australia
1998	10	5	-31.142689	149.10107	EBird Australia
1998	10	5	-31.044256	149.07375	EBird Australia
1998	10	5	-31.12222	149.11028	EBird Australia
1998	10	6	-31.277414	148.99855	EBird Australia
1998	11	30	-31.68947403	147.829487	BioNet Atlas of NSW Wildlife
1999	1	14	-31.28361	148.9703	BirdLife Australia
1999	1	16	-30.16667	150.05	BirdLife Australia
1999	6	3	-30.75028	149.1103	BirdLife Australia
1999	9	24	-31.69639	147.8408	BirdLife Australia
1999	10	28	-31.33333	149.2833	BirdLife Australia
1999	11	13	-30.66083403	148.8131	BioNet Atlas of NSW Wildlife
2000	1	13	-30.90741603	149.521772	BioNet Atlas of NSW Wildlife
2000	4	24	-31.6925	147.8436	BirdLife Australia
2000	9	14	-31.75	147.7833	BirdLife Australia
2000	10	2	-30.24929003	149.795675	BioNet Atlas of NSW Wildlife
2000	10	8	-31.2975	148.9933	BirdLife Australia
2000	10	10	-30.88361	148.8308	BirdLife Australia
2000	11	8	-30.28050303	150.148557	BioNet Atlas of NSW Wildlife
2000	11	8	-30.31352303	150.159888	BioNet Atlas of NSW Wildlife
2000	11	16	-31.69306	147.84	BirdLife Australia
2001	1	3	-31.69444	147.6194	BirdLife Australia
2001	1	4	-31.5	148.2167	BirdLife Australia
2001	1	29	-31.32140403	148.438936	BioNet Atlas of NSW Wildlife
2001	5	9	-31.423334	148.61806	EBird Australia
2001	5	9	-31.42694	148.6353	BirdLife Australia
2001	7	20	-30.32531	149.78673	EBird Australia
2001	8	4	-31.28056	148.9883	BirdLife Australia
2001	9	7	-32.04361	147.978	BirdLife Australia
2001	9	10	-31.13176603	149.476154	BioNet Atlas of NSW Wildlife
2001	9	22	-30.27889	150.1647	BirdLife Australia
2001	9	22	-30.795	148.9828	BirdLife Australia
2001	9	27	-31.29602	148.9931	EBird Australia
2001	10	21	-30.35048503	149.957294	BioNet Atlas of NSW Wildlife
2001	10	27	-30.89375	148.81851	EBird Australia
2001	10	27	-30.88361	148.8308	BirdLife Australia
2001	10	30	-30.57155203	150.182282	BioNet Atlas of NSW Wildlife
2001	11	3	-31.66248803	148.750643	BioNet Atlas of NSW Wildlife
2001	11	14	-31.18432103	149.235217	BioNet Atlas of NSW Wildlife

Appendix 3. Records of Little Eagle along the N2N rail corridor

Year	Month	Day	Latitude	Longitude	Source
2001	11	17	-30.62222	150.1583	BirdLife Australia
2001	12	16	-31.29289303	149.039412	BioNet Atlas of NSW Wildlife
2002	1	21	-31.76948703	147.802743	BioNet Atlas of NSW Wildlife
2002	1	23	-30.29167	150.1889	BirdLife Australia
2002	2	14	-31.03111	149.0936	BirdLife Australia
2002	11	25	-31.21038203	148.70228	BioNet Atlas of NSW Wildlife
2003	2	11	-32.10494703	148.306961	BioNet Atlas of NSW Wildlife
2003	2	11	-32.10051903	148.29895	BioNet Atlas of NSW Wildlife
2003	3	3	-32.10258903	148.023965	BioNet Atlas of NSW Wildlife
2003	7	30	-30.33407003	149.576093	BioNet Atlas of NSW Wildlife
2003	8	8	-31.72056	148.65694	EBird Australia
2003	8	8	-30.40113803	150.055676	BioNet Atlas of NSW Wildlife
2003	9	5	-31.29222	149.2889	BirdLife Australia
2003	9	10	-31.27361	148.9583	BirdLife Australia
2004	9	4	-30.66272	149.41956	EBird Australia
2004	10	11	-30.34056	149.7567	BirdLife Australia
2005	2	17	-31.75	148.75	EBird Australia
2005	2	26	-31.25	148.4167	EBird Australia
2005	3	1	-31.02417	148.35	EBird Australia
2005	3	25	-30.36976	149.52289	EBird Australia
2005	3	27	-30.61667	150.1453	BirdLife Australia
2005	4	12	-30.43472	150.1361	BirdLife Australia
2005	8	29	-31.277414	148.99855	EBird Australia
2005	9	23	-31.75	148.75	EBird Australia
2006	4	26	-31.75	148.75	EBird Australia
2006	9	16	-30.21305	149.9225	BirdLife Australia
2006	9	16	-30.14667	150.0525	BirdLife Australia
2007	3	27	-30.20583	149.3083	BirdLife Australia
2007	3	31	-31.693027	147.84355	EBird Australia
2007	12	4	-31.12643	149.40582	EBird Australia
2008	9	20	-31.277414	148.99855	EBird Australia
2009	10	17	-30.34167	149.7597	BirdLife Australia
2009	10	17	-30.33	149.75	BirdLife Australia
2010	9	7	-30.25	149.41666	EBird Australia
2010	9	24	-31.6975	147.83476	EBird Australia
2010	10	5	-30.79261	148.98431	EBird Australia
2011	1	8	-30.28167	150.178055	BirdLife Australia
2011	7	30	-31.27083	148.96001	BirdLife Australia
2011	10	10	-30.49292303	149.637803	BioNet Atlas of NSW Wildlife
2011	10	10	-30.49108203	149.727224	BioNet Atlas of NSW Wildlife
2011	10	15	-30.265045	149.55302	EBird Australia
2011	11	15	-30.28255	150.14275	EBird Australia

Appendix 3. Records of Little Eagle along the N2N rail corridor

Year	Month	Day	Latitude	Longitude	Source
2011	11	21	-30.50242203	149.885704	BioNet Atlas of NSW Wildlife
2012	9	15	-30.243889	149.451386	BirdLife Australia
2012	10	3	-31.28417	149.0986	BirdLife Australia
2012	11	6	-30.30861	149.5236	EBird Australia
2013	1	23	-31.29904603	149.012736	BioNet Atlas of NSW Wildlife
2013	4	4	-31.70278	148.666672	BirdLife Australia
2013	4	7	-31.70235	148.671	EBird Australia
2013	7	13	-30.32531	149.78673	EBird Australia
2013	8	14	-30.41666	149.58333	EBird Australia
2013	9	13	-31.27083	148.960007	BirdLife Australia
2013	10	11	-30.34222	149.99222	EBird Australia
2014	1	10	-30.3447	150.02763	EBird Australia
2014	1	19	-30.85004	149.45894	EBird Australia
2014	9	8	-31.28417	149.0986	BirdLife Australia
2015	1	12	-30.48159703	150.116937	BioNet Atlas of NSW Wildlife
2015	2	2	-30.60431003	150.15558	BioNet Atlas of NSW Wildlife
2015	5	29	-31.632711	147.99486	EBird Australia
2015	6	25	-31.41667	148.91667	EBird Australia
2015	8	30	-30.28056	150.1664	BirdLife Australia
2015	9	3	-31.68526803	147.845958	BioNet Atlas of NSW Wildlife
2015	9	19	-30.85528	149.475	BirdLife Australia
2015	10	14	-30.63821003	150.02555	BioNet Atlas of NSW Wildlife
2015	10	17	-30.53232703	149.599798	BioNet Atlas of NSW Wildlife
2016	1	23	-31.25805	149.12805	EBird Australia
2016	4	16	-30.33472	149.76	BirdLife Australia
2016	5	20	-31.38543203	147.694166	BioNet Atlas of NSW Wildlife
2016	9	13	-30.74463	149.28995	EBird Australia
2016	10	23	-30.54892403	148.994663	BioNet Atlas of NSW Wildlife
2016	10	27	-30.59276603	150.126017	BioNet Atlas of NSW Wildlife
2017	1	21	-30.91750303	149.274726	BioNet Atlas of NSW Wildlife
2017	8	10	-30.54088003	150.0581	BioNet Atlas of NSW Wildlife
2017	10	14	-30.99737	149.23434	EBird Australia
2017	10	23	-30.37259803	149.528743	BioNet Atlas of NSW Wildlife
2017	11	7	-30.53491403	150.11544	BioNet Atlas of NSW Wildlife
2017	11	9	-31.70457	148.65805	EBird Australia
2018	1	20	-30.37667	149.53028	BirdLife Australia
2018	2	9	-31.277414	148.99855	EBird Australia
2018	3	10	-30.334705	149.96213	EBird Australia
2018	3	15	-31.693027	147.84355	EBird Australia
2018	3	15	-31.69501	147.8398	BirdLife Australia
2018	3	18	-31.563889	147.7089	EBird Australia
2018	3	18	-31.511	147.69386	BirdLife Australia

Appendix 3. Records of Little Eagle along the N2N rail corridor

Year	Month	Day	Latitude	Longitude	Source
2018	4	18	-30.062967	149.06297	EBird Australia
2018	5	6	-30.334705	149.96213	EBird Australia
2018	5	16	-30.348103	148.89818	EBird Australia
2018	7	7	-31.693027	147.84355	EBird Australia
2018	8	22	-30.62985703	150.153828	BioNet Atlas of NSW Wildlife
2018	9	8	-30.3452	149.89856	EBird Australia
2018	10	5	-31.72950003	147.85476	BioNet Atlas of NSW Wildlife
2018	10	12	-31.277414	148.99855	EBird Australia
2018	11	20	-30.62985703	150.153828	BioNet Atlas of NSW Wildlife
2018	11	21	-30.62985703	150.153828	BioNet Atlas of NSW Wildlife
2019	1	6	-30.347534	149.78848	EBird Australia
2019	9	11	-30.687748	149.54045	EBird Australia
2019	11	4	-31.693027	147.84355	EBird Australia
2019	11	11	-31.280888	148.97552	EBird Australia
2020	1	25	-31.277414	148.99855	EBird Australia
2020	3	1	-30.358173	148.96568	EBird Australia
2020	4	12	-30.320757	149.78706	EBird Australia
2020	6	7	-31.693027	147.84355	EBird Australia
2020	6	12	-31.17884	149.08698	EBird Australia
2020	7	18	-30.2234	149.44142	EBird Australia
2020	7	31	-30.36976	149.52289	EBird Australia
2020	9	1	-30.33673	149.7584	EBird Australia
2020	9	4	-31.277435	148.99057	EBird Australia
2020	9	19	-31.27245503	149.267189	BioNet Atlas of NSW Wildlife
2020	10	14	-30.282568	148.82213	EBird Australia
2020	11	6	-30.56444003	150.107333	BioNet Atlas of NSW Wildlife
2020	11	15	-31.334254	148.683454	GHD
			-30.95	149.08	BirdLife Australia
			-31.55	148.78	BirdLife Australia
			-31.55	148.78	BirdLife Australia
			-31.58	148.41	BirdLife Australia
			-31.08	149.08	BirdLife Australia
			-31.63	148.61	BirdLife Australia
			-31.41	148.91	BirdLife Australia
			-31.3	148.16	BirdLife Australia
			-32.25	148.25	BirdLife Australia
			-31.28	148.96	BirdLife Australia
			-30.91	149.08	BirdLife Australia
			-31.25	149.25	BirdLife Australia
			-31.25	148.91	BirdLife Australia
			-31.58	148.58	BirdLife Australia
			-32.08	148.08	BirdLife Australia

Appendix 3. Records of Little Eagle along the N2N rail corridor

Year	Month	Day	Latitude	Longitude	Source
			-31.25	148.91	BirdLife Australia
			-31.25	148.91	BirdLife Australia
			-31.25	148.91	BirdLife Australia
			-31.25	149.25	BirdLife Australia
			-31.41	148.58	BirdLife Australia
			-32.08	148.08	BirdLife Australia
			-31.25	148.91	BirdLife Australia
			-31.25	148.91	BirdLife Australia
			-31.25	149.25	BirdLife Australia
			-31.41	148.58	BirdLife Australia
			-31.25	148.91	BirdLife Australia
			-32.08	148.08	BirdLife Australia
			-31.25	148.91	BirdLife Australia
			-31.25	149.25	BirdLife Australia
			-30.58	148.91	BirdLife Australia
			-31.08	149.58	BirdLife Australia
			-31.25	148.91	BirdLife Australia
			-31.41	148.58	BirdLife Australia
			-31.25	149.25	BirdLife Australia
			-31.25	148.91	BirdLife Australia
			-31.25	149.08	BirdLife Australia
			-31.75	148.75	BirdLife Australia
			-31.25	149.25	BirdLife Australia
			-31.25	149.25	BirdLife Australia
			-31.08	149.41	BirdLife Australia
			-31.25	148.91	BirdLife Australia
			-31.25	149.25	BirdLife Australia
			-31.25	148.91	BirdLife Australia
			-31.91	147.75	BirdLife Australia
			-31.25	149.25	BirdLife Australia
			-31.25	149.08	BirdLife Australia
			-31.25	149.08	BirdLife Australia
			-31.25	148.91	BirdLife Australia
			-31.08	149.41	BirdLife Australia
			-30.91	148.58	BirdLife Australia
			-31.25	148.91	BirdLife Australia
			-30.25	150.08	BirdLife Australia
			-31.25	149.08	BirdLife Australia
			-31.08	149.41	BirdLife Australia
			-31.25	148.91	BirdLife Australia
			-31.25	149.25	BirdLife Australia
			-31.08	149.08	BirdLife Australia

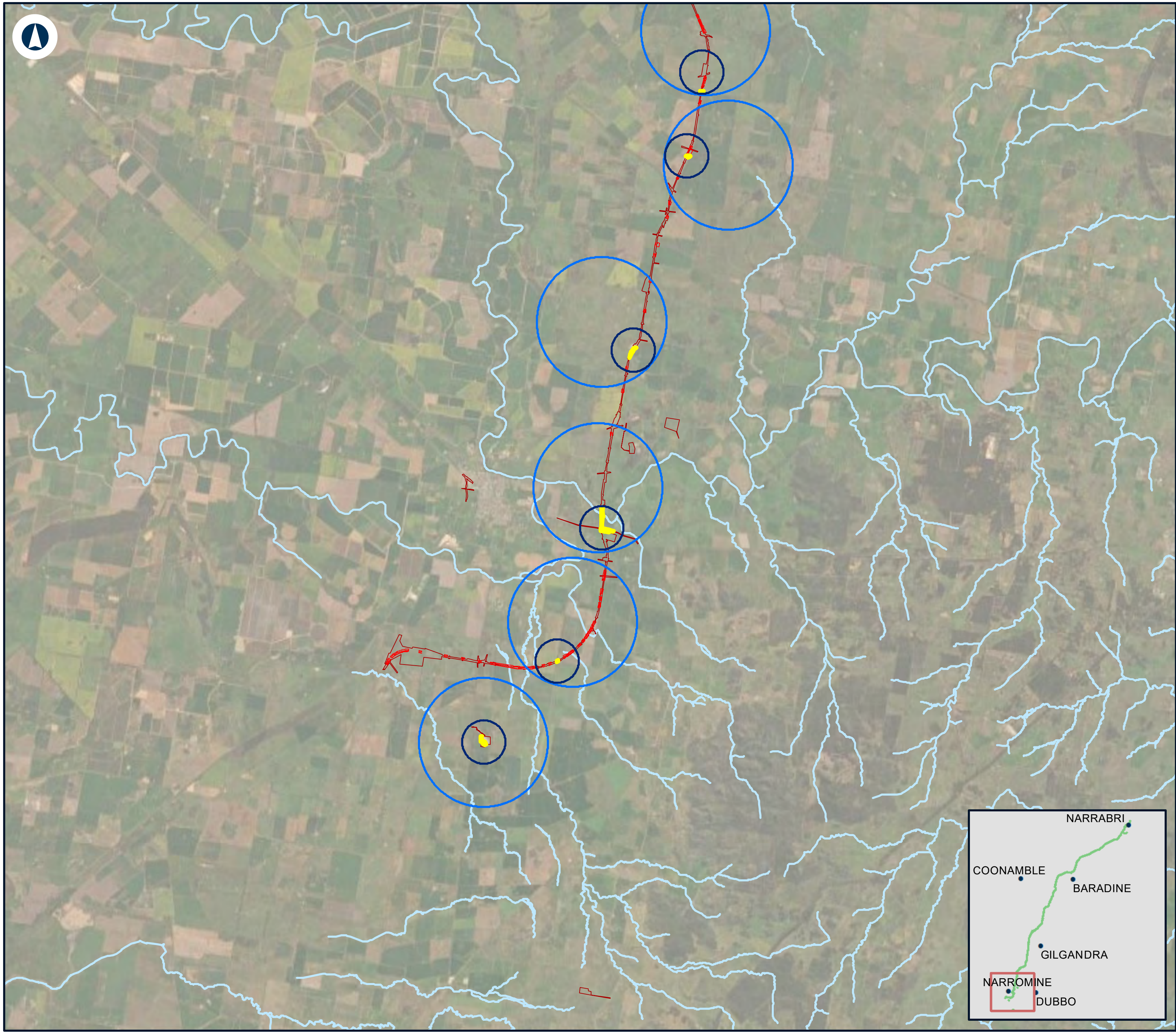
Appendix 3. Records of Little Eagle along the N2N rail corridor

Year	Month	Day	Latitude	Longitude	Source
			-30.91	149.08	BirdLife Australia
			-30.91	149.41	BirdLife Australia
			-31.25	149.08	BirdLife Australia
			-31.41	148.58	BirdLife Australia
			-31.25	149.08	BirdLife Australia
			-31.25	149.25	BirdLife Australia
			-31.75	148.75	BirdLife Australia
			-30.25	150.08	BirdLife Australia
			-31.41	149.08	BirdLife Australia
			-31.25	149.08	BirdLife Australia
			-30.25	149.91	BirdLife Australia
			-31.25	148.91	BirdLife Australia
			-32.25	148.25	BirdLife Australia
			-31.25	149.41	BirdLife Australia
			-31.58	147.91	BirdLife Australia
			-31.41	148.91	BirdLife Australia
			-31.25	149.25	BirdLife Australia
			-31.25	148.91	BirdLife Australia
			-31.58	147.91	BirdLife Australia
			-30.58	149.91	BirdLife Australia
			-31.25	149.08	BirdLife Australia
			-31.08	148.25	BirdLife Australia
			-31.25	148.91	BirdLife Australia
			-31.08	149.41	BirdLife Australia
			-31.25	148.41	BirdLife Australia
			-30.25	150.25	BirdLife Australia
			-31.08	148.75	BirdLife Australia
			-31.41	149.25	BirdLife Australia
			-31.25	149.08	BirdLife Australia
			-31.08	148.75	BirdLife Australia
			-31.58	147.75	BirdLife Australia
			-30.91	149.41	BirdLife Australia
			-31.25	149.25	BirdLife Australia
			-31.58	148.41	BirdLife Australia
			-30.91	149.08	BirdLife Australia
			-30.25	149.25	BirdLife Australia
			-31.25	148.75	BirdLife Australia
			-31.75	147.91	BirdLife Australia
			-31.41	149.08	BirdLife Australia
			-31.25	148.58	BirdLife Australia
			-30.91	149.08	BirdLife Australia
			-31.58	148.41	BirdLife Australia

Appendix 3. Records of Little Eagle along the N2N rail corridor

Year	Month	Day	Latitude	Longitude	Source
			-31.25	148.75	BirdLife Australia
			-30.91	149.08	BirdLife Australia
			-31.41	149.08	BirdLife Australia
			-31.25	148.58	BirdLife Australia
			-30.25	150.08	BirdLife Australia
			-31.75	148.75	BirdLife Australia
			-31.41	149.08	BirdLife Australia
			-31.08	148.91	BirdLife Australia
			-30.75	149.08	BirdLife Australia
			-31.08	148.91	BirdLife Australia
			-30.58	149.91	BirdLife Australia
			-30.91	149.08	BirdLife Australia
			-30.91	149.08	BirdLife Australia
			-30.91	149.08	BirdLife Australia
			-31.75	147.91	BirdLife Australia
			-30.91	149.08	BirdLife Australia
			-30.91	149.08	BirdLife Australia
			-31.58	147.75	BirdLife Australia

Appendix 4. Little Eagle Species polygons N2N distribution



The Australian Government is delivering Inland Rail through the Australian Rail Track Corporation (ARTC) in partnership with the private sector

NARROMINE TO NARRABRI

Little Eagle potential habitat and species polygon within the Pilliga

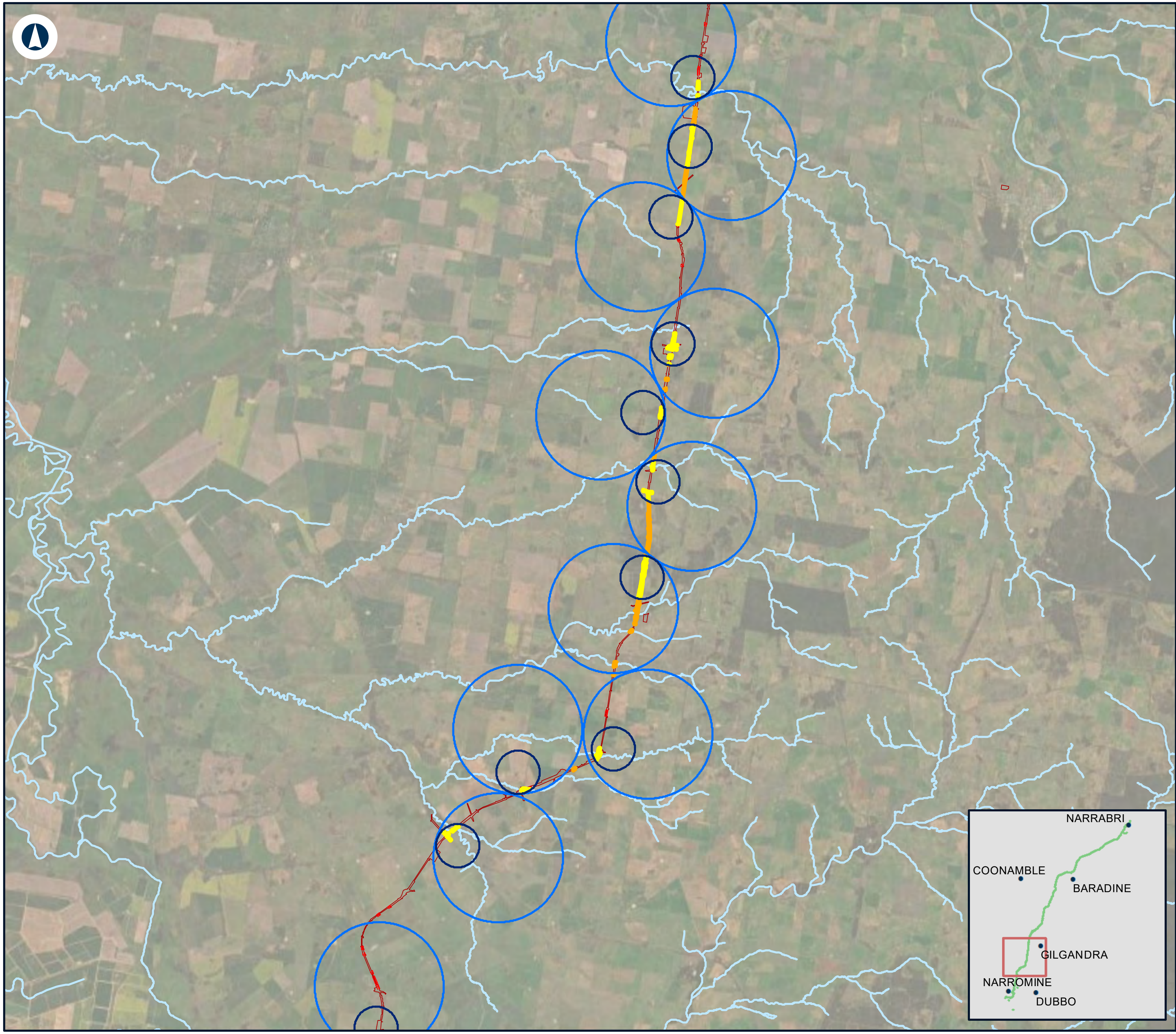
LEGEND

- Construction impact zone
- Culvert easement
- Breeding/forgaing territory (2800 ha)
- Indicative nest tree 1km buffer
- Little Eagle species polygon
- Little Eagle potential breeding habitat

0 4 8 Km

Coordinate System: GDA 1994 MGA Zone 55

Date: 2021-11-22
Paper: A4
Author: JacobsGHD
Scale: 1:250,000
Data Sources: Basemap layers: NSWSS, esri;



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NARROMINE TO NARRABRI

Little Eagle potential habitat and species polygon within the Pilliga

LEGEND

- Construction impact zone
- Culvert easement
- Breeding/forging territory (2800 ha)
- Indicative nest tree 1km buffer
- Little Eagle species polygon
- Little Eagle potential breeding habitat

0 4 8 Km

Coordinate System: GDA 1994 MGA Zone 55

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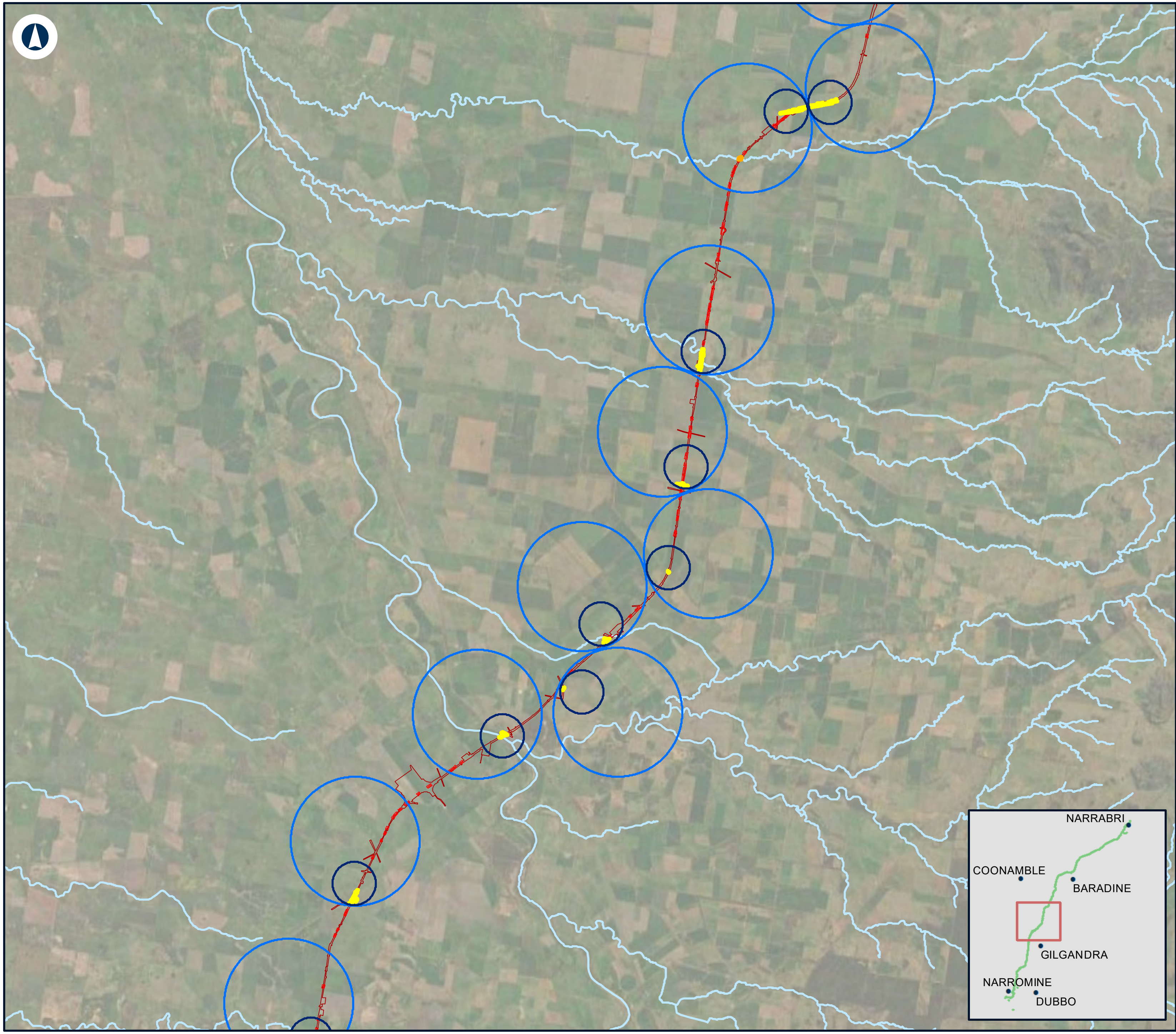

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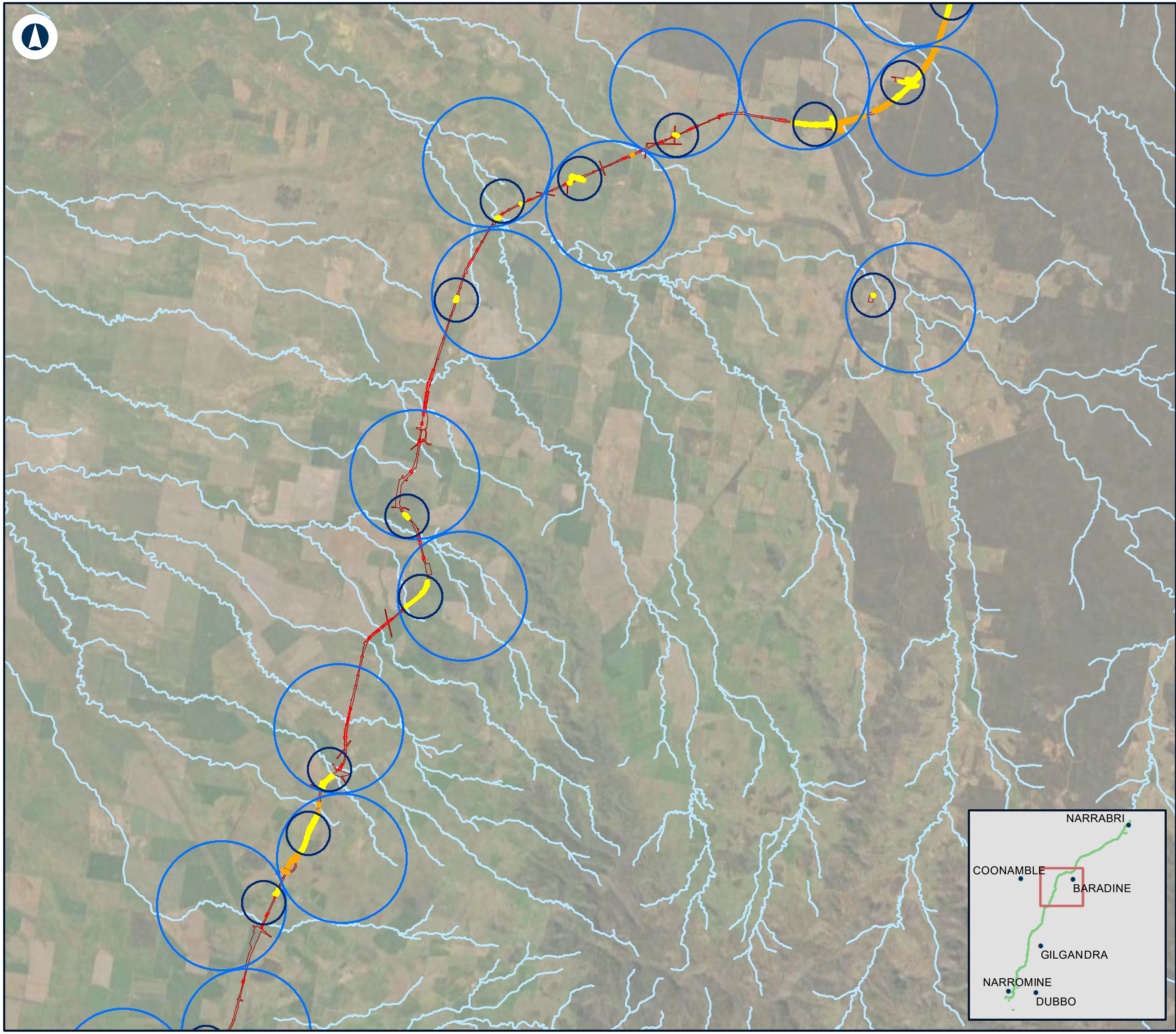

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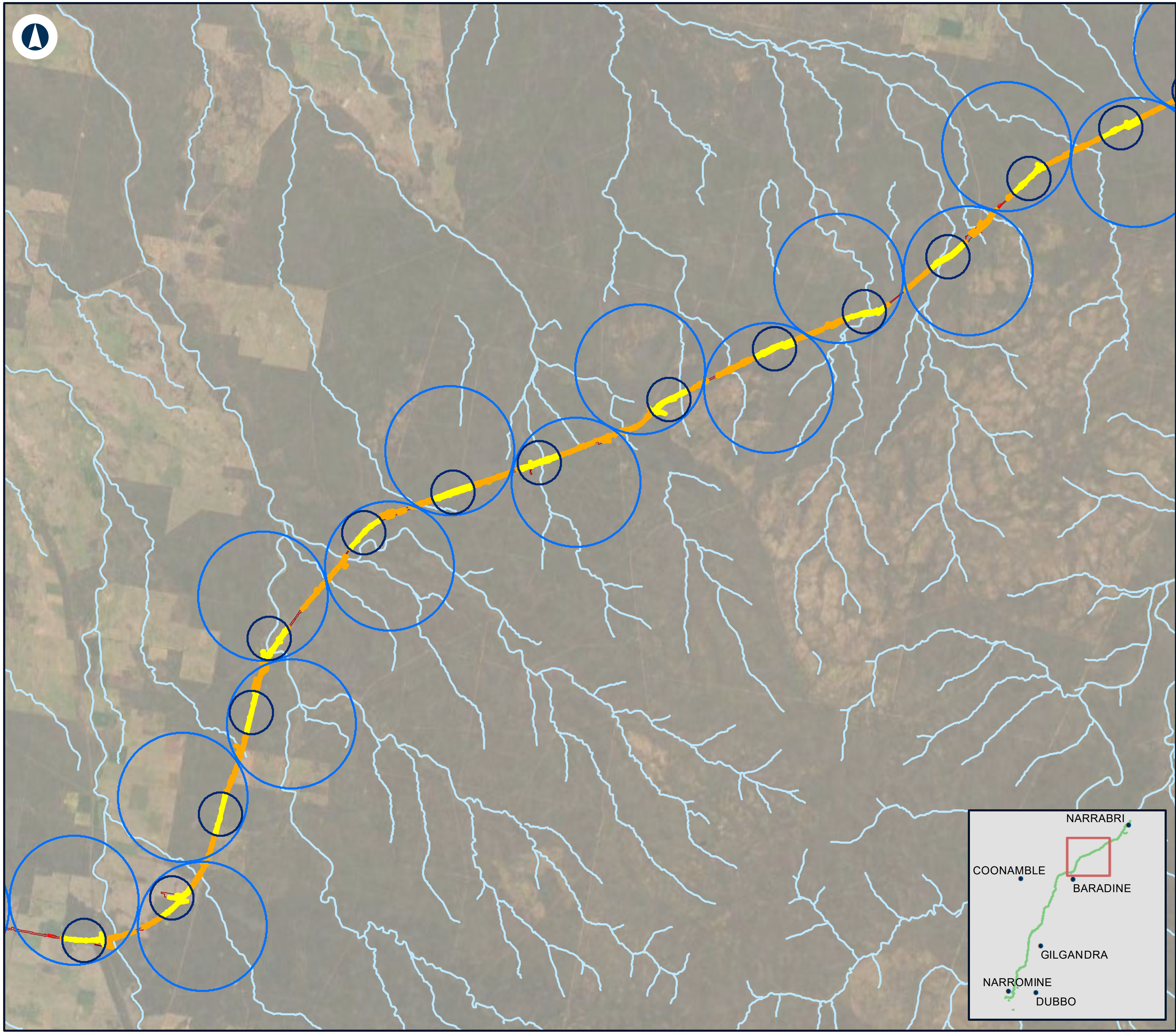

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INLAND RAIL

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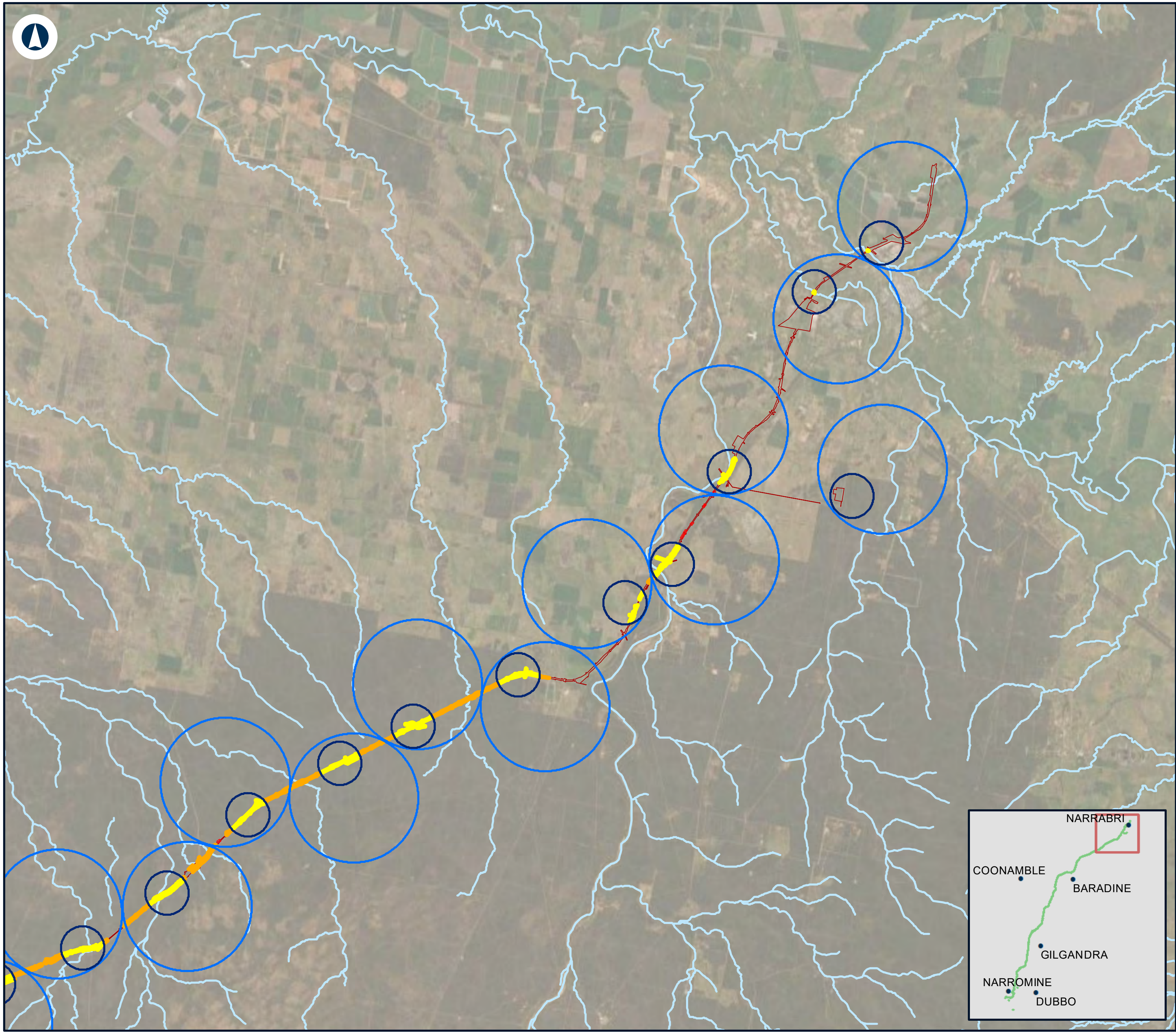
NARROMINE TO NARRABRI

Little Eagle potential habitat and species polygon within the Pilliga



LEGEND

- Construction impact zone
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Appendix 5. Little Eagle Species polygons calculations within each PCT

IBRA subregion	PCT ID	PCT Name	Condition	Area
Bogan-Macquarie	36	River Red Gum tall to very tall open forest/woodland wetland on rivers on floodplains mainly in the Darling Riverine Plains Bioregion	Good	2.07
Bogan-Macquarie	56	Poplar Box - Belah woodland on clay-loam soils on aluvial plains on north central NSW	Good	0.37
Bogan-Macquarie	248	Mixed box eucalypt woodland on low sandy-loam rises on alluvial plains in central western NSW	Good	7.52
Bogan-Macquarie	255	Mugga Ironbark - Buloke - Pillga Box - White Cypress Pine shrubby woodland	Good	3.26
Castlereagh-Barwon	56	Poplar Box - Belah woodland on clay-loam soils on aluvial plains on north central NSW	Good	4.88
Castlereagh-Barwon	78	River Red Gum riparian tall woodland / open forest wetland in the Nandewar Bioregion and Brigalow Belt South Bioregion	Good	8.46
Castlereagh-Barwon	88	Pilliga Box - White Cypress Pine - Buloke shrubby woodland in the Brigalow Belt South Bioregion	Good	2.01
Castlereagh-Barwon	145	Western Rosewood - Wilga - Wild Orange - Belah low woodland of the Brigalow Belt South Bioregion and eastern Darling Riverine Plains Bioregion	Good	1.41
Castlereagh-Barwon	244	Poplar Box grassy woodland on alluvial clay-loam soils mainly in the temperate (hot summer) climate zone of central NSW (wheatbelt)	Good	6.79
Castlereagh-Barwon	444	Silver-leaved Ironbark grassy tall woodland on clay-loam soils on plains in the Brigalow Belt South Bioregion	Good	1.68
Liverpool Plains	78	River Red Gum riparian tall woodland / open forest wetland in the Nandewar Bioregion and Brigalow Belt South Bioregion	Good	0.17
Pilliga	36	River Red Gum tall to very tall open forest/woodland wetland on rivers on floodplains mainly in the Darling Riverine Plains Bioregion	Good	2.95
Pilliga	55	Belah woodland on alluvial plains and low rises in the central NSW wheatbelt to Pilliga and Liverpool Plains regions	Good	2.76
Pilliga	78	River Red Gum riparian tall woodland / open forest wetland in the Nandewar Bioregion and Brigalow Belt South Bioregion	Good	0.62
Pilliga	88	Pilliga Box - White Cypress Pine - Buloke shrubby woodland in the Brigalow Belt South Bioregion	Good	87.47
Pilliga	145	Western Rosewood - Wilga - Wild Orange - Belah low woodland of the Brigalow Belt South Bioregion and eastern Darling Riverine Plains Bioregion	Good	5.88
Pilliga	206	Dirty Gum - White Cypress Pine tall woodland of alluvial sand (sand monkeys) in the Darling Riverine Plains Bioregion and Brigalow Belt South Bioregion	Good	3.33
Pilliga	244	Poplar Box grassy woodland on alluvial clay-loam soils mainly in the temperate (hot summer) climate zone of central NSW (wheatbelt)	Good	7.69
Pilliga	394	Narrow-leaved Ironbark - White Cypress pine woodland on slopes and flats in the Coonabarabran - Pilliga Scrub regions	Good	3.27
Pilliga	394	Narrow-leaved Ironbark - White Cypress pine woodland on slopes and flats in the Coonabarabran - Pilliga Scrub regions	Good_Fire_Affected	5.68
Pilliga	398	Narrow-leaved Ironbark - White Cypress Pine - Buloke tall open forest on lower slopes and flats in the Pilliga Scrub and surrounding forests in the central north Brigalow Belt South Bioregion	Good	97.09
Pilliga	399	Red gum - Rough-barked Apple +/- tea tree sandy creek woodland (wetland) in the Pilliga - Goonoo sandstone forests, Brigalow Belt South Bioregion	Good	11.41
Pilliga	404	Red Ironbark - White Bloodwood +/- Burrows Wattle heathy woodland on sandy soil in the Pilliga forests	Good	14.58

Appendix 5. Little Eagle Species polygons calculations within each PCT

IBRA subregion	PCT ID	PCT Name	Condition	Area
Pilliga	406	White Bloodwood - Motherumbah - Red Ironbark shrubby sandstone hill woodland / open forest mainly in east Pilliga forests	Good	2.40
Pilliga	409	Dirty (Baradine) Gum - White Bloodwood - White Cypress Pine - Motherumbah shrubby woodland on sandy soils in the Pilliga Scrub and surrounding region, Brigalow Belt South Bioregion	Good	0.76
Pilliga	1384	White Cypress Pine - Bulloak - ironbark woodland of the Pilliga area of the Brigalow Belt South Bioregion	Good	0.62
Pilliga Outwash	78	River Red Gum riparian tall woodland / open forest wetland in the Nandewar Bioregion and Brigalow Belt South Bioregion	Good	9.28
Pilliga Outwash	88	Pilliga Box - White Cypress Pine - Buloke shrubby woodland in the Brigalow Belt South Bioregion	Good	36.90
Pilliga Outwash	148	Dirty Gum - Buloke - White cypress pine - ironbark shrubby woodland of the deep sandy soils on the Liverpool Plains Region of the Brigalow Belt South Bioregion	Good	7.71
Pilliga Outwash	397	Poplar Box - White Cypress Pine shrub grass tall woodland of the Pilliga - Warialda region, Brigalow Belt South Bioregion	Good	4.45
Pilliga Outwash	398	Narrow-leaved Ironbark - White Cypress Pine - Buloke tall open forest on lower slopes and flats in the Pilliga Scrub and surrounding forests in the central north Brigalow Belt South Bioregion	Good	84.05
Pilliga Outwash	398	Narrow-leaved Ironbark - White Cypress Pine - Buloke tall open forest on lower slopes and flats in the Pilliga Scrub and surrounding forests in the central north Brigalow Belt South Bioregion	Mod_shrubs_removed	7.05
Pilliga Outwash	399	Red gum - Rough-barked Apple +/- tea tree sandy creek woodland (wetland) in the Pilliga - Goonoo sandstone forests, Brigalow Belt South Bioregion	Good	20.12
Pilliga Outwash	435	White Box – White Cypress Pine shrub grass hills woodland in the Brigalow Belt South bioregion and Nandewar bioregion	Good	0.31
Pilliga Outwash	473	Red gum - Rough-barked Apple - Narrow-leaved Ironbark - cypress pine grassy open forest on flats and drainage lines in the Goonoo and surrounding forests, southern Brigalow Belt South Bioregion	Good	10.38

TOTAL SPECIES POLYGON	465.40
TOTAL SPECIES POLYGON (PILLIGA FORESTS)	277.01

Strategic Assessment

for the

Square-tailed Kite *Lophoictinia isura*

in the

Narromine to Narrabri

Inland Rail

Alignment

Report prepared for JacobsGHD

Prepared by Dr Tony Saunders and Dr Stephen Debus
Merops Services Pty Ltd

Prepared December 2021

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1. Justification for the Experts' Report

ARTC proposes to construct the Narromine to Narrabri (N2N) section of Inland Rail (the proposal). Due to the large areas of land that require assessment for the proposal, and access constraints generally relating to private landholdings, it is not feasible to conduct targeted threatened species surveys across the entire assessment area. As such, in accordance with Section 6 of the Biodiversity Assessment Method (BAM) 2017 (OEH 2017), a species expert report was required to assess the impacts on the Square-tailed Kite (*Lophoictinia isura*). This report was updated in December 2021 due to changes to the Construction Impact Zone (CIZ) to allow for flood mitigation, and to meet the requirements of BAM 2020 (DPIE 2020), following completion of the transition period.

The presence in the inland rail alignment of suitable habitat for foraging and breeding for the Square-tailed Kite, combined with the low density for this species and the difficulties with gaining sufficient access for surveys to establish the presence and habitat use by the Square-tailed Kite within the alignment, has meant that what survey effort has been possible has not been sufficient to establish the potential importance of the area for the Square-tailed Kite.

An expert in the breeding and foraging ecology of the Square-tailed Kite was required to assess the importance of the habitat remnants and the likelihood of occurrence within the rail alignment. The Square-tailed Kite is a forest and woodland specialist whose major food in its breeding season is forest and woodland birds, particularly small to medium-sized passerines and the contents of their nests, but also in recent times introduced and native pigeons and doves, and an abundant native bird (the Noisy Miner *Manorina melanocephala*), which is increasing in disturbed and fragmented forest and woodland. Therefore, an expert would also need to also be expert on the avifauna populations occurring in forest and woodland in New South Wales.

The Square-tailed Kite is listed in New South Wales as vulnerable under the *Biodiversity Conservation Act 2016* and is an uncommon species found in coastal and sub-coastal forests and woodlands. Inland, it shows a preference for timbered watercourses, though not necessarily strictly so near the coast, and is a summer breeding migrant to south-eastern Australia, arriving in September and leaving by March. Records for this species exist in and around the area to be impacted by the inland rail alignment. However, the species is encountered infrequently in this area and its interactions with local habitat are not well known.

The existence of potential habitat for the Square-tailed Kite and of records for the species within the area has meant that a more detailed assessment of the likelihood of impacts from the development in the area was required, particularly of the species' potential for foraging and breeding in the area. Targeted surveys could gather this information, but the survey effort required to collect sufficient data would be great and in the order of hundreds of hours in the appropriate seasons over several years, assuming access across the whole footprint was possible. This would also require tracking of individual birds to gather information on foraging, breeding locations and behaviour at nests etc. In particular, the whole 300-kilometre length of the alignment would need to be searched to a width of between 650 and 700 metres allowing for a buffer of 300 metre radius around active nests. All emergent trees would need to be searched for raptor stick nests and each found nest would need its position recorded so that it could be checked over several consecutive breeding seasons for nesting activity. Knowledge of the habitat structure and plant community types (PCTs) that the Square-tailed Kite has been recorded in within the Narromine to Narrabri area and of the ecology of the species can be used as a surrogate for the paucity of fieldwork.

2. Description and Ecology of the Square-tailed Kite

Species Description

Adult Square-tailed Kites are brown with a white crown and face, with dark streaked rufous nape and underparts. The tail is about half the total length and is grey brown with a dark terminal band (Debus 2019). They can be confused with other raptors but can be distinguished by the white cap (in adults), long and widely splayed, boldly banded primaries when soaring or gliding on upswept wings, slender bill, small feet, and very short legs hidden by feathers when perched and with the long wing tips crossing below the tail tip at rest (Debus 2017). It can often be observed circling low over the tree canopy on upswept wings with spread 'fingers' (Saunders pers. obs.).

Life Cycle

Square-tailed Kites usually occur singly, in pairs or (in the post-fledging period) family groups of adult(s) and fledgling(s) (Debus 2017). The highest count in one survey within the Cumberland County was 4 (CBOC Atlas accessed 28-04-2021), and most records for the Cumberland IBRA subregion were of single birds (ALA accessed 28-04-2021). They are generally solitary during the non-breeding season (Debus 1993). They appear to be long term monogamous as breeding pairs, as they are intolerant of other adults of the same species within their breeding territory, and they occupy the same nest site for many years (Debus *et al.* 1993; Bischoff *et al.* 2000; Russell and Franklin 2018). In eastern New South Wales, nest building occurs in July to October, laying in August, incubation in September to November, hatching occurs in September to October, nestlings occur from October to December and fledglings from November to December (Debus 1996; Bischoff *et al.* 2000; Brown *et al*. 2000; Griffiths *et al.* 2002; Lutter *et al.* 2003,2004; Stowe 2009). In the Cumberland County breeding has been recorded from July to February (CBOC Atlas, accessed 29-06-2018). Nestlings remain in the nest for between 55 and 60 days (Barnes *et al.* 1999, 2001; Lutter *et al.* 2003, 2004). Fledglings are dependent on the parents for about 2 months after which they generally disperse (Bischoff *et al.* 2000; Barnes *et al.* 2001; Lutter *et al.* 2003). The generational cycle is estimated to be 10 years (Garnett & Crowley 2000).

Distribution and Abundance

The Square-tailed Kite is an endemic species found over most of the Australian mainland and some larger offshore islands. It avoids the most arid, treeless central regions, where it is scarce or absent (Debus 2019). It is primarily found in open eucalypt forests, woodland, and mallee where passerines are common (Garnett 1993). They are generally absent from south-eastern New South Wales during the non-breeding period (Debus 1993) and are a summer breeding migrant to the southeast of New South Wales (Square-tailed Kite species profile, OEH Website, accessed 29-06-2018). Reporting rates were lower during the May to June period in the Central and South Coast regions of New South Wales (Cooper *et al.* 2014). The Kite has been recorded from August to April across the Cumberland County from the coast to the western edge of the Cumberland Plain, with a more widespread distribution in the northern half of the County (CBOC Atlas, accessed 28-04-2021).

The global population of the Square-tailed Kite is estimated to be between 1000 and 10,000 birds (Ferguson-Lees and Christie 2001). Density estimates are based mainly on breeding territories. In the Bendigo area of Victoria, the estimate was 25.8 pairs per 1000 km^2 of forest (Robinson *et al.* 2016). In northern coastal NSW the estimates vary from one pair per 120 km^2 to one pair per 170 km^2 and with a home range of up to 4 km around an active nest (Debus 1996a, Lutter *et al.* 2004). Spacing between adjacent nests was generally > 7 km (Debus 1996b, Lutter *et al.* 2004, Spencer 2007, Robinson et al. 2016).

There was a twofold increase in reporting rates in NSW over a 20-year period prior to 2006, mostly concentrated in coastal areas (Cooper *et al.* 2014). Barrett *et al.* (2007) reported a 40.8% increase in reporting rates for NSW, but this was not considered a significant change due to small sample size. Morris *et al.* (1981) reported that the Kite was scarce in coastal NSW based on records prior to the date of publication.

There have been suggestions as to why the Kite has increased in some areas. It appears to be adapting to urban bushland areas around coastal cities where it feeds on abundant native passerines and introduced bird species (Bischoff *et al.* 2000, Debus 2019). Lower competition from the Brown Goshawk *Accipiter fasciatus* (nestling predation) has been suggested as a possible explanation for the increase in breeding observed in the Bendigo area (Robinson *et al.* 2016). However, reporting rates for the Brown Goshawk have increased from 2% to 7% over the last six decades in Cumberland Plain woodland sites where the Kite has also increased and so does not support this suggestion (Saunders 2018).

Habitat Requirements

Square-tailed Kites are found mainly in coastal and sub-coastal eucalypt dominated forests and woodland, as well as treed areas in urban habitats (Debus 1993, Olsen 1995, Debus 2017), open forests and woodland (Cupper & Cupper 1981, Chafer *et al.* 1999, Barrett *et al.* 2007), passerine-rich woodlands when breeding and more open country when not breeding (Olsen *et al.* 1993) and open forests that are contiguous with very large areas of forest (Griffiths *et al.* 2002). They prefer timbered watercourses through open or cleared land and the margins between open and timbered country (Debus 1993).

When breeding, the Kite requires open forest where it can forage for nestlings in the canopy and approach the nest easily (Hollands 1984). Tall living eucalypt trees are chosen for nest sites (Debus 1993), especially where they are close to open edges (Lutter *et al.* 2004). They can tolerate human disturbance and use areas of urban bushland (Bischoff *et al.* 2000, Griffiths *et al.* 2002). Nests are mostly between 15 and 28 metres above ground in trees that range from 20 to 40 metres tall (Cupper & Cupper 1981, Bischoff *et al.* 2000, Barnes *et al.* 2001, Griffiths *et al.* 2002, Lutter *et al.* 2003, 2004, Stowe 2009, Optland 2015; Russell and Franklin 2018). The minimum requirements for nesting based on the literature review are described in Tables 1 and 2 below.

Table 1. Minimum distances of active Square-tailed Kite nests from developments (collated from various studies cited by Debus 2017, eastern/south-eastern Australia):

Parameter	Measurement
Dwelling	60–70 m
Urban area	Within*
Industrial building	–
Sealed road	5–10 m**
Unsealed road	15 m
Track/path	0 m#

*In the carpark of a suburban facility (animal hospital) in a bushland setting
**Almost overhanging the verge of a highway
#Directly over a trail-bike track

Table 2. Minimum criteria for active Square-tailed Kite nest-site characteristics (collated from various studies cited by Marchant and Higgins 1993 and Debus 2017, eastern/south-eastern Australia):

Parameter	Measurement
Forest/woodland patch size	5 ha*
Nest-tree height	20 m
Reference tree height**	10 m
Nest-tree DBH#	30 cm
Reference tree DBH	–
Nest height	9 m

*In fragmented landscapes with much larger patches nearby
**Reference trees are other trees within the nest patch
#Diameter at breast height

Foraging requires areas of woodland and open forest and adjacent open areas because the preferred prey is mainly canopy foraging prey species. These include mostly passerines and the contents of their nests (typically honeyeaters), but also doves, pigeons and parrots to lorikeet and rosella size, various arboreal or winged insects and their larvae, some reptiles and tree frogs, and rarely small mammals (e.g., juvenile rabbits) (studies cited by Marchant and Higgins 1993 and Debus 2017).

The NSW Threatened Biodiversity Data Collection indicates that the Square-tailed Kite has the potential to inhabit the plant communities listed in Table 3 that are found within the N2N alignment.

Table 3. List of Plant Community Types (PCT) found along the inland rail alignment that are utilised by the Square-tailed Kite.

PCT No.	PCT Type (abbreviated)
36	River Red Gum tall to very tall open forest/woodland
55	Belah Woodland
56	Poplar Box - Belah woodland
78	River Red Gum riparian tall woodland/open forest
81	Western Grey Box - cypress pine shrub grass shrub tall woodland in the Brigalow Belt South Bioregion
88	Pilliga Box - White Cypress Pine - Buloke shrubby woodland
141	Broombush - Wattle very tall shrubland
145	Western Rosewood- Wilga - Wild Orange - Belah low woodland
148	Dirty Gum - Buloke - White Cypress Pine

PCT No.	PCT Type (abbreviated)
202	Fuzzy Box woodland
206	Dirty Gum - White Cypress Pine - Buloke shrubby woodland
244	Poplar Box grassy woodland
248	Mixed Box eucalypt woodland
255	Mugga Ironbark - Buloke - Pillaga Box - White Cypress Pine
394	Narrow-leaved Ironbark - White Cypress Pine woodland
397	Poplar Box - White Cypress Pine tall woodland
398	Narrow-leaved Ironbark - White Cypress Pine - Buloke
399	Red Gum - Rough-barked Apple sandy creek woodland
404	Red Ironbark - White Bloodwood heathy woodland
406	White Bloodwood - Motherumbah - Red Ironbark woodland
409	Dirty Gum - White Bloodwood - White Cypress Pine woodland
411	Buloke - White Cypress Pine woodland
414	White Mallee - Dwyer's Red Gum mallee heath
473	Red Gum - Rough-barked Apple - Narrow-leaved Ironbark
469	White Cypress Pine - Narrow-leaved Ironbark - Buloke grassy open forest of the Dubbo region, southern Brigalow Belt South Bioregion
589	White Box - White Cypress Pine - Silver-leaved Ironbark
599	Blakely's Red Gum - Yellow Box tall woodland
746	Brown Bloodwood - Cypress - Ironbark heathy woodland
1384	White Cypress Pine - Buloke - Ironbark woodland

The habitat requirements discussed above have been used in this report to identify important habitat areas. They have been grouped into the habitat criteria listed below. The greater the number of criteria that are met the more likely it is that the remnant will provide habitat for Square-tailed Kite.

1. The site contains tall open forest or woodland.
2. The site is near or along a timbered watercourse.
3. The site contains one or more of the following PCTs: -
   36, 55, 56, 78, 88, 141, 145, 148, 202, 206, 244, 248, 255, 394, 397, 398, 399, 404, 406, 409, 411, 414, 473, 589, 599, 746, 1384.
4. Canopy foliage nesters, particularly honeyeaters, are common on site.
5. The site contains forest edge tolerant bird species e.g. Noisy Miner, Red Wattlebird, Lorikeets, Crested Pigeon or Common Bronzewing.
6. Forest or woodland that has open edges around remnants, timbered corridors and along watercourses.
7. Forest or woodland that has tall trees (> 20m) near outer edges or emergent trees suitable for nesting.
8. Site is within a habitat area larger than 5 ha in fragmented landscapes with much larger patches nearby.

3. Methods Used in the Preparation of the Report

Field Methods

Breeding habitat surveys were undertaken over 4 days from the 9th to the 12th of August 2021. Fifty aerial map sites out of 111 aerial maps were accessed. Thirty-three map sections were not visited because there were no potential habitat areas present on those sections. Any woodland appeared to be very sparse, or too low, or contained patches smaller than 5 hectares. The remaining 28 map sections were not visited because in many cases access to private lands along the rail alignment were denied (this affected 16 of the map sections), points of access in forest sites were too difficult to access and some of the other sites were not visited because Covid restrictions meant that the fieldwork was terminated one day short of the proposed survey period. The degree of access and survey effort for each aerial section map is described in Table 4 below.

Table 4. Site access and survey status for Square-tailed Kite potential breeding habitat.
Accessed and Surveyed (n=50): Aerial map area reached and surveyed at one or more points (see Methods for more details)
Habitat Inferred (n=28): Access not achieved, and habitat inferred from aerial photo (see Methods for more details)
No Suitable Habitat (n=33): No open forest or woodland providing suitable habitat, so area not surveyed.

Aerial Photo No.	Access		Aerial Photo No.	Access
1	No Suitable Habitat		57	Habitat Inferred
2	No Suitable Habitat		58	Habitat Inferred
3	No Suitable Habitat		59	Habitat Inferred
4	Accessed & Surveyed		60	Habitat Inferred
5	Accessed & Surveyed		61	Habitat Inferred
6	Habitat Inferred		62	No Suitable Habitat
7	Accessed & Surveyed		63	No Suitable Habitat
8	Accessed & Surveyed		64	Accessed & Surveyed
9	Accessed & Surveyed		65	Accessed & Surveyed
10	No Suitable Habitat		66	Accessed & Surveyed
11	No Suitable Habitat		67	Accessed & Surveyed
12	Habitat Inferred		68	Accessed & Surveyed
13	Accessed & Surveyed		69	Accessed & Surveyed
14	Accessed & Surveyed		70	Accessed & Surveyed
15	No Suitable Habitat		71	Accessed & Surveyed
16	Accessed & Surveyed		72	Accessed & Surveyed
17	Accessed & Surveyed		73	Accessed & Surveyed
18	Habitat Inferred		74	Accessed & Surveyed
19	Habitat Inferred		75	Accessed & Surveyed
20	Habitat Inferred		76	Accessed & Surveyed
21	Habitat Inferred		77	Accessed & Surveyed
22	Habitat Inferred		78	Accessed & Surveyed
23	Habitat Inferred		79	Habitat Inferred
24	Habitat Inferred		80	Accessed & Surveyed
25	Accessed & Surveyed		81	Accessed & Surveyed
26	No Suitable Habitat		82	Accessed & Surveyed
27	Accessed & Surveyed		83	Accessed & Surveyed
28	Accessed & Surveyed		84	Accessed & Surveyed
29	Accessed & Surveyed		85	Accessed & Surveyed
30	No Suitable Habitat		86	Accessed & Surveyed
31	Accessed & Surveyed		87	Accessed & Surveyed
32	No Suitable Habitat		88	Accessed & Surveyed
33	No Suitable Habitat		89	Accessed & Surveyed
34	No Suitable Habitat		90	Habitat Inferred
35	Accessed & Surveyed		91	Accessed & Surveyed
36	Habitat Inferred		92	No Suitable Habitat
37	Habitat Inferred		93	Accessed & Surveyed
38	Habitat Inferred		94	No Suitable Habitat
39	Habitat Inferred		95	Accessed & Surveyed
40	No Suitable Habitat		96	Accessed & Surveyed
41	Accessed & Surveyed		97	No Suitable Habitat
42	No Suitable Habitat		98	No Suitable Habitat
43	No Suitable Habitat		99	Habitat Inferred
44	Habitat Inferred		100	Habitat Inferred
45	Accessed & Surveyed		101	No Suitable Habitat
46	Accessed & Surveyed		102	No Suitable Habitat
47	No Suitable Habitat		103	Habitat Inferred
48	Accessed & Surveyed		104	No Suitable Habitat
49	Accessed & Surveyed		105	No Suitable Habitat
50	No Suitable Habitat		106	No Suitable Habitat
51	No Suitable Habitat		107	Accessed & Surveyed

Aerial Photo No.	Access		Aerial Photo No.	Access
52	No Suitable Habitat		108	No Suitable Habitat
53	Habitat Inferred		109	No Suitable Habitat
54	Habitat Inferred		110	Habitat Inferred
55	No Suitable Habitat		111	Habitat Inferred
56	No Suitable Habitat			

For the 50 map sections that could be surveyed, 15 to 30 minutes was spent at least at one access point along the rail alignment if the habitat appeared to be uniform along the alignment in that map section. If the habitat varied along the map section, then several points were visited and surveyed where possible.

At each survey point a transect of about 100 to 200 metres was traversed to assess the habitat quality along the rail alignment section that could be accessed. The plant community type (PCT), dominant tree species, forest height and diameter at breast height (DBH) range, presence, height and DBH of any emergent trees, presence of a nearby watercourse, shrub cover density, ground cover density and type of cover, presence of ground prey and tree canopy prey species and the existence of any potential raptor nests were recorded during each survey.

For any potential nest observed the location's latitude and longitude were recorded and the position plotted on the relevant section map. The tree species, tree height and DBH, nest size and position in the tree were also recorded.

Criteria used for the Determination of Potential Habitat Areas

Habitat data collected from each site were then used to assess the level of suitability of the habitat remnant for either breeding or foraging for the Square-tailed Kite and how well each remnant satisfied the list of eight criteria characterising quality breeding habitat (see Habitat Requirements above). If at least criteria 1, 7 and 8 were met then the habitat area was potential breeding habitat. The greater the number of criteria that were met the more likely it was that the habitat area would provide breeding habitat for Square-tailed Kite. Some areas were identified as potential foraging areas when some of the criteria but not 1, 7 and 8 were met. Such areas may be more important if they are also within a breeding territory as their loss would reduce the foraging area close to a nest and thus impact nesting success. There is also the potential for the development to reduce the size of a remnant to below the minimum requirements of 5 hectares. This is relevant if parts of the remnant are both within and adjacent to the transport alignment.

Visiting many of the sites allowed habitat remnants to be checked for plant community type and vegetation structure. This was then compared with what was shown in the aerial photographs of the alignment sections for those same sites. Hence the plant community type and vegetation structure could be reasonably well determined from the aerial photographs for sites that could not be reached. and for areas of section maps that had only limited access where the habitat polygon could be extended by extrapolating to include similar habitat area along the rail alignment. If a remnant could not be approached because of limited access, then the structure and suitability of the habitat remnant was inferred from the aerial photographs.

The size of each potential habitat area was determined by drawing polygons around each area within the rail alignment and calculating the area within each polygon in the Avenza Maps app in the aerial photographs of each map section. The position of each remnant was determined from the geo-referenced aerial photographs of each section of the rail alignment.

Data Collection to Determine the Status of the Local Population of the Square-tailed Lite

The Atlas of Living Australia was accessed on the 17-08-2021 to search for all records of the Square-tailed Kite within 50 km either side of the rail alignment. The Atlas of Living Australia also collects data from eBird, BirdLife Australia, NSW Bionet Atlas and NSW Bird Atlas. The combination of all datasets means that most of the available data is accessed. The records were tabulated and plotted onto a map of the greater area to show their distribution. Where 2 or more birds were counted on a survey, they are assumed to be a breeding pair as the Kites are generally solitary outside the breeding season. These survey points are coded differently on the map with the other records to highlight the position of likely breeding territories. However, a record of a single bird could still represent a breeding pair as one bird may have been foraging when observed while the other bird was attending the nest and may have been missed during the survey. The number of breeding territories is calculated for the length of the rail alignment, based on the presence of suitable breeding habitat and 7 kilometres between adjacent pairs of nesting Kites (see paragraph on breeding density in section on Distribution and Abundance).

4. Location and Area of Potential Habitat Areas

Habitat patch position, size, criteria met, status for each map section are listed in Appendix 1. Each habitat patch is numbered according to the aerial photograph containing each patch. If there was more than one patch within each photograph, then they were numbered consecutively from south to north. The patch number, status and area in hectares are also shown as maps in Appendix 2 for the inland rail alignment based on the supplied aerial photo map sections.

The rail alignment and borrow pits were divided into 111 map sections for the field surveys. Fifty of the map sections were visited out of the 78 that appeared to have suitable habitat. The other 33 map sections either contained no suitable woodland habitat, or the remnant was too low and/or sparse, or the remnant intersected by the rail alignment was smaller than 5 hectares. Suitable breeding habitat was inferred from the aerial map sections of the 28 map sections that could not be reached (see Field Methods above for reasons) by comparing the structure to other maps where similar vegetation structure had been identified during ground surveys of the map sections that were visited and these were identified as containing potential breeding habitat. Seventy-five of the aerial map sections contained potential breeding habitat while another 3 contained potential foraging habitat. Outside of the forested areas, where remnants were relatively small and narrow, the rail alignment footprint did not reduce the size of any habitat areas to less than 5 hectares. This means that the rest of the remnant was still large enough to be potential breeding habitat. This was also not an issue in the forested areas where contiguous habitat exists either side of the rail alignment.

The total area of potential breeding habitat for the inland rail alignment was 822.99 hectares while the potential additional foraging habitat was 17.97 hectares.

One possible nest was found near Bohena Creek at -30.458509 149.660993 in a 25 m tall Pilliga Box *Eucalyptus pilligaensis* with a DBH of > 0.8 m. The nest was between 0.5 and 0.7 m wide and 0.4 m deep and was located about 23 m above the ground and 4 m in from the foliage edge in a near vertical fork with one branch nearly horizontal. The sticks comprising the nest appeared to be about 10 to 15 mm in diameter. The nest structure, position in the tree, tree height and habitat area strongly suggest that this is a nest of a Little Eagle, but there is also the possibility that it is one of a Square-tailed Kite.

Note that habitat mapping has been updated to take into account flood mitigation. The updated habitat maps are those provided in Appendix 2. A comparison with the original assessment is provided in Appendix 1.

5. Status of the Local Population of the Square-tailed Kite

Distribution of Records along the N2N Alignment

There were 129 records of Square-tailed Kites within 50 km of the inland rail alignment in the records from the Atlas of Living Australia (accessed 17-08-2021). These records for the rail alignment are shown in Appendix 3. The distribution of those records is shown in Figure 1 and those records which are likely to represent breeding pairs (i.e., records of 2, 3 or 4 birds from a survey) are indicated as a different colour (n=19). Many of the survey points for records represent sightings made over several years or months from the same location and so one dot on the map may represent 2 to 5 records from the combined atlas data.

Of the 129 records approximately 11 records are within 4 km of the rail alignment and 3 of those are likely to represent breeding pairs. The data show that many of the records are in areas of fragmented woodland and forest, as well as within contiguous forest areas. Considering that much of the rail alignment is on private lands or goes through areas of forest where access is very difficult, and that many of the surveys in the data set were contributed by volunteer bird watchers, it is very likely that the distribution of surveys under-estimates the actual population occurring along the rail alignment.

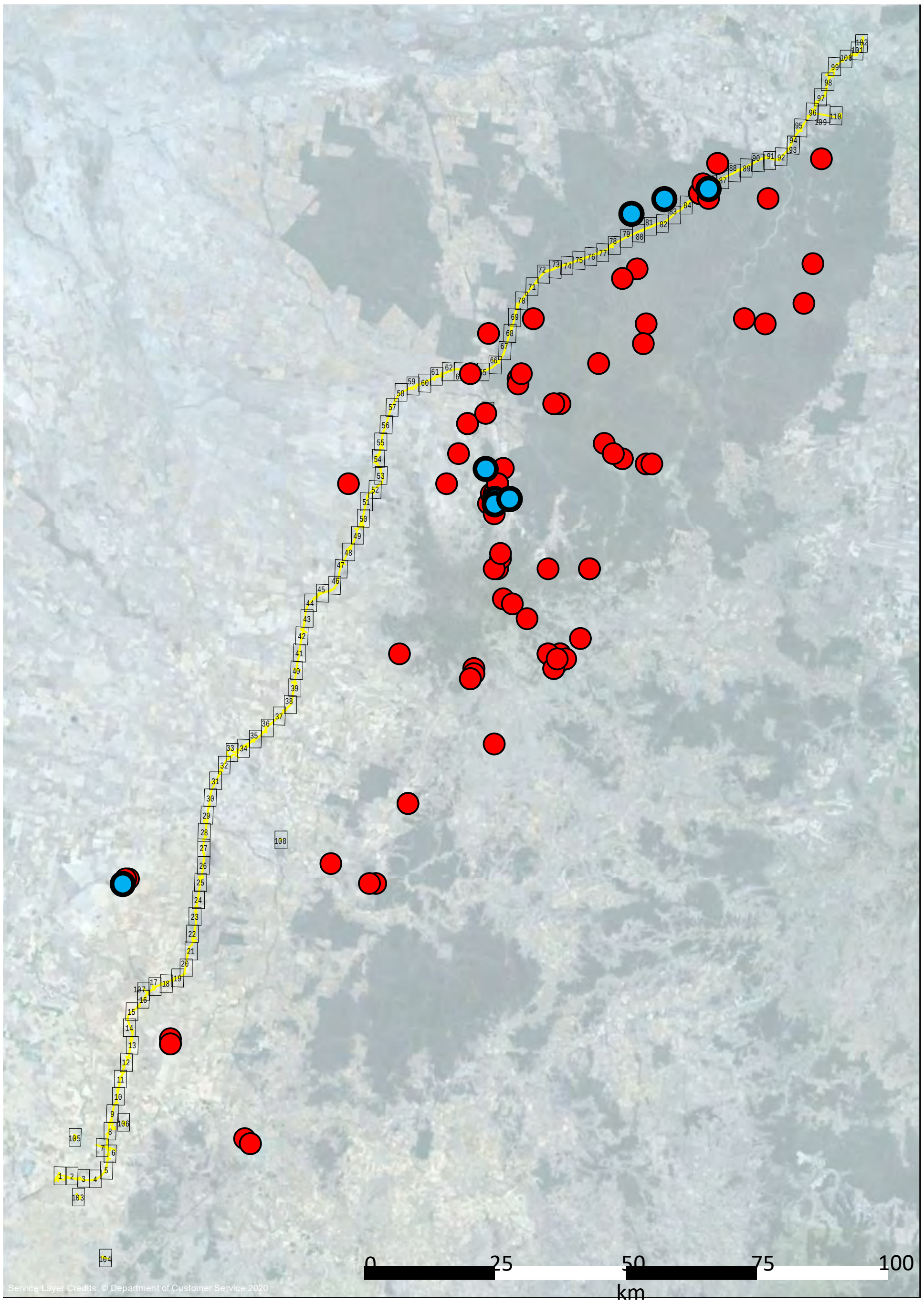

Figure1. Distribution of Square-tailed Kite records along N2N Rail Alignment (n=129, blue markers indicate where 2 or more birds were recorded in survey (n=19), red markers are all other records of single birds or where number of individuals not recorded in the survey).

No Square-tailed Kites or evidence of breeding were detected during the 4 days of the survey period. This was to be expected as the surveys were conducted just before the commencement of the breeding season and before they are likely to arrive in the area from further north which would be expected to begin in September each year.

Species Polygon

Based on the locations of potential breeding habitat along the rail alignment and the distance between adjacent breeding pairs found in the literature, it is estimated that up to 52 breeding pairs of Square-tailed Kite may occur along the rail alignment. At least twelve of these are likely to occur within the 80 km long Pilliga forests section of the rail alignment, but there may be more as some adjacent nests can be less than 7 km from each other (see paragraph on breeding density in section on Distribution and Abundance). In order to create the species polygon in areas where potential habitat is relatively continuous, a buffer of 1 km radius within the potential territories has been created over the potential breeding habitat. The Threatened Biodiversity Data Collection recommends a 300 m buffer for this species, however given the linear nature of the alignment, this has been increased to a 1km buffer for the purposes of this assessment. The total species polygon for the Square-tailed Kite was determined to be 407.11 hectares of which 235.57 hectares are within the Pilliga forests. The distribution of potential breeding/foraging territories, indicative nest tree buffers and the species polygon are shown in the maps in Appendix 4. The species polygon calculations for each PCT and the total polygon area are shown in Appendix 5.

6. Recommendations for Impact Minimisation and Mitigation Measures

Of the 823 hectares of potential breeding habitat along the inland rail alignment 576 hectares are within the Pilliga state forests. These forests are critically important for the Square-tailed Kite and many other threatened bird species that were encountered during the short visits to each map section through the forest. It is recommended that another route for the rail alignment be found outside the state forest areas. A route through grazing and or cropping areas would reduce the impact on important wildlife refuge areas in an already greatly fragmented landscape and reduce the potential breeding habitat impacts by 576 hectares.

Other sections of the proposed rail alignment overlap remnant vegetation along road easements and vegetation s between open grazed areas. Many of these areas are potential breeding habitat for the Square-tailed Kite and several other threatened bird species were also recorded within some of these patches. It is recommended that the route be shifted to pass alongside instead of through these areas wherever possible. The relevant map sections are numbers 6, 22, 23, 27, 28, 45, 46, 48, 49, 53 and 54. This would remove another 114 hectares from the potential impacted breeding habitat area.

These recommendations combined would reduce the impacted habitat area for the Square-tailed Kite by around 700 hectares. Another route will have impacts on habitat areas along it, but if the principles relating to the above recommendations are implemented along an alternative route any impacts could be kept to a minimum.

The status of the possible Square-tailed Kite nest in map section 93 at -30.458509 149.660993 is unknown. It is recommended that the nest be monitored during the coming breeding season to see if it is an active nest.

7. References

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8. Credentials of the Experts Providing this Report

Credentials and Relevant Publications

Dr. Tony Saunders
BSc University of Sydney 1976, PhD University of Western Sydney 2005.
Company Director and Avian Ecologist, Merops Services Pty Ltd 1995 to present.

Relevant experience in surveys and the study of woodland birds including the Square-tailed Kite:

- Woodland bird surveys throughout NSW for the NSW Bird Atlas and then for BirdLife Australia from 1982 to the present.
- Cumberland Plain woodland bird surveys on the UWS Hawkesbury Campus 1998 to 2005.
- Woodland bird surveys for managed reserves and bushland remnants in rural and peri-urban landscapes.
- Survey for threatened woodland birds in proposed urban expansion areas, rural subdivisions and mine developments
- Avifauna surveys of sites for development applications and assessment of status of threatened bird species with recommendations for minimising impact of development on these species within New South Wales. (22 years)
- Bird habitat assessment of managed landscapes and natural habitat areas and recommendations for habitat enhancement and rehabilitation for birds. (22 years)

Relevant publications relating to woodland birds and the Square-tailed Kite:

- Saunders, T. (2016). Birds of the Cumberland Plain. What was there? What have we lost? Abstract from 'Birds of the Cumberland Plain: Past distributions, present studies and the outlook for their future' Australian Bird Study Association Conference - 23 January 2016. *Corella* **40**: 46.
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- Saunders, T. 2019 *Assessment of Breeding Habitat and Potential Nests for either the Little Eagle or the Square-Tailed Kite at 7 Kyte Place Tumbi Umbi*. Report prepared for Central Coast Council NSW.
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Dr. Stephen Debus
Bachelor Arts (Biology/Behavioural. Science), Dip. Natural Resources (Wildlife), MSc. (Zoology), PhD (Zoology)
Adjunct associate lecturer/research associate, Zoology University of New England, Armidale. 2004 to present
Senior Ecologist (casual) Eco Logical Australia 2014 to 2019

Relevant experience in surveys and the study of the Square-tailed Kite *Lophoictinia isura* and of woodland birds:

- Birds of Prey Monitoring project: nest sites and productivity of threatened raptors on the tablelands – field survey and report (Northern Tablelands Local Land Services 2017-21); two Square-tailed Kite nests as at 2021 (plus experience of four active nests pre-2017)
- Regent Honeyeater, Swift Parrot, raptor and woodland bird surveys and reporting (North West Local Land Services 2015-21)

Relevant publications and reports relating to foraging and breeding biology of the Square-tailed Kite *Lophoictinia isura*:

- Barnes, C.P., Zillmann, E.E., Rose, A.B. and Debus, S.J.S. 2001 Diet and biology of Square-tailed Kites *Lophoictinia isura* breeding in south-eastern Queensland: nest building to post-fledging. *Australian Bird Watcher* 19: 28-43.
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Curriculum Vitae

Dr Tony Saunders:

Academic Qualifications:

BSc University of Sydney 1976
Dip Ed Sydney Teachers College 1977
PhD University of Western Sydney 2005

Other Qualifications:

LR Drivers Licence
Work Health & Safety General Construction Induction (White Card)
Chemical Use and Handling Certificate
Resuscitation Certificate
Emergency Care Certificate
Anaphylaxis Training Certificate
Drone Essentials Certificate

Fields of expertise:

Bird habitat assessment on reserves, lands in production and potential offset property.
Bird monitoring in natural, modified and managed habitats.
Assessment of likelihood of threatened woodland bird species occurrence on development sites.
Coordinating projects between government and non-government organisations.
Coordination of volunteers collecting wildlife data.
Ecotourism: guiding general interest and specialists groups in flora and fauna.
Environmental and science education at high school, TAFE, and university levels.
Habitat management for terrestrial woodland birds and other wildlife.
Presentations on ecology to public interest groups and at professional workshops.
Remote area wildlife atlassing.
Wildlife database design and management.
Land for Wildlife assessments and habitat enhancement planning.

Professional positions held:

2010 - 2021	Merops Services Pty Ltd (director, avifaunal ecologist). Environmental and landscape consultant and contractor, flora and fauna surveys, habitat enhancement plans.
2013 - 2021	Land for Wildlife Assessor for Community Environment Network
1995 - 2010	Merops Services (avifaunal ecologist). Environmental and landscape consultant and contractor.
2006 - 2017	Part-time teacher, mainly Science, but also Industrial Arts, English and Maths, Crookwell High School, Goulburn High School and Trinity Grammar School.
1997 - 2005	Part-time bird guide and ecotourism bus driver.

1993 - 2004 Part-time lecturer, supervisor and demonstrator, University of Western Sydney (biology, ecology and field survey techniques).

2001 - 2004 Atlas Facilitator, Birds Australia (organising remote atlassing, facilitating data exchange and communication between Birds Australia, state government organizations and other non-government organisations).

1997 Field Technical Officer, Birds Australia (monitoring breeding success of the endangered Regent Honeyeater).

1996 Field Technical Officer, University of Western Sydney (reptile, bird and plant survey techniques and data analysis).

1978 - 1994 High School Science Teacher at Marsden, Heathcote, Penrith and Kingswood High Schools.

Other volunteer positions held:

2014 - 2017 Assistant to Co-ordinator of the Sydney Bird Fair.

2015 – 2021 President - Crookwell Native Flora and Fauna Club.

2013 - 2021 Secretary - Grabine/Foggs Crossing Landcare Group

2001 - 2020 Avifaunal Advisor and Education Officer for Oolong Sanctuary, Dalton.

1997 - 2010 Project Manager for Atlas of Birds of the County of Cumberland.

2010 - 2021 Technical advisor to the Cumberland Bird Observer's Club's Atlas Databasae Management Committee.

1996 - 2009 Committee Member (Records Officer & Bird Database Manager)- CBOC (Cumberland Bird Observers Club Inc.).

1998 – 2014 CBOC representative to Bird Interest Group Network (BIGnet).

1997 - 2002 Faunal Advisor for the Hawkesbury Rainforest Network.

1999 - 2002 Member of Steering Committee of Birds in Backyards for Birds Australia.

1998 - 1999 Consultant to Birds Australia Birds for Birds in Backyards Project.

1998 - 2003 Regional Organiser for Sydney and the Blue Mountains, NSW facilitator and NSW/ACT representative on the Steering Committee for the National Bird Atlas for Birds Australia.

2002 Representative on NSW NPWS Wildlife Issues Advisory Panel for Birds Australia.

Relevant experience:

Co-ordination, facilitation and organization of exhibits and presentations at field-day events and indoor venues. This has involved allocating space, providing necessary facilities and setting-up audio-visual equipment for exhibitors and presenters (18 years)

Co-ordinator of volunteers for the CBOC Inc. and the Birds Australia national birds atlas. (13 years)

Facilitated the BIGnet data exchange agreement between Birds Australia, NSW Bird Atlassers, Canberra Ornithologists Group and the Cumberland Bird Observers Club. Facilitated bird data exchanges between Birds Australia, NSW State Forests and NSW DECC. (4 years)

Presenter at seminars for Bushcare, Landcare, Greening Australia, Wires and local councils, conservation societies and garden clubs on habitat management for birds and bird survey techniques. (33 years)

Educator at public, tertiary and secondary levels in the area of bird habitat management and bird survey methodology. (25 years)

Ecotourism and bird guiding (23 years).

Undertaking avifauna surveys of sites for development applications and assessment of status of threatened bird species on sites and making recommendations for minimising impact of development on these species. (23 years)

Bird habitat assessment of managed landscapes and natural habitat areas and recommendations for habitat enhancement and rehabilitation for birds. (23 years)

Design, building and management of the bird database for the birds of the County of Cumberland on behalf of CBOC Inc. (17years)

Critical assessment of habitat and population status for Little Eagle *Hieraaetus morphnoides* and Square-tailed Kite *Lophoictinia isura* (Listed as an expert in the DPIE website for site assessments (4years)

Membership and professional affiliations:

Australian Bird Study Association
Birdlife Australia
Crookwell Native Flora and Fauna Society
Cumberland Bird Observers Club (Life Member)
Ecological Consultants Association of NSW
Grabine/Foggs Crossing Landcare Group
NSW Bird Atlassers
Royal Zoological Society (Scientific member)

Papers, Articles and Reports:

Saunders, T. 1985. Common Bronzewings at Round Hill Nature Reserve. *CBOC Newsletter* Vol. 6 No. 6 : 5

Saunders, T. 1986. Eastern Bristlebird at Ku-Ring-Gai Chase National Park. *CBOC Newsletter* Vol. 8 No. 2 : 1

Saunders, T. 1990. Bird watching on North Stradbroke Island. *SIMO Newsletter*

Saunders, T. 1990. Sooty Oystercatcher. *CBOC Newsletter* Vol. 11 No. 3 : 3

Saunders, T. 1991. Keeping Records of Bird Observations. *CBOC Newsletter* Vol. 12 No. 5 : 6-7.

Saunders, T. 1997. Birdscaping Gardens *CBOC Newsletter* Vol. 18 No. 4 : 6

Saunders, A.S.J. 1993. Seasonal variation in the distribution of the Noisy Friarbird *Philemon corniculatus* and the Red Wattlebird *Anthochaera carunculata* in eastern New South Wales. *Australian Bird Watcher* 15: 49-59.

Saunders, A.S.J., Ambrose, S.J. & Burgin, S. 1995. Gape width and prey selectivity in the Noisy Friarbird *Philemon corniculatus* and Red Wattlebird *Anthochaera carunculata*. *Emu* 95: 297-300.

Whelan, H. (ed.) 1997. *Australian Geographic Birdwatcher's Journal.* Australian Geographic. Chapters 'How to Watch Birds' and 'Bringing Birds into Your Garden'.

Healey, J. (ed.) 1997. *Encyclopaedia of Australian Wildlife.* Reader's Digest, Sydney. Chapters on Honeyeaters and Chats.

Saunders, A.S.J. & Burgin, S. 2001. Selective foliage foraging by Red Wattlebirds, *Anthochaera carunculata*, and Noisy Friarbirds, *Philemon corniculatus*. *Emu* 101: 163-166.

Saunders, T. 2002 *Bird Monitoring of Federal Park and White's Creek Valley Park, Annandale*. Leichhardt Council, Unpublished Report.

Saunders, T. 2002 Bird Habitat Issues and Management of Urban Bushland. *Caring For Our Bushland and Waterways: Forum Proceedings*. 2002 Wollondilly Catchment Landcare Forum.

Saunders, A.S.J., Burgin, S. & Jones, H. 2003 The importance of eucalypt nectar in the diet of large honeyeaters. *Corella* 27: 1-12.

Saunders, T. 2003 *Managing Avian Biodiversity in the Leichhardt Local Government Area.* Leichhardt Council, Unpublished Report.

Saunders, T. 2003 *Breeding Waterbird Study at Sydney Olympic Park.* Sydney Olympic Park Authority, Unpublished Report.

Saunders, T. 2004 *Bush Bird Status at Sydney Olympic Park.* Sydney Olympic Park Authority, Unpublished Report.

Saunders, T. 2005 *Bush Bird Project at Sydney Olympic Park.* Sydney Olympic Park Authority, Unpublished Report.

Saunders, T. 2005 *Habitat Survey of Sydney Olympic Park.* Sydney Olympic Park Authority, Unpublished Report.

Darcovich, K., Saunders, T. & O'Meara, J. 2005. *Revegetation on an Olympic scale - case studies in building fauna habitat on constructed parkland landscapes.* Sydney Olympic Park Authority, Conference poster.

Saunders, T. 2006 *Flora and Fauna Assessment of Badgerys Creek.* Unpublished Report.

Saunders, T. 2007 *Bird Habitat Management within Holroyd Local Government Area.* Holroyd City Council, Unpublished Interim Report.

Burgin, S. & Saunders, T. 2007 Parrots of the Sydney region: population changes over 100 years. Pp. 185-194 in *Pest or Guest; The Zoology of Overabundance*, edited by Lunney, D., Eby, P., Hutchings, P. & Burgin, S. Royal Zoological Society of NSW, Mosman.

Saunders, T. 2008 *Avian Biodiversity Monitoring and Bird Habitat Management within the Leichhardt LGA.* Leichhardt Council, Unpublished Report.

Saunders, T. 2009 *Bird Habitat Management within Holroyd Local Government Area.* Holroyd City Council, Unpublished Report.

Saunders, T. 2009 *Sydney Olympic Park Bush Bird Survey* Sydney Olympic Park Authority, Unpublished Report.

Saunders, T. 2010 *Bird Habitat Monitoring in Holroyd LGA* Holroyd City Council, Unpublished Interim Report.

Saunders, T. 2010 *Bird Monitoring at Sydney Olympic Park 1999 to 2009* Sydney Olympic Park Authority, Unpublished Report.

Saunders, T. 2011 *Bird Habitat Monitoring in Holroyd LGA* Holroyd City Council, Unpublished Interim Report.

Saunders, T. 2011 *Habitat Enhancement Plan for 'Heathfield' Cowra*, Unpublished Report.

Saunders, T. 2011 *Habitat Enhancement Plan for 'Girragirra' Cowra*, Unpublished Report.

Saunders, T. 2011 *Habitat Enhancement Plan for 'Garrallan' Cowra*, Unpublished Report.

Saunders, T. 2011 *Habitat Enhancement Plan for 'Garraroo' Binda*, Unpublished Report.

Saunders, T. 2011 *Habitat Enhancement Plan for 'Watervale' Boorowa*, Unpublished Report.

Saunders, T. 2011 *Habitat Enhancement Plan for 'Wookie Hills' Cowra*, Unpublished Report.

Saunders, T. 2011 *Habitat Enhancement Plan for 'Orchre Arch' Cowra*, Unpublished Report.

Saunders, T. 2011 *Habitat Enhancement Plan for 'Raintree-Marra' Cowra*, Unpublished Report.

Saunders, T. 2011 *Criteria for Ranking Priorities for Habitat Enhancement for Lachlan Catchment Management Authority,* Unpublished Report.

Saunders, T. 2012 *Bird Habitat Monitoring in Holroyd LGA* Holroyd City Council, Unpublished Final Report.

Saunders, T. 2013 Birdscaping Gardens. p 16 *Our Gardens* Volume 55, The Garden Clubs of Australia.

Saunders, T. 2014 *Habitat Survey of Sydney Olympic Park.* Sydney Olympic Park Authority, Unpublished Report.

Saunders, T. 2015 *Land for Wildlife Assessment for 'Mitchell' Binda*, Unpublished Report.

Saunders, T. 2015 *Land for Wildlife Assessment for 'Douglass' Binda*, Unpublished Report.

Saunders, T. 2015 *Land for Wildlife Assessment for 'Holmes' Peelwood*, Unpublished Report.

Saunders, T. 2015 *Habitat Assessment and Enhancement Plan for 'Ollis' Bigga*, Unpublished Report.

Saunders, T. 2015 *Habitat Assessment and Enhancement Plan for 'Flat Rocks' Bigga*, Unpublished Report.

Saunders, T. 2015 *Land for Wildlife Assessment for 'Gunthori' Yass*, Unpublished Report.

Saunders, T. 2015 *Land for Wildlife Assessment for Lot3 DP 789337 Taralga*, Unpublished Report.

Saunders, T. 2015 *Land for Wildlife Assessment for Lot 57 Bevendale*, Unpublished Report.

Saunders, T. 2015 *Flora and Fauna Assessment of DP 48541Abercrombie for Pejar Aboriginal Land Council*, Unpublished Report.

Saunders, T. 2015 *Flora and Fauna Assessment of DP 48016 Abercrombie for Pejar Aboriginal Land Council*, Unpublished Report.

Saunders, T. 2015 *Flora and Fauna Assessment of DP 823525 Binda for Pejar Aboriginal Land Council*, Unpublished Report.

Saunders, T. 2015 *Flora and Fauna Assessment of DP 753055 Binda for Pejar Aboriginal Land Council*, Unpublished Report.

Saunders, T. 2016 *Land for Wildlife Assessment for DP 1217631 Reids Flat*, Unpublished Report.

Saunders, T. 2016 *Land for Wildlife Assessment for 'Callarah' Reids Flat*, Unpublished Report.

Saunders, T. 2016 *Land for Wildlife Assessment for 'The Angle' Reids Flat*, Unpublished Report.

Saunders, T. 2016 *Land for Wildlife Assessment for 'Bobbins' Reids Flat*, Unpublished Report.

Saunders, T. 2016 Birds of the Cumberland Plain. What was there? What have we lost? Abstract from 'Birds of the Cumberland Plain: Past distributions, present studies and the outlook for their future.' Australian Bird Study Association Conference - 23 January 2016. *Corella* 40: 46

Saunders, T. 2016 *Bird surveys, likelihhood for threatened birds and habitat description for Syerston Mine Project, Fifield,* Unpublished Report.

Saunders, T. 2017 *Land for Wildlife Assessment for 'Tanjenong' Abercrombie*, Unpublished Report.

Saunders, T. 2017 *Land for Wildlife Assessment for 'Bohara' Breadalbane*, Unpublished Report.

Saunders, T. 2017 *Land for Wildlife Assessment for 'Greendale' Breadalbane*, Unpublished Report.

Saunders, T. 2017 *Land for Wildlife Assessment for 'Bunduluk' Laggan*, Unpublished Report.

Saunders, T. 2017 *Flora and Fauna Assessment of DP 48618 Windellama for Pejar Aboriginal Land Council*, Unpublished Report.

Saunders, T. 2017 *Flora and Fauna Assessment of DP 1185604 Windellama for Pejar Aboriginal Land Council*, Unpublished Report.

Saunders, T. 2017 *Flora and Fauna Assessment of DP 823489 Cullulla for Pejar Aboriginal Land Council*, Unpublished Report.

Saunders, T. 2017 *Bird surveys, likelihhood for threatened birds and habitat description for Vickery Mine Project, Boggabri,* Unpublished Report.

Saunders, T. 2017 *Land for Wildlife Assessment for 'Bimbimbie' Bigga*, Unpublished Report.

Saunders, T. 2017 *Habitat Assessment and Enhancement Plan for 'Tanjenong' Abercrombie*, Unpublished Report.

Saunders, T. 2017 *Habitat Assessment and Enhancement Plan for DP 1162296 Crookwell*, Unpublished Report.

Saunders, T. 2017 *Habitat Assessment and Enhancement Plan for 1206394 Red Ground*, Unpublished Report.

Saunders, T. & Debus, S. 2018 *Strategic Assessment for the Square-tailed Kite Lophoictinia isura in the Greater Macarthur Growth Area and the Wilton Growth Area* Unpublished Report. Department of Planning and the Environment

Saunders, T. & Debus, S. 2018 *Strategic Assessment for the Little Eagle Hieraaetus morphnoides in the Greater Macarthur Growth Area and the Wilton Growth Area* Unpublished Report. Department of Planning and the Environment

Saunders, T. 2018 *Bird surveys, likelihhood for threatened birds and habitat description for Maxwell Mine Project, Jerrys Plains,* Unpublished Report.

Saunders, T. 2018 *Bird surveys, likelihhood for threatened birds and habitat description for Mount Pleasant Mine Project, Muswellbrook,* Unpublished Report.

Saunders, T. 2018 *Preliminary habitat description for Mount Thorley/Warkworth Mine Project, Warkworth,* Unpublished Report.

Saunders, T. 2018 Trends in woodland bird populations on the Cumberland Plain, New South Wales, from long-term datasets. *Australian Zoologist* 38(4): 675-697. Royal Zoological Society of NSW, Mosman.

Saunders, T. 2019 Wombat Tunnel Under a Fence: A Solution to Damaged Fences. *WIRES Southern Tablelands Branch Newsletter* No. 50 p 10.

Saunders, T. 2019 *Assessment of Breeding Habitat and Potential Nests for either the Little Eagle or the Square-Tailed Kite at 7 Kyte Place Tumbi Umbi*. Unpublished Report.

Saunders, T. 2019 *Assessment of Potential Breeding and Foraging Habitat for the Little Eagle at DP 2944 and DP 1229317, Colo Vale.* Unpublished Report.

Saunders, T. 2019 *Habitat trends 2004 to 2019: Woodland birds project.* Sydney Olympic Park. Unpublished Report.

Saunders, T. 2019 *Bird and habitat trends 2004 to 2019: Woodland birds project.* Sydney Olympic Park. Unpublished Report.

Saunders, T. 2019 Changes in the flora and fauna of the Upper Lachlan Shire over the last 40 years. Crookwell Native Flora and Fauna Club Newsletter.

Saunders, T. 2019 Woodland Birds of the Cumberland Plain. CBOC Newsletter Vol. 40-6. pp 1-5.

Saunders, T. 2019 Impact Assessment on Nesting Australian Pied Oystercatcher *Haematopus longirostris* at Crooked River Inlet, Gerroa, NSW.

Saunders, T. 2019 Test of Significance as applied to nesting Australian Pied Oystercatcher *Haematopus longirostris* at Crooked River Inlet, Gerroa, NSW.

Saunders, T. 2020 The Cumberland County Bird Database. CBOC Newsletter Vol. 41-6. pp 8-9.

Saunders, T. 2020 Review of updates to the development footprints of the Greater Macarthur and Wilton urban growth areas in relation to strategic assessments on the Little Eagle and the Square-tailed Kite. Report prepared for Biosis Pty Ltd.

O'Meara, J. & Saunders, T. 2020. Restoring the restoration: Bringing back woodland birds. pp 188-213 in: 20 years of healing: Delivering the ecological legacy of the Green Games. Sydney Olympic Park Authority.

Saunders, T. 2020 Scarlet Robin population and habitat monitoring on private lands within the Bigga region: initial habitat monitoring and spring surveys. Report prepared for the Foundation of National Parks of NSW.

Saunders, T. 2021 Birdscaping Gardens. CBOC Newsletter Vol. 42-5. pp 1-5.

Saunders, T. 2021 Habitat Enhancement Plan for 15 Turkey Hill Road Limerick NSW. Report prepared for the Foundation of National Parks of NSW, Saving Our Species, K2W Glideways Project.

Saunders, T. 2021 Habitat Enhancement Plan for 2617 Rugby Rd Rugby NSW. Report prepared for the Foundation of National Parks of NSW, Saving Our Species, K2W Glideways Project.

Saunders, T. & Debus, S. 2021 Strategic Assessment for the Square-tailed Kite *Lophoictinia isura* within the proposed Western Sydney Transport Corridors Report prepared for Transport NSW.

Saunders, T. & Debus, S. 2021 Strategic Assessment for the Little Eagle *Hieraaetus morphnoides* within the proposed Western Sydney Transport Corridors Report prepared for Transport NSW.

Dr Stephen Debus:

Abridged CV: Stephen John Stewart DEBUS

BA (Biol./Behav. Sc.) Macquarie Uni 1978, Dip. Natural Resources (Wildlife) Uni of New England 1981, Dip. Ed. (Sci.) UNE 1983, MSc. (Zool.) UNE 1994, PhD (Zool.) UNE 2004

Contact details:

Ph: 02 6773 2510 (BH), mobile: 0409 779 766

Addresses: Zoology, University of New England, Armidale NSW 2351 (business) PO Box 1015 (6 Holloway St), Armidale NSW 2350 (private)

Website www.une.edu.au/staff-profiles/ers/sdebus

Professional capacities:

Vertebrate fauna surveys. Research and survey of threatened forest and woodland birds, particularly raptors and owls. Ecology/biology/behaviour of birds, especially predatory species. Conservation and management of threatened bird species. Distribution, status and biology/ecology of NSW birds. Reviews and biological profiles of bird species. Editing ornithological papers. Peer review of ornithological documents/EISs/species impact statements. Impact assessment (avifauna). Review of conservation status of NSW fauna.

Computer skills:

Proficient in Word and Excel, limited experience with GIS and ArcView

Employment:

Eco Logical Australia 2011-19 (casual; senior ecologist: fauna survey and report)

EA Systems (now EnviroAg Australia) 2000-14 (casual; ecologist: fauna survey and assessment)

Research assistant, Zoology, UNE, casual 1984-2014 (field ornithology: bird banding, bird surveys/censusing, ecological studies)

Tutor/demonstrator, Zoology UNE (casual), 2007-13

NSW Dept Environment & Climate Change, 2008-09 (temporary) (threatened species officer: Project Officer, NSW Scientific Committee)

Research Assistant, Ecosystem Management UNE (casual), 2008-09 (bird survey)

Post-doctoral research fellow, Zoology, UNE, 2005-07 (ecology of woodland birds)

Junior research fellow, Zoology, University of New England, 1990-1993, 1998-2004 (ecology of rare forest owls in relation to habitat and forest management; ecology and management of birds)

Technical officer, University Partnerships Pty Ltd (UNE), 1995-1996 (fauna survey and report, Eastlink EIS)

Casual assistant demonstrator, Depts Zoology and Ecosystem Management, UNE, 1988-2002 (field practical classes on population ecology and behavioural ecology of birds)

Casual teacher, New England Institute of TAFE, 1987-1993 (bird biology: including laboratory and field practical classes on classification, identification and ecology)

Field technician, National Parks & Wildlife Service Armidale, 1986 (fauna inventory, vegetation sampling and analysis)

Research assistant, Department of Ecosystem Management, University of New England, casual 1986-1987 (field survey of vegetation and fauna)

Honorary position:

Adjunct associate lecturer/research associate, Zoology UNE, 2004-2021 (includes collaborative research and publication, co-supervision of Honours/Masters/PhD students)

Consultant biologist (selected recent clients):

Northern Tablelands Local land Services 2017-21 (Birds of Prey Monitoring project: nest sites and productivity of threatened raptors on the tablelands – field survey and report)

North West Local Land Services 2015-2021 (Regent Honeyeater, Painted Honeyeater, Swift Parrot, raptor and woodland bird surveys and reporting)

University of New England 2019-2021 (Murray-Darling Basin waterbird monitoring)

Brisbane City Council 2020 (revision and updating of Conservation Action Statements for large forest owls, including Masked and Barking Owl, and Eastern Grass Owl)

BirdLife Australia – Northern NSW (for Bundarra-Barraba Operations Group of the Regent Honeyeater Recovery Team), 2007-20 (Regent Honeyeater/woodland bird survey and monitoring)

Minter Ellison 2019–2021 (White-bellied Sea-Eagle expert reports)

28 South Environmental 2013-2020 (threatened fauna survey/assessment and report)

ERM 2020 (Masked Owl and Barking Owl BioBanking assessment expert report)

Eco Logical Australia 2010-2011 (threatened bird research, fauna database compilation); 2019- 2020 (Regent Honeyeater BioBanking assessment expert reports)

Fenner School of Environment and Society, Australian National, University 2016-19 (Regent Honeyeater surveys and data submission; habitat assessment)

NSW OEH/NPWS 2019 (fauna inventory in Service estate; expert workshop on Red Goshawk)

Greencap Pty Ltd 2019 (BioBanking assessment expert report: threatened raptors and Regent Honeyeater)

NSW Department of Planning and Environment 2018 (biodiversity assessment expert report: Square-tailed Kite and Little Eagle)

Whitehaven Coal 2018 (field survey, assessment and expert report on potential BioBank site for Regent Honeyeater)

Cumberland Ecology 2004-2012, 2018 (fauna survey and report; Regent Honeyeater BioBanking assessment expert report)

Central Coast Council 2017 (expert report: White-bellied Sea-Eagle)

Southern New England Landcare 2014-16 (fauna surveys on farms, data submission, landholder workshop, report review)

Ecotone Environmental Services 2012-13 (peer review of threatened fauna assessment; targeted fauna survey: federally listed birds)

NSW National Parks & Wildlife Service/Dept Environment & Conservation/DECC 1987-2013 (fauna survey, review of avifaunal component of environmental impact statements/ fauna impact statements/fauna reports, preparation of recovery plans and species profiles for threatened species)

Australian Museum, 1995, 2012 (review of fauna impact statement, avifauna; feather sampling of wild-caught birds for DNA analysis)

State Forests of NSW 1987-2009 (fauna survey, review of avifaunal component of environmental impact statements/fauna impact statements/fauna reports, fauna survey worskhop)

ACT Planning & Land Authority 2005-06 (fauna survey and assessment) ANCA 1995-1996 (fauna survey, Jervis Bay National Park)
SA National Parks & Wildlife Service, 1995 (fauna survey, Strzelecki Desert)

Grants and awards:

Search for Red Goshawk in NSW: $1,000 from the Australian Bird Environment Fund (Bird Observers Club of Aust.), 1987.

Distribution, status and habitat requirements of the Sooty Owl in northern NSW: $2,000 as a Cayley Memorial Scholarship (Gould League of NSW) 1990-93; with Associate Professors Hugh Ford & Harry Recher (UNE), $34,280 from WWF Australia and $64,835 from ANPWS (Endangered Species Program) 1990-93.

Will wildlife corridors work for sedentary birds?: with Professor Hugh Ford, $42,565 from the NSW Environmental Trust 2005, $43,359 in 2006-07.

Bird Observers Club of Australia: Distinguished Service Award, 2005 (editing the *Australian Bird Watcher*/*Australian Field Ornithology* for 21 years 1984-2005).

Royal Zoological Society of NSW Whitley Award, 2013 (*Birds of Prey of Australia: A Field Guide*, 2nd edn, best vertebrate guide in 2012)

BirdLife Australia's D.L. Serventy Medal for publication in ornithology, 2015

Voluntary work:

Editor: *Australasian Raptor Association News* 1980-1989 and *Boobook* (re-named) 2004-19 (biannual journal for bird-of-prey enthusiasts); *Australian Field Ornithology* 1984-2015 (quarterly journal)

Sub-editor: *Corella* Wedge-tailed Eagle special issue, 2007; White-bellied Sea-Eagle special issue, 2009; rare raptors special issue, 2011

Committee member: Australian Bird Study Association 1981-1988, 2005-17; Birds Australia Northern NSW Group 1996-99, 2004-12, 2015-17; Australasian Ornithological Conference 2009 organising committee 2008-09; ABSA/BirdLife Southern NSW conference organising committee 2013-14

Regent Honeyeater Recovery Team: Bundarra-Barraba Operations Group rep, 2008-21 Red Goshawk National Recovery Team 2014-21

Publications:

~150 refereed papers (selection appended), books and book contributions, theses: see following list

Refereed publications (selected titles):

Debus, S.J.S. 1984. Biology of the Little Eagle on the Northern Tablelands of New South Wales. *Emu* 84: 87-92.

_____, Ley, A.J., Trémont, S. & Trémont, R. 1991. Breeding behaviour and diet of the Australian Hobby *Falco longipennis* in northern New South Wales. *Aust. Bird Watcher* 14: 123-137.

Debus, S.J.S. 1992. A survey of diurnal raptors in north-east New South Wales, 1987-1990. *Aust. Birds* 25: 67-77.

Debus, S.J.S. 1993a. The mainland Masked Owl *Tyto novaehollandiae*: a review. *Aust. Bird Watcher* 15: 168-191.

_____ 1993b. The status of the Red Goshawk *Erythrotriorchis radiatus* in New South Wales, in Olsen, P.D. (Ed.), *Australian Raptor Studies*, pp. 182-191. Australasian Raptor Association, RAOU, Melbourne.

Debus, S.J.S., Ley, A.J., Trémont, S.M., Trémont, R.M. & Collins, J.L. 1993. Breeding behaviour and diet of the Collared Sparrowhawk *Accipiter cirrhocephalus* in northern New South Wales. *Aust. Bird Watcher* 15: 68-91.

Debus, S.J.S., McAllan, I.A.W. & Mead, D.A. 1993a,b. Museum specimens of the Red Goshawk *Erythrotriorchis radiatus*. I. Annotated list of specimens; II. Morphology, biology and conservation status in eastern Australia. *Sunbird* 23: 5-28; 75-89.

Debus, S.J.S., McAllan, I.A.W. & Morris, A.K. 1993. The Square-tailed Kite *Lophoictinia isura* in New South Wales. *Aust. Birds* 26: 104-118.

Peake, P., Conole, L.E., Debus, S.J.S., McIntyre, A. & Bramwell, M. 1993. The Masked Owl *Tyto novaehollandiae* in Victoria. *Aust. Bird Watcher* 15: 124-136.

Ford, H.A., Davis, W.E., Debus, S., Ley, A., Recher, H. & Williams, B. 1993. Foraging and aggressive behaviour of the Regent Honeyeater *Xanthomyza phrygia* in northern New South Wales. *Emu* 93: 277-281.

Debus, S.J.S. 1994. The Sooty Owl *Tyto tenebricosa* in New South Wales. *Aust. Birds* 28 supplement: 4-19.

_____ & Chafer, C.J. 1994. The Powerful Owl *Ninox strenua* in New South Wales. *Aust. Birds* 28 supplement: 21-38.

_____ & Rose, A.B. 1994. The Masked Owl *Tyto novaehollandiae* in New South Wales. *Aust. Birds* 28 supplement: 40-64.

Debus, S.J.S. 1995. Surveys of large forest owls in northern New South Wales: methodology, calling behaviour and owl responses. *Corella* 19: 38-50.

Kavanagh, R.P., Debus, S., Tweedie, T. & Webster, R. 1995. Distribution of nocturnal forest birds and mammals in north-eastern New South Wales: relationships with environmental variables and management history. *Wildlife Research* 22: 359-377.

Debus, S.J.S. 1997a. A survey of the raptors of Jervis Bay National Park. *Aust. Birds* 30: 29- 44.

_____ 1997b. The Barking Owl in New South Wales. *Aust. Birds* 30: 53-80.

_____ 1997c. Aspects of the biology of captive-bred, hack-released Masked Owls *Tyto novaehollandiae*. In Czechura, G. & Debus, S. (Eds), *Australian Raptor Studies II*, pp. 14- 33. Birds Australia Monograph 3, Birds Australia, Melbourne.

_____ 1997d. Vocal behaviour of the Southern Boobook *Ninox novaeseelandiae* and other nocturnal birds. In Czechura, G. & Debus, S. (Eds), *Australian Raptor Studies II*, pp. 71- 85. Birds Australia Monograph 3, Birds Australia, Melbourne.

Mathieson, M.T., Debus, S.J.S., Rose, A.B., McConnell, P.J. & Watson, K.M. 1997. Breeding diet of the Letter-winged Kite *Elanus scriptus* and Black-shouldered Kite *Elanus axillaris* during a House Mouse plague. *Sunbird* 27: 65-71.

Debus, S.J.S., Maciejewski, S.E. & McAllan, I.A.W. 1998. The Grass Owl in New South Wales. *Aust. Birds* 31: 29-45.

Brigham, R.M., Debus, S.J.S. & Geiser, F. 1998. Cavity selection for roosting, and roosting ecology of forest-dwelling Australian Owlet-nightjars (*Aegotheles cristatus*). *Aust. J. Ecol.* 23: 424-429.

Bischoff, T., Lutter, H. & Debus, S. 2000. Square-tailed Kites breeding on the mid-north coast of New South Wales. *Aust. Bird Watcher* 18: 233-240.

Brown, B., Brown, F. & Debus, S.J.S. 2000. Further observations on a pair of Square-tailed Kites nesting near Grafton, New South Wales. *Aust. Bird Watcher* 18: 270-273.

Debus, S.J.S. & Rose, A.B. 2000. Diet of Grey Falcons *Falco hypoleucos* breeding extralimitally in New South Wales. *Aust. Bird Watcher* 18: 280-281.

Harrington, G.N. & Debus, S.J.S. 2000. Dietary items of the Rufous Owl *Ninox rufa* on the Atherton Tableland, north Queensland. *Aust. Bird Watcher* 18: 251-252.

Debus, S.J.S. 2001. Surveys of the Barking Owl and Masked Owl on the North-west Slopes of New South Wales. *Corella* 25: 5-11.

Barnes, C.P., Zillmann, E.E., Rose, A.B. & Debus, S.J.S. 2001. Diet and biology of the Square- tailed Kite *Lophoictinia isura* in south-eastern Queensland: nest-building to post-fledging. *Aust. Bird Watcher* 19: 28-43.

Debus, S.J.S., Agnew, L.R. & Schulz, M. 2001. Surveys of the Grass Owl *Tyto capensis* in coastal New South Wales. *Aust. Bird Watcher* 19: 94-102.

Debus, S.J.S. 2002. Distribution, taxonomy, status and major threatening processes of owls of the Australasian Region. In Newton, I., Kavanagh, R., Olsen, J. & Taylor, I. (Eds), *Ecology and Conservation of Owls*, pp. 355-363. CSIRO, Melbourne.

Griffiths, H., Lutter, H., Rose, A.B. & Debus, S.J.S. 2002. Breeding and diet of a pair of Square- tailed Kites *Lophoictinia isura* on the mid-north coast of New South Wales. *Aust. Bird Watcher* 19: 184-193.

Debus, S.J.S. & Rose, A.B. 2003. Diet of a Barking Owl *Ninox connivens* in the channel country of south-west Queensland. *Corella* 27: 18-19.

Lutter, H., Dinnie, R. & Debus, S.J.S. 2003. Square-tailed Kites breeding in northern coastal New South Wales: post-fledging diet and behaviour. *Aust. Field Ornithology* 20: 94-104.

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Appendix 1. Habitat patch location, size, criteria met and status

Aerial Photo No.	Patch No.	Location of Patch	Updated map page	Updated area ID	Patch size (ha)	Criteria Met	Patch Status
1	-	-	-	-	-	nil	No likely foraging or breeding habitat
2	-	-	-	-	-	nil	No likely foraging or breeding habitat
3	-	-	-	-	-	nil	No likely foraging or breeding habitat
4	1	-32.304133 148.275800	1	1	0.37	1,3,4,5,6,7,8	Potential breeding habitat
5	1	-32.282196 148.296023	2		2.6	3,5,6	Potential foraging habitat
6	1	-32.249567 148.298424	3	2	9.59	1,2,3,4,5,6,7,8	Potential breeding habitat
7	1	-32.243128 148.296847	4	Part of patch above		1,2,3,4,5,6,7,8	Potential breeding habitat
8	1	-32.214903 148.311744	5		8.23	1,3,4,5,6,8	Potential foraging habitat
9	1	-32.175076 148.301389	6	3	2.26	1,3,5,6,7,8	Potential breeding habitat
10	-	-	-	-	-	nil	No likely foraging or breeding habitat
11	-	-	-	-	-	nil	No likely foraging or breeding habitat
12	1	-32.092719 148.336277	8	4	1.03	1,3,5,6,7,8	Potential breeding habitat
13	1	-32.065674 148.343204	9	5	0.61	1,3,5,6,7,8	Potential breeding habitat
14	1	-32.045983 148.346025	10		7.14	3,5,6,8	Potential foraging habitat
15	-	-	-	-	-	nil	No likely foraging or breeding habitat
16	1	-31.976173 148.376090	11	6	2.5	1,3,4,5,6,7,8	Potential breeding habitat
17	1	-31.973991 148.380779	12	7	2.09	1,2,3,4,5,6,7,8	Potential breeding habitat

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Aerial Photo No.	Patch No.	Location of Patch	Updated map page	Updated area ID	Patch size (ha)	Criteria Met	Patch Status
18	1	-31.957344 148.414566	13	8	3.36	1,2,3,4,5,6,7,8	Potential breeding habitat
19	1	-31.948363 148.438759	14	9	0.73	1,3,4,5,6,7,8	Potential breeding habitat
20	1	-31.941729 148.450777	14	10	3.41	1,2,3,4,5,6,7,8	Potential breeding habitat
21	1	-31.908958 148.457322	16	11	0.19	1,3,4,5,6,7,8	Potential breeding habitat
21	2	-31.904089 148.458163	16	12	0.62	1,2,3,4,5,6,7,8	Potential breeding habitat
21	3	-31.890718 148.465629	16	13	0.47	1,2,3,4,5,6,7,8	Potential breeding habitat
21	4	-31.887410 148.467535	16	14	0.25	1,3,4,5,6,7,8	Potential breeding habitat
22	1	-31.87548 148.470628	17	15	31.64	1,2,3,4,5,6,7,8	Potential breeding habitat
23	1	-31.845306 148.473905	18	15	6.06	1,3,4,5,6,7,8	Potential breeding habitat
23	2	-31.832405 148.473188	19	15	3.53	1,3,4,5,6,7,8	Potential breeding habitat
24	1	-31.822013 148.474848	19	16	1.84	1,2,3,4,5,6,7,8	Potential breeding habitat
24	2	-31.799522 148.478893	20	17	3.62	1,3,4,5,6,7,8	Potential breeding habitat
25	1	-31.789838 148.480655	20	18	0.70	1,3,4,5,6,7,8	Potential breeding habitat
25	2	-31.785313 148.481435	20	19	0.64	1,3,4,5,6,7,8	Potential breeding habitat
25	3	-31.779168 148.482582	21	20	0.48	1,3,4,5,6,7,8	Potential breeding habitat
25	4	-31.775948 148.483051	21	21	1.49	1,3,4,5,6,7,8	Potential breeding habitat
25	5	-31.769950 148.484260	21	22	8.21	1,3,4,5,6,7,8	Potential breeding habitat
26	-	-	-	-	-	nil	No likely foraging or breeding habitat

Appendix 1. Habitat patch location, size, criteria met and status

Aerial Photo No.	Patch No.	Location of Patch	Updated map page	Updated area ID	Patch size (ha)	Criteria Met	Patch Status
27	1	-31.712812 148.487350	22	23	13.27	1,3,5,6,7,8	Potential breeding habitat
28	1	-31.692157 148.490669	23	24	10.33	1,3,4,5,6,7,8	Potential breeding habitat
29	1	-31.675190 148.493440		Part of patch above		1,3,4,5,6,7,8	Potential breeding habitat
29	2	-31.667279 148.494819	24	25	0.58	1,2,3,4,5,6,7,8	Potential breeding habitat
29	3	-31.662347 148.494927	24	26	1.77	1,2,3,4,5,6,7,8	Potential breeding habitat
30	-	-	-	-	-	nil	No likely foraging or breeding habitat
31	1	-31.599568 148.512363	25	27	4.12	1,3,5,6,7,8	Potential breeding habitat
31	2	-31.600878 148.513350	25	28	0.76	1,3,4,5,6,7,8	Potential breeding habitat
32	-	-	-	-	-	nil	No likely foraging or breeding habitat
33	-	-	-	-	-	nil	No likely foraging or breeding habitat
34	-	-	-	-	-	nil	No likely foraging or breeding habitat
35	1	-31.531581 148.583707	26	29	2.42	1,2,3,4,5,6,7,8	Potential breeding habitat
36	1	-31.511593 148.613129	27	30	0.26	1,3,5,6,7,8	Potential breeding habitat
37	1	-31.491457 148.633418	28	31	2.16	1,3,4,5,6,7,8	Potential breeding habitat
38	1	-31.462253 148.663325	29	32	0.29	1,3,5,6,7,8	Potential breeding habitat
39	1	-31.425821 148.669603	30	33	2.20	1,3,4,5,6,7,8	Potential breeding habitat
40	-	-	-	-	-	nil	No likely foraging or breeding habitat

Appendix 1. Habitat patch location, size, criteria met and status

Aerial Photo No.	Patch No.	Location of Patch	Updated map page	Updated area ID	Patch size (ha)	Criteria Met	Patch Status
41	1	-31.377517 148.677182	31	34	1.74	1,3,4,5,6,7,8	Potential breeding habitat
41	2	-31.371657 148.678119	31	34	5.20	1,2,3,4,5,6,7,8	Potential breeding habitat
42	-	-	-	-	-	nil	No likely foraging or breeding habitat
43	-	-	-	-	-	nil	No likely foraging or breeding habitat
44	1	-31.289016 148.695574	32	35	1.21	1,2,3,4,5,6,7,8	Potential breeding habitat
45	1	-31.268259 148.724047	33	36	16.52	1,3,4,5,6,7,8	Potential breeding habitat
46	1	-31.265165 148.739048	34	Part of patch above		1,3,4,5,6,7,8	Potential breeding habitat
47	-	-	-	-	-	nil	No likely foraging or breeding habitat
48	1	-31.199721 148.771820	35	37	1.84	1,3,4,5,6,7,8	Potential breeding habitat
48	2	-31.191433 148.775858	35	38	0.95	1,3,4,5,6,7,8	Potential breeding habitat
48	3	-31.185299 148.780388	35	39	21.07	1,3,4,5,6,7,8	Potential breeding habitat
49	1	-31.173910 148.787053	35	Part of patch above		1,3,4,5,6,7,8	Potential breeding habitat
49	2	-31.163197 148.791262	35	40	0.5	1,3,5,6,7,8	Potential breeding habitat
49	3	-31.154104 148.794150	37	41	6.3	1,3,4,5,6,7,8	Potential breeding habitat
50	-	-	-	-	-	nil	No likely foraging or breeding habitat
51	-	-	-	-	-	nil	No likely foraging or breeding habitat
52	-	-	-	-	-	nil	No likely foraging or breeding habitat

Appendix 1. Habitat patch location, size, criteria met and status

Aerial Photo No.	Patch No.	Location of Patch	Updated map page	Updated area ID	Patch size (ha)	Criteria Met	Patch Status
53	1	-31.072579 148.841200	38	42	4.56	1,3,4,5,6,7,8	Potential breeding habitat
54	1	-31.042216 148.831482	40	43	1.32	1,3,4,5,6,7,8	Potential breeding habitat
55	-	-	-	-	-	nil	No likely foraging or breeding habitat
56	-	-	-	-	-	nil	No likely foraging or breeding habitat
57	1	-30.951540 148.853930	41	44	1.41	1,3,4,5,6,7,8	Potential breeding habitat
58	1	-30.917447 148.873355	42	45	0.92	1,2,3,4,5,6,7,8	Potential breeding habitat
58	2	-30.911198 148.884592	42	46	0.26	1,3,5,6,7,8	Potential breeding habitat
59	1	-30.900628 148.909499	43	47	4.79	1,3,4,5,6,7,8	Potential breeding habitat
60	1	-30.900409 148.912896		Part of patch above		1,3,4,5,6,7,8	Potential breeding habitat
61	1	-30.889991 148.938040	44	48	0.27	1,3,5,6,7,8	Potential breeding habitat
61	2	-30.881580 148.958973	45	49	0.69	1,3,5,6,7,8	Potential breeding habitat
62	-	-	-	-	-	nil	No likely foraging or breeding habitat
63	-	-	-	-	-	nil	No likely foraging or breeding habitat
64	1	-30.876062 149.022922	47	50	9.17	1,3,4,6,7,8	Potential breeding habitat
65	1	-30.874562 149.041210	48	51	24.24	1,2,3,4,5,6,7,8	Potential breeding habitat
66	1	-30.862915 149.067378	48	52, 53	24.93	1,2,3,4,5,6,7,8	Potential breeding habitat
67	1	-30.837387 149.086388	50	54	20.34	1,2,3,4,5,6,7,8	Potential breeding habitat

Appendix 1. Habitat patch location, size, criteria met and status

Aerial Photo No.	Patch No.	Location of Patch	Updated map page	Updated area ID	Patch size (ha)	Criteria Met	Patch Status
68	1	-30.812828 149.093674	51	55	26.44	1,2,3,4,5,6,7,8	Potential breeding habitat
69	1	-30.778468 149.105288	52	56	28.81	1,3,4,5,7,8	Potential breeding habitat
70	1	-30.754347 149.113782	53	57	24.35	1,2,3,4,5,6,7,8	Potential breeding habitat
71	1	-30.723579 149.140754	54	58	21.42	1,2,3,4,5,6,7,8	Potential breeding habitat
72	1	-30.704949 149.156471	55	59	10.42	1,2,3,4,5,6,7,8	Potential breeding habitat
72	2	-30.696075 149.169399	56	60	9.69	1,2,3,4,5,6,7,8	Potential breeding habitat
73	1	-30.694509 149.175992	56	61	3.5	1,3,4,5,6,7,8	Potential breeding habitat
73	2	-30.689606 149.190317	56	62	19.34	1,3,4,5,6,7,8	Potential breeding habitat
74	1	-30.683187 149.210205	57	63	28.36	1,3,4,5,6,7,8	Potential breeding habitat
75	1	-30.678579 149.224593	58	64	6.42	1,3,4,5,7,8	Potential breeding habitat
75	2	-30.674234 149.238098	58	65	13.44	1,3,4,5,7,8	Potential breeding habitat
76	1	-30.668046 149.257415	59	66	17.4	1,2,3,4,5,7,8	Potential breeding habitat
77	1	-30.662830 149.273206	59	67	7.69	1,2,3,4,5,7,8	Potential breeding habitat
77	2	-30.658163 149.286298	60	68	12.76	1,2,3,4,5,7,8	Potential breeding habitat
78	1	-30.652881 149.293912	60	69	1.77	1,2,3,4,5,7,8	Potential breeding habitat
78	2	-30.645048 149.305746	61	70	21.24	1,2,3,4,5,7,8	Potential breeding habitat
78	3	-30.640835 149.314939	61	71	1.22	1,2,3,4,5,7,8	Potential breeding habitat

Appendix 1. Habitat patch location, size, criteria met and status

Aerial Photo No.	Patch No.	Location of Patch	Updated map page	Updated area ID	Patch size (ha)	Criteria Met	Patch Status
79	1	-30.639164 149.318731	62	72	4.44	1,3,4,5,7,8	Potential breeding habitat
79	2	-30.632739 149.332859	62	73	14.81	1,2,3,4,5,7,8	Potential breeding habitat
80	1	-30.623081 149.354288	63	74	33.16	1,3,4,5,7,8	Potential breeding habitat
81	1	-30.617404 149.370727	64	75	8.56	1,3,4,5,7,8	Potential breeding habitat
81	2	-30.612430 149.38474	64	76	12.46	1,3,4,5,7,8	Potential breeding habitat
82	1	-30.607744 149.401239	65	77	16.4	1,2,3,4,5,7,8	Potential breeding habitat
83	1	-30.585897 149.433199	66	78	15.38	1,2,3,4,5,7,8	Potential breeding habitat
84	1	-30.580969 149.441241	67	79	11.3	1,2,3,4,5,7,8	Potential breeding habitat
84	2	-30.566848 149.457054	67	80	16.9	1,2,3,4,5,7,8	Potential breeding habitat
85	1	-30.552309 149.472990	68	81	18.71	1,3,4,5,6,7,8	Potential breeding habitat
86	1	-30.539541 149.494699	69	82	18.17	1,2,3,4,5,7,8	Potential breeding habitat
87	1	-30.526693 149.524278	70	83	23.82	1,3,4,5,7,8	Potential breeding habitat
88	1	-30.516533 149.544715	71	84	17.62	1,3,4,5,7,8	Potential breeding habitat
89	1	-30.505174 149.569551	72	85	15.6	1,3,4,5,7,8	Potential breeding habitat
89	2	-30.512284 149.558253	73	86	17.23	1,3,4,5,7,8	Potential breeding habitat
90	1	-30.494550 149.592623		Part of patch above		1,3,4,5,7,8	Potential breeding habitat
91	1	-30.489432 149.605107	73	87	6.78	1,3,4,5,7,8	Potential breeding habitat
92	-	-	-	-	-	nil	No likely foraging or breeding habitat

Appendix 1. Habitat patch location, size, criteria met and status

Aerial Photo No.	Patch No.	Location of Patch	Updated map page	Updated area ID	Patch size (ha)	Criteria Met	Patch Status
93	1	-30.463028 149.658864	75	88	6.44	1,3,4,5,6,7,8	Potential breeding habitat
93	2	-30.453765 149.663193	75	89	1.58	1,3,4,5,6,7,8	Potential breeding habitat
94					This map is a repeat of map 93.		
95	1	-30.445227 149.670391	76	90	22.13	1,2,3,4,5,6,7,8	Potential breeding habitat
96	1	-30.405518 149.701346	77	91	9.00	1,2,3,4,5,6,7,8	Potential breeding habitat
97	-	-	-	-	-	nil	No likely foraging or breeding habitat
98	-	-	-	-	-	nil	No likely foraging or breeding habitat
99	1	-30.327447 149.742093	78	92	0.29	1,2,3,5,6,7,8	Potential breeding habitat
100	1	-30.309597 149.767481	79	93	0.17	1,2,3,5,6,7,8	Potential breeding habitat
101	-	-	-	-	-	nil	No likely foraging or breeding habitat
102	-	-	-	-	-	nil	No likely foraging or breeding habitat
103	1	-32.338373 148.240096	80	94	3.26	1,3,4,5,6,7,8	Potential breeding habitat
104	-	-	-	-	-	nil	No likely foraging or breeding habitat
105	-	-	-	-	-	nil	No likely foraging or breeding habitat
106	-	-	-	-	-	nil	No likely foraging or breeding habitat
107	1	-31.976108 148.376053		Repeat of page 11		1,3,4,5,6,7,8	Potential breeding habitat
108	-	-	-	-	-	nil	No likely foraging or breeding habitat
109	-	-	-	-	-	nil	No likely foraging or breeding habitat

Appendix 1. Habitat patch location, size, criteria met and status

Aerial Photo No.	Patch No.	Location of Patch	Updated map page	Updated area ID	Patch size (ha)	Criteria Met	Patch Status
110	1	-30.411686 149.756024	81	95	2.12*	1,3,4,5,6,7,8	Potential breeding habitat
111	1	-30.946724 149.055913	82	96	0.31	1,3,4,5,6,7,8	Potential breeding habitat
			-	-	-		
TOTAL POTENTIAL FORAGING HABITAT					**17.97**		
TOTAL POTENTIAL BREEDING HABITAT					**822.99**		

* Note: This patch (Borrow Pit D) has been cleared, however, it is still showing as vegetated on aerial photos.

Appendix 2. Habitat maps

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NARROMINE TO NARRABRI

Appendix 2

Habitat areas and status

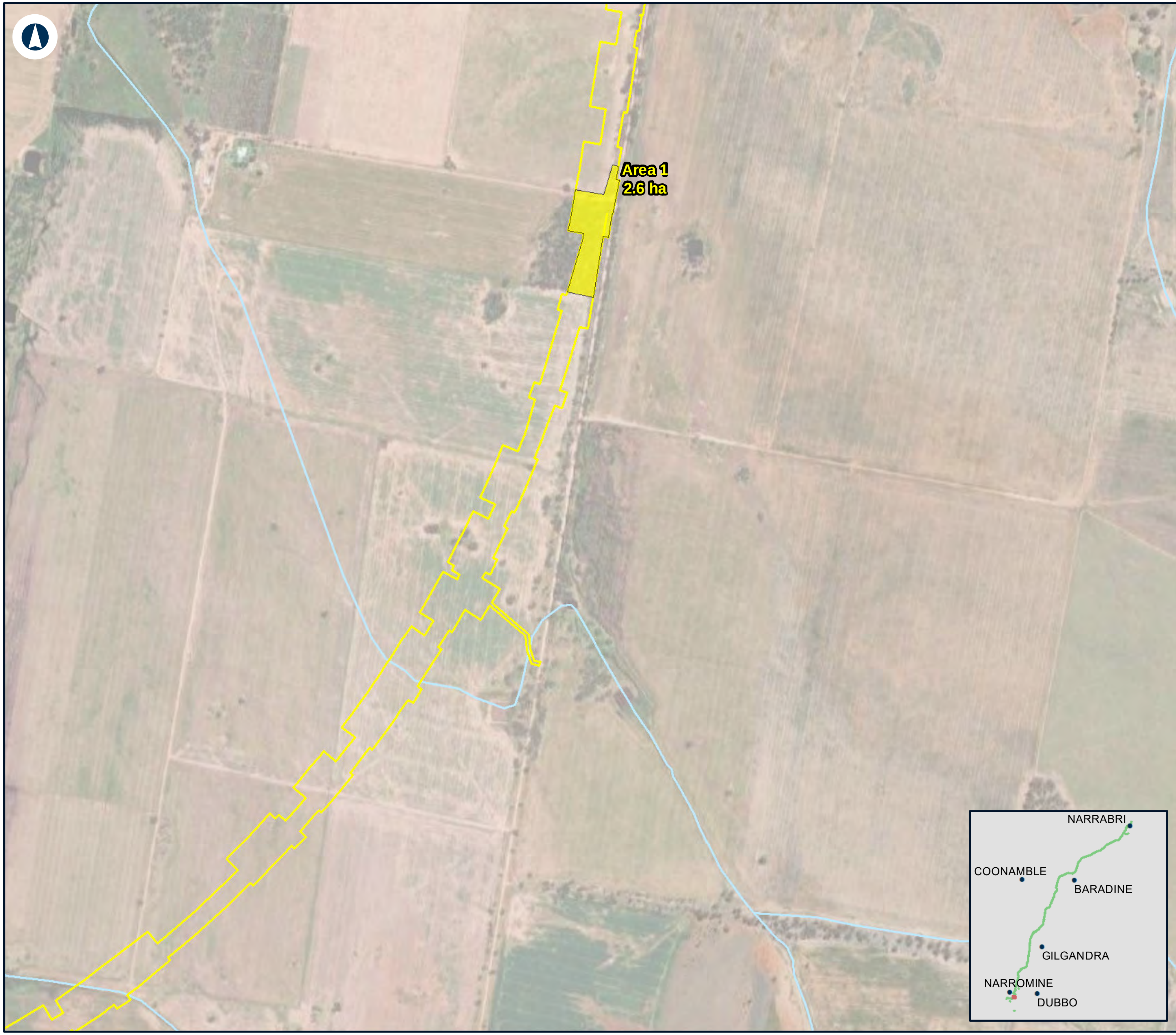
LEGEND

- Construction impact zone
- Square-tailed Kite potential breeding habitat

0 200 400 Metres

Coordinate System: GDA 1994 MGA Zone 55

Date: 2021-11-30
Paper: A4
Author: JacobsGHD
Scale: 1:15,000
Data Sources: Basemap layers: NSWSS, esri;



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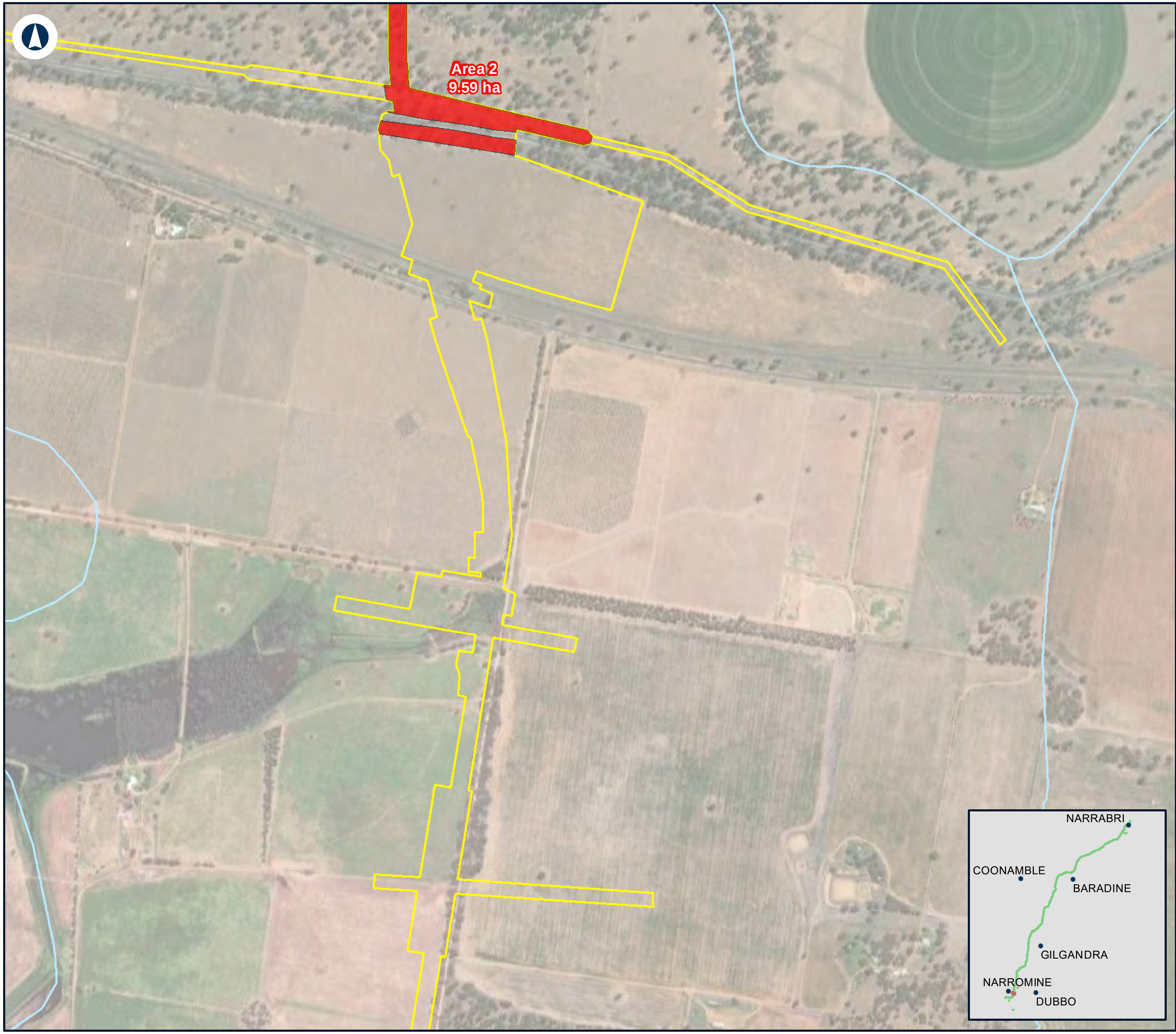

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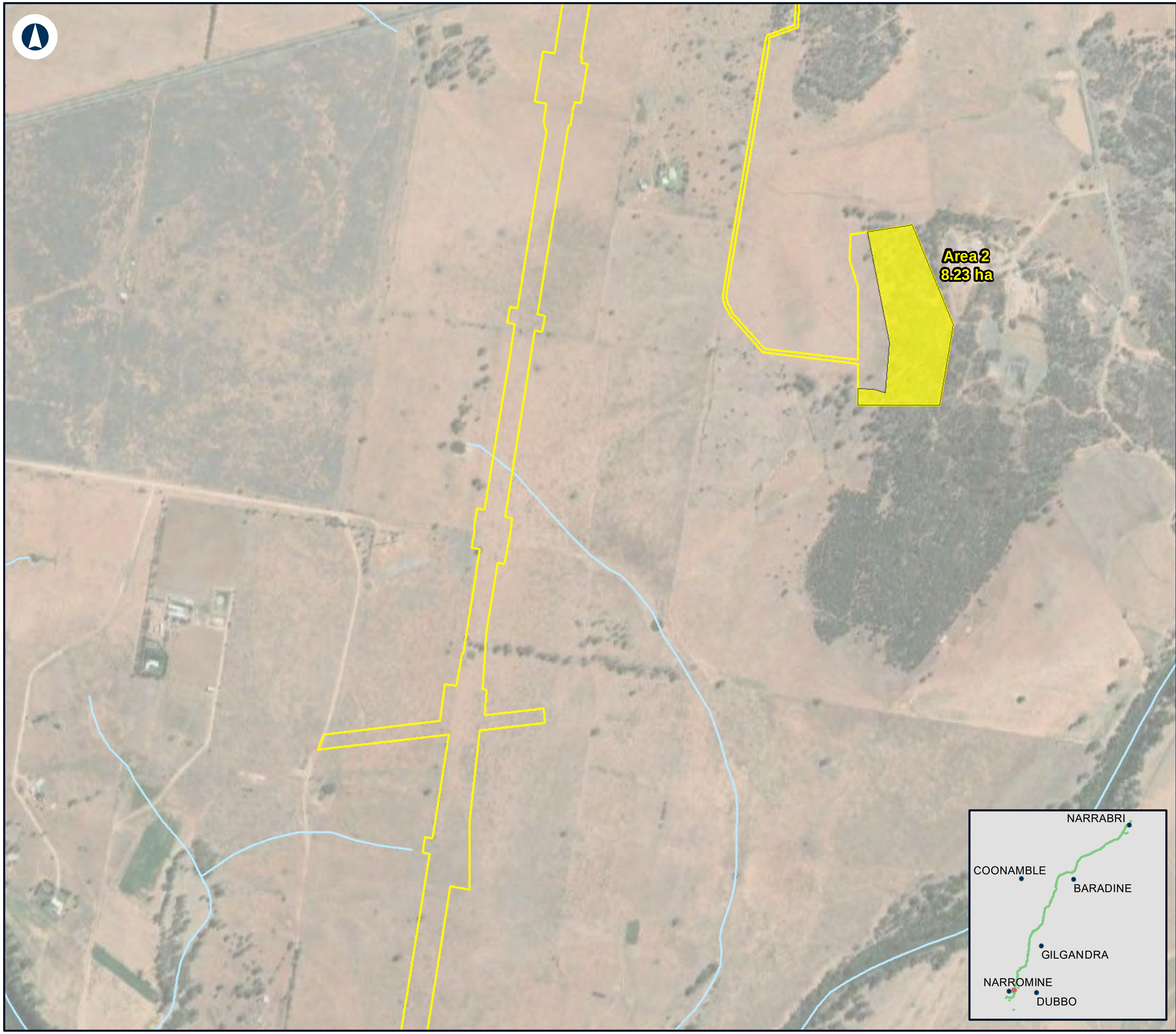

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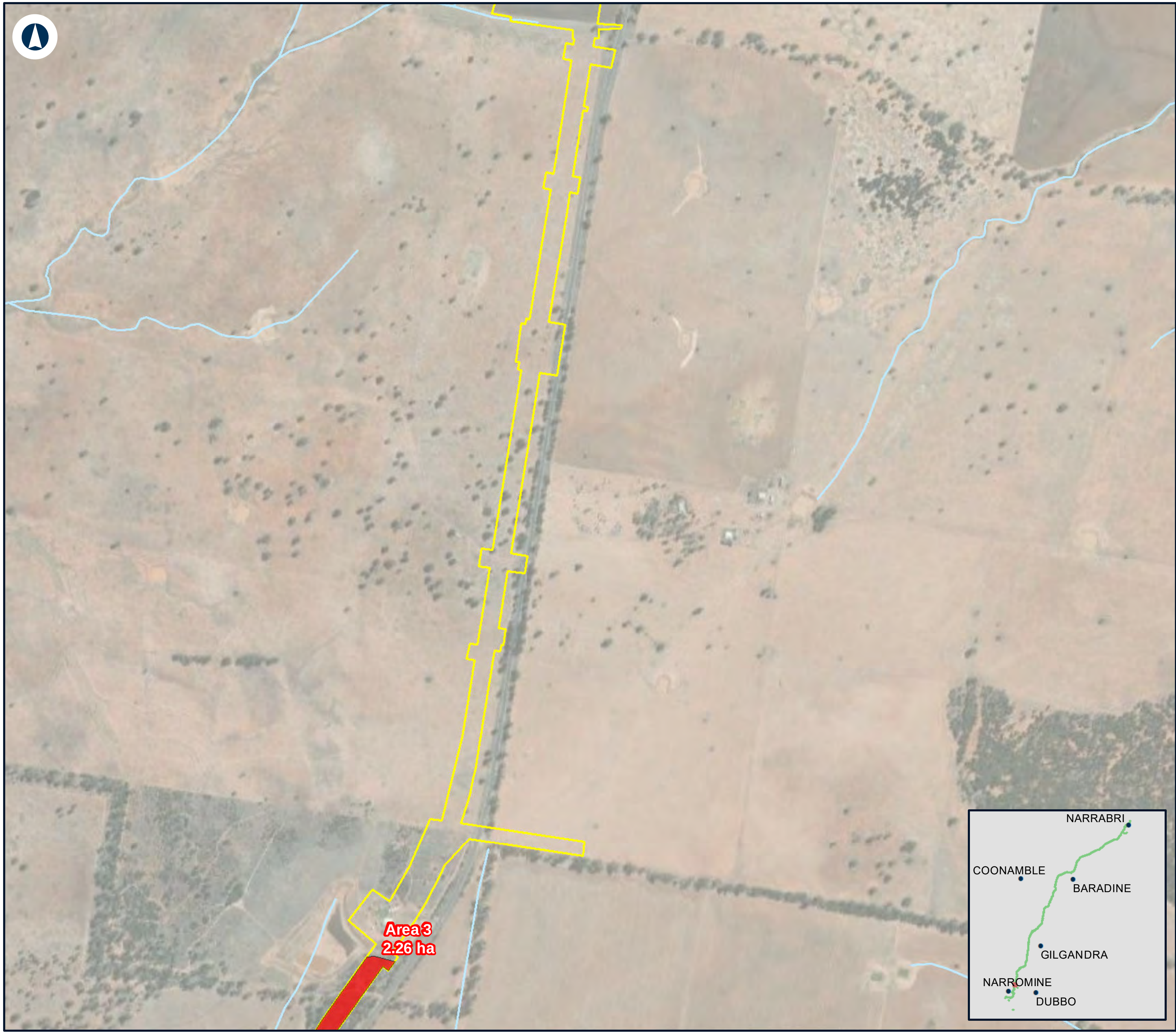

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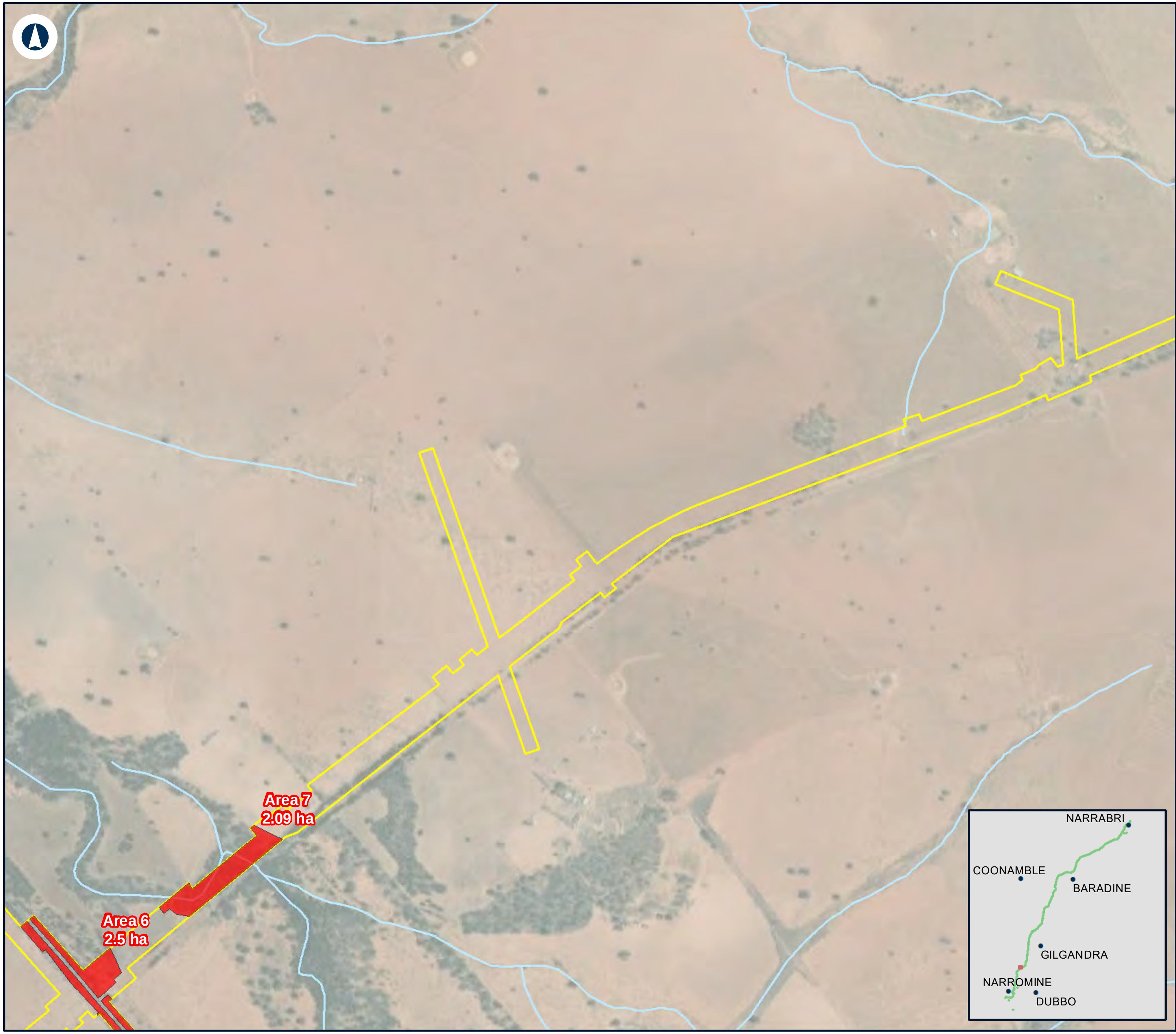

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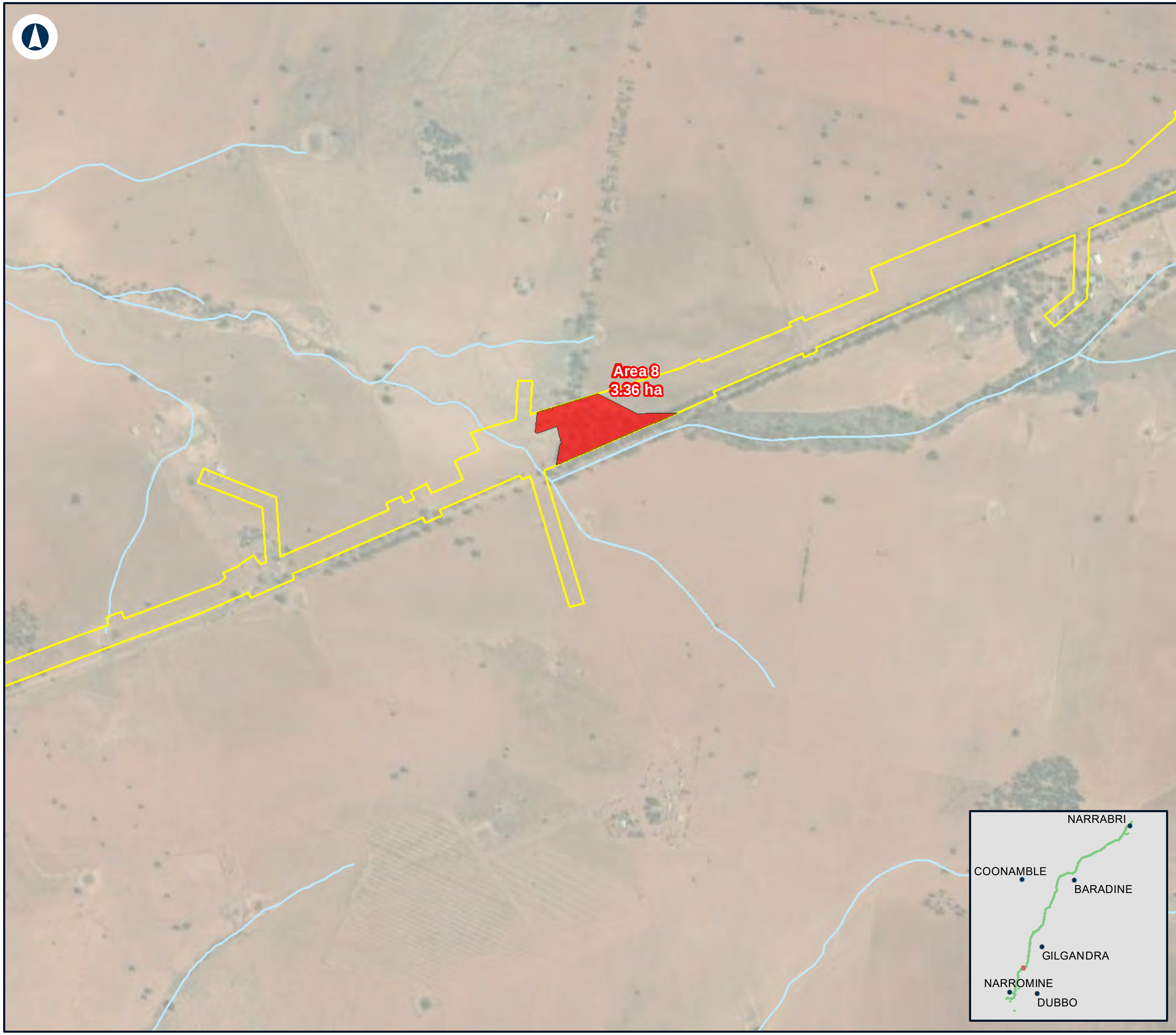

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Habitat areas and status

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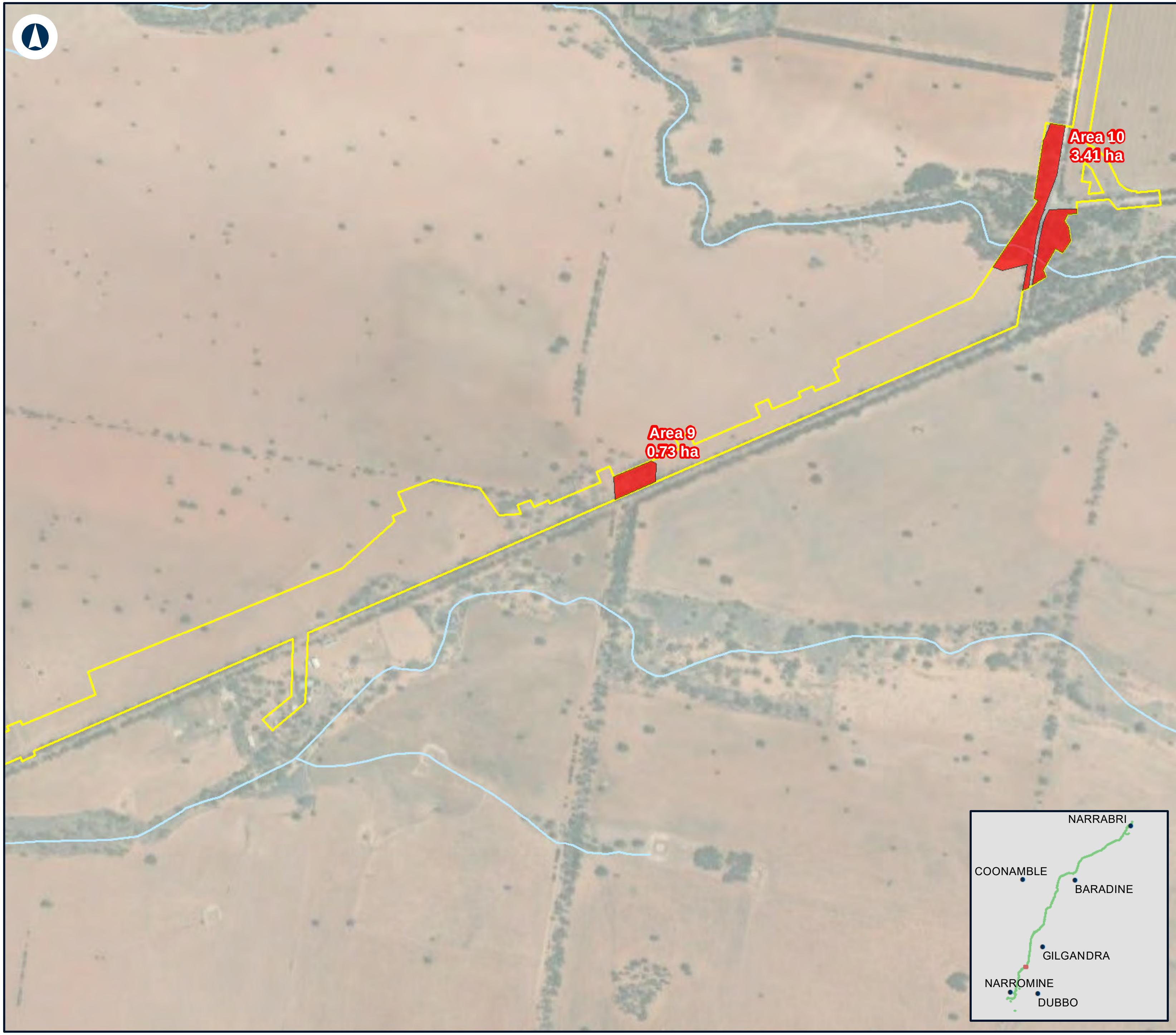

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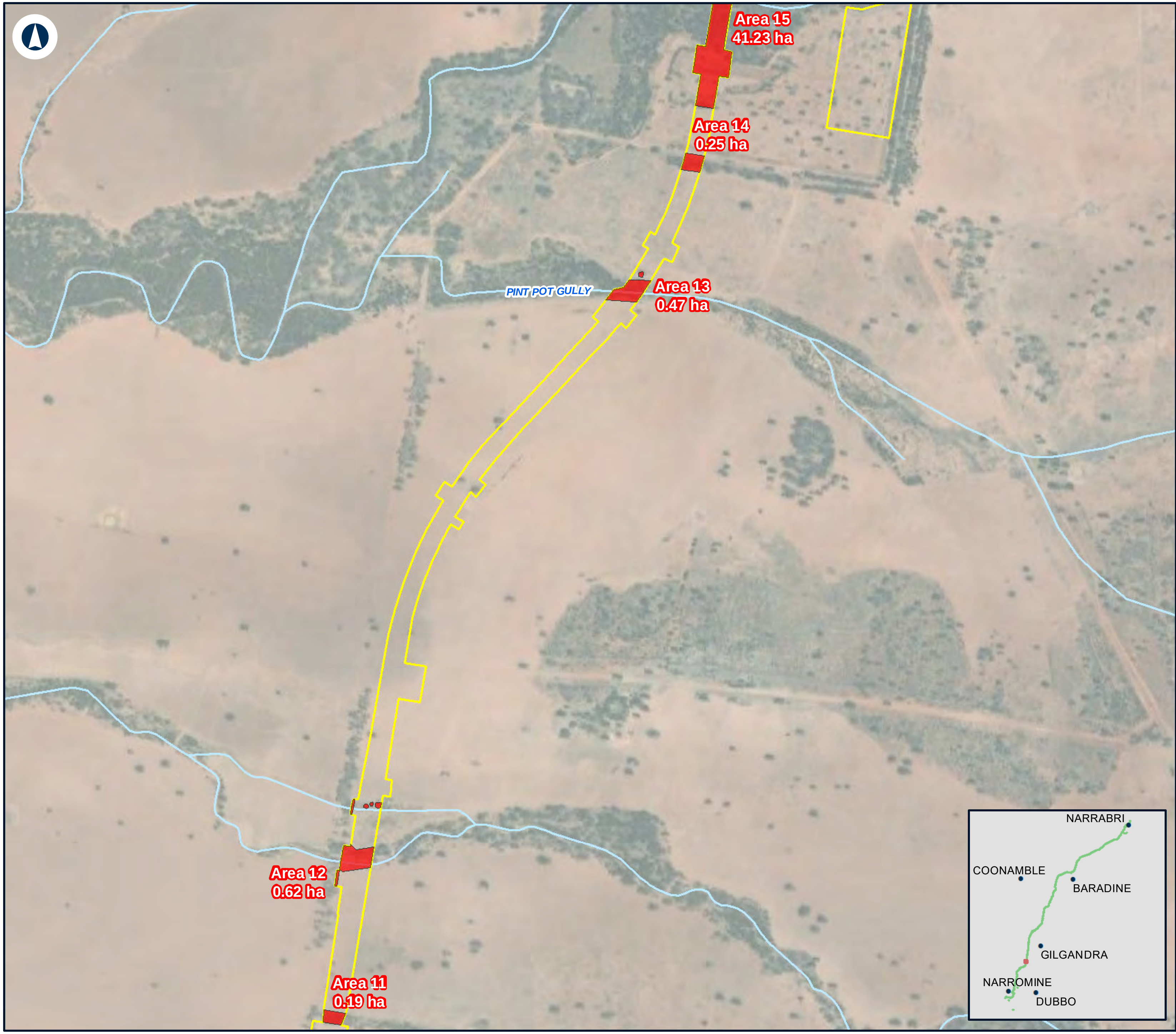

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Appendix 2

Habitat areas and status

LEGEND

- Construction impact zone
- Square-tailed Kite potential breeding habitat

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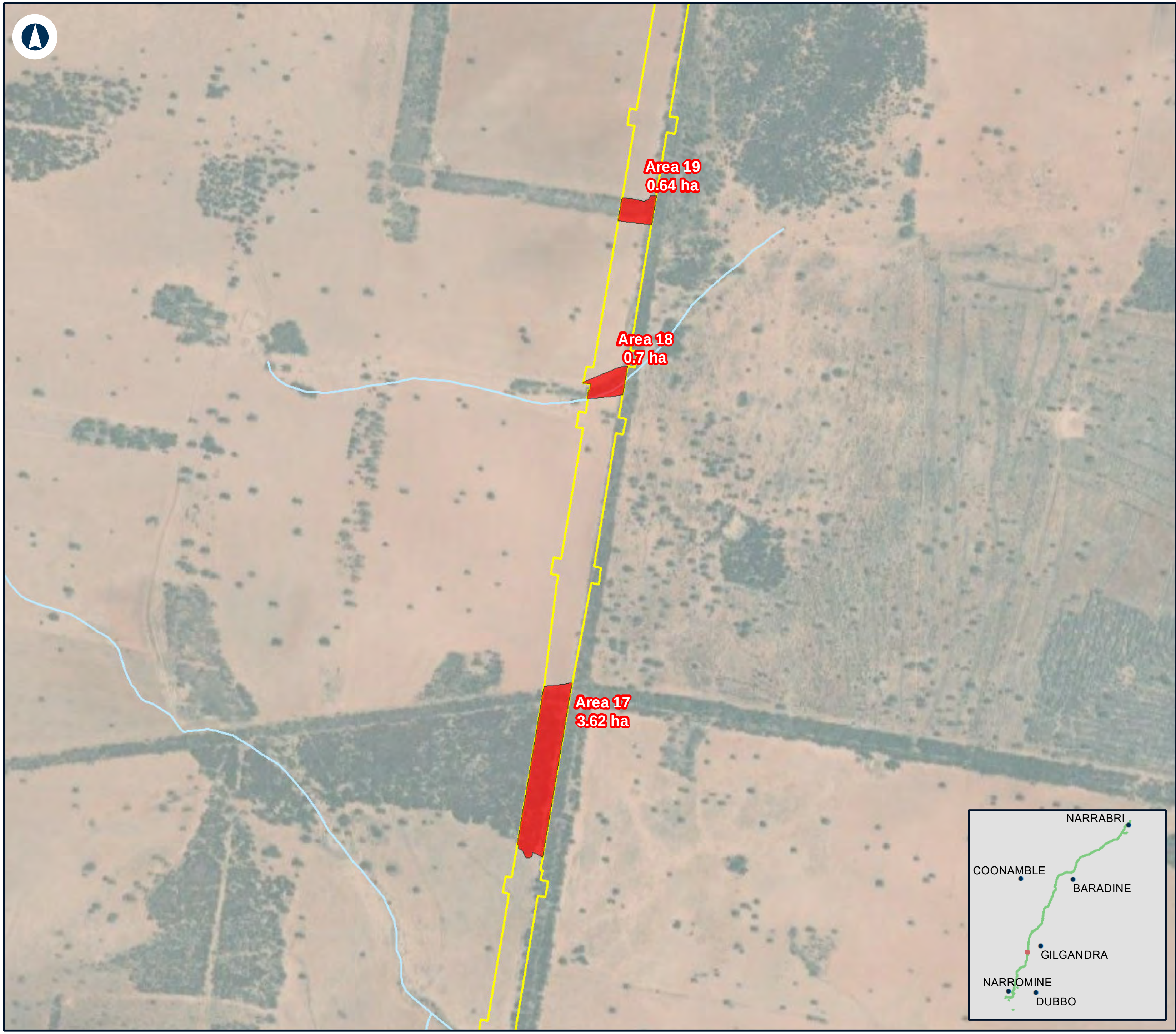

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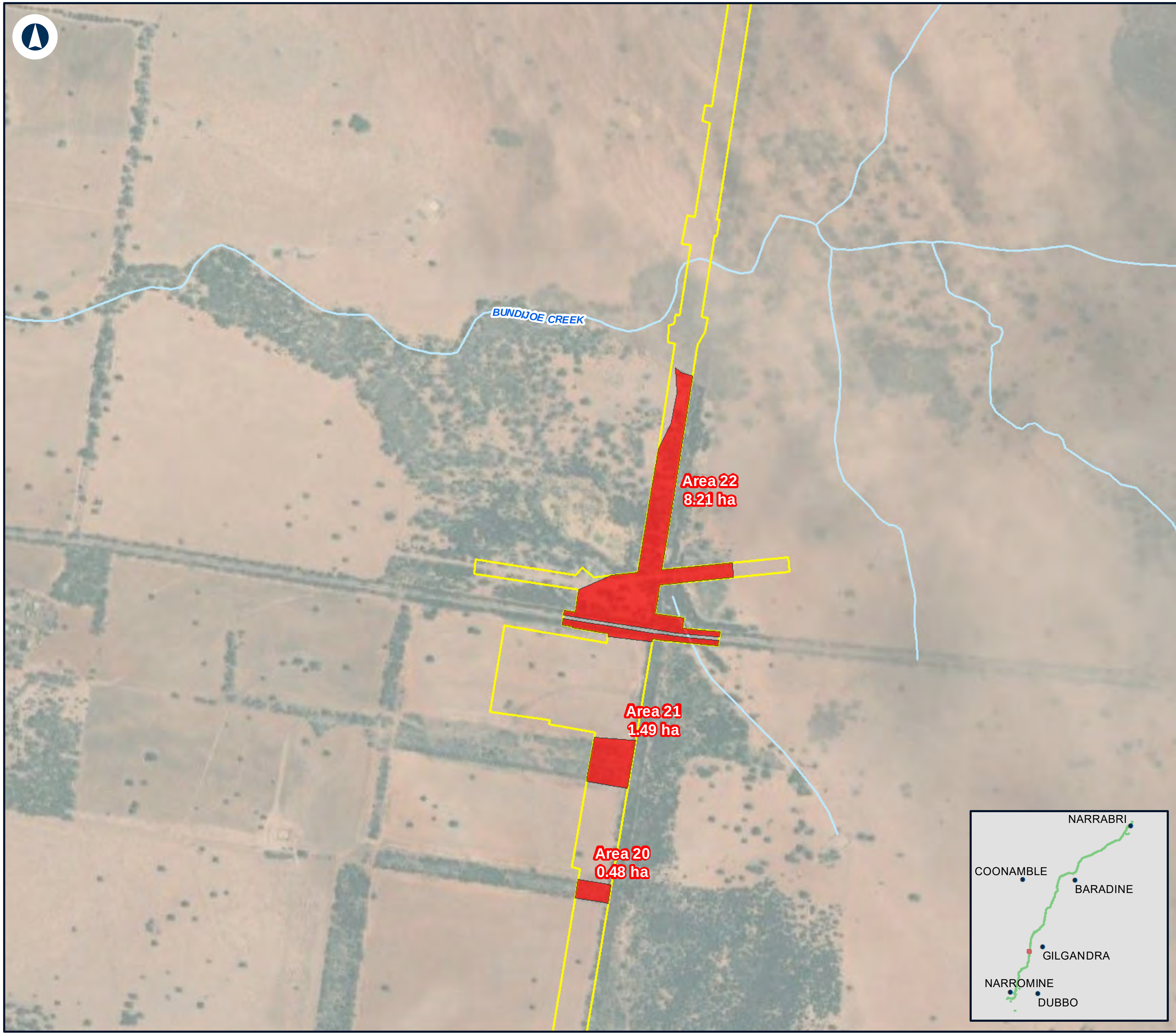

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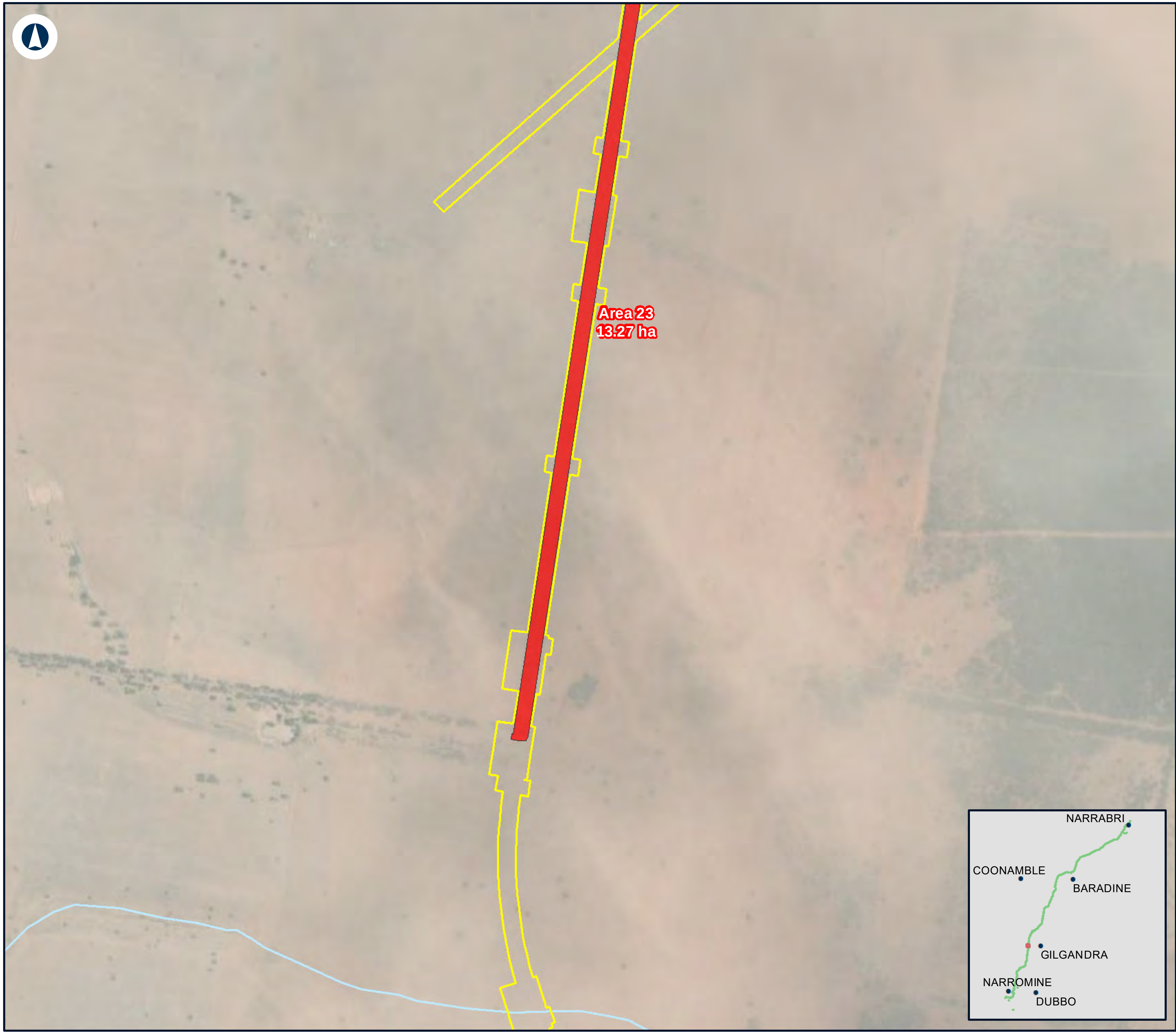

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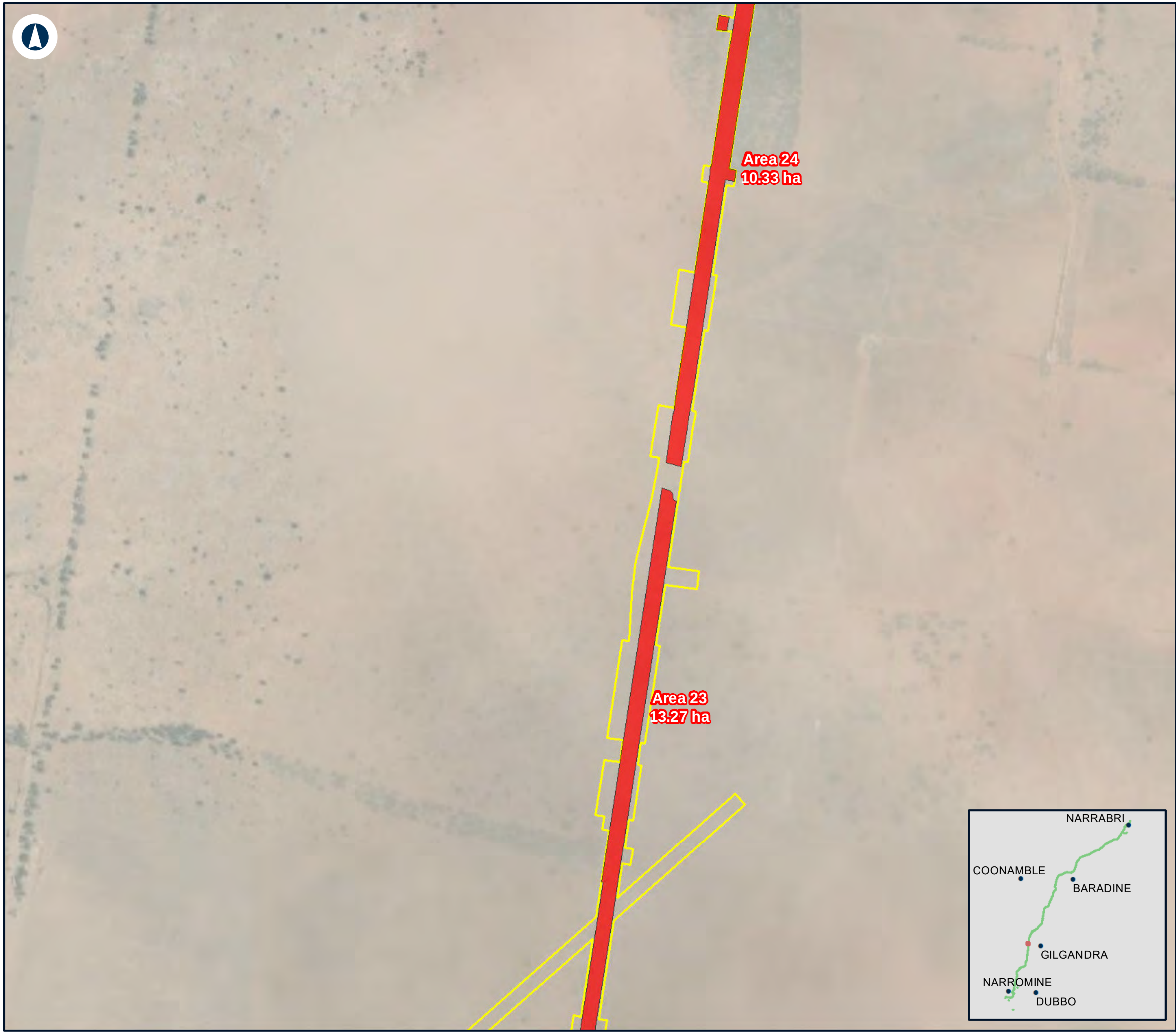

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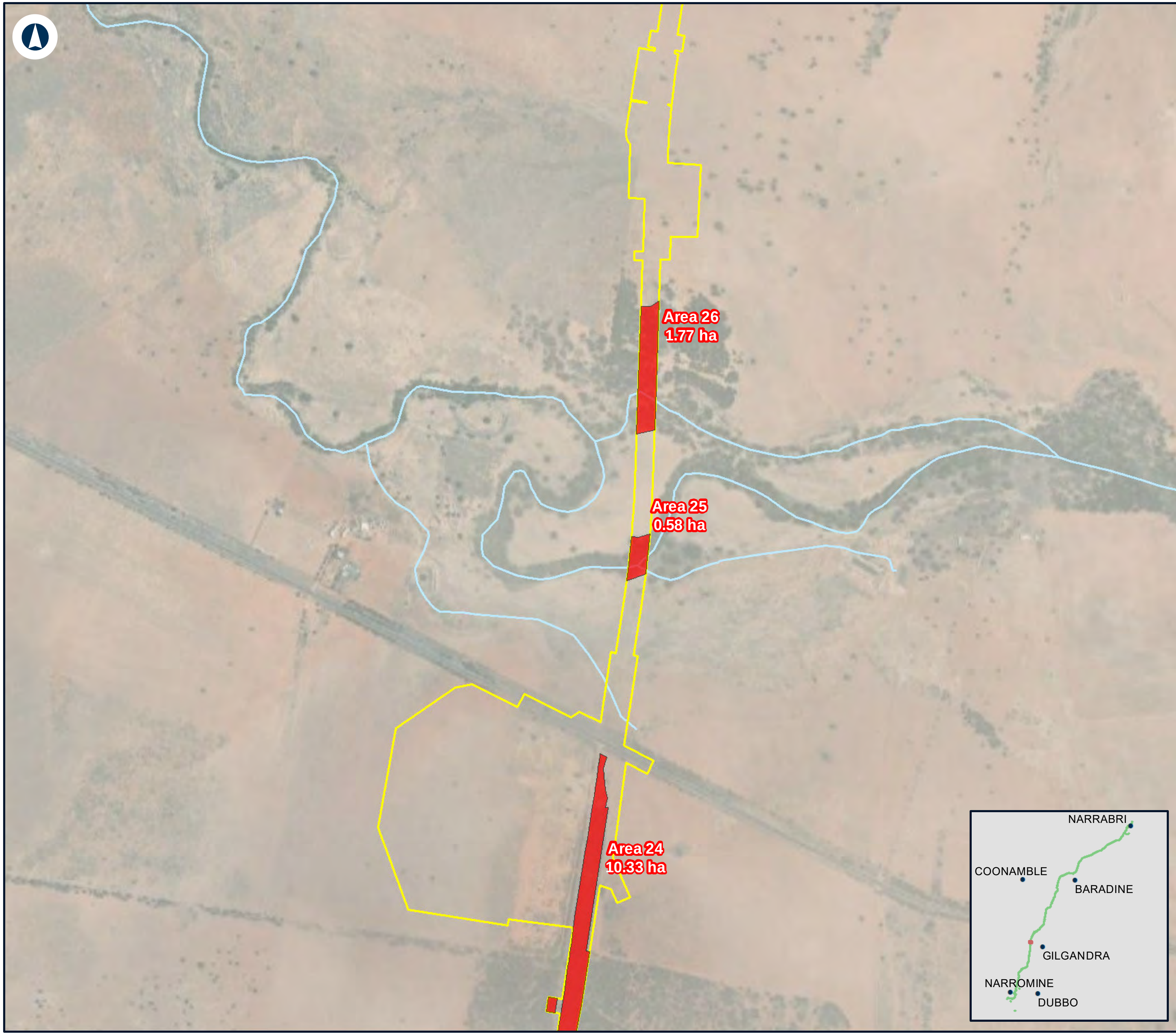

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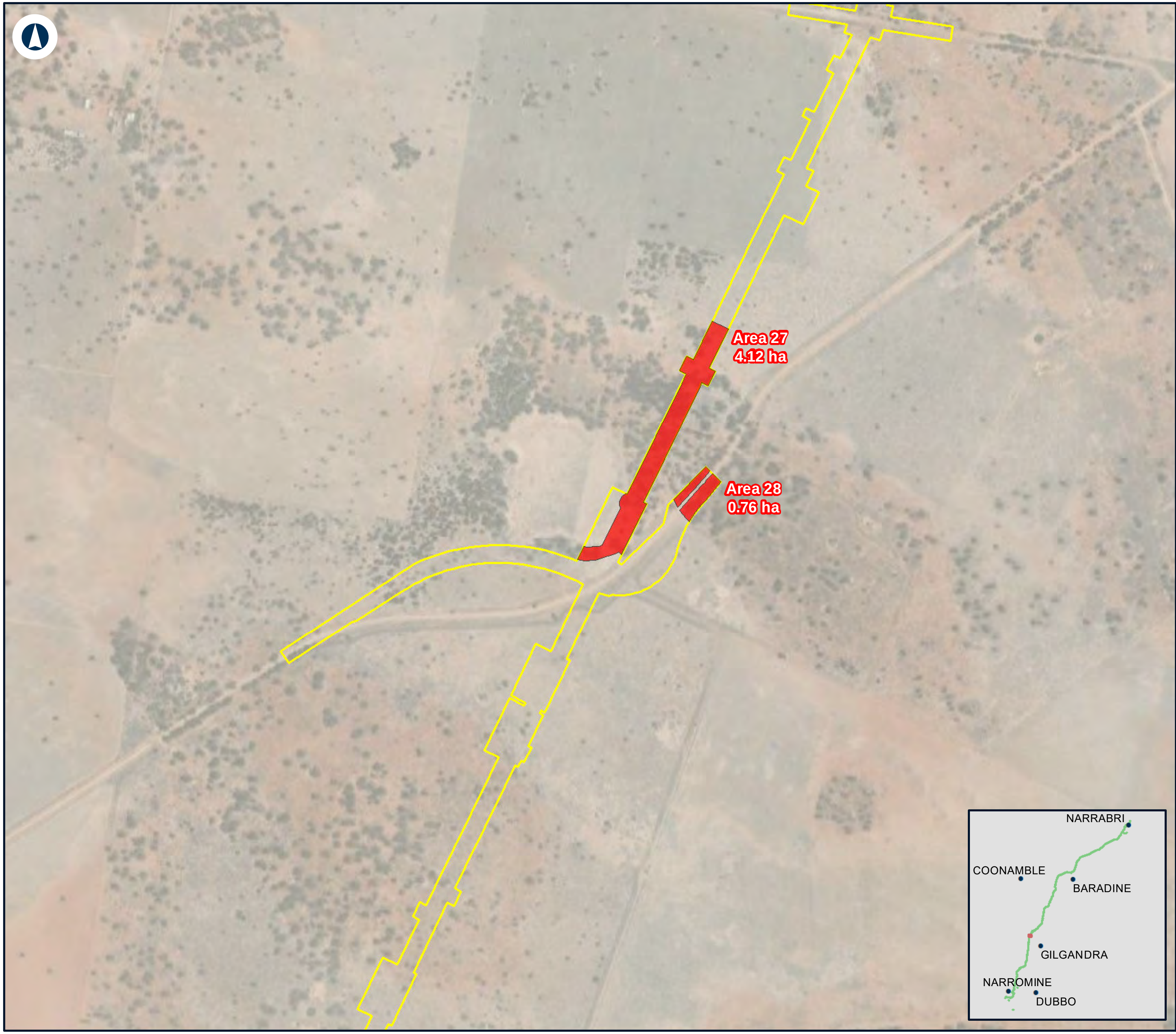

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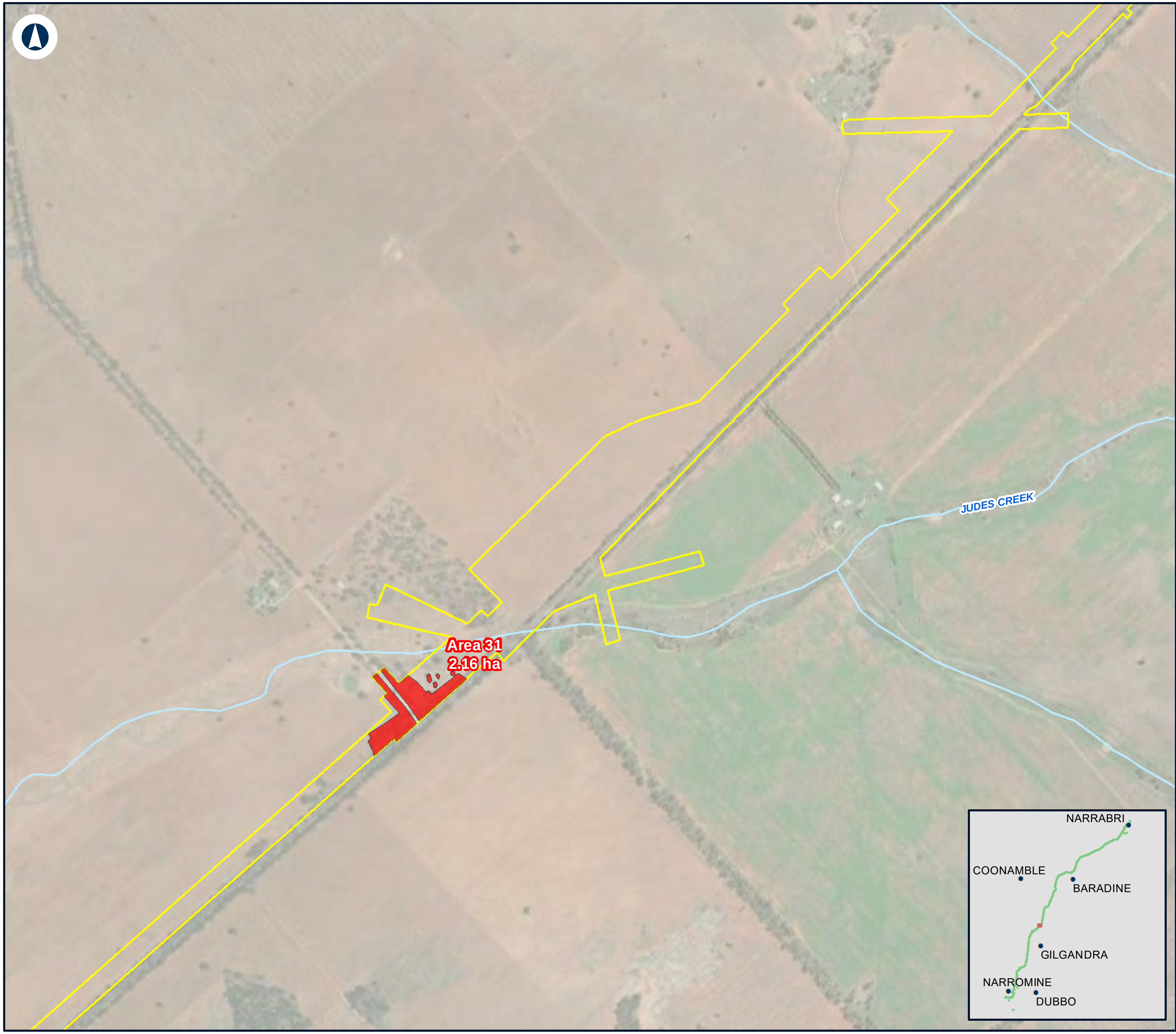

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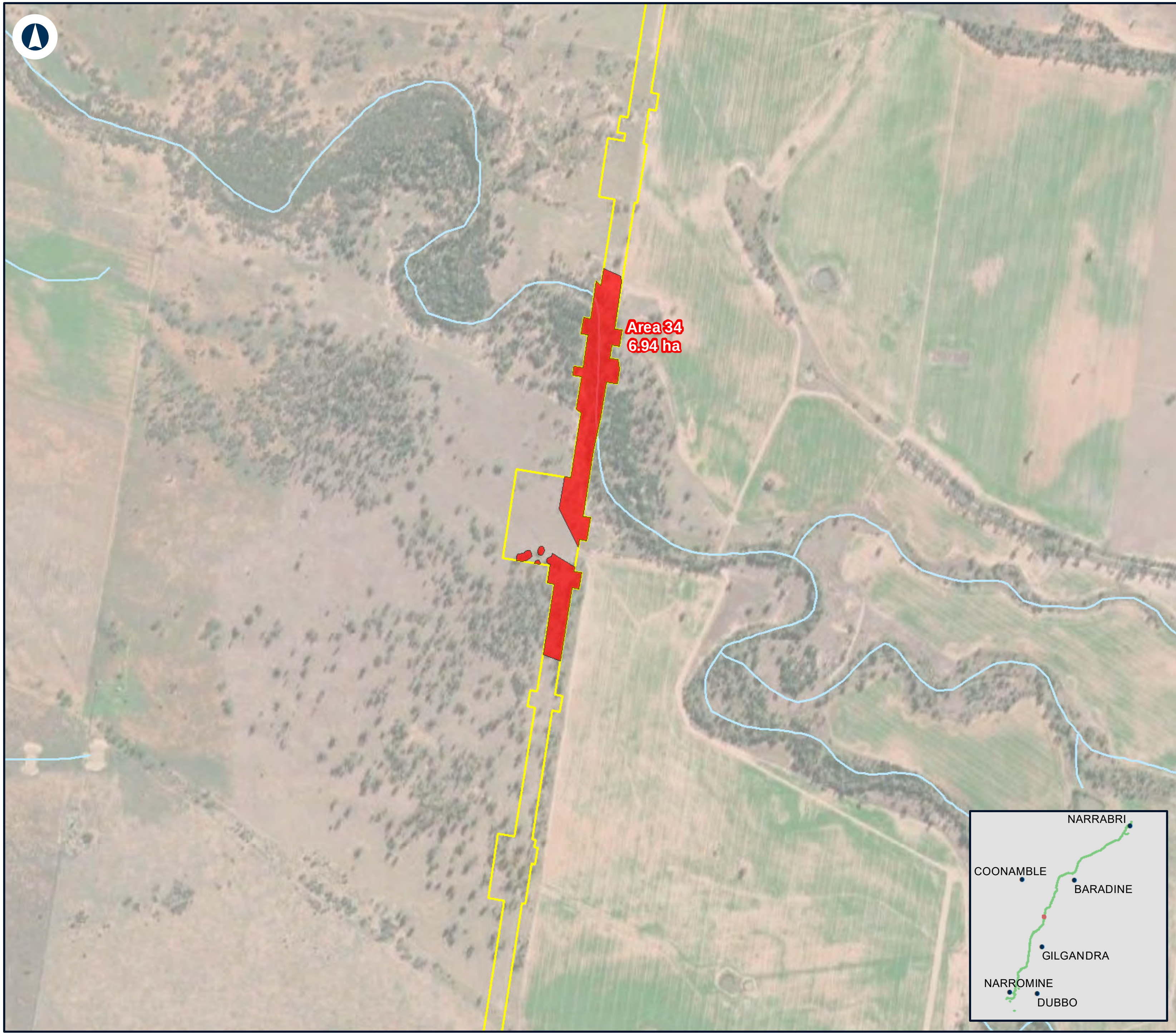

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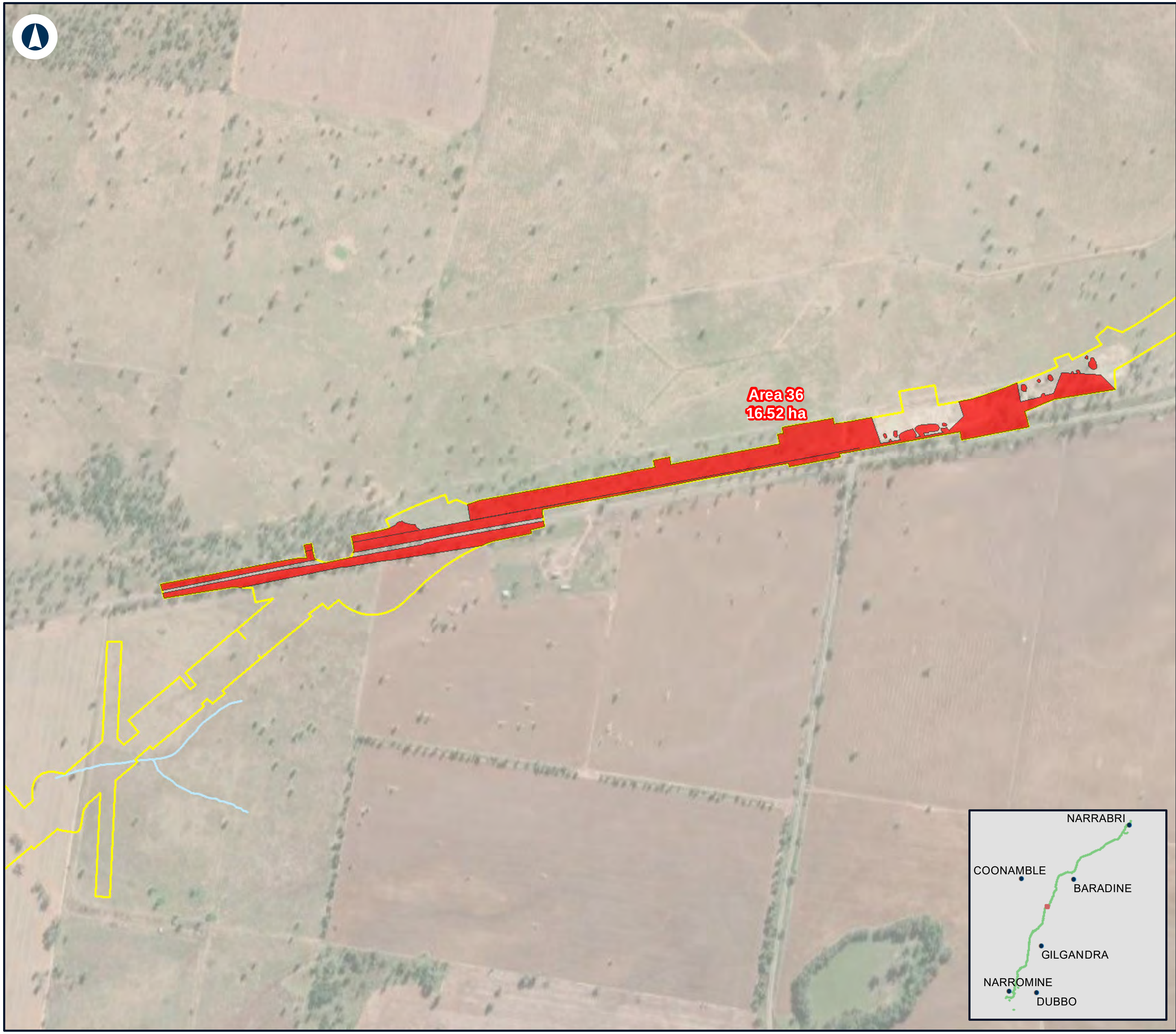

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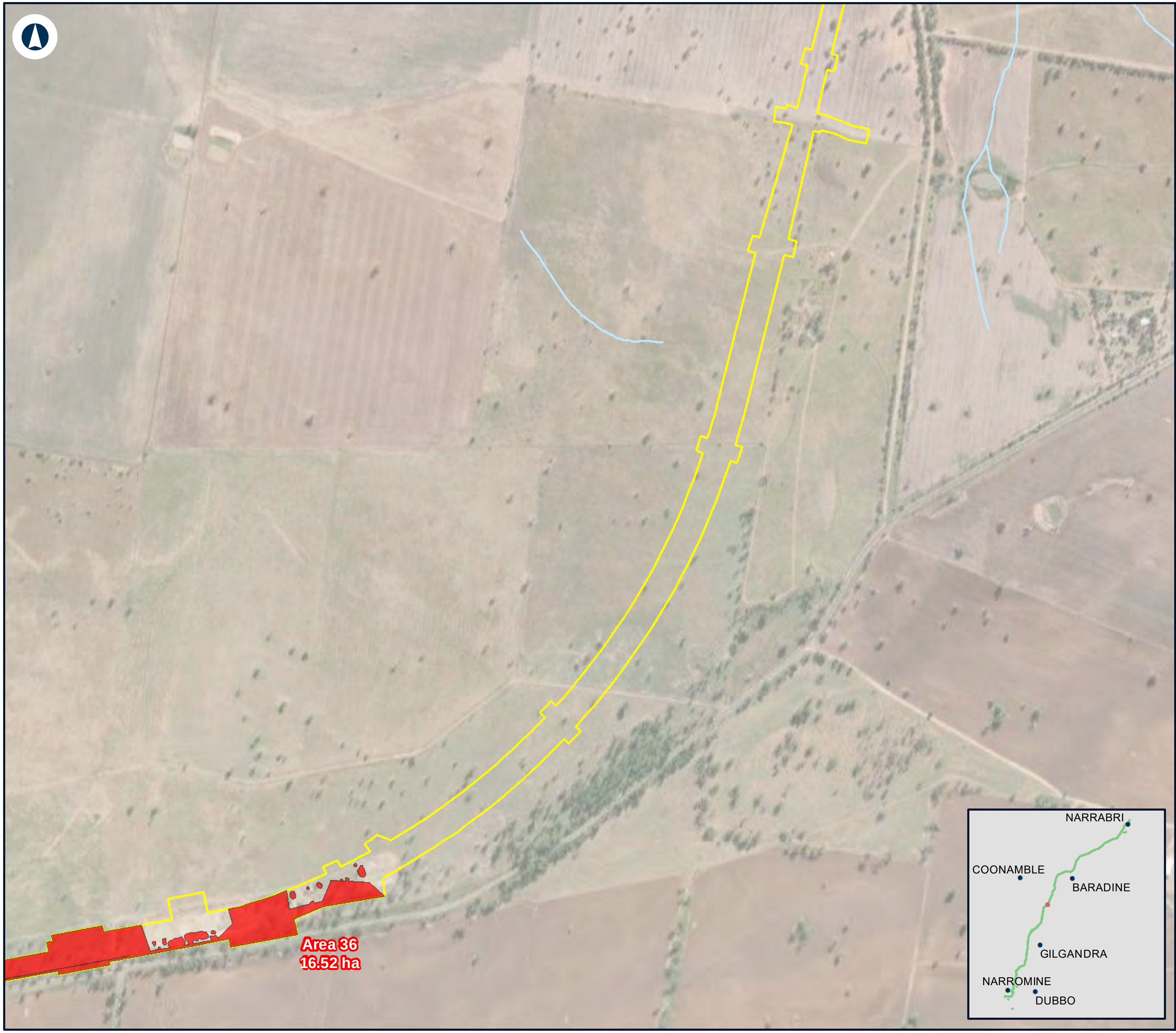

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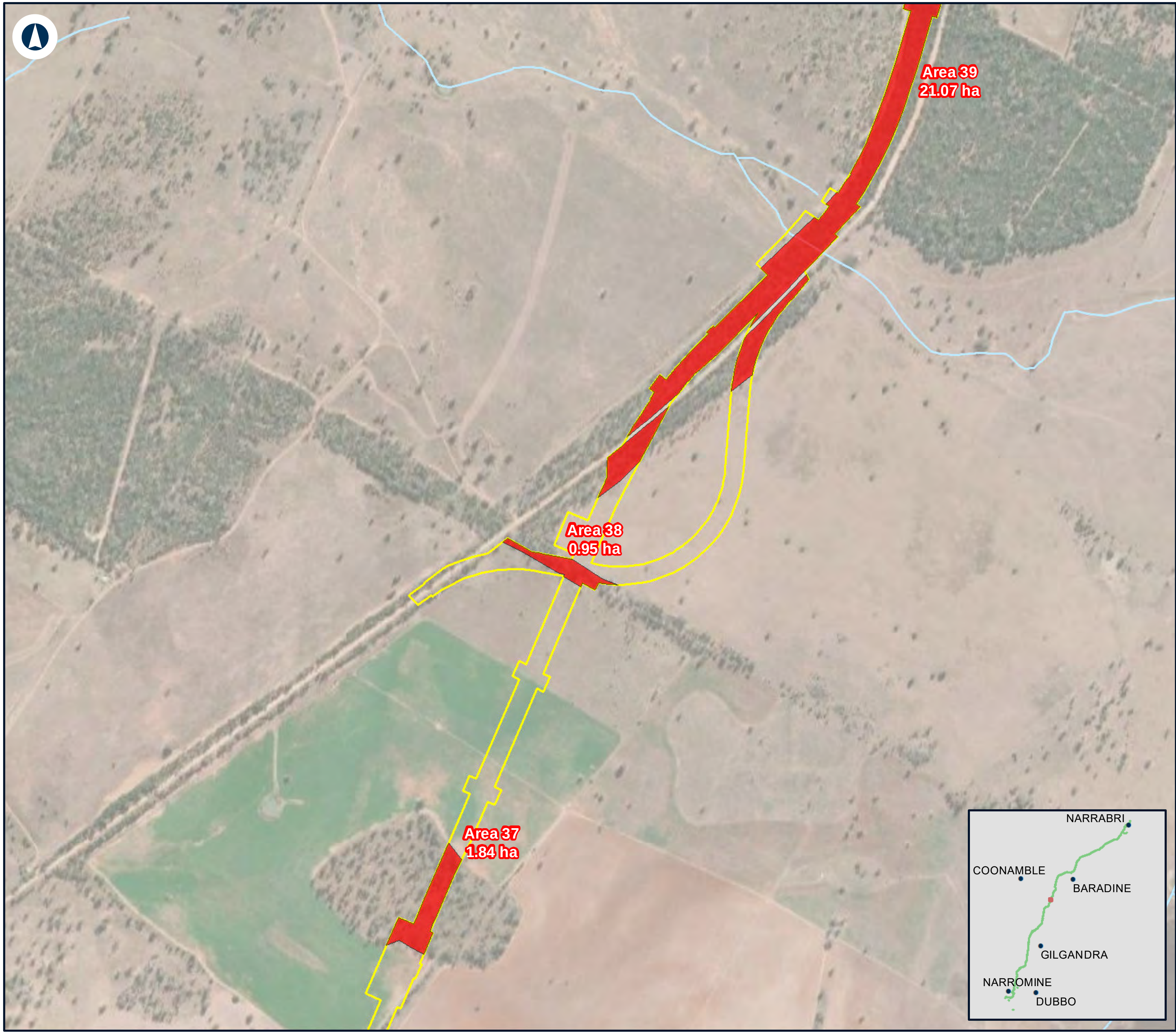

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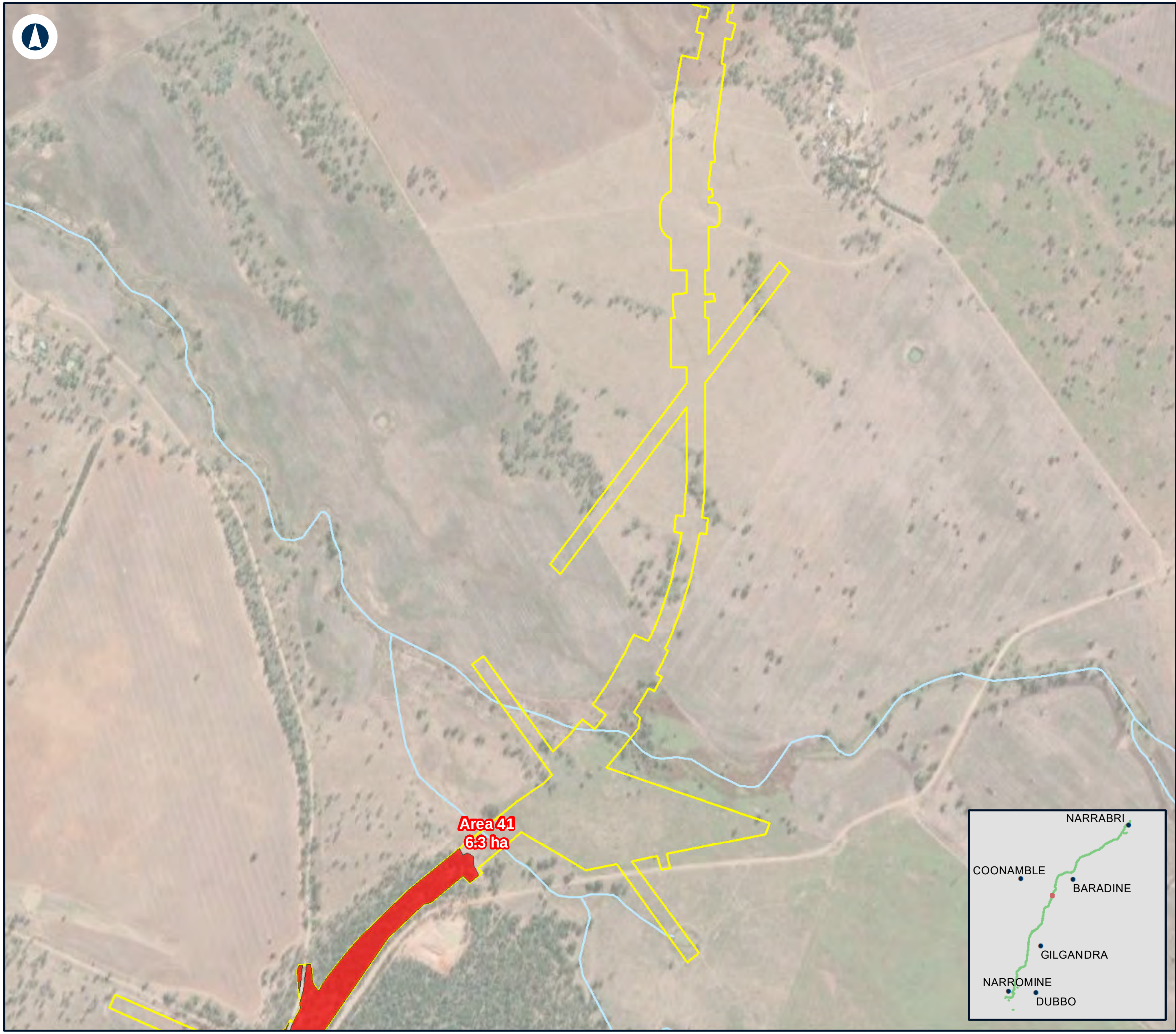

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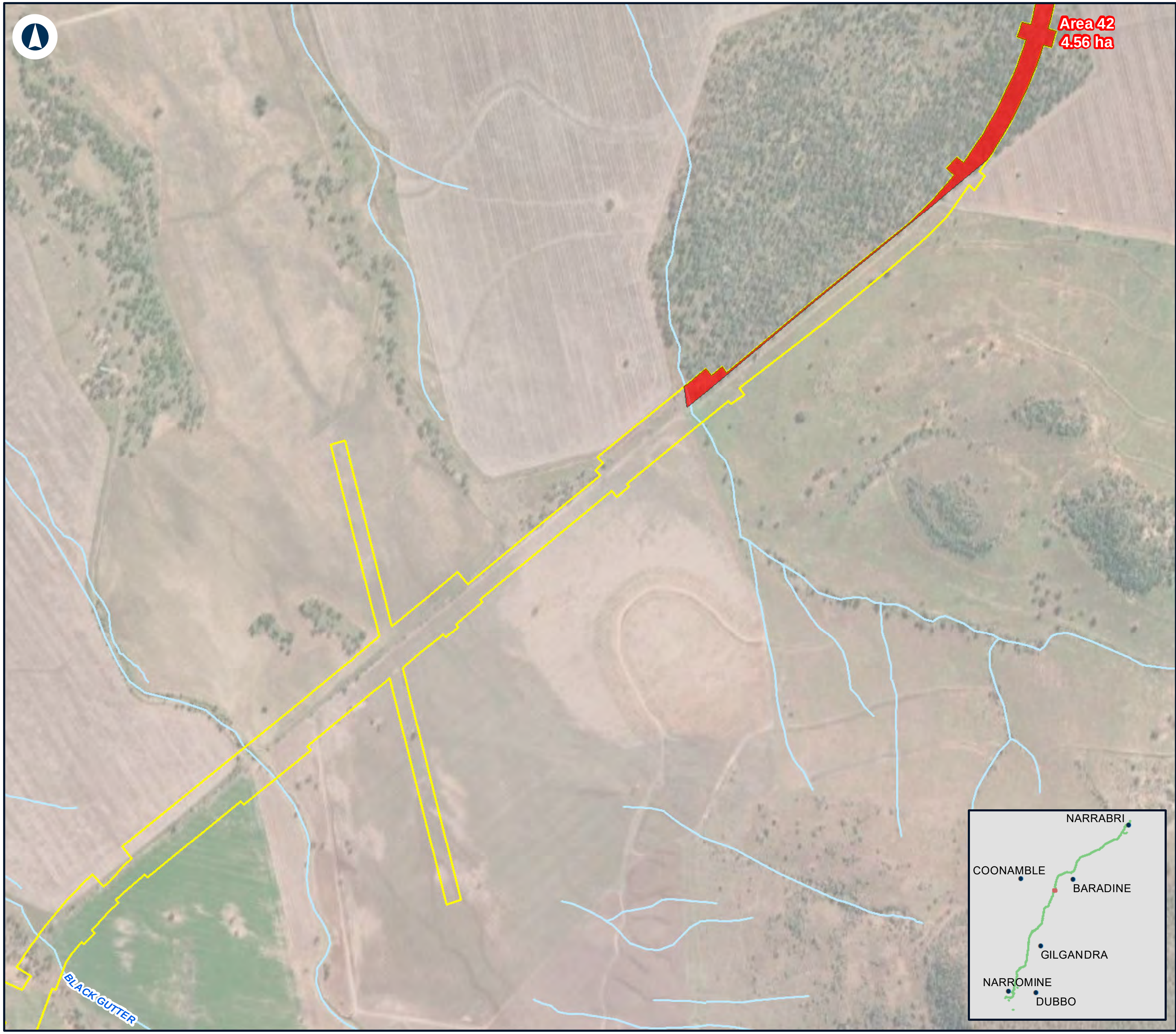

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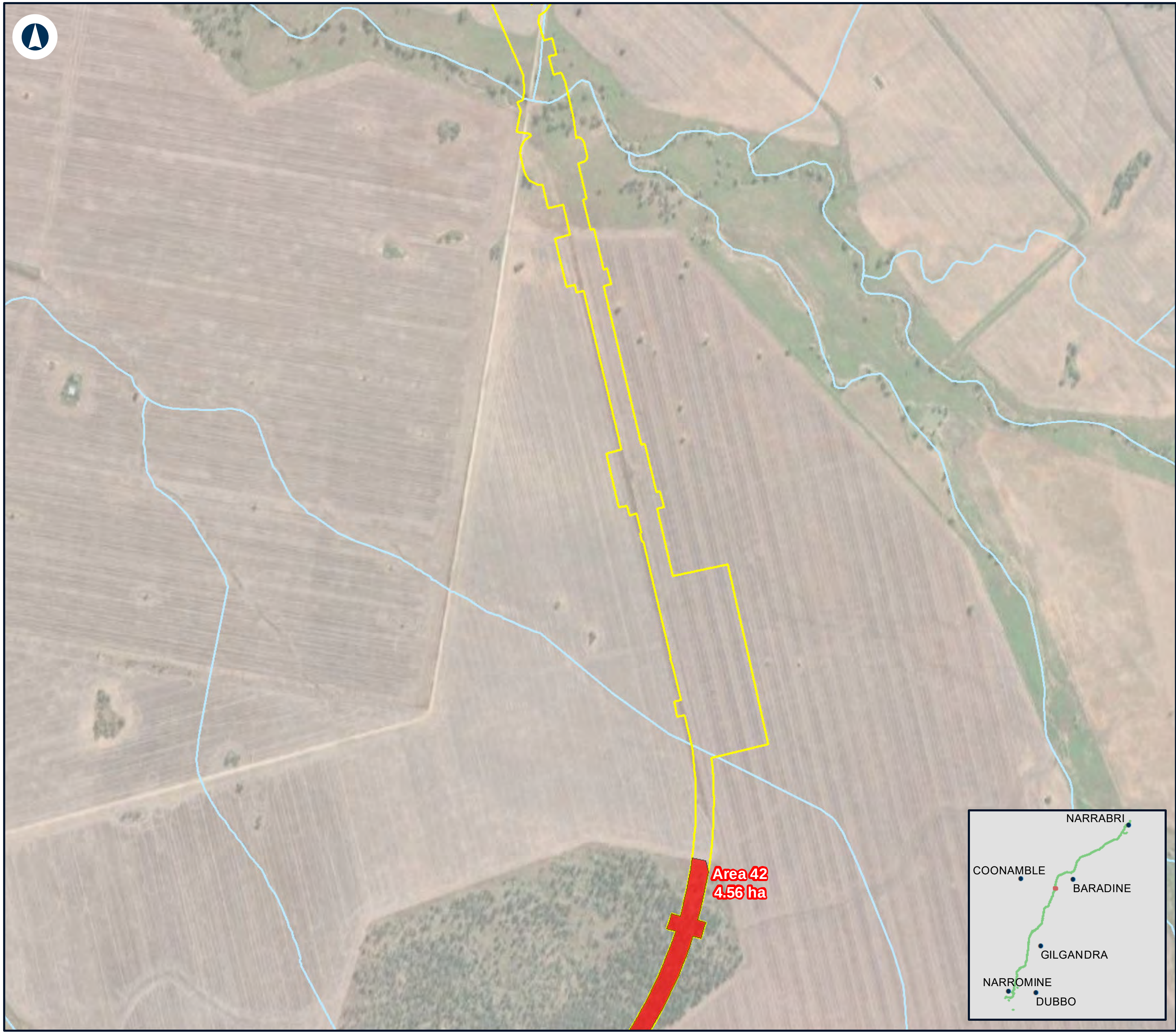

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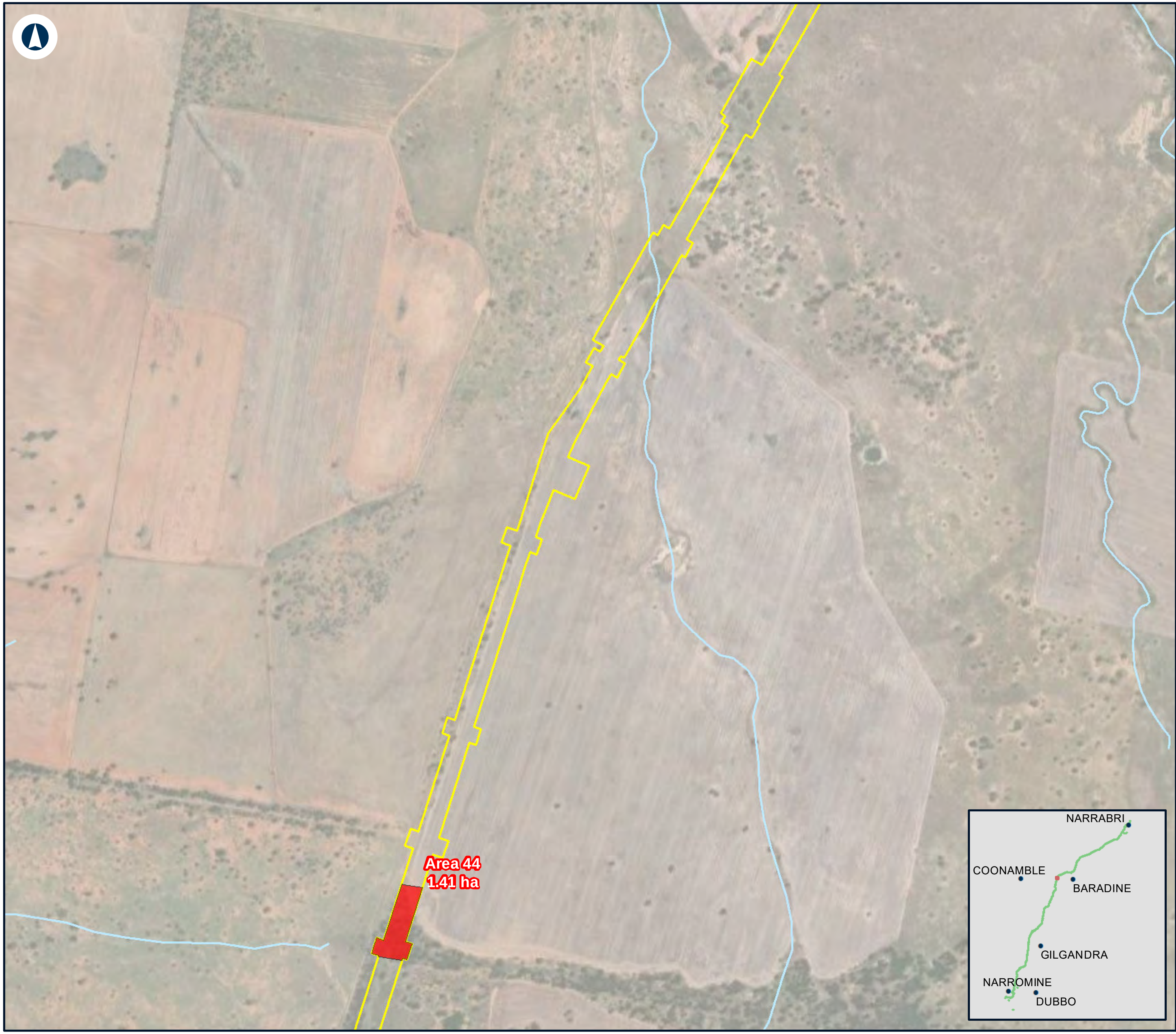

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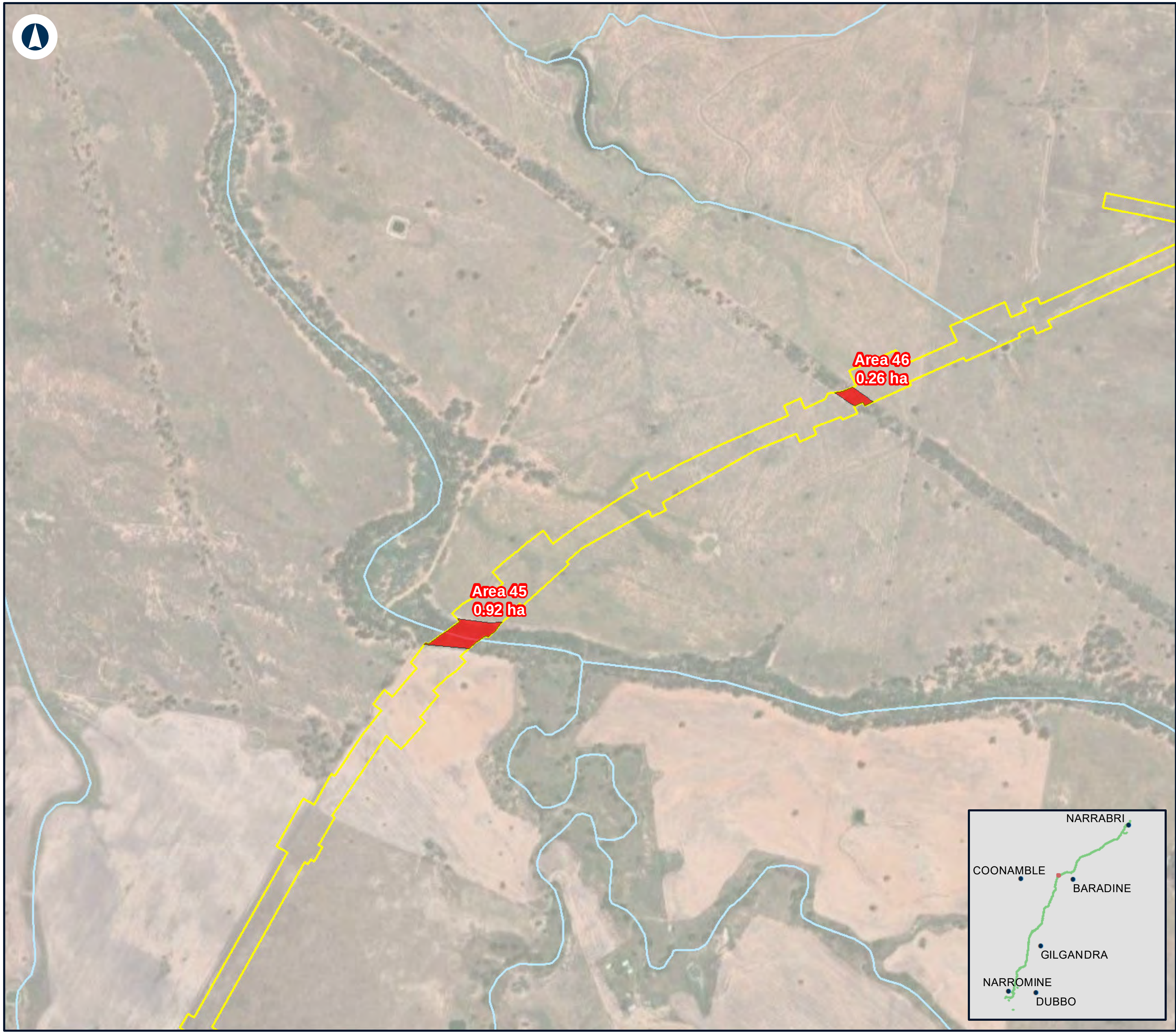

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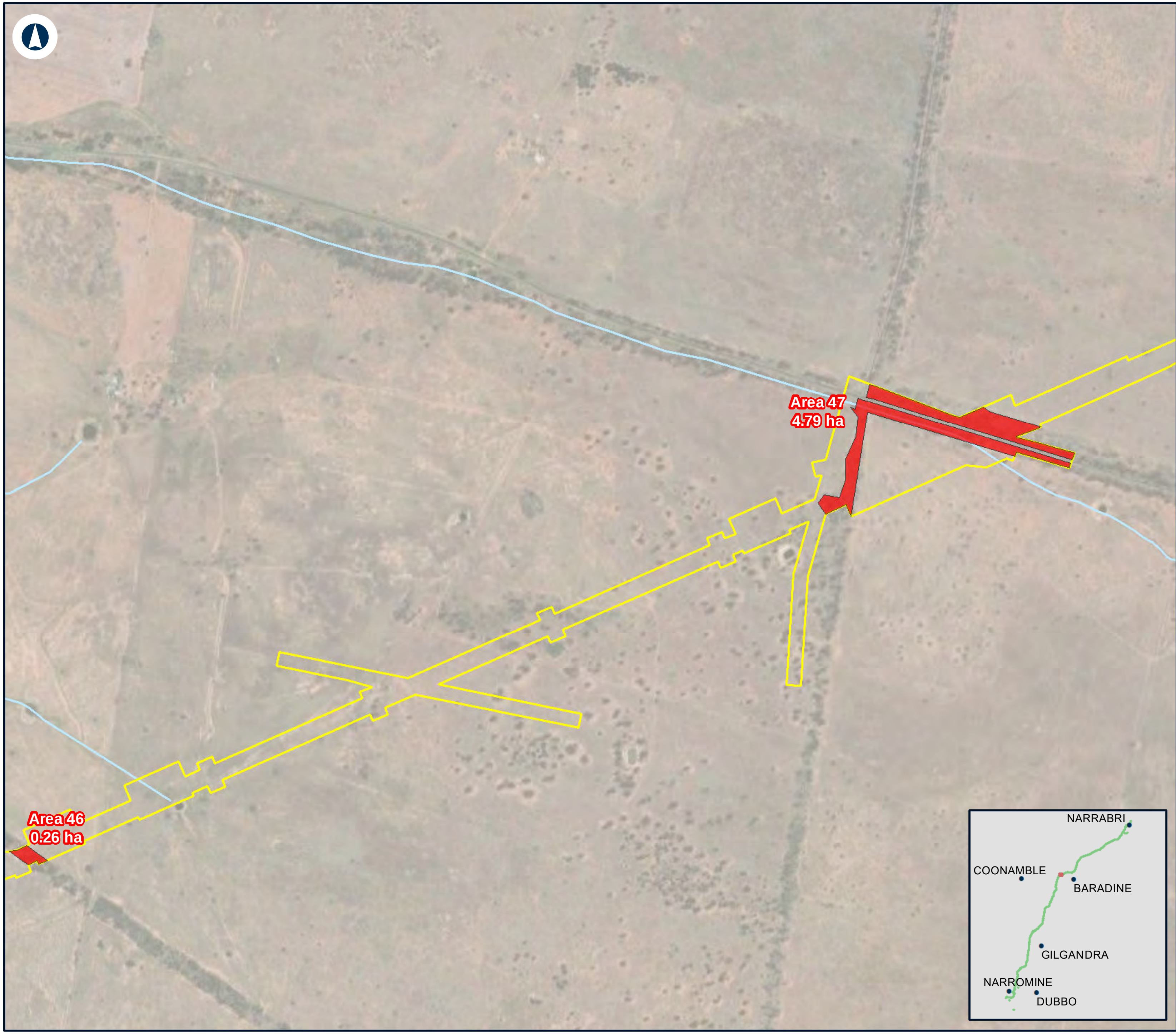

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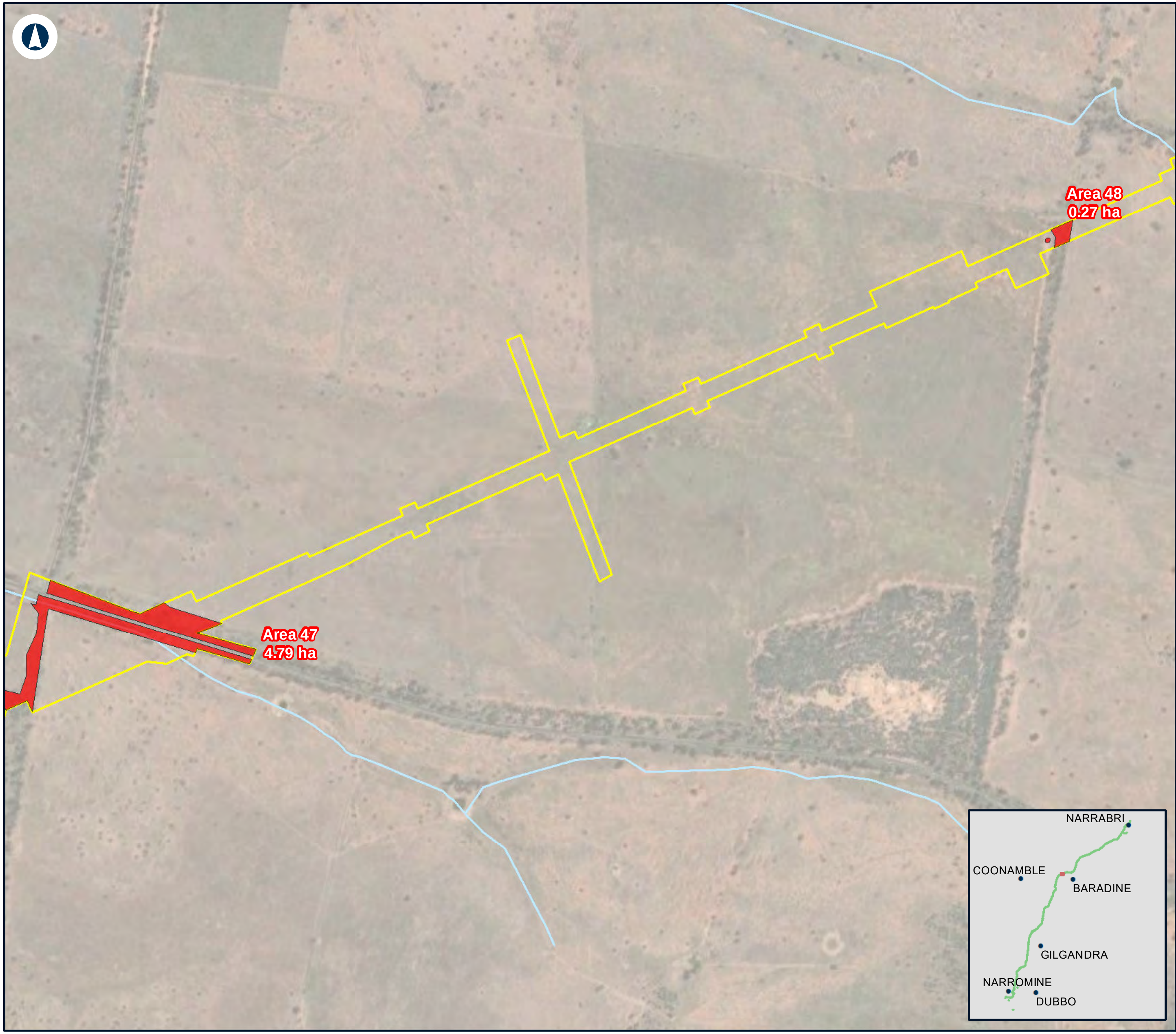

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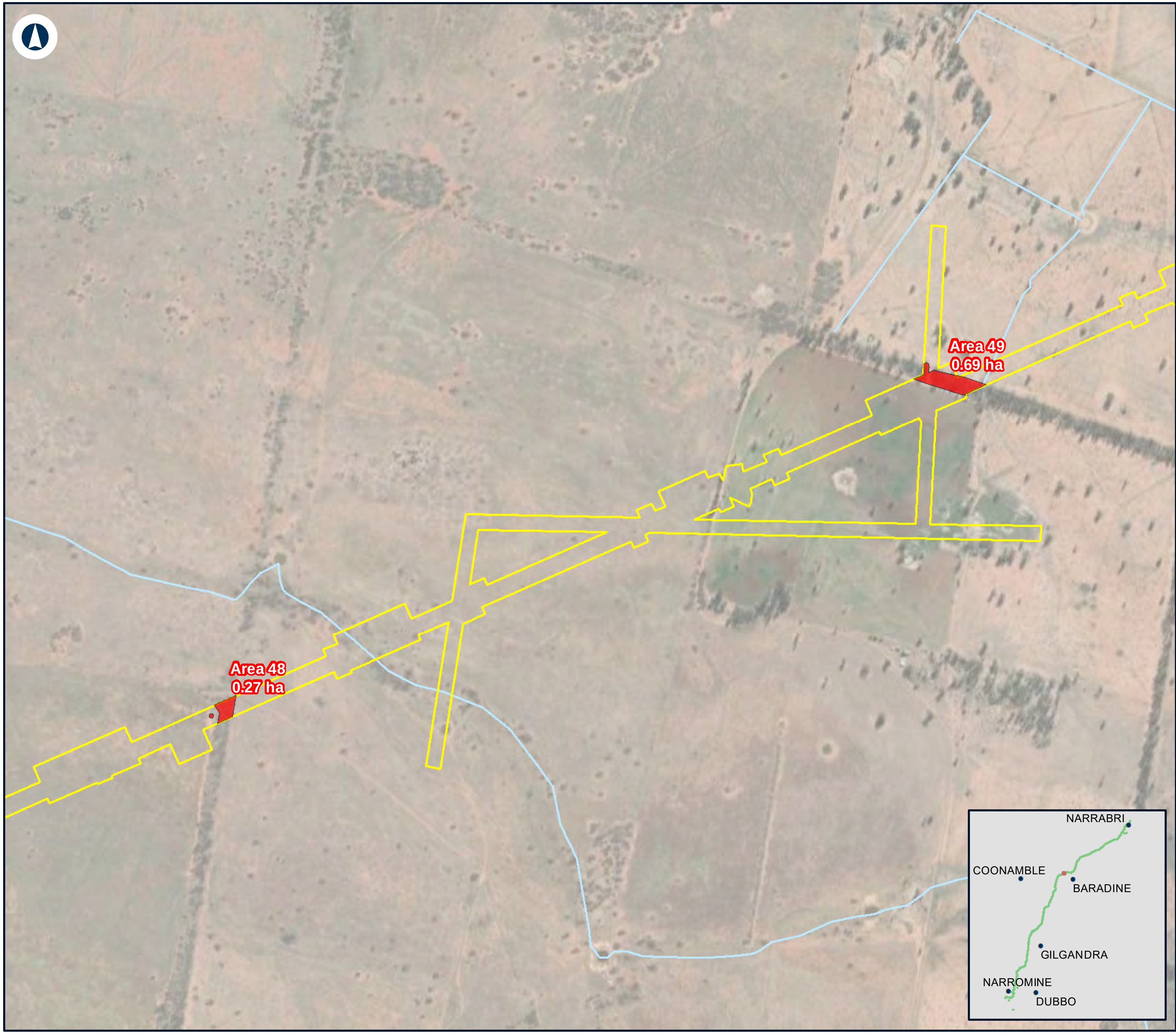

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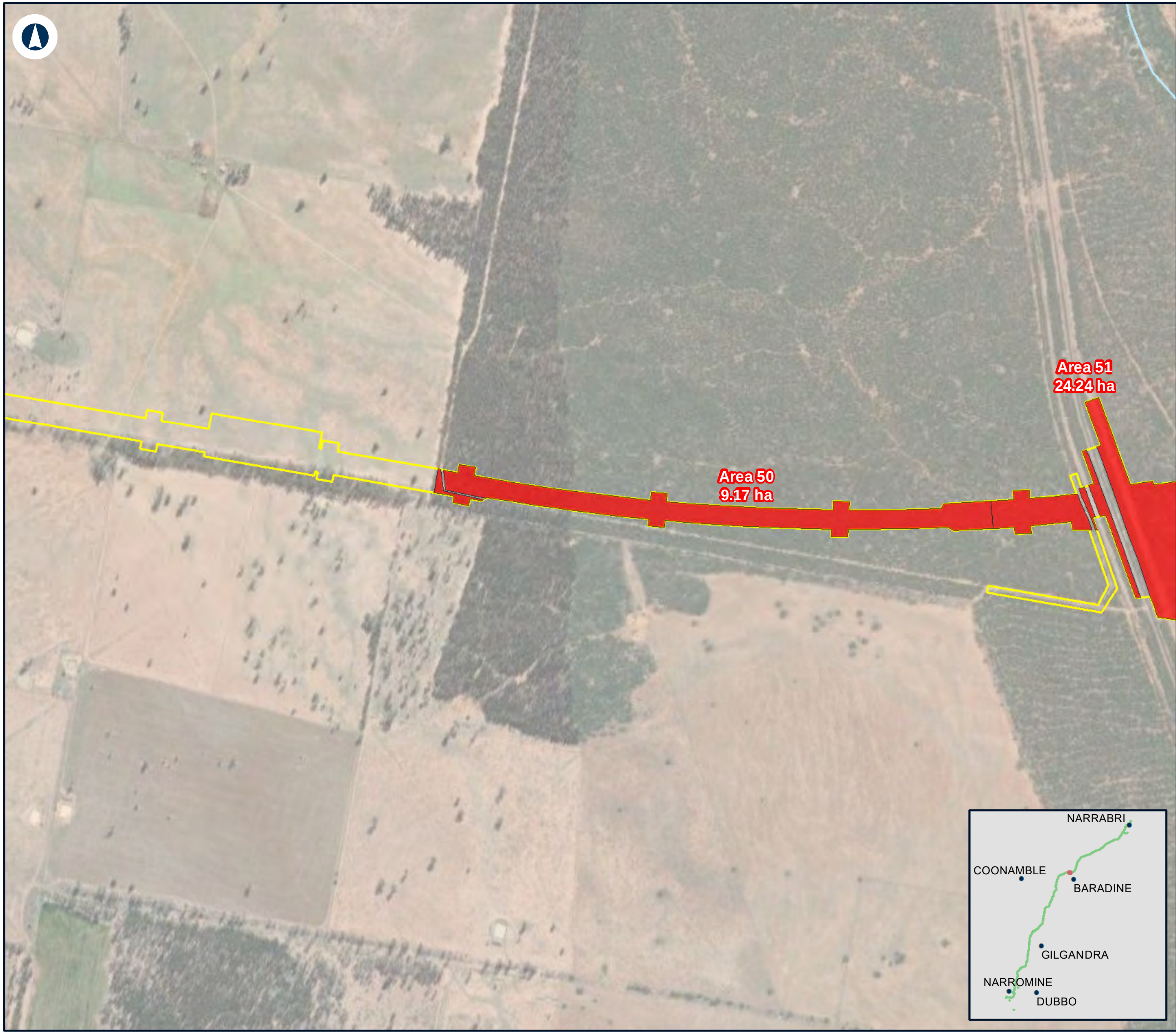

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NARROMINE TO NARRABRI

Appendix 2

Habitat areas and status

LEGEND

- Construction impact zone
- Square-tailed Kite potential breeding habitat

0 200 400 Metres

Coordinate System: GDA 1994 MGA Zone 55

Date: 2021-11-30

Paper: A4

Author: JacobsGHD

Scale: 1:15,000

Data Sources: Basemap layers: NSWSS, esri;

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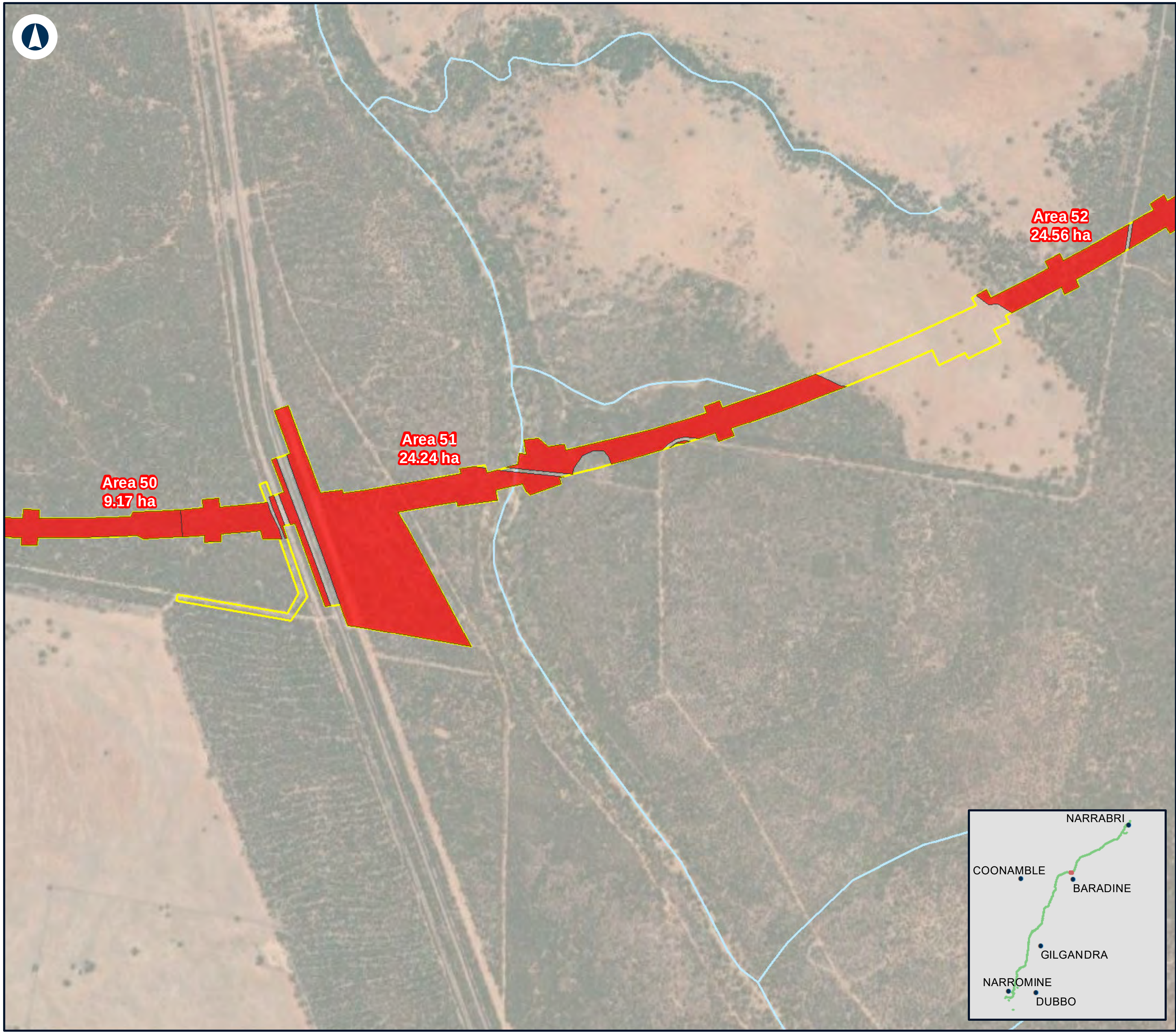

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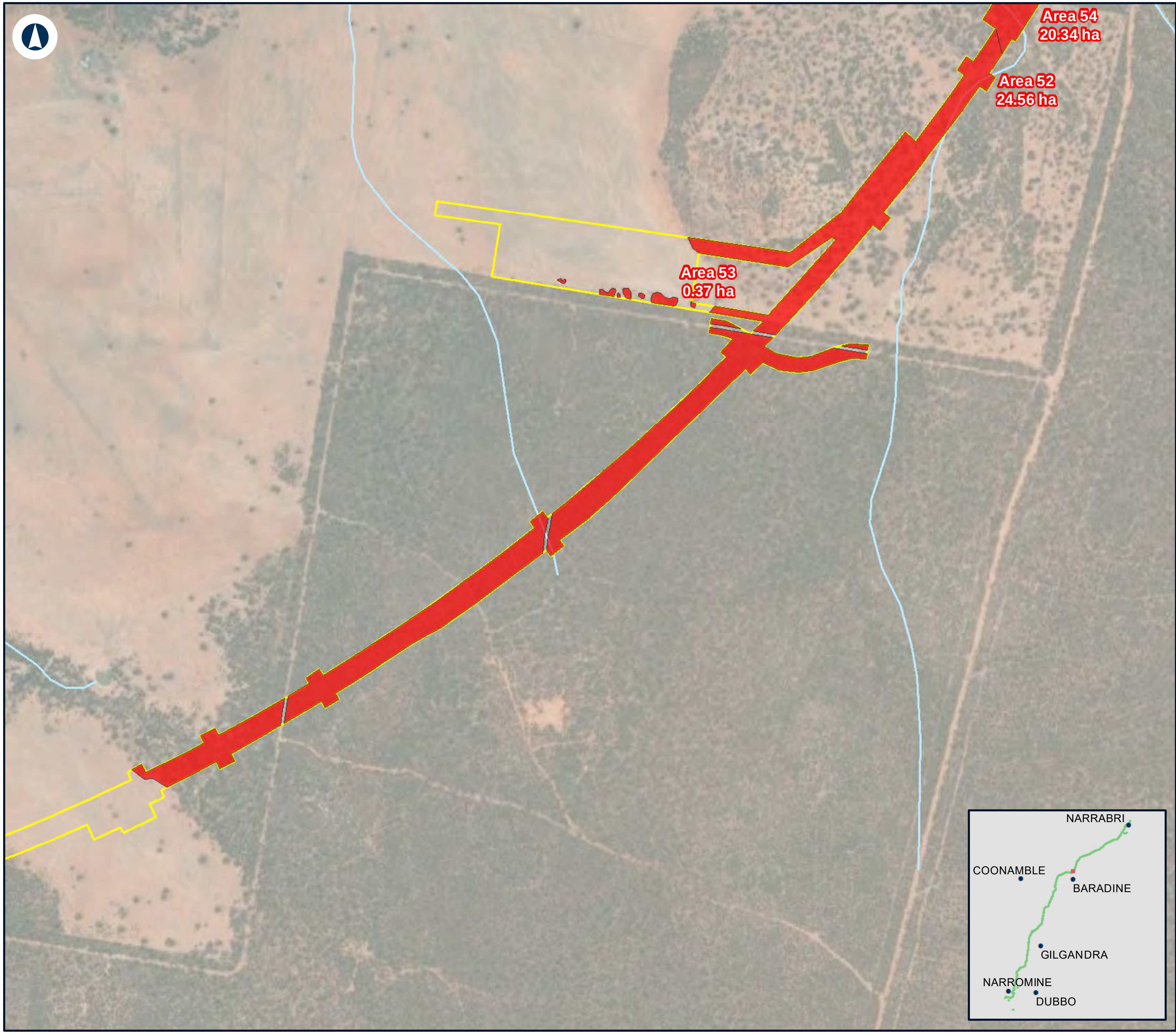

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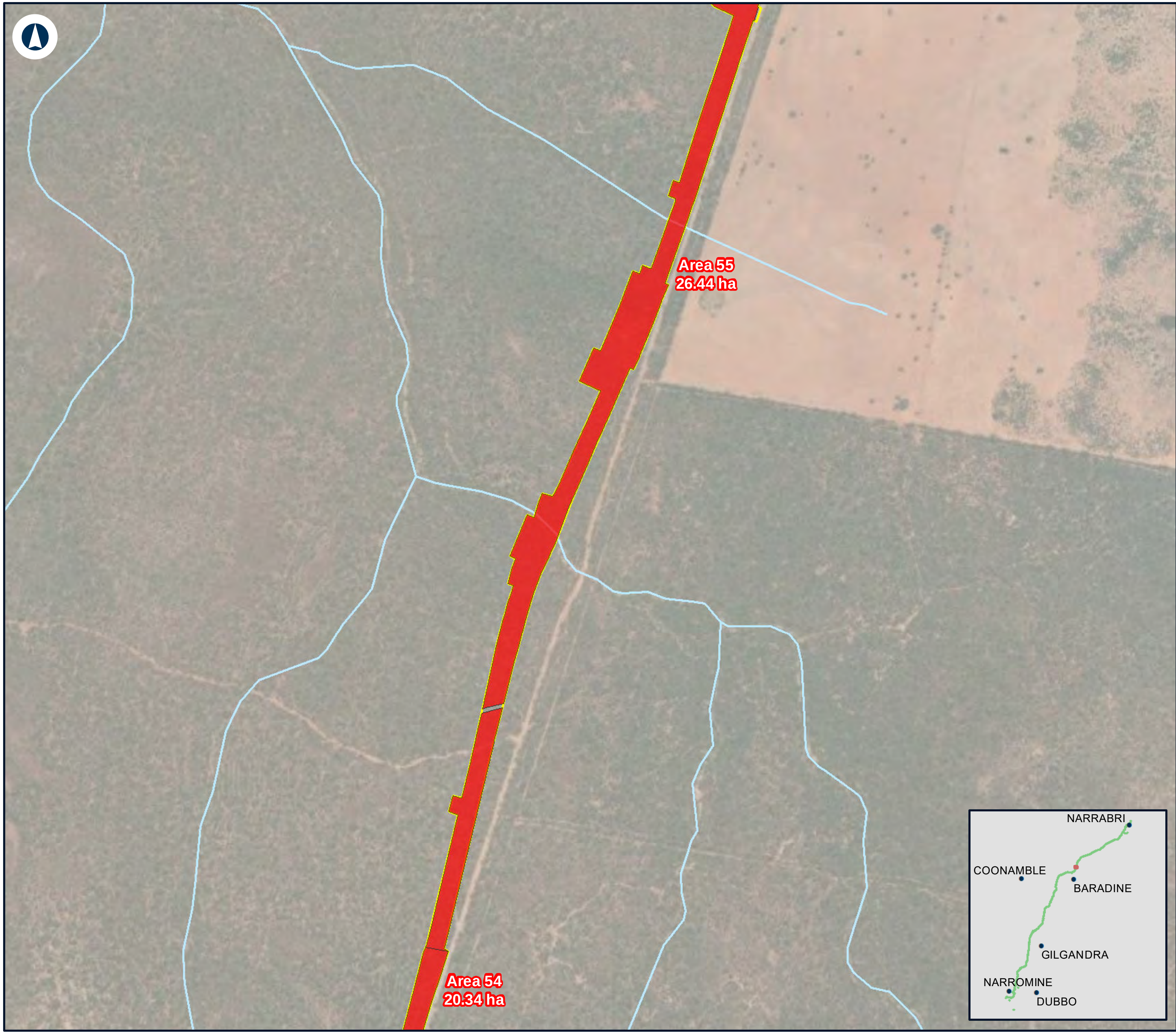

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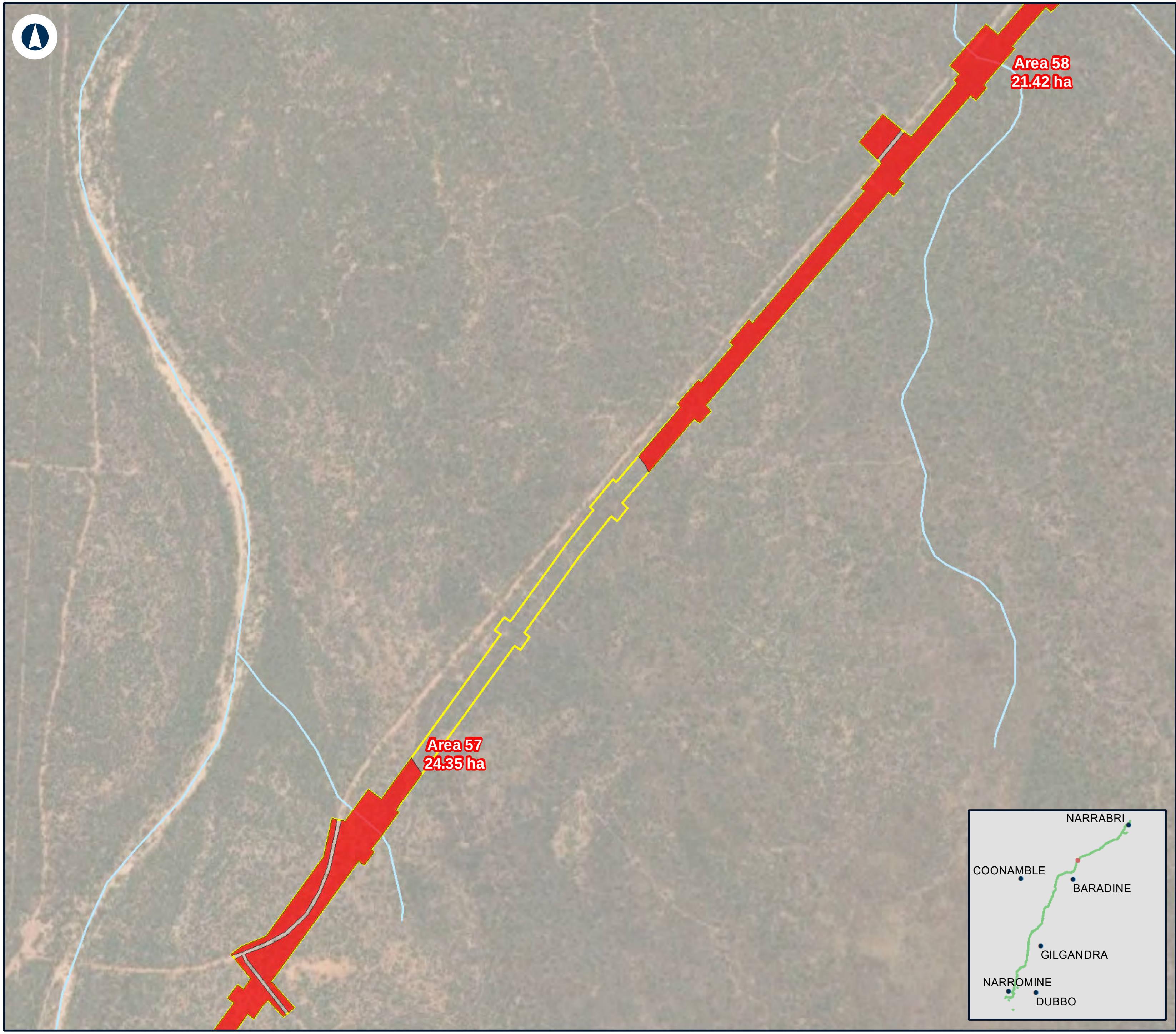

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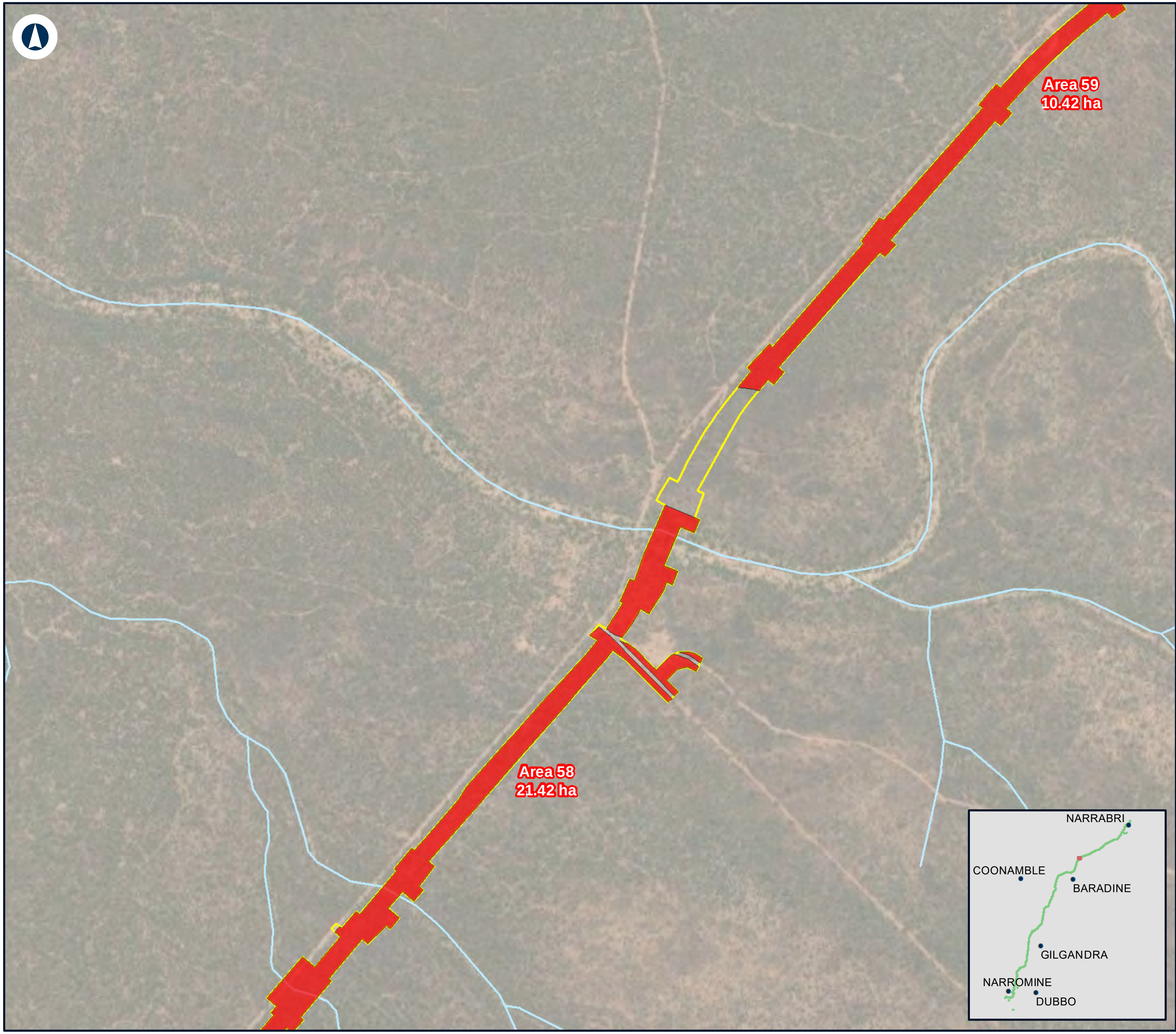

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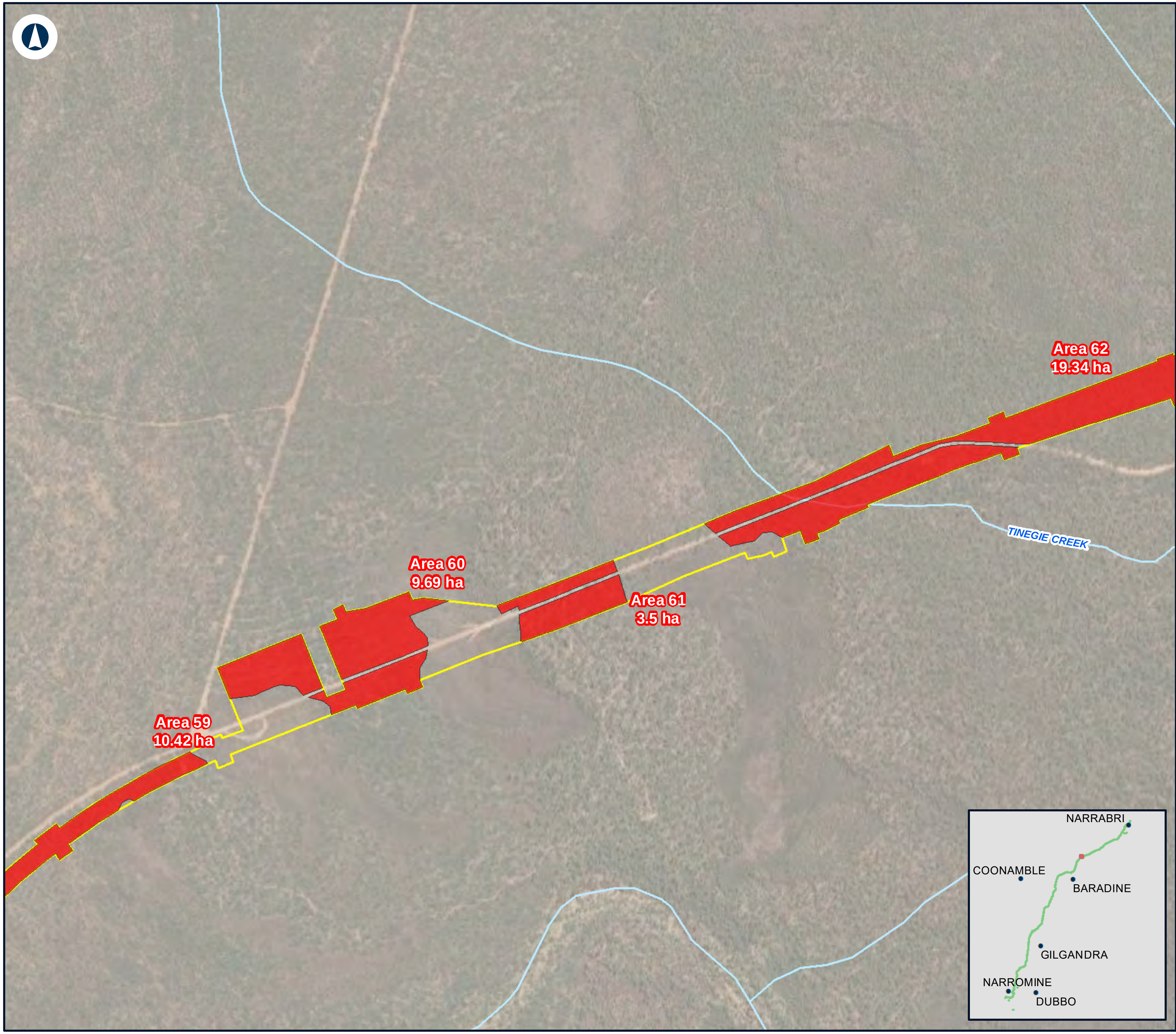

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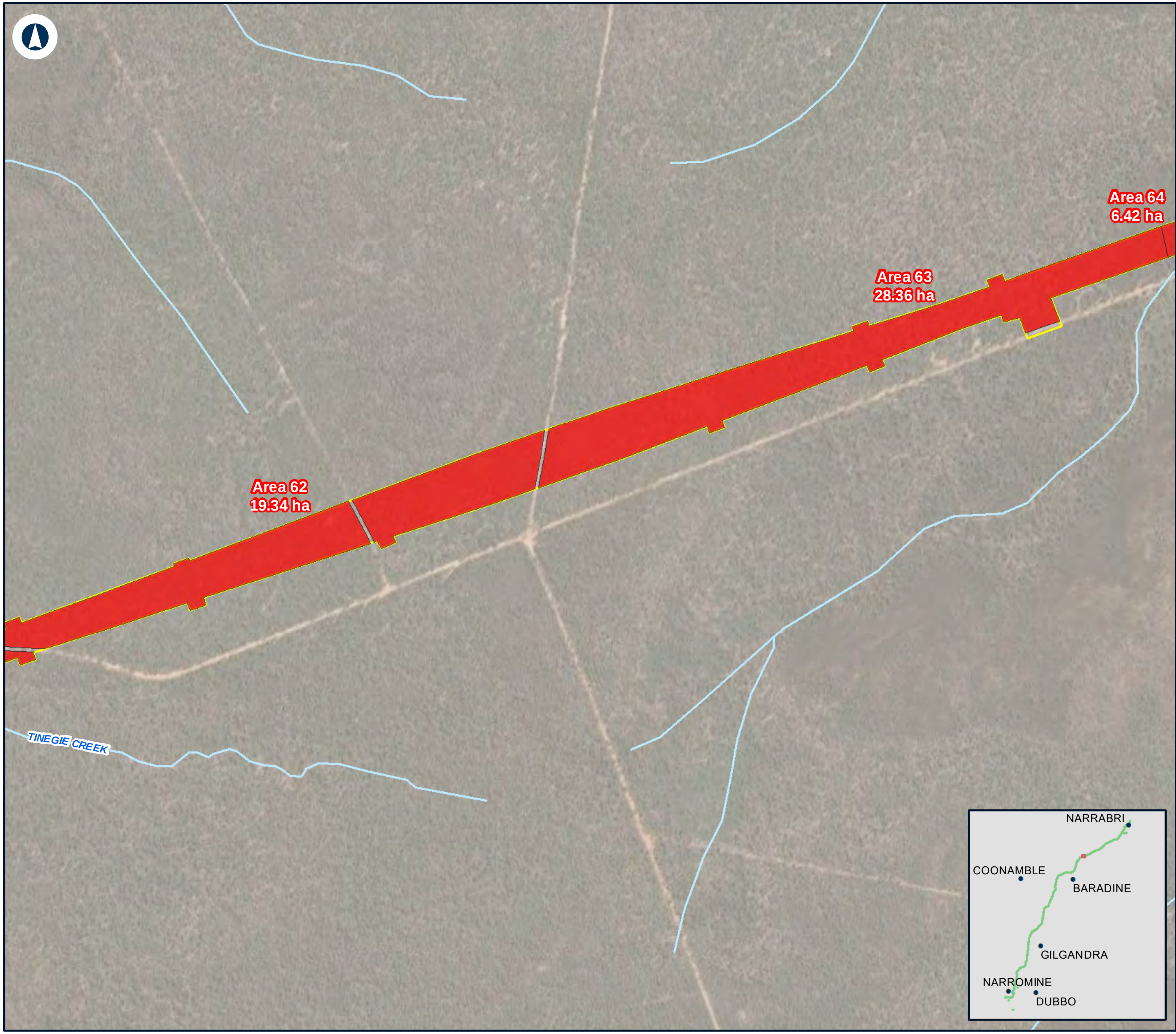

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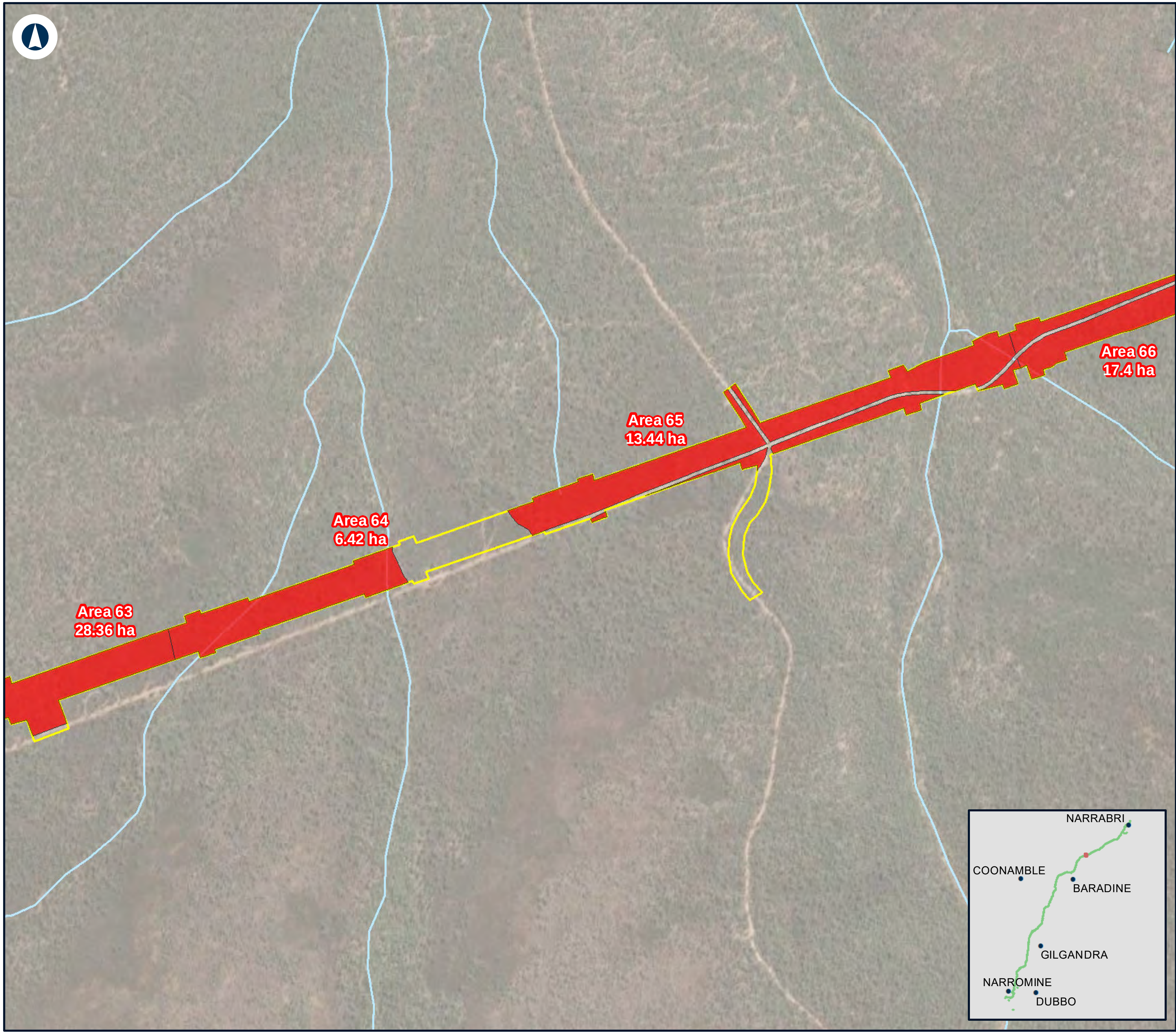

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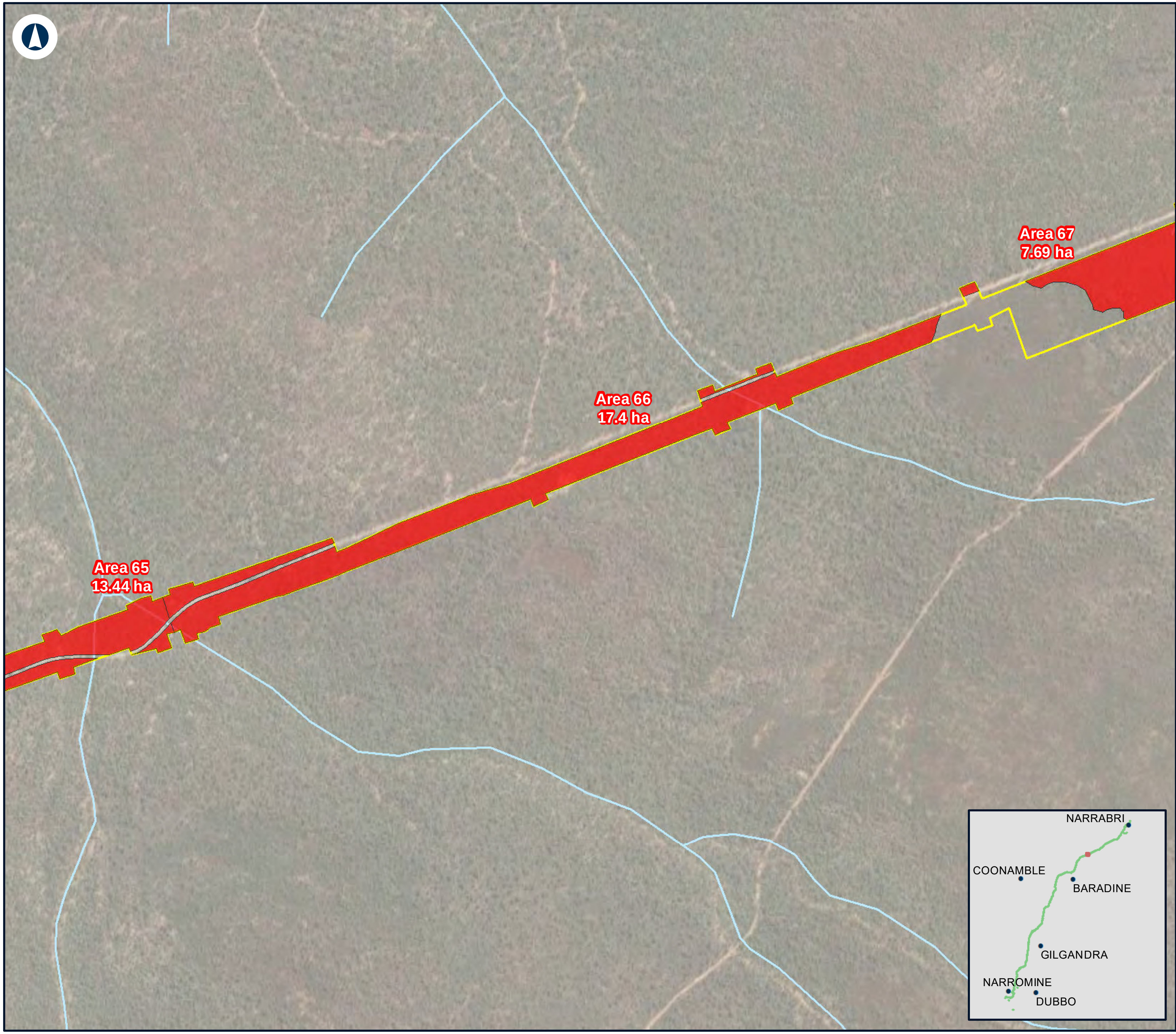

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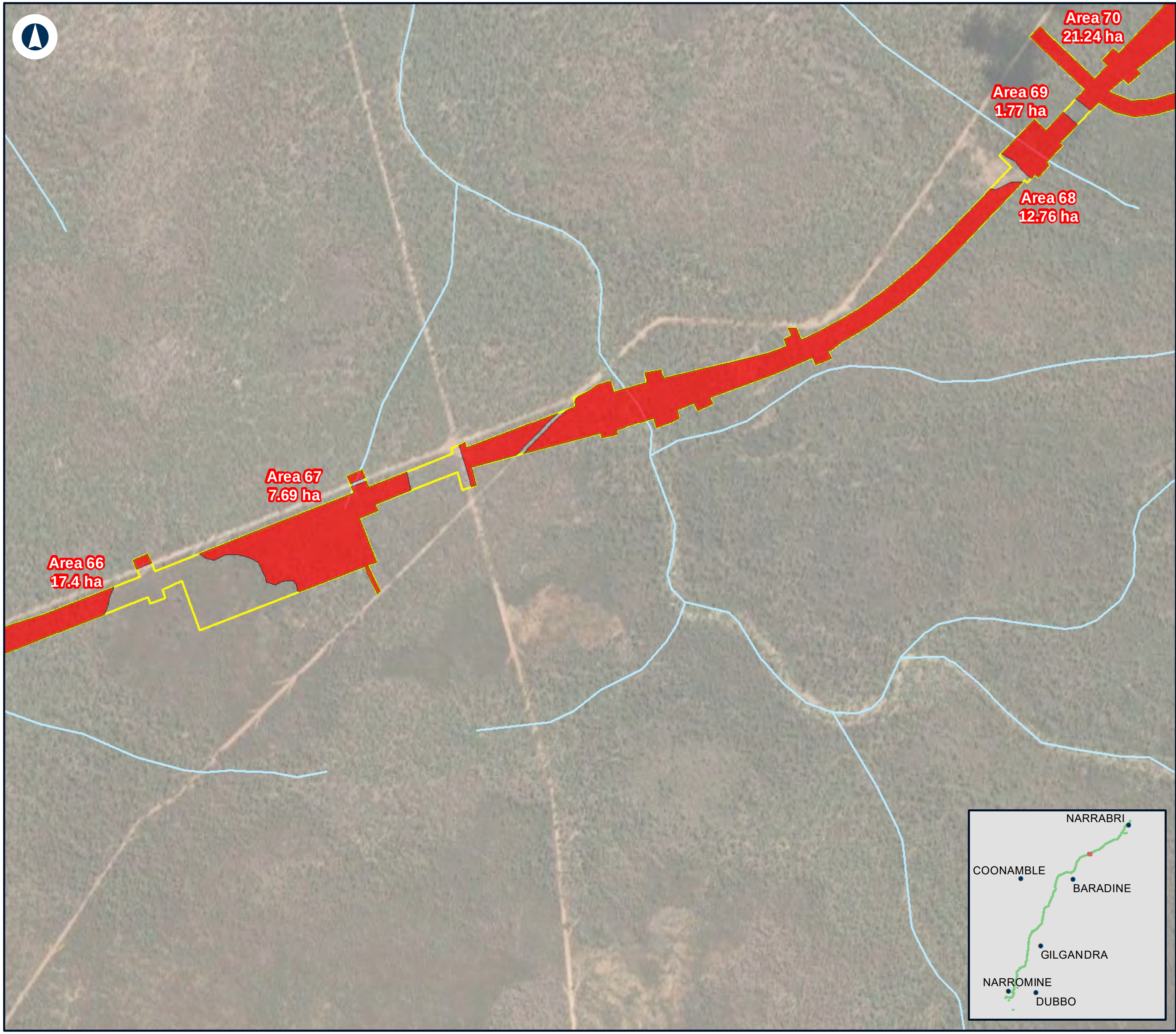

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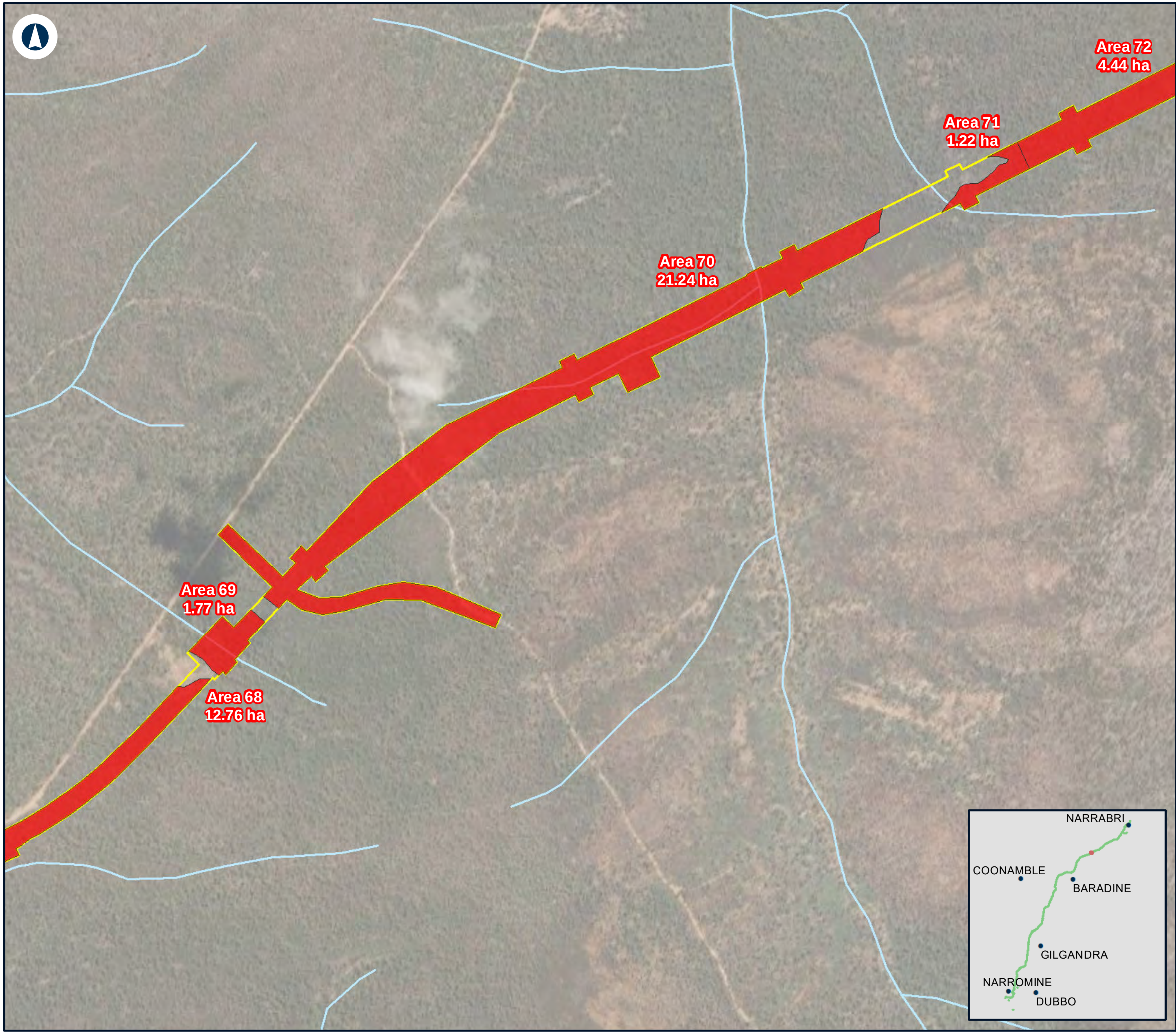

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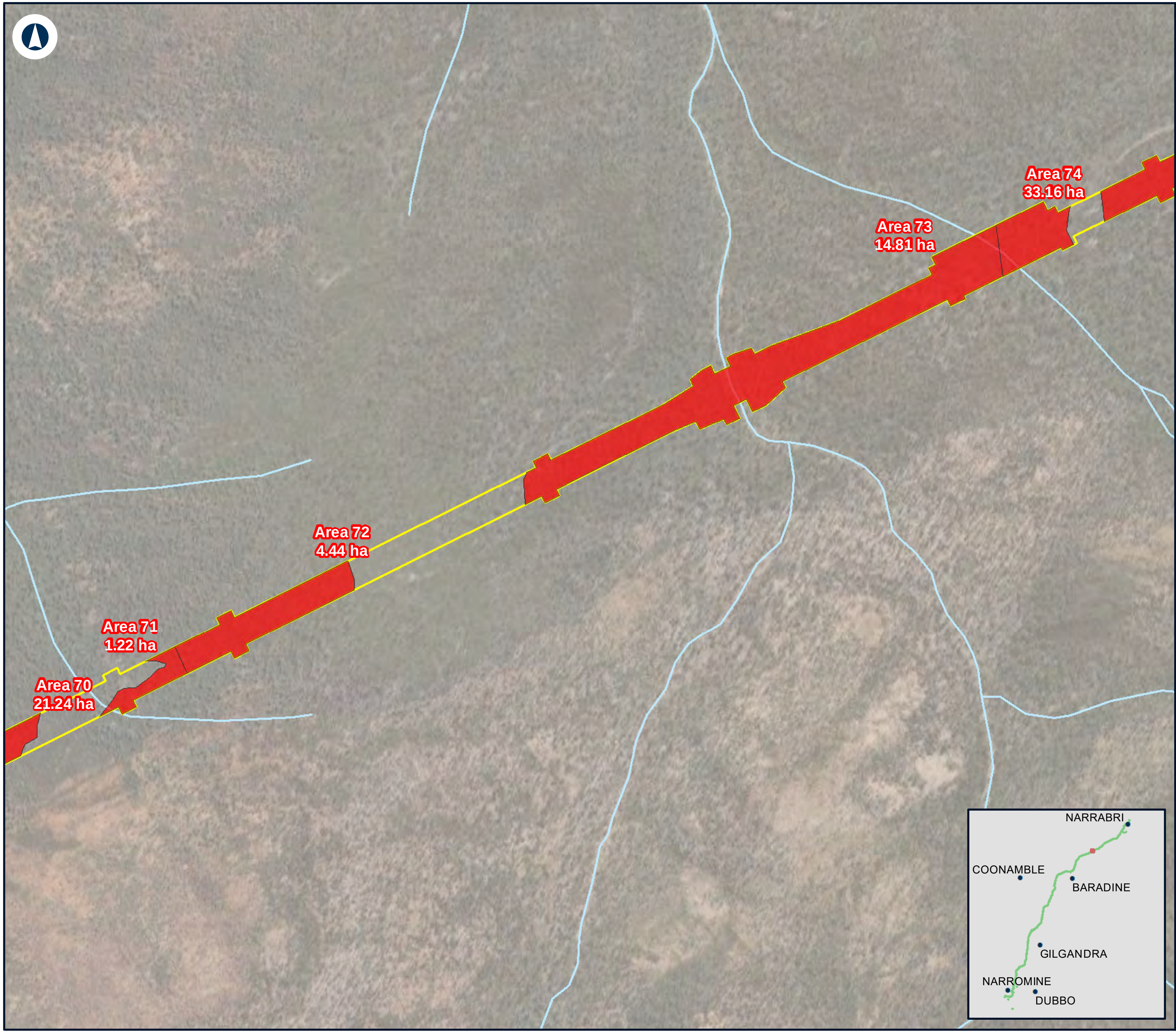

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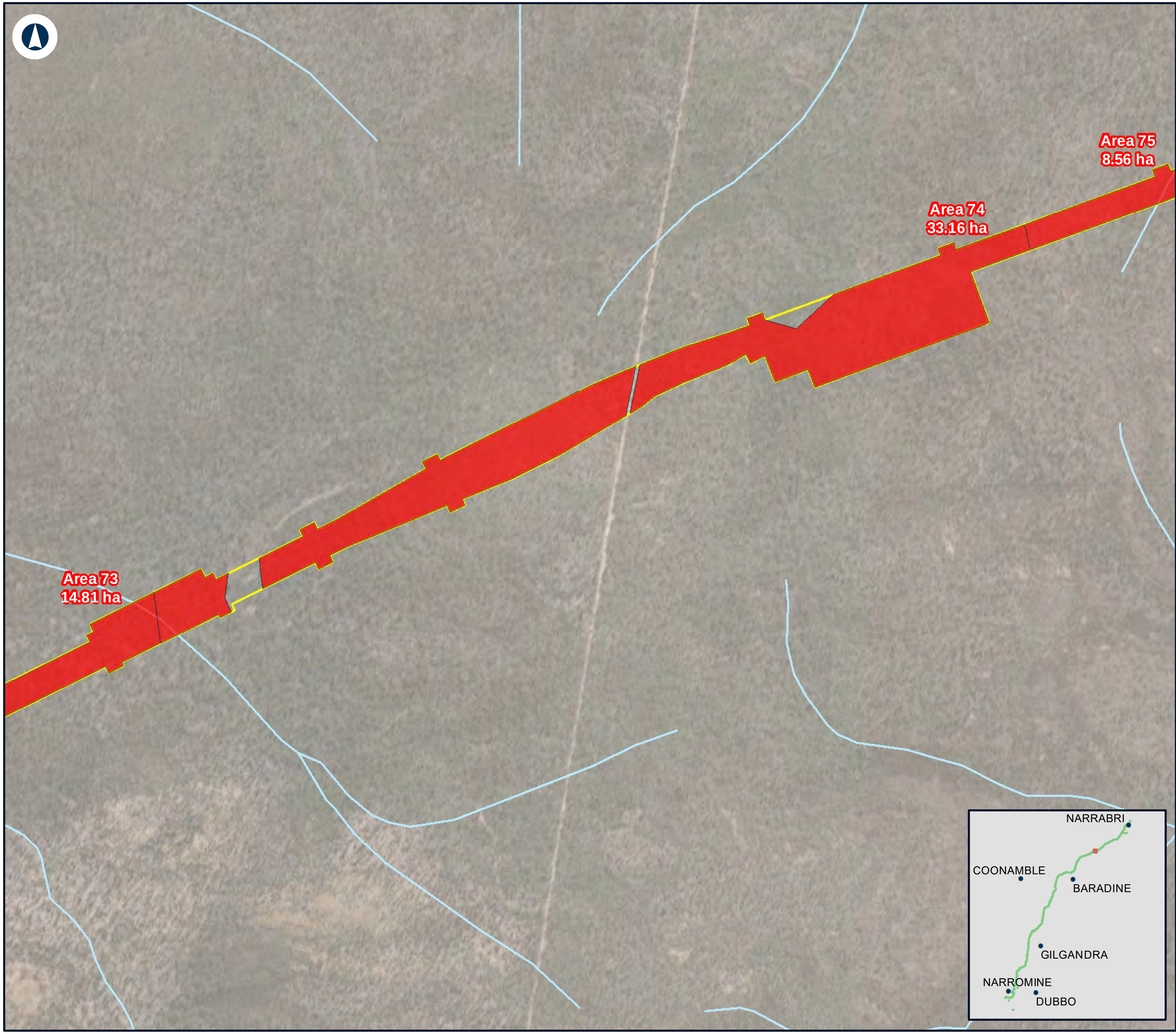

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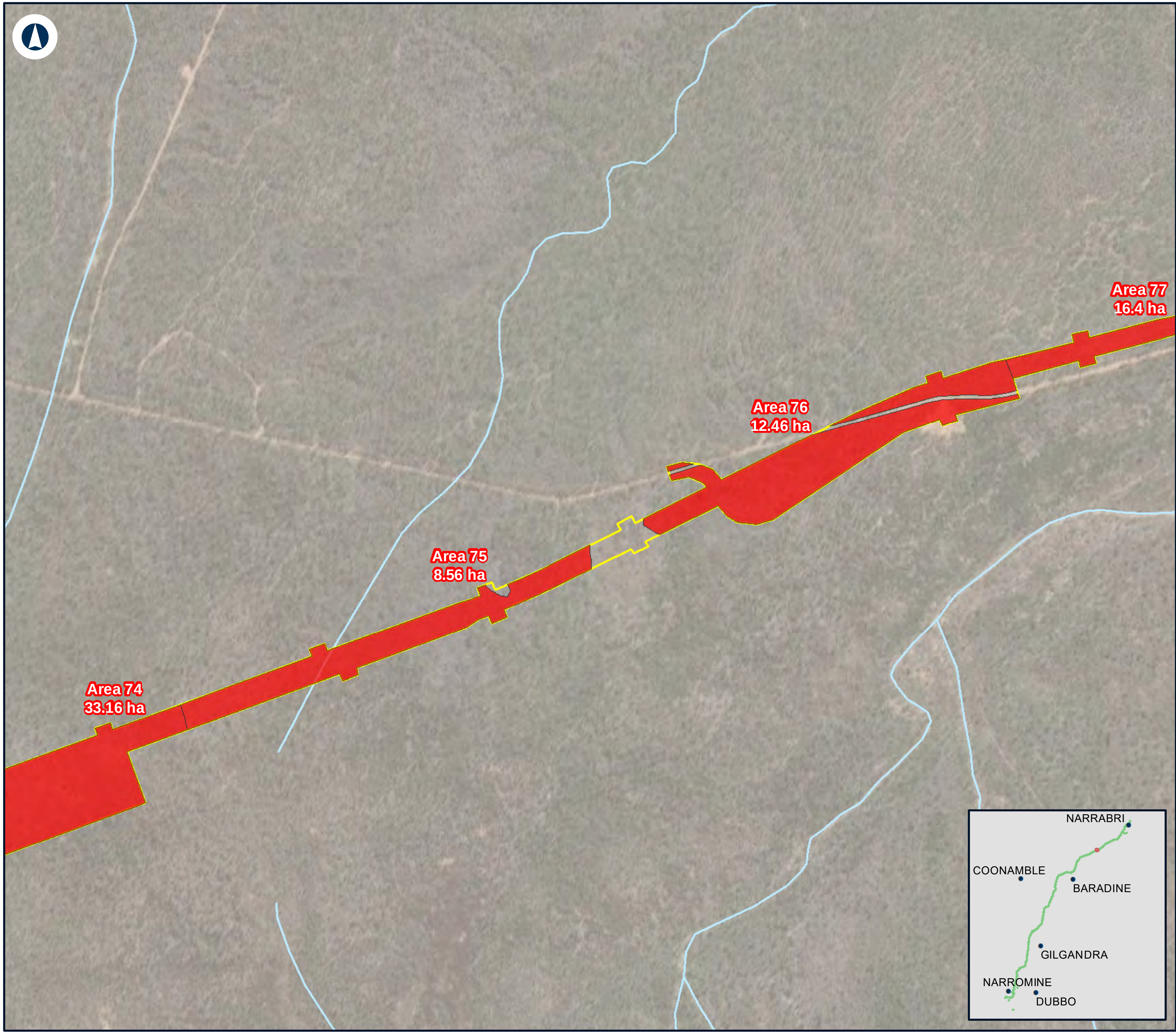

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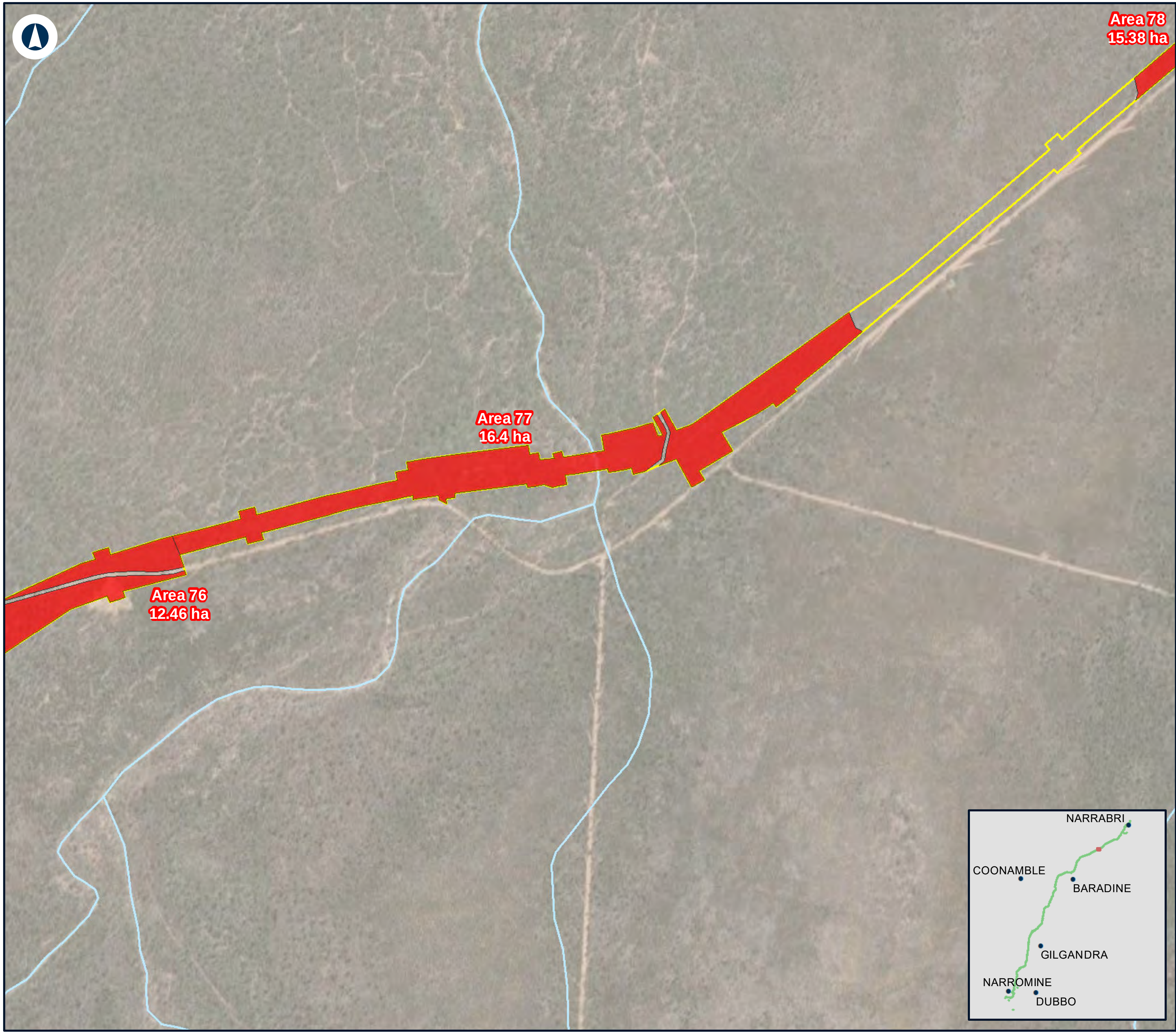

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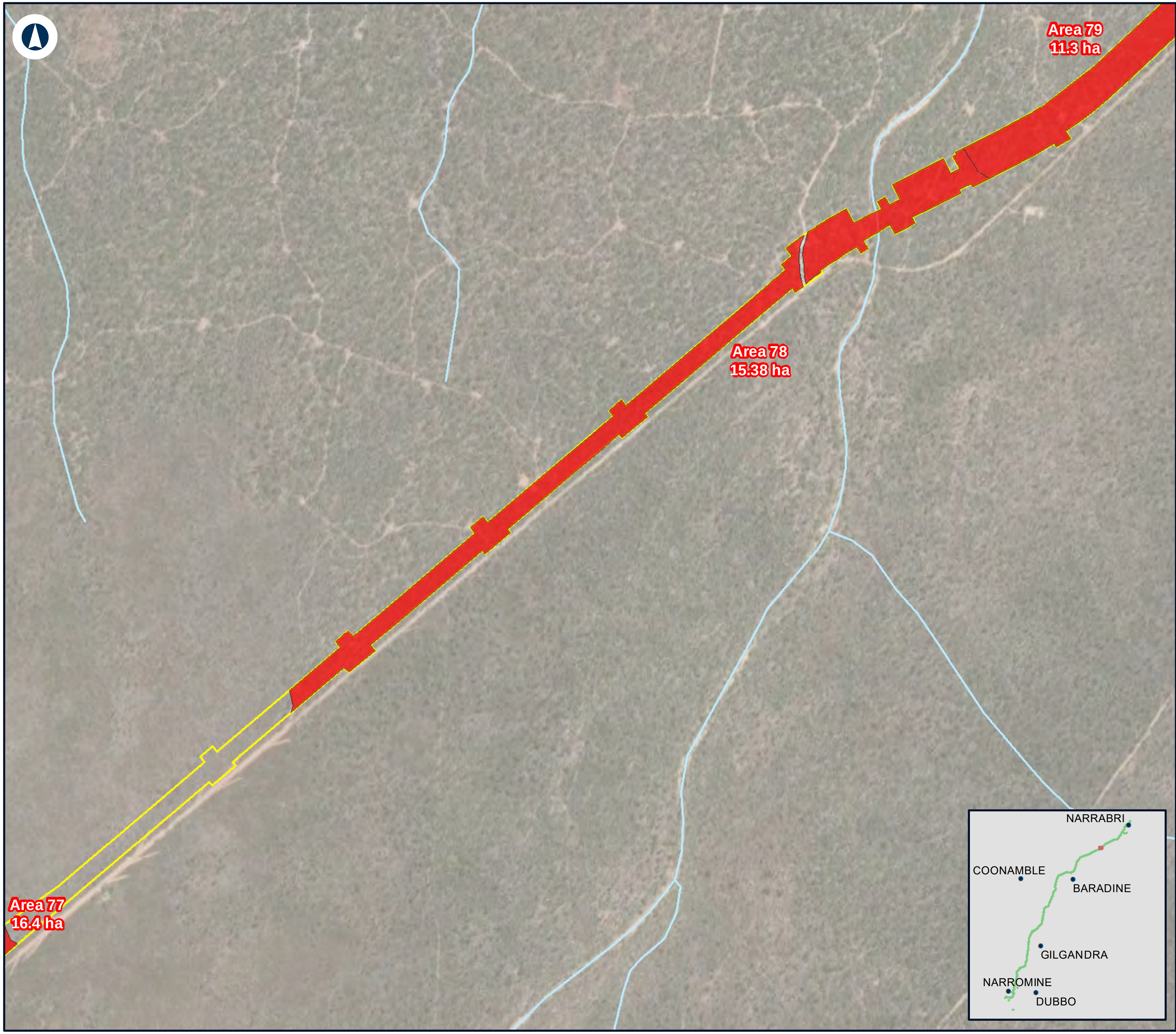

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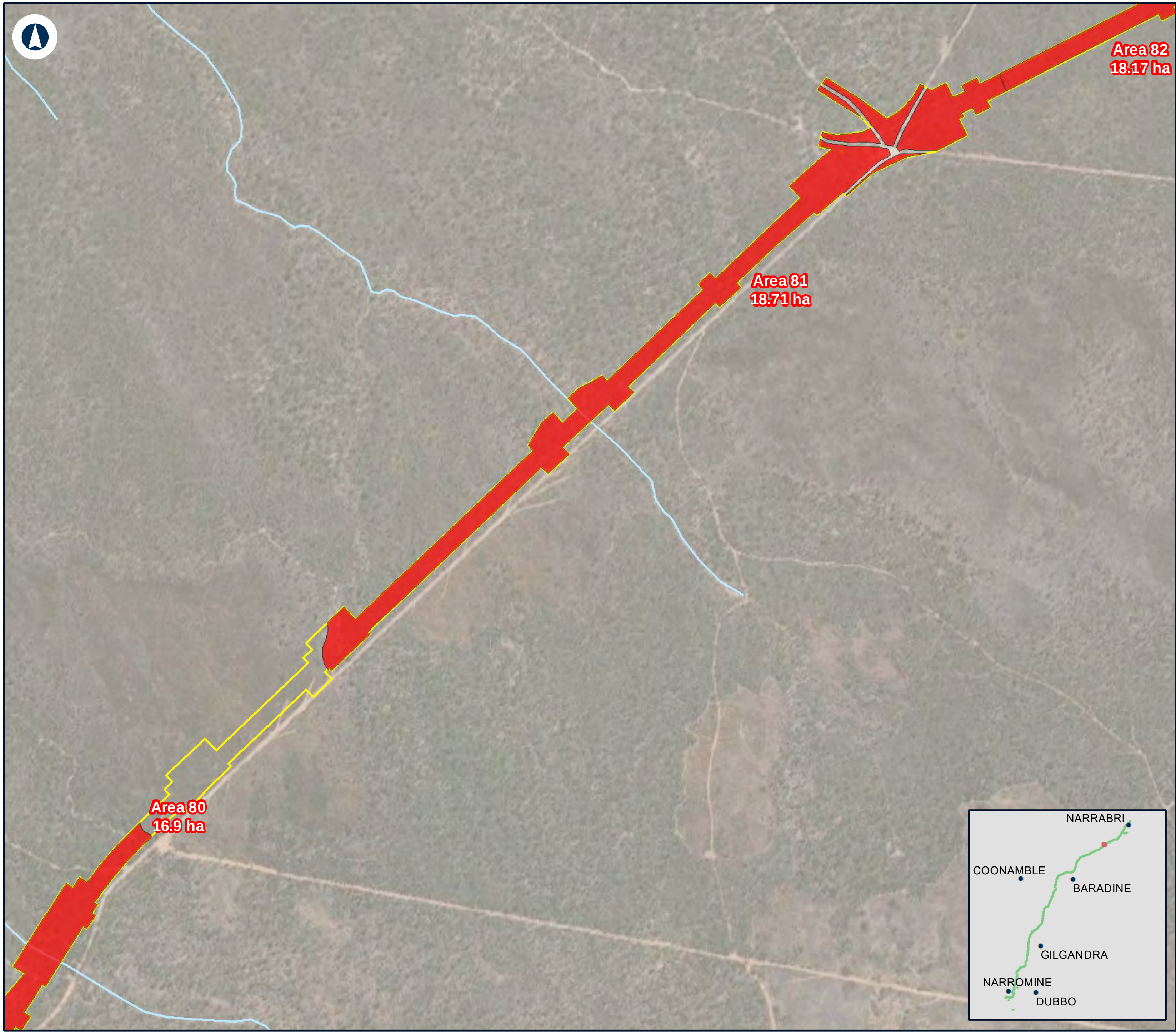

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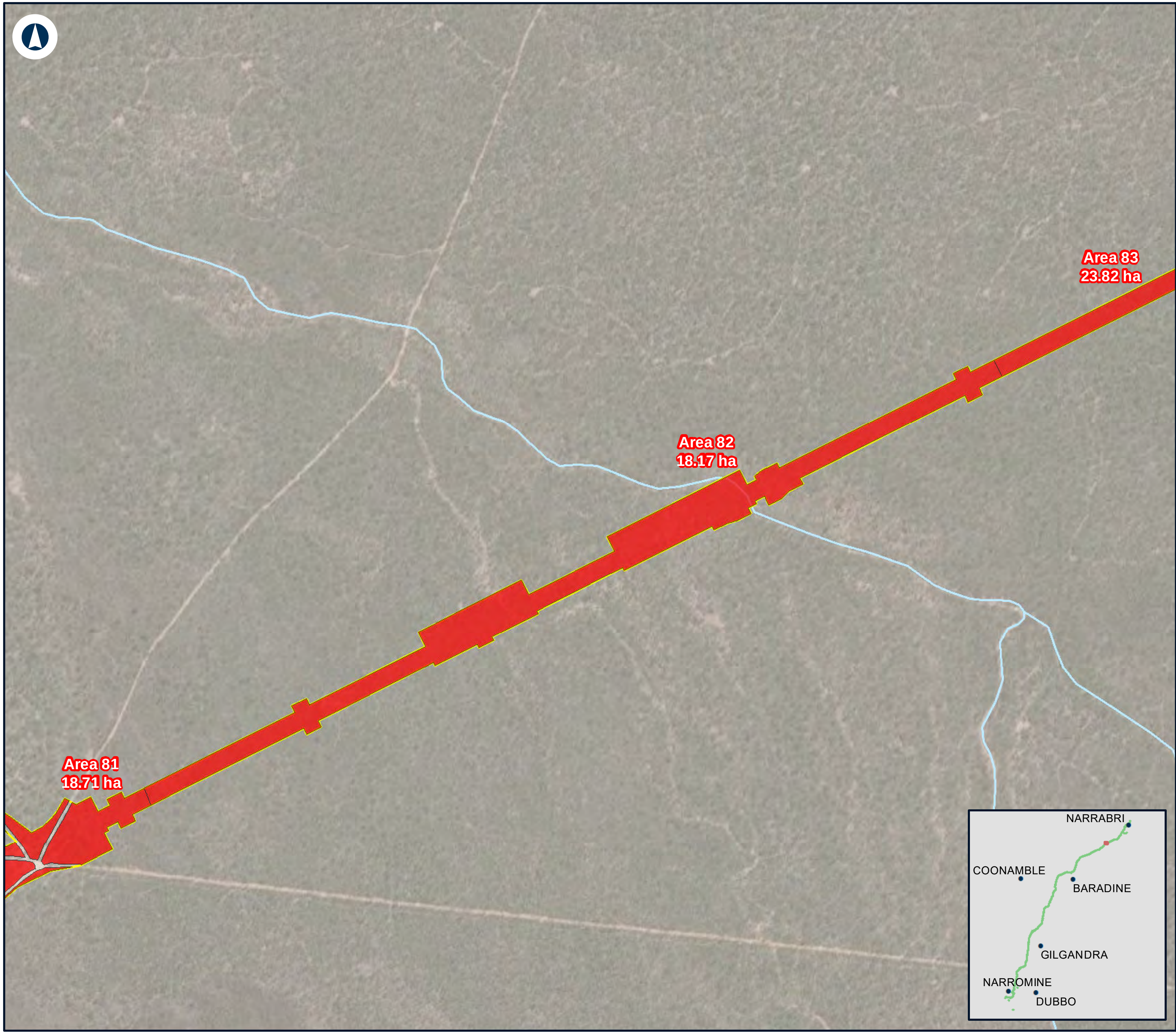

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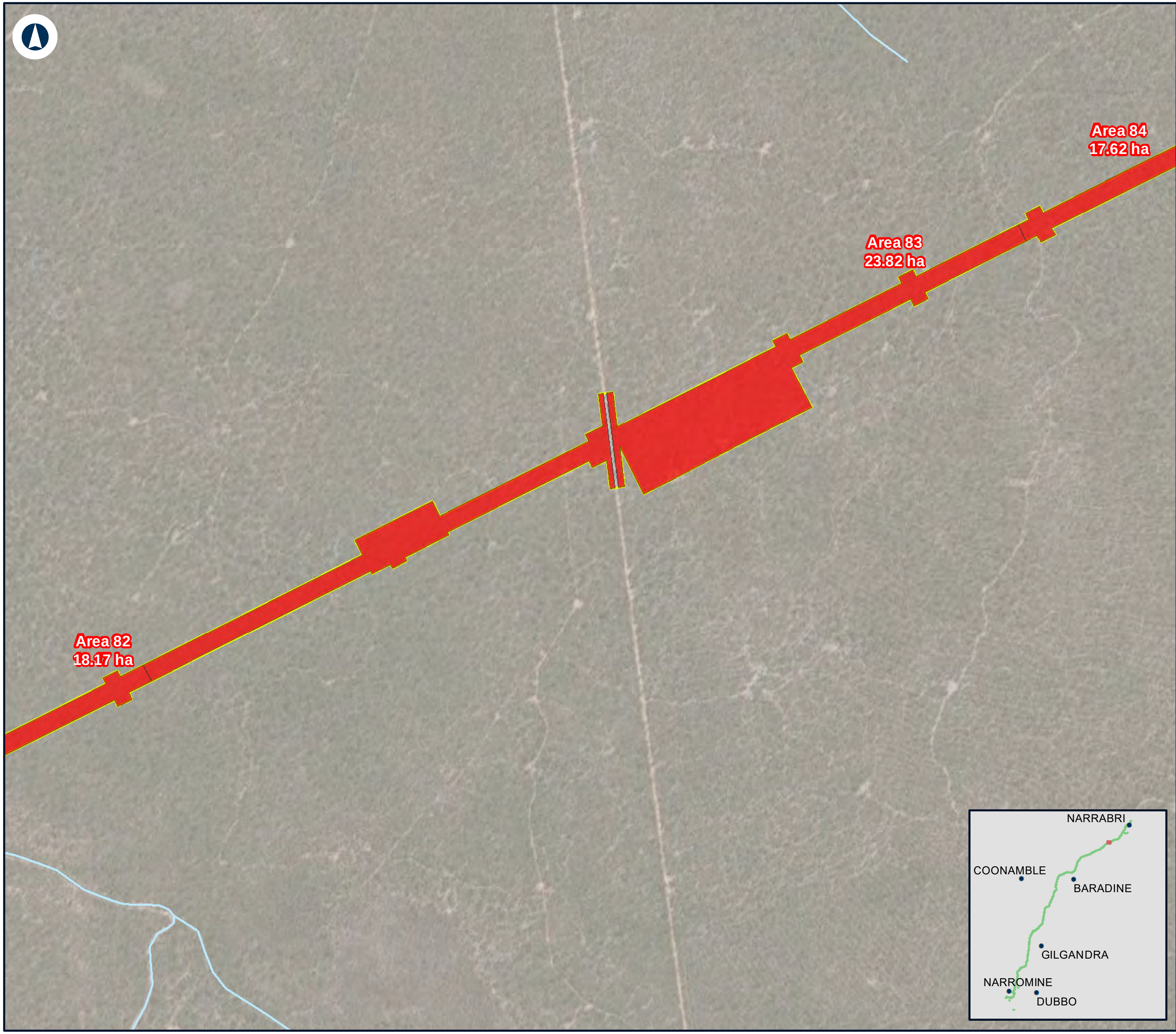

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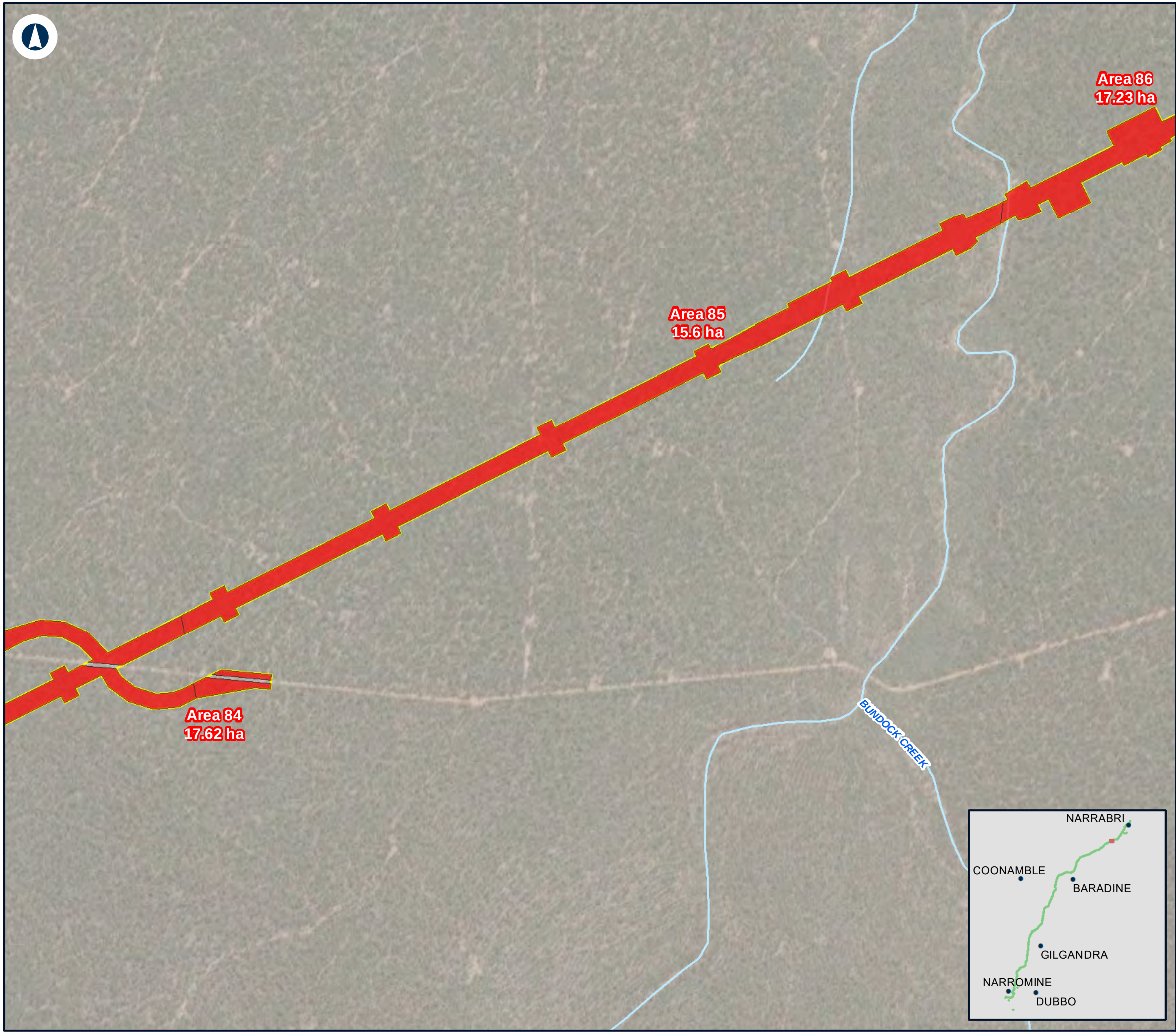

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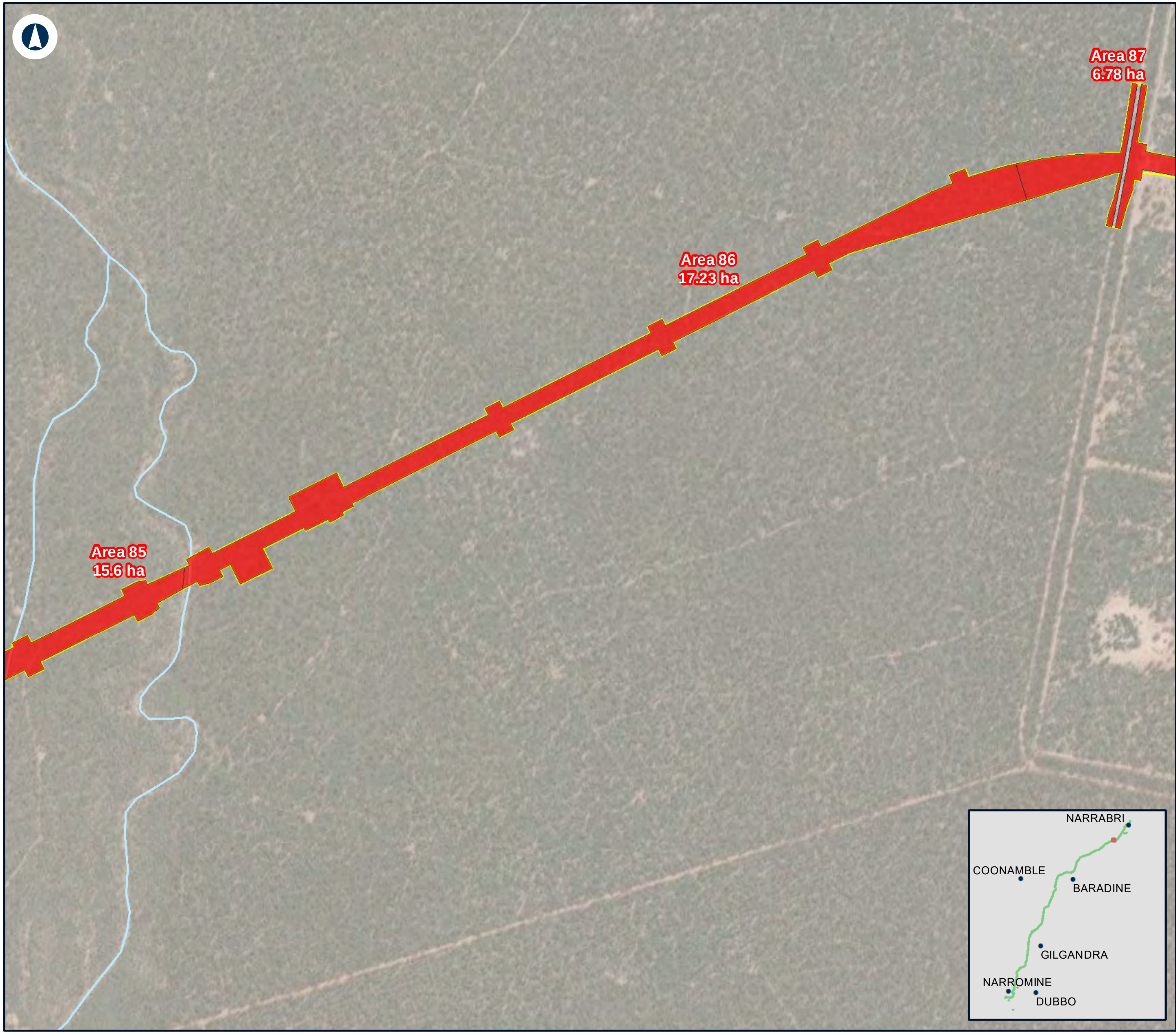

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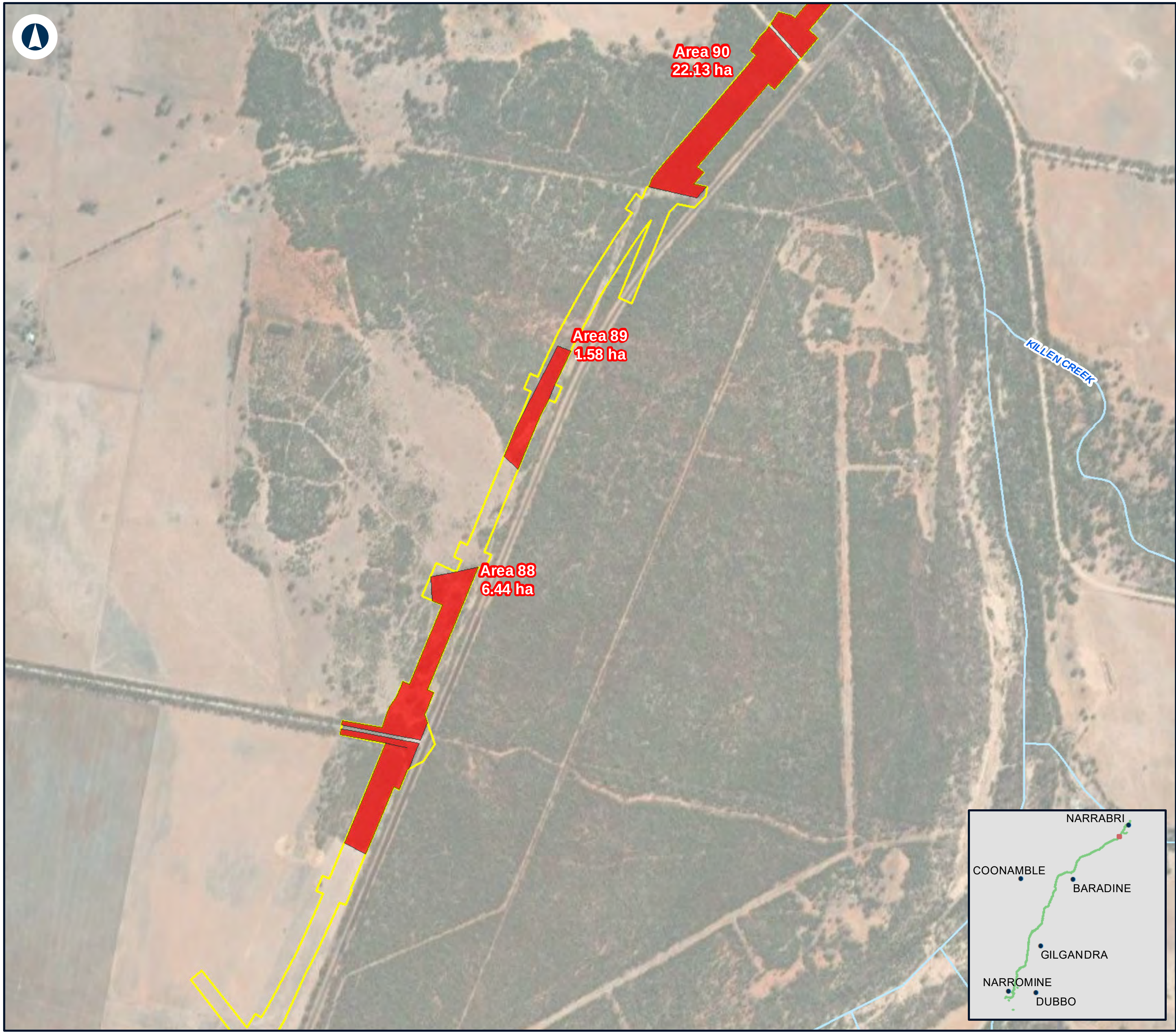

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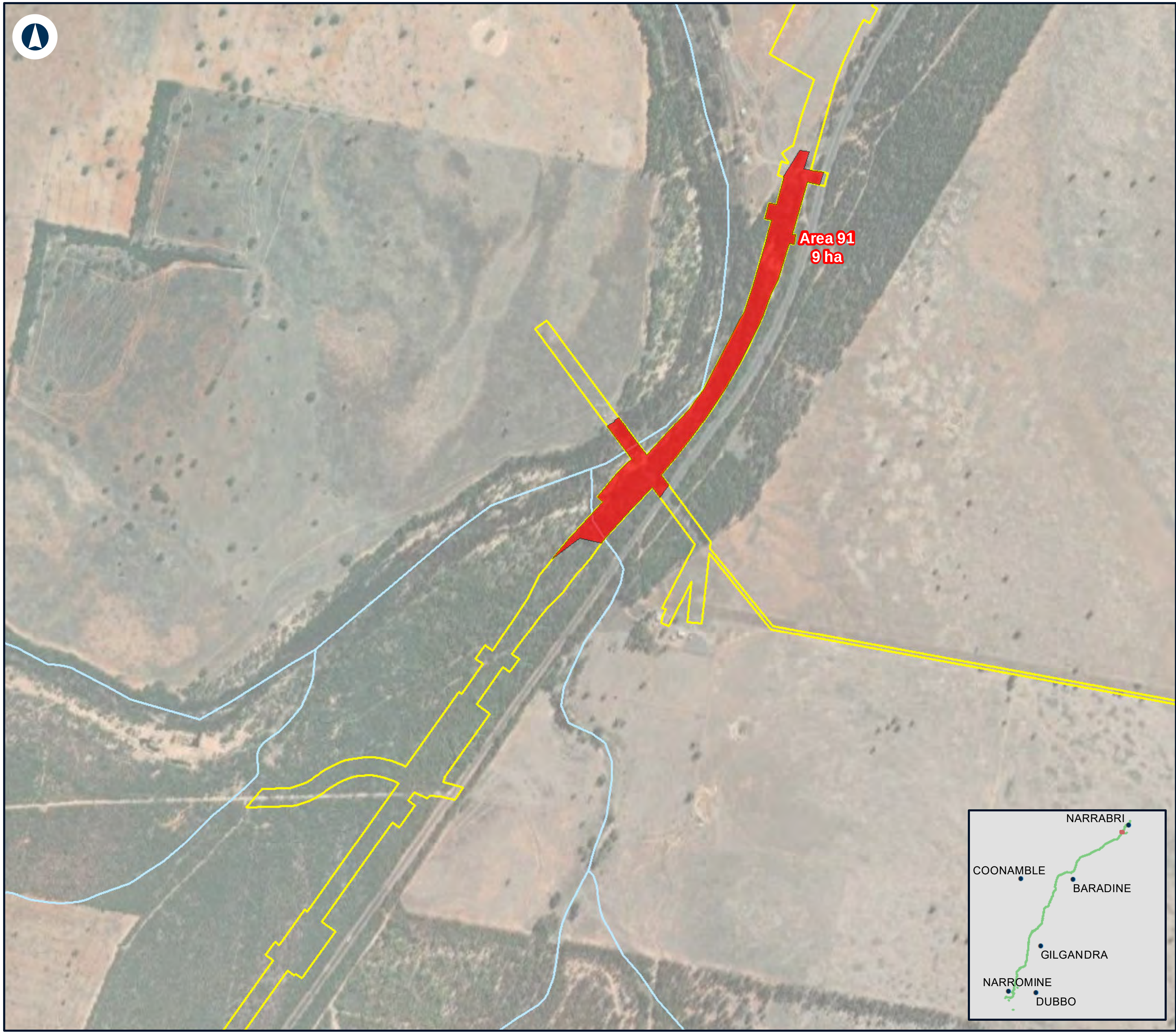

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Appendix 2

Habitat areas and status

LEGEND

- Construction impact zone
- Square-tailed Kite potential breeding habitat

0 200 400 Metres

Coordinate System: GDA 1994 MGA Zone 55

Date: 2021-11-30
Paper: A4
Author: JacobsGHD
Scale: 1:15,000
Data Sources: Basemap layers: NSWSS, esri;

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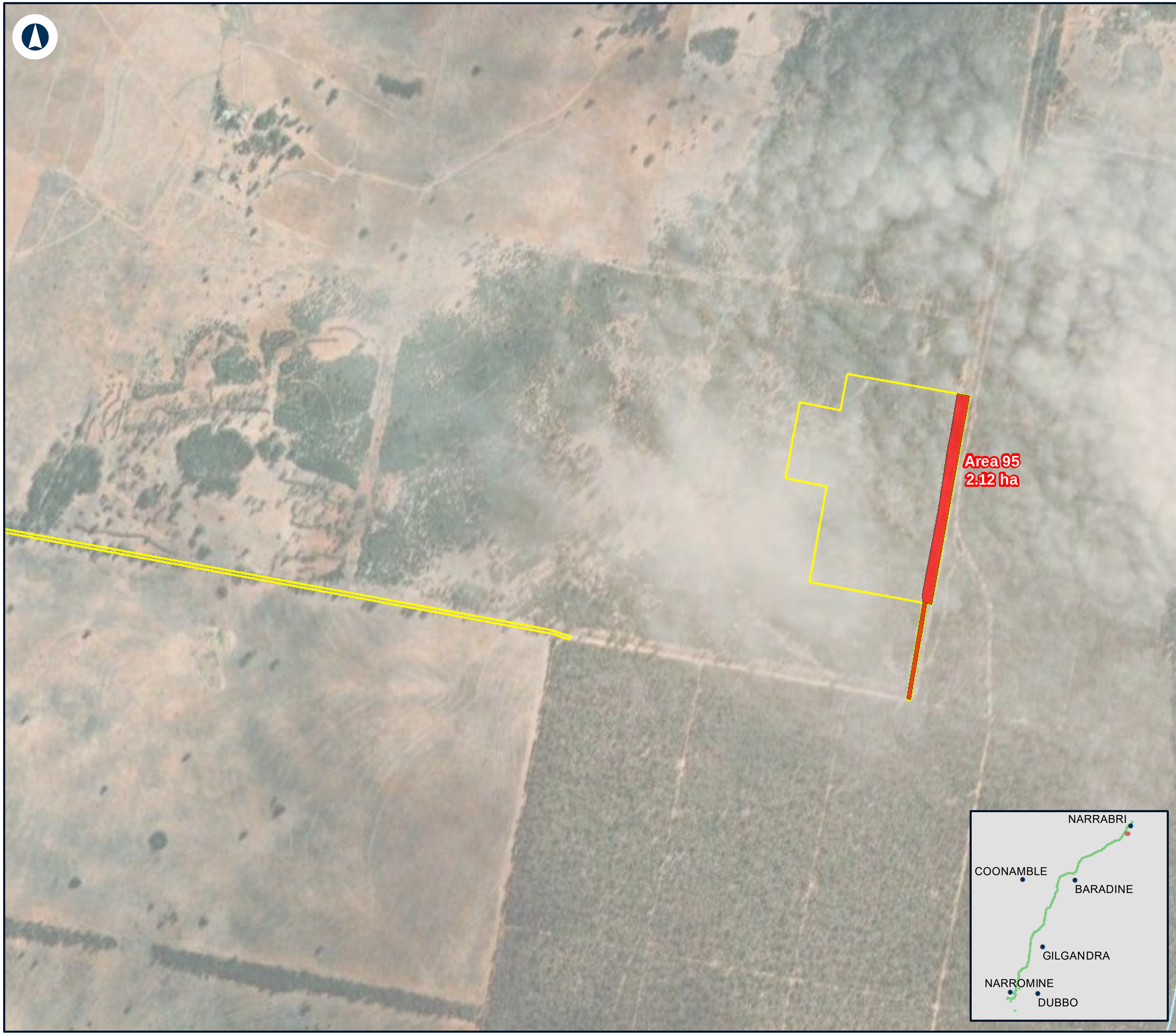

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Appendix 3. Records of Square-tailed Kite along N2N Inland Rail Corridor

Year	Month	Day	Latitude	Longitude	Source
1900			-32.22	148.23	Ornithology
1909			-32.03	147.98	Ornithology
1974			-30.88	149.04	BioNet Atlas of NSW Wildlife
1977			-30.26	150.17	BioNet Atlas of NSW Wildlife
1980			-30.94	149.12	BioNet Atlas of NSW Wildlife
1981			-30.94	149.12	BioNet Atlas of NSW Wildlife
1981			-30.94	149.12	BioNet Atlas of NSW Wildlife
1981			-30.94	149.12	BioNet Atlas of NSW Wildlife
1981			-31.26	149.31	BioNet Atlas of NSW Wildlife
1981			-30.94	149.12	BioNet Atlas of NSW Wildlife
1981			-30.94	149.12	BioNet Atlas of NSW Wildlife
1981			-31.22	149.36	BioNet Atlas of NSW Wildlife
1981			-30.94	149.12	BioNet Atlas of NSW Wildlife
1981			-30.94	149.12	BioNet Atlas of NSW Wildlife
1981			-30.94	149.12	BioNet Atlas of NSW Wildlife
1982			-31.3	148.99	BioNet Atlas of NSW Wildlife
1983			-30.95	149.07	BioNet Atlas of NSW Wildlife
1984			-31.3	148.99	BioNet Atlas of NSW Wildlife
1985			-30.95	149.07	BioNet Atlas of NSW Wildlife
1986			-30.83	149.44	Ebird Australia
1991			-30.95	149.07	BioNet Atlas of NSW Wildlife
1991			-30.94	149.07	BioNet Atlas of NSW Wildlife
1992			-30.94	149.07	BioNet Atlas of NSW Wildlife
1992			-30.93	149.07	BioNet Atlas of NSW Wildlife
1992			-30.95	149.07	BioNet Atlas of NSW Wildlife
1998			-31.14	149.1	Ebird Australia
1998			-31.28	149	Ebird Australia
1998			-30.93	149.07	Ebird Australia
1998			-30.93	149.07	BioNet Atlas of NSW Wildlife
2000			-30.87	149.58	BioNet Atlas of NSW Wildlife
2000			-30.87	149.6	BioNet Atlas of NSW Wildlife
2000			-30.86	149.5	BioNet Atlas of NSW Wildlife
2006			-31.28	149.27	BioNet Atlas of NSW Wildlife
2007			-31.05	149.09	BioNet Atlas of NSW Wildlife
2007			-30.97	149.07	BioNet Atlas of NSW Wildlife
2007			-30.85	149.47	BioNet Atlas of NSW Wildlife
2008			-30.67	149.42	Ebird Australia
2008			-30.92	149.08	Ebird Australia
2008			-30.92	149.08	Ebird Australia
2008			-31.08	149.08	Ebird Australia
2008			-31.28	149.27	BioNet Atlas of NSW Wildlife
2008			-30.58	149.2	BioNet Atlas of NSW Wildlife
2009			-30.94	149.07	Ebird Australia

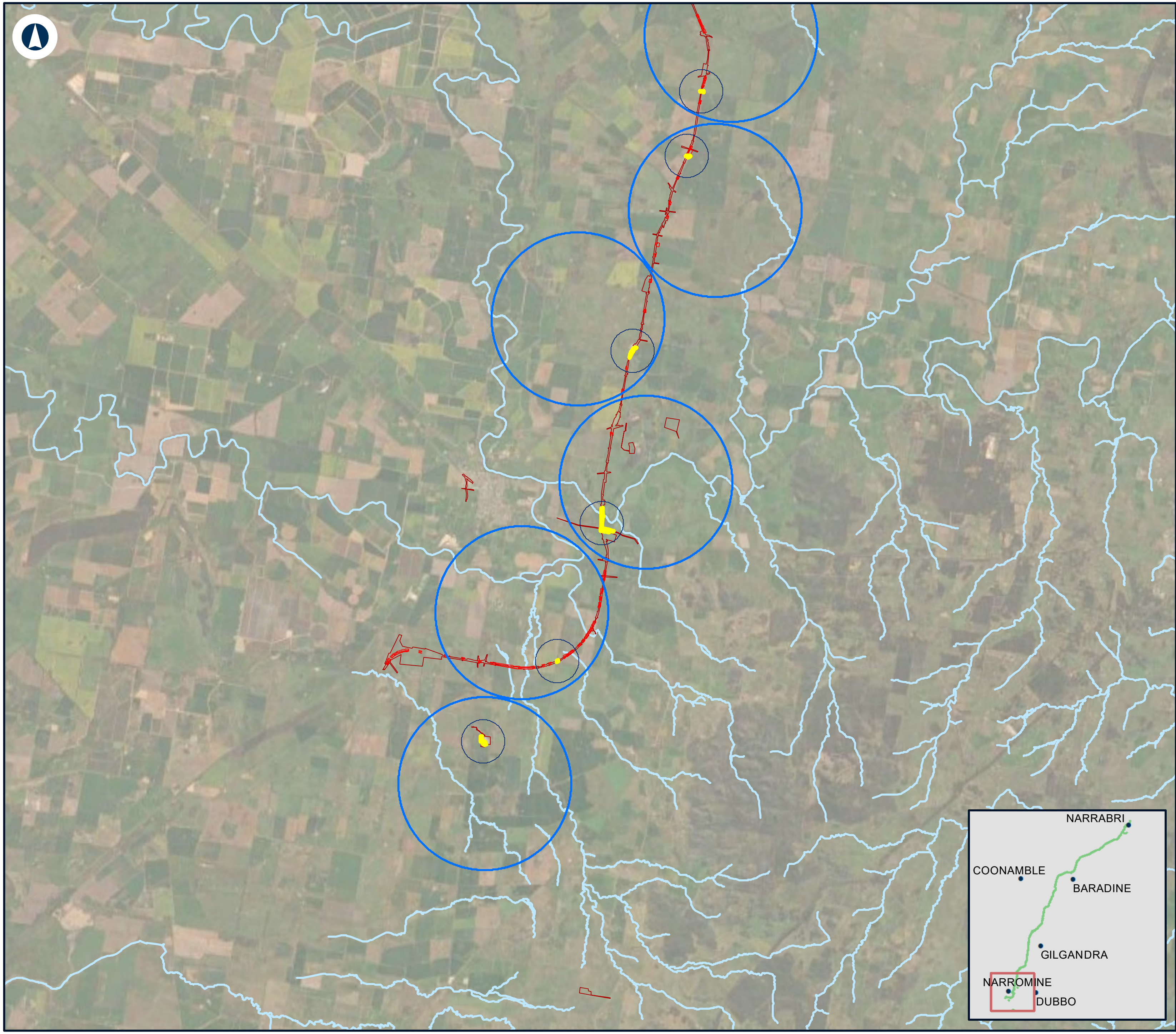
Appendix 3. Records of Square-tailed Kite along N2N Inland Rail Corridor

Year	Month	Day	Latitude	Longitude	Source
2009			-31.25	149.25	Ebird Australia
2009			-30.92	149.08	Ebird Australia
2009			-30.92	149.08	Ebird Australia
2009			-30.63	149.57	BioNet Atlas of NSW Wildlife
2009			-31.71	148.65	BioNet Atlas of NSW Wildlife
2010			-31.7	147.84	Ebird Australia
2011			-31.28	149	Ebird Australia
2011			-30.94	149.07	Ebird Australia
2012			-30.94	149.07	Ebird Australia
2012			-30.37	149.53	Ebird Australia
2012			-31.08	149.39	BioNet Atlas of NSW Wildlife
2012			-31.08	149.39	BioNet Atlas of NSW Wildlife
2012			-31.08	149.39	BioNet Atlas of NSW Wildlife
2013			-30.34	149.99	Ebird Australia
2014			-30.59	149.58	Ebird Australia
2014			-30.32	149.79	Ebird Australia
2014			-30.31	149.77	BioNet Atlas of NSW Wildlife
2015			-30.32	149.78	Ebird Australia
2015			-30.47	150.14	BioNet Atlas of NSW Wildlife
2015			-30.59	149.98	BioNet Atlas of NSW Wildlife
2015			-30.34	149.79	BioNet Atlas of NSW Wildlife
2015			-30.69	148.99	BioNet Atlas of NSW Wildlife
2016			-30.79	148.98	Ebird Australia
2016			-30.33	149.76	Ebird Australia
2016			-30.75	149.29	Ebird Australia
2016			-30.79	148.98	Ebird Australia
2016			-30.33	149.76	Ebird Australia
2016			-30.79	148.98	Ebird Australia
2016			-30.55	150.11	BioNet Atlas of NSW Wildlife
2017			-30.33	149.76	Birds Australia
2017			-30.69	149.16	Birds Australia
2018			-31.15	149.13	Ebird Australia
2018			-30.32	149.79	Ebird Australia
2018			-32.02	147.98	Birds Australia
2019			-31.71	147.82	Ebird Australia
2019			-31.71	148.67	Ebird Australia
2020			-30.27	149.82	Ebird Australia
2020			-31.67	148.52	Ebird Australia
2020			-30.34	149.64	Ebird Australia
2020			-30.27	149.82	Ebird Australia
2020			-31.25	149.25	BioNet Atlas of NSW Wildlife
2020			-31.18	149.18	BioNet Atlas of NSW Wildlife
			-31.25	149.29	Birds Australia

Appendix 3. Records of Square-tailed Kite along N2N Inland Rail Corridor

Year	Month	Day	Latitude	Longitude	Source
			-30.7	149.15	Birds Australia
			-30.95	149.07	Birds Australia
			-30.88	149.1	Birds Australia
			-31.06	149.09	Birds Australia
			-30.94	149.07	Birds Australia
			-31.25	149.29	Birds Australia
			-30.85	148.95	Birds Australia
			-30.48	149.55	Birds Australia
			-30.77	149.04	Birds Australia
			-30.61	149.05	Birds Australia
			-31.29	149	Birds Australia
			-31.25	149.29	Birds Australia
			-31.08	149.07	Birds Australia
			-30.95	149.07	Birds Australia
			-30.95	149.05	Birds Australia
			-31.43	149.07	Birds Australia
			-30.95	149.07	Birds Australia
			-31.27	149.28	Birds Australia
			-30.93	149.06	Birds Australia
			-31.25	149.29	Birds Australia
			-30.75	149.27	Birds Australia
			-30.95	149.07	Birds Australia
			-30.71	149.15	Birds Australia
			-32.23	148.25	Birds Australia
			-30.95	149.08	Birds Australia
			-31.7	147.83	Birds Australia
			-32.03	147.98	Birds Australia
			-31.55	148.78	Birds Australia
			-30.91	149.08	Birds Australia
			-32.23	148.25	Birds Australia
			-31.55	148.78	Birds Australia
			-31.26	149.28	Birds Australia
			-30.5	149.5	Birds Australia
			-31.25	148.75	Birds Australia
			-31.08	149.25	Birds Australia
			-30.91	148.58	Birds Australia
			-30.91	149.08	Birds Australia
			-30.58	149.91	Birds Australia
			-30.91	149.08	Birds Australia
			-30.91	149.08	Birds Australia
			-30.91	148.91	Birds Australia
			-30.91	149.08	Birds Australia
			-30.91	149.08	Birds Australia

Appendix 4. Square-tailed Kite species polygon



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NARROMINE TO NARRABRI

Square-tailed Kite potential habitat and species polygon within the Pilliga

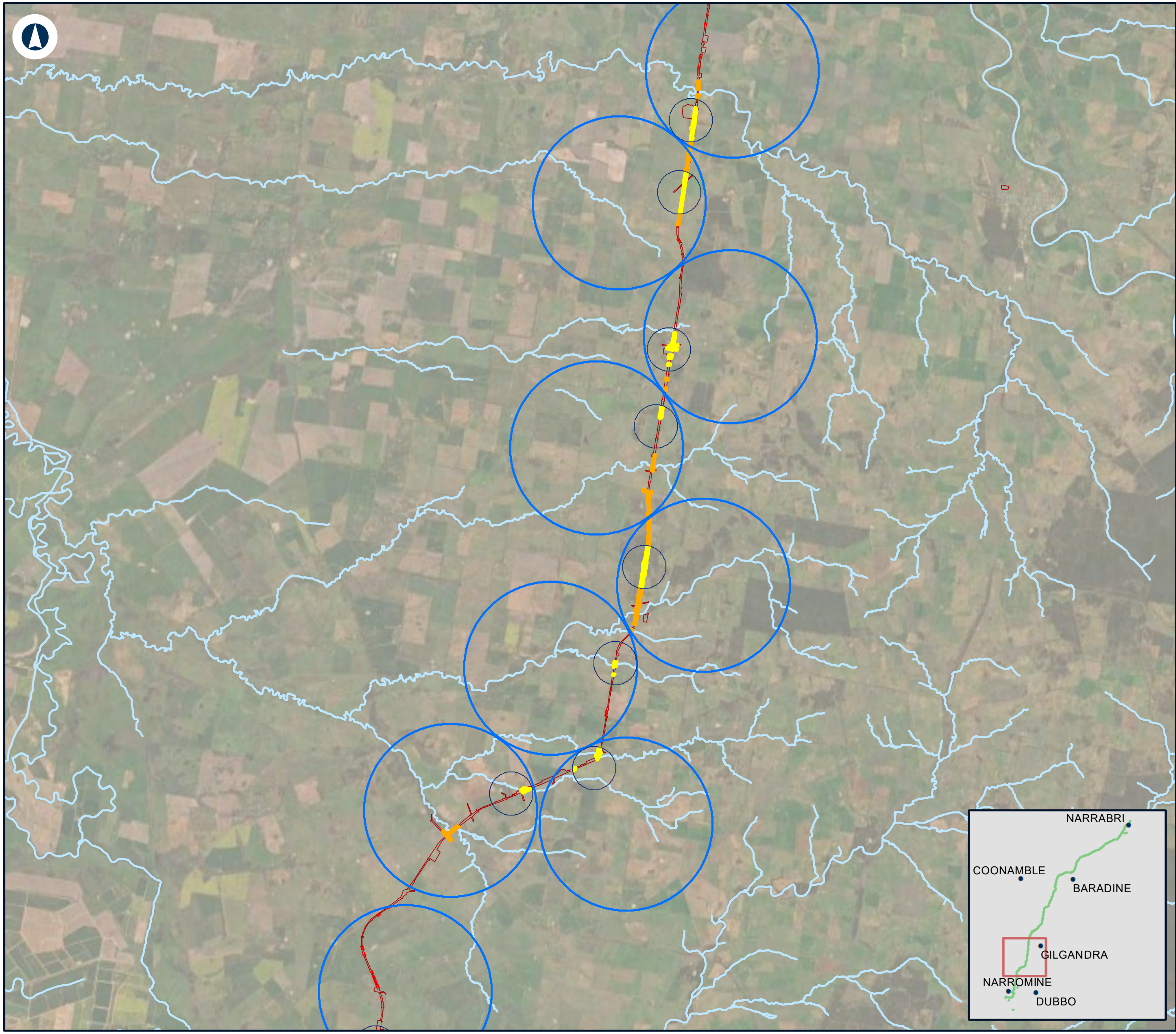
LEGEND

- Construction impact zone
- Culvert easement
- Breeding/forgaing territory - indicative nest tree 4km buffer
- Indicative nest tree 1km buffer
- Square-tailed Kite species polygon
- Square-tailed Kite potential breeding habitat

0 4 8 Km

Coordinate System: GDA 1994 MGA Zone 55

Date: 2021-11-22
Paper: A4
Author: JacobsGHD
Scale: 1:250,000
Data Sources: Basemap layers: NSWSS, esri;



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NARROMINE TO NARRABRI

Square-tailed Kite potential habitat and species polygon within the Pilliga

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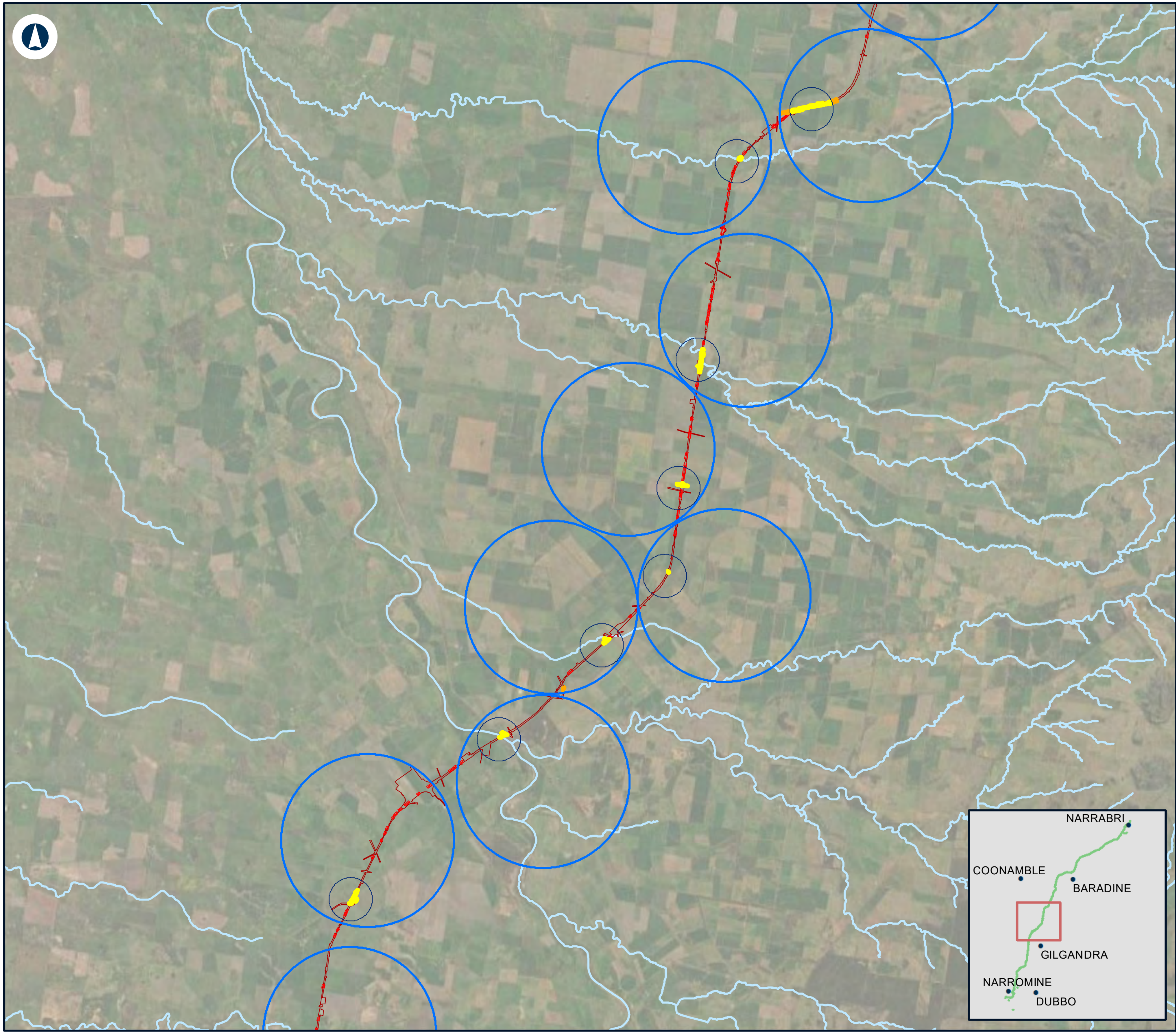

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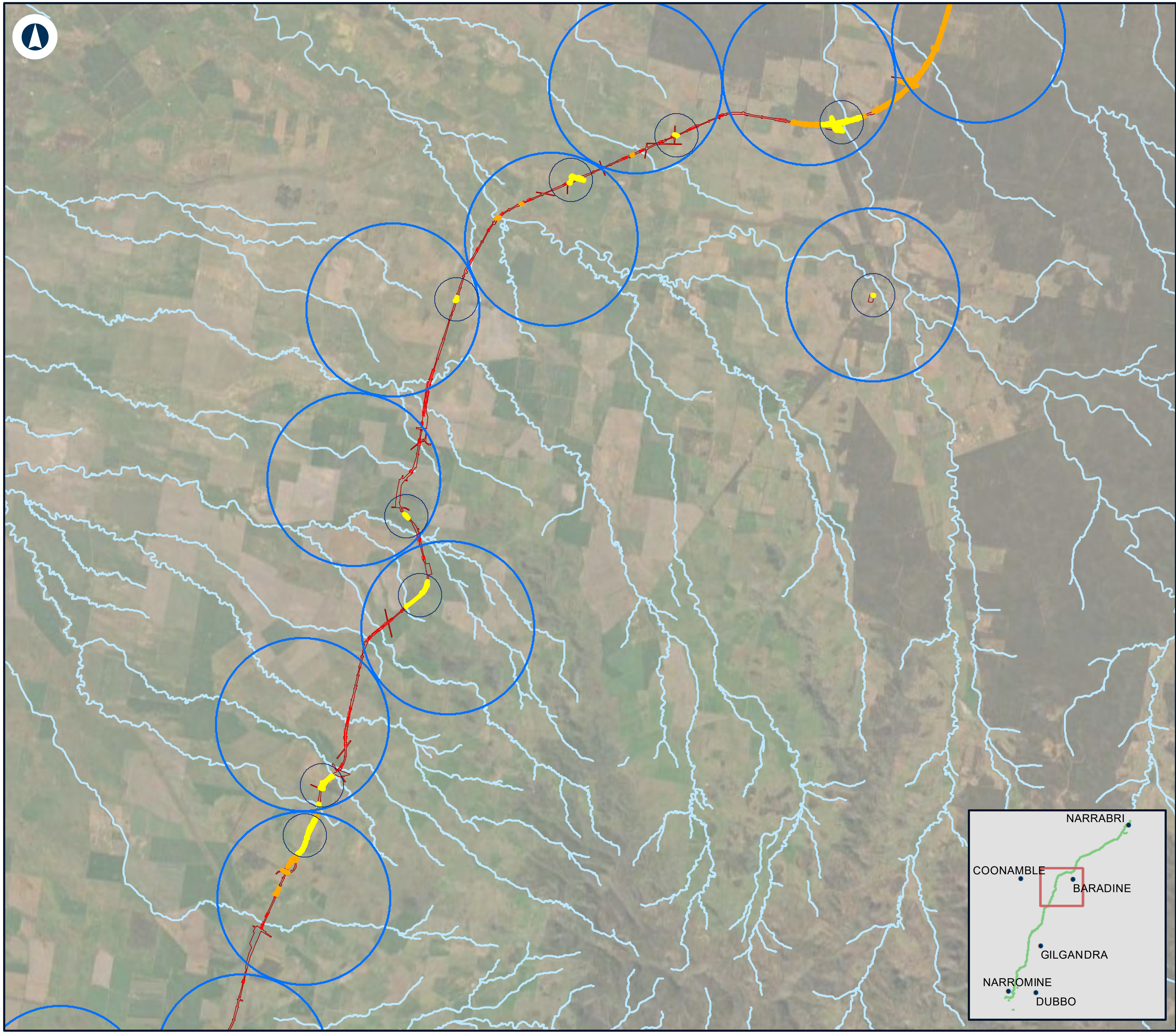

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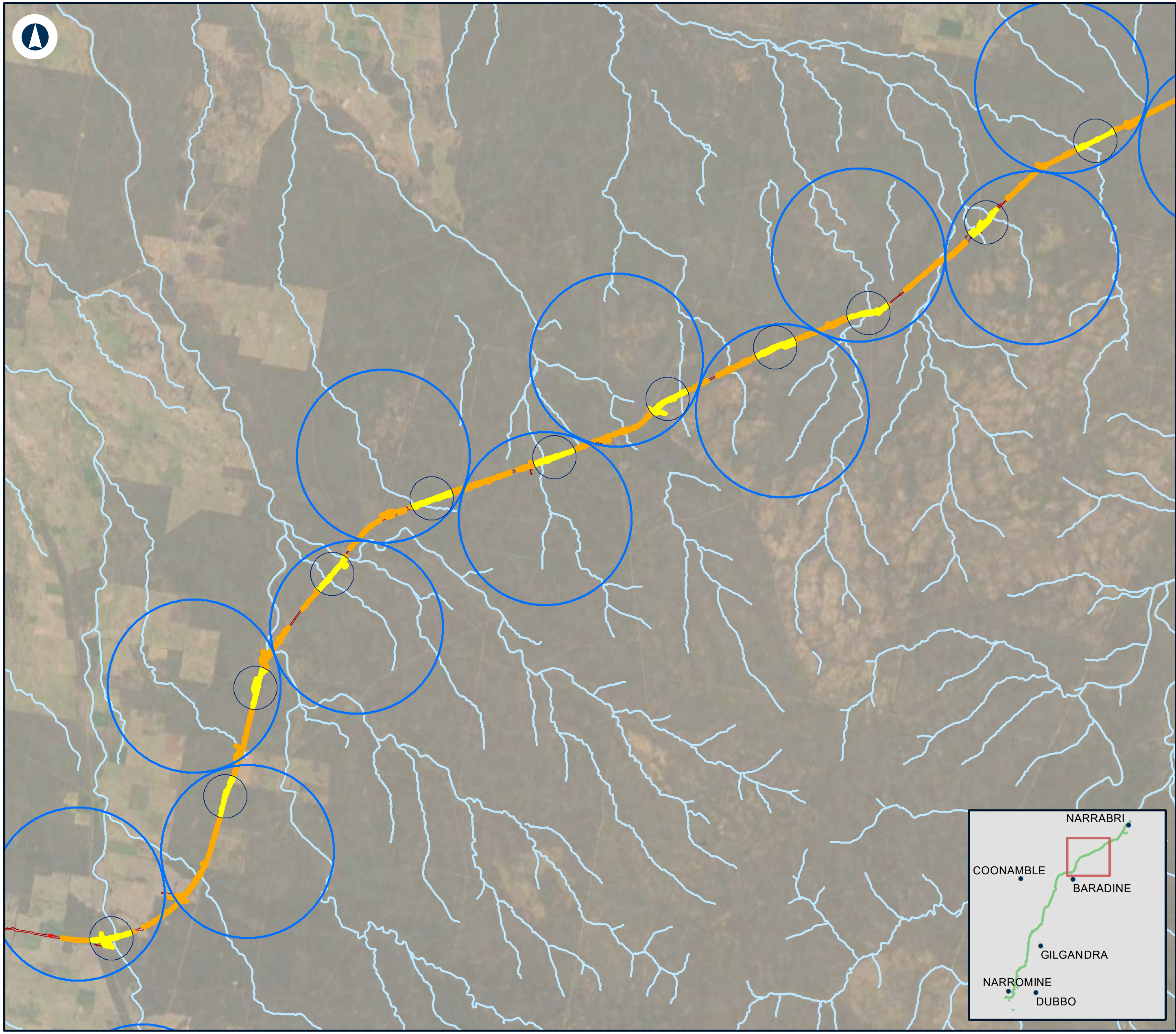

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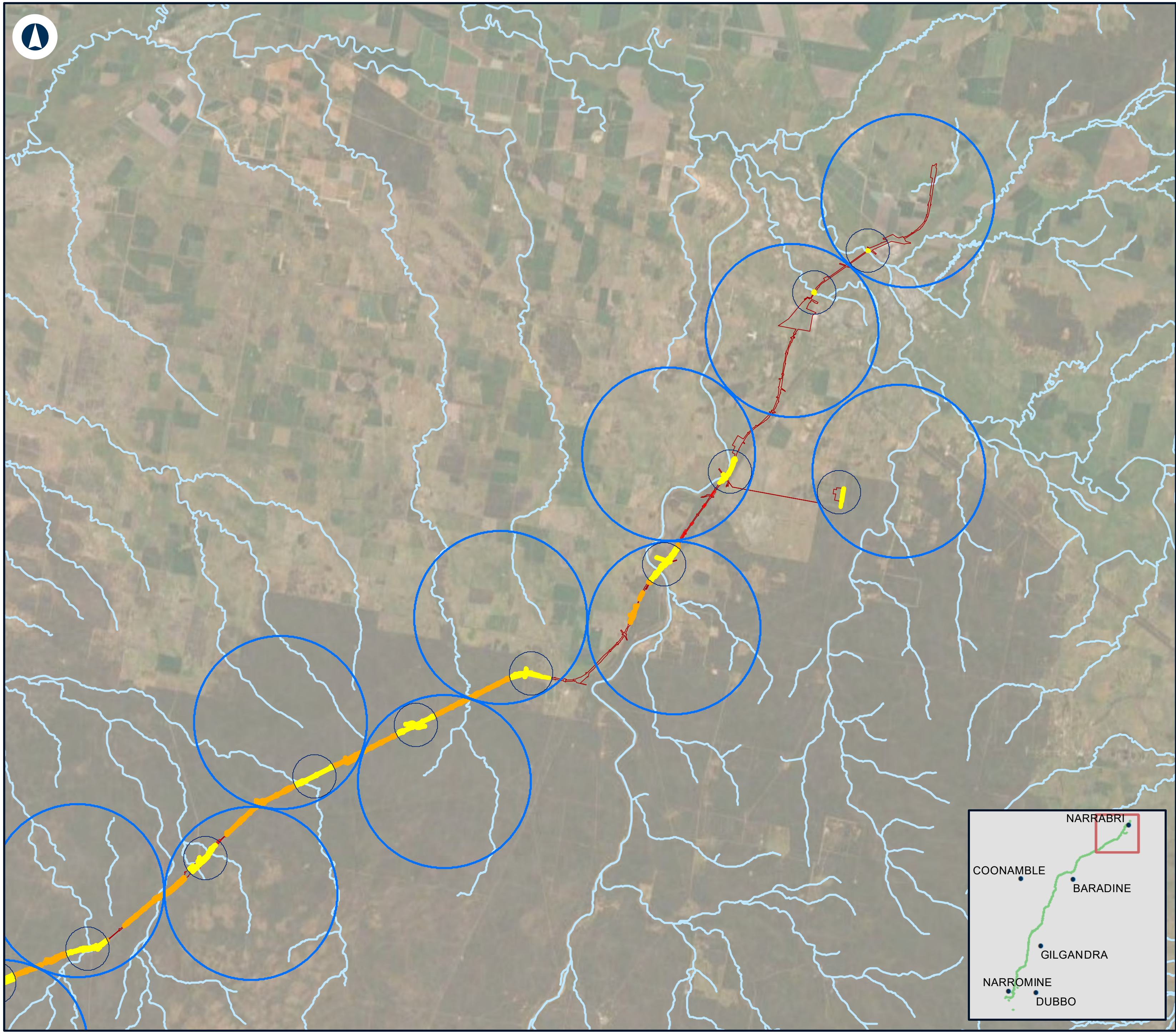

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Appendix 5. Square-tailed Kite Species polygons calculations within each PCT

IBRA Subregion	PCT ID	PCT name	Condition	Area
Bogan-Macquarie	36	River Red Gum tall to very tall open forest/woodland wetland on rivers on floodplains mainly in the Darling Riverine Plains Bioregion	Good	2.07
Bogan-Macquarie	56	Poplar Box - Belah woodland on clay-loam soils on aluvial plains on north central NSW	Good	0.37
Bogan-Macquarie	248	Mixed box eucalypt woodland on low sandy-loam rises on alluvial plains in central western NSW	Good	7.52
Bogan-Macquarie	255	Mugga Ironbark - Buloke - Pillga Box - White Cypress Pine shrubby woodland	Good	3.26
Castlereagh-Barwon	56	Poplar Box - Belah woodland on clay-loam soils on aluvial plains on north central NSW	Good	4.88
Castlereagh-Barwon	78	River Red Gum riparian tall woodland / open forest wetland in the Nandewar Bioregion and Brigalow Belt South Bioregion	Good	5.20
Castlereagh-Barwon	88	Pilliga Box - White Cypress Pine - Buloke shrubby woodland in the Brigalow Belt South Bioregion	Good	1.75
Castlereagh-Barwon	145	Western Rosewood - Wilga - Wild Orange - Belah low woodland of the Brigalow Belt South Bioregion and eastern Darling Riverine Plains Bioregion	Good	1.41
Castlereagh-Barwon	206	Dirty Gum - White Cypress Pine tall woodland of alluvial sand (sand monkeys) in the Darling Riverine Plains Bioregion and Brigalow Belt South Bioregion	Good	1.87
Castlereagh-Barwon	244	Poplar Box grassy woodland on alluvial clay-loam soils mainly in the temperate (hot summer) climate zone of central NSW (wheatbelt)	Good	7.39
Castlereagh-Barwon	444	Silver-leaved Ironbark grassy tall woodland on clay-loam soils on plains in the Brigalow Belt South Bioregion	Good	0.94
Liverpool Plains	78	River Red Gum riparian tall woodland / open forest wetland in the Nandewar Bioregion and Brigalow Belt South Bioregion	Good	0.17
Pilliga	36	River Red Gum tall to very tall open forest/woodland wetland on rivers on floodplains mainly in the Darling Riverine Plains Bioregion	Good	0.86
Pilliga	55	Belah woodland on alluvial plains and low rises in the central NSW wheatbelt to Pilliga and Liverpool Plains regions	Good	0.78
Pilliga	56	Poplar Box - Belah woodland on clay-loam soils on aluvial plains on north central NSW	Good	1.17
Pilliga	78	River Red Gum riparian tall woodland / open forest wetland in the Nandewar Bioregion and Brigalow Belt South Bioregion	Good	1.14
Pilliga	88	Pilliga Box - White Cypress Pine - Buloke shrubby woodland in the Brigalow Belt South Bioregion	Good	84.18
Pilliga	145	Western Rosewood - Wilga - Wild Orange - Belah low woodland of the Brigalow Belt South Bioregion and eastern Darling Riverine Plains Bioregion	Good	5.88

Appendix 5. Square-tailed Kite Species polygons calculations within each PCT

IBRA Subregion	PCT ID	PCT name	Condition	Area
Pilliga	206	Dirty Gum - White Cypress Pine tall woodland of alluvial sand (sand monkeys) in the Darling Riverine Plains Bioregion and Brigalow Belt South Bioregion	Good	4.87
Pilliga	244	Poplar Box grassy woodland on alluvial clay-loam soils mainly in the temperate (hot summer) climate zone of central NSW (wheatbelt)	Good	6.45
Pilliga	394	Narrow-leaved Ironbark - White Cypress pine woodland on slopes and flats in the Coonabarabran - Pilliga Scrub regions	Good	7.03
Pilliga	397	Poplar Box - White Cypress Pine shrub grass tall woodland of the Pilliga - Warialda region, Brigalow Belt South Bioregion	Good	3.13
Pilliga	398	Narrow-leaved Ironbark - White Cypress Pine - Buloke tall open forest on lower slopes and flats in the Pilliga Scrub and surrounding forests in the central north Brigalow Belt South Bioregion	Good	95.66
Pilliga	399	Red gum - Rough-barked Apple +/- tea tree sandy creek woodland (wetland) in the Pilliga - Goonoo sandstone forests, Brigalow Belt South Bioregion	Good	11.31
Pilliga	404	Red Ironbark - White Bloodwood +/- Burrows Wattle heathy woodland on sandy soil in the Pilliga forests	Good	7.15
Pilliga	406	White Bloodwood - Motherumbah - Red Ironbark shrubby sandstone hill woodland / open forest mainly in east Pilliga forests	Good	2.40
Pilliga Outwash	78	River Red Gum riparian tall woodland / open forest wetland in the Nandewar Bioregion and Brigalow Belt South Bioregion	Good	9.28
Pilliga Outwash	88	Pilliga Box - White Cypress Pine - Buloke shrubby woodland in the Brigalow Belt South Bioregion	Good	37.83
Pilliga Outwash	148	Dirty Gum - Buloke - White cypress pine - ironbark shrubby woodland of the deep sandy soils on the Liverpool Plains Region of the Brigalow Belt South Bioregion	Good	7.71
Pilliga Outwash	394	Narrow-leaved Ironbark - White Cypress pine woodland on slopes and flats in the Coonabarabran - Pilliga Scrub regions	Good	4.00
Pilliga Outwash	397	Poplar Box - White Cypress Pine shrub grass tall woodland of the Pilliga - Warialda region, Brigalow Belt South Bioregion	Good	2.30
Pilliga Outwash	398	Narrow-leaved Ironbark - White Cypress Pine - Buloke tall open forest on lower slopes and flats in the Pilliga Scrub and surrounding forests in the central north Brigalow Belt South Bioregion	Good	53.36
Pilliga Outwash	399	Red gum - Rough-barked Apple +/- tea tree sandy creek woodland (wetland) in the Pilliga - Goonoo sandstone forests, Brigalow Belt South Bioregion	Good	16.63

Appendix 5. Square-tailed Kite Species polygons calculations within each PCT

IBRA Subregion	PCT ID	PCT name	Condition	Area
Pilliga Outwash	435	White Box – White Cypress Pine shrub grass hills woodland in the Brigalow Belt South bioregion and Nandewar bioregion	Good	0.31
Pilliga Outwash	473	Red gum - Rough-barked Apple - Narrow-leaved Ironbark - cypress pine grassy open forest on flats and drainage lines in the Goonoo and surrounding forests, southern Brigalow Belt South Bioregion	Good	4.59
TOTAL SPECIES POLYGON				407.11
TOTAL SPECIES POLYGON (PILLIGA FORESTS)				235.57

Kirsten Crosby

From: Renee Shepherd <Renee.Shepherd@environment.nsw.gov.au>
Sent: Wednesday, 4 August 2021 6:26 PM
To: Tony Saunders (InTouch)
Cc: OEH ROD North West Mailbox; Sharon Ziko; Lucian McElwain; Kirsten Crosby; Ben Ellis
Subject: Application to be a BAM species expert - application number BE 21 14 - Dr Tony Saunders

Hi Tony,

Thank you for your application (received on 21 July 2021) to be considered as an expert within the meaning of the Biodiversity Assessment Method, and to prepare an expert report on the square-tailed kite and little eagle for the following project:

Project Name: Inland Rail – Narromine to Narrabri
Project Type: Major Project
Local Government Areas: Narromine Shire Council, Gilgandra Shire Council, Warrumbungle Shire Council, Coonamble Shire Council and Narrabri Shire Council

The Biodiversity, Conservation and Science Directorate, North West Branch, has reviewed your application against your state-wide approval to prepare expert reports for both the square-tailed kite and the little eagle.

Your state-wide expert status has been considered **valid and acceptable** for the purposes of preparing an expert report for these species for the Inland Rail Narromine to Narrabri project.

Please note that any expert report prepared for this project must demonstrate your expert status by addressing the criteria in section 6.5.2.3 of the BAM (BAM 2017) within the BDAR.

Regards,
Renee.

Renee Shepherd
Acting Senior Team Leader Planning, North West

Biodiversity, Conservation and Science Directorate | Department of Planning, Industry and Environment
T 02 6883 5355 | **M** 0488 444 953 | **E** renee.shepherd@environment.nsw.gov.au
48-52 Wingewarra Street, Dubbo NSW 2830
www.dpie.nsw.gov.au

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We work flexibly. *I'm sending this message now because it's a good time for me. I don't expect that you will read, respond to, or action this message outside of your own regular hours.*

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PLEASE CONSIDER THE ENVIRONMENT BEFORE PRINTING THIS EMAIL

TECHNICAL REPORT 01

Biodiversity development assessment report

Appendix O Key changes to the BDAR between the exhibited and updated versions

NARROMINE TO NARRABRI RESPONSE TO SUBMISSIONS

Table O1 Key changes made between the Exhibited BDAR (BAM 2017) and the Updated BDAR BAM 2020

Key change	Description	Section
BAM 2017 to BAM 2020	The BDAR has been updated to meet the requirements of BAM 2020	Throughout
Change to CIZ	Changes to the CIZ resulted in changes to vegetation zone mapping areas and additional footprint included in the proposal for flood mitigation. Some vegetation zone areas increased due to assignment of previous grasslands to parent derived communities. This resulted in associated changes in species polygon areas.	Appendix G (vegetation zone mapping) Appendix H (PCT extent of impacts) Appendix I (species polygons)
Additional surveys	The majority of 2018 and 2019 surveys were conducted during drought conditions, which affected vegetation integrity of plots surveyed. Following good rainfall in 2020, additional spring surveys were undertaken in September, October and November 2020 to take advantage of better conditions. These targeted areas of potential habitat for threatened flora species, and areas where access was previously not possible but was now available. The main aim of these surveys was to gain a better understanding of proposal impacts to threatened flora and to complete vegetation integrity plots outside of drought conditions and in areas previously extrapolated due to access restrictions. Additional targeted fauna surveys were undertaken in the November 2020 survey round. Following exhibition, targeted thermal drone surveys for the Koala were conducted in July 2021 by Wildlife Drones, and surveys were conducted in August 2021 by experts Dr Steve Phillips (for the Koala) and Dr Tony Saunders (for the Square-tailed Kite and Little Eagle). Additional targeted surveys were conducted in March 2022 to confirm presence/absence of Coolabah Bertya (SAII entity) and Scant Pomaderris in the remote sections of the CIZ in the Pilliga.	Section 3.4 (methods) Section 6 (Threatened species) Section 13 (Offsetting) Appendix N (expert reports) Appendix I (Threatened species information, species polygon maps and justification for species polygons)
Expert reports	Expert reports were prepared by Dr Steve Phillips (for the Koala) and Dr Tony Saunders (for the Square-tailed Kite and Little Eagle)	Appendix N (expert reports)

Key change	Description	Section
Vegetation zone mapping	Vegetation zone mapping was revised as a result of additional surveys, and also to remove derived grassland PCTs that had been identified in the exhibited BDAR (particularly PCT 619). Any areas of derived native grassland were assigned to the appropriate woodland or forest parent community based on results of vegetation integrity plot surveys and identity of nearby woodland or forest PCTs. This has resulted in changes to areas of these PCTs, and associated areas of impact for some threatened ecological communities. Lignum vegetation that was identified in the exhibited EIS due to regional mapping was removed as a result of on-ground surveys in spring 2020. Surveys in August 2021 identified several areas where land that was previously mapped as derived native grassland had since been cropped.	Section 3.4 (flora surveys) Appendix B (detailed PCT profiles) Appendix G (vegetation zone mapping) Appendix H (PCT extent of impacts) Appendix L (plot justifications)
Additional BAM-C cases	The exhibited BDAR comprised one BAM-C case, which was split by project segment to allow staging of retirement of credits. In the updated BDAR, seven related cases were set up under one parent case for the proposal, to account for each of the IBRA subregions the proposal crosses, as requested by BCS. This allowed for more rigorous assessment of appropriate PCTs and candidate threatened species. As a result, separate landscape assessments and habitat suitability assessments for threatened species were required for each IBRA subregion, and species polygons updated accordingly.	Section 3.9 (BAM calculations) Section 4 (Landscape context) Figure 4.1 (Landscape features) Section 6 (Threatened species) Section 13.1 (BC Act offsets) Appendix I (species credit justifications and species polygons)
Prescribed impacts	The identification and assessment of prescribed impacts has been revised to meet the requirements of BAM 2020	Section 8 (identification of prescribed impacts) Section 10.2 (assessment of prescribed impacts)
Prescribed impact offsets	A framework for assigning additional credits for impacts on connectivity has been developed to meet the requirements of the BAM 2020 and significant residual impacts on threatened species	Section 10.3 (assessment of residual prescribed impacts) Section 13.1.4 (offsets for prescribed impacts)
SAII assessments	The assessment of SAII entities has been revised to meet the requirements of BAM 2020	Section 10.1 (SAII)

Key change	Description	Section
Species polygons	Detailed revisions of species polygons were conducted in consultation with BCS in 2021. These included reviews of areas where presence was assumed, and provision of justification for inclusion and exclusion of vegetation polygons in a new GIS layer. Results of surveys conducted since exhibition contributed to the revisions. Additional justification for candidate species and species polygons is also provided. Revisions were made to the species polygons for Coolabah Bertya (removed due to lack of evidence in the proposal site) and Scant Pomaderris (polygon area reduced due to lack of evidence in the Pilliga), following targeted surveys in March 2022.	Section 3.9.4 (Methods – candidate threatened species) Section 6.2.4 (Candidate threatened species) Section 13.1 (Species credits) Appendix I (Threatened species information, species polygon maps and justification for species polygons)
Impacts on TSRs	Identification of TSRs crossed by the proposal and the associated impacts were incorporated into the Updated BDAR.	Section 5.6 (Travelling stock reserves) Section 9.3 (Construction impacts)
Preliminary Fauna Connectivity Strategy	Connectivity values and mitigation for impacts on connectivity were provided in the exhibited BDAR. These were compiled into a stand-alone Preliminary Fauna Connectivity Strategy in the Updated BDAR.	Appendix J (Preliminary Fauna Connectivity Strategy)
Changes to ecosystem credits in the Castlereagh-Barwon subregion	Ecosystem credits reduced for each PCT in the Castlereagh-Barwon subregion for the final version due to updates to the risk weighting for a species in the credit calculator in June 2022.	Section 13.2 (ecosystem credits)

Table O2 Changes in vegetation zone areas impacted and ecosystem credit obligations

PCT ID	Vegetation zone – condition	Exhibited BDAR area (ha)	Exhibited BDAR ecosystem credits required	Updated BDAR area (ha)	Updated BDAR ecosystem credits required	Additional credits for prescribed impacts
27		**3.05**	**127**	**6.5**	**175**	
	Weeping Myall open woodland of the Darling Riverine Plains Bioregion and Brigalow Belt South Bioregion – Good			6.5	175	
35		**0.61**	**19**	**7.3**	**155**	
	Brigalow – Belah open forests / woodland on alluvial often gilgaied clay from Pilliga scrub to Gondiwindi, Brigalow Belt South bioregion – DNG			5.9	111	
	Brigalow – Belah open forests / woodland on alluvial often gilgaied clay from Pilliga scrub to Goondiwindi, Brigalow Belt South bioregion – Good			1.4	44	
36		**5.08**	**115**	**5.7**	**133**	
	River Red Gum tall to very tall open forest/woodland wetland on rivers on floodplains mainly in the Darling Riverine Plains Bioregion – Good			5.5	133	
49		**176.1**	**2843**	**330.1**	**9,837**	
	Partly derived Windmill Grass - Copperburr alluvial plains shrubby grassland of the Darling Riverine Plains Bioregion and Brigalow Belt South bioregion – Good			330.1	9,837	
55		**0.21**	**5**	**4**	**102**	
	Belah woodland on alluvial plains and low rises in the central NSW wheatbelt to Pilliga and Liverpool Plains regions – Good			4	102	
56		**19.5**	**564**	**38.19**	**1,043**	
	Poplar Box - Belah woodland on clay-loam soils on alluvial plains on north central NSW – DNG			18.4	369	
	Poplar Box - Belah woodland on clay-loam soils on alluvial plains on north central NSW – Good			19.8	674	
78		**26.23**	**585**	**30.8**	**847**	
	River Red Gum riparian tall woodland / open forest wetland in the Nandewar Bioregion and Brigalow Belt South Bioregion – DNG			1.3	23	
	River Red Gum riparian tall woodland / open forest wetland in the Nandewar Bioregion and Brigalow Belt South Bioregion – Good			29.4	824	

PCT ID	Vegetation zone – condition	Exhibited BDAR area (ha)	Exhibited BDAR ecosystem credits required	Updated BDAR area (ha)	Updated BDAR ecosystem credits required	Additional credits for prescribed impacts
81		**-**	**-**	**0.91**	**36**	
	Western Grey Box - cypress pine shrub grass shrub tall woodland in the Brigalow Belt South Bioregion			0.91	36	
88		**277.79**	**5166**	**402.1**	**6,633**	**884**
	Pilliga Box - White Cypress Pine - Buloke shrubby woodland in the Brigalow Belt South bioregion – DNG			89.8	1,169	
	Pilliga Box - White Cypress Pine - Buloke shrubby woodland in the Brigalow Belt South bioregion – Good			310.6	5,435	884
	Pilliga Box - White Cypress Pine - Buloke shrubby woodland in the Brigalow Belt South bioregion – Low			1.7	29	
141		**29.47**	**425**	**30.92**	**432**	**299**
	Broombush - wattle very tall shrubland of the Pilliga to Goonoo regions, Brigalow Belt South Bioregion – Good			30.92	432	299
145		**53.99**	**645**	**70.9**	**991**	
	Western Rosewood - Wilga - Wild Orange - Belah low woodland of the Brigalow Belt South Bioregion and eastern Darling Riverine Plains Bioregion – DNG			5.76	92	
	Western Rosewood - Wilga - Wild Orange - Belah low woodland of the Brigalow Belt South Bioregion and eastern Darling Riverine Plains Bioregion – Good			65.14	899	
148		**45.04**	**1697**	**141.67**	**2678**	
	Dirty Gum - Buloke - White cypress pine - ironbark shrubby woodland of the deep sandy soils on the Liverpool Plains Region of the Brigalow Belt South Bioregion – DNG			95.43	1493	
	Dirty Gum - Buloke - White cypress pine - ironbark shrubby woodland of the deep sandy soils on the Liverpool Plains Region of the Brigalow Belt South Bioregion – Good			46.24	1185	
168		**8.56**	**286**	**7.3**	**244**	
	Derived Copperburr shrubland of the NSW northern inland alluvial floodplain – Good			7.3	244	
185		**1.37**	**0**	**13.46**	**51**	
	Dwyer's Red Gum - White Cypress Pine - Currawang shrubby woodland – DNG			12.1	0	
	Dwyer's Red Gum - White Cypress Pine - Currawang shrubby woodland – Good			1.4	51	

PCT ID	Vegetation zone – condition	Exhibited BDAR area (ha)	Exhibited BDAR ecosystem credits required	Updated BDAR area (ha)	Updated BDAR ecosystem credits required	Additional credits for prescribed impacts
202		**3.59**	**179**	**3.6**	**179**	
	Fuzzy Box woodland on colluvium and alluvial flats in the Brigalow Belt South and Nandewar bioregions (including Pilliga) – Good			3.6	179	
206		**12.66**	**376**	**10.13**	**269**	
	Dirty Gum – White Cypress Pine – Buloke shrubby woodland in the Brigalow Belt South Bioregion – Good			10.13	269	
244		**31.84**	**677**	**43.95**	**1,289**	
	Poplar Box grassy woodland on alluvial clay-loams soils mainly in the temperate (hot summer) climate zone of central NSW (wheatbelt) – Good			43.95	1,289	
247	*Lignum shrubland wetland on regularly flooded alluvial depressions in the Brigalow Belt South Bioregion and Darling Riverine Plains Bioregion*	***6.91***	***234***	***0***	***0***	
248		**14.71**	**470**	**16.28**	**482**	
	Mixed box eucalypt woodland on low sandy-loam rises on alluvial plains in central western NSW – Good			16.28	482	
250	*Derived tussock grassland of the central western plains and lower slopes of NSW*	***82.84***	***2845***	***0***	***0***	
255		**11.77**	**190**	**12.15**	**227**	
	Mugga Ironbark - Buloke - Pilliga Box - White Cypress Pine shrubby woodland on sandstone in the Dubbo region, south-western Brigalow Belt South Bioregion – Good			12.15	227	
256		**0.27**	**4**	**0.3**	**5**	**3**
	Green Mallee tall mallee woodland on rises in the Pilliga - Goonoo regions, southern Brigalow Belt South Bioregion – Good			0.3	5	3
394		**69.66**	**1159**	**81.07**	**1,330**	**709**
	Narrow-leaved Ironbark - White Cypress pine woodland on slopes and flats in the Coonabarabran - Pilliga Scrub regions – DNG			15.4	233	
	Narrow-leaved Ironbark - White Cypress pine woodland on slopes and flats in the Coonabarabran - Pilliga Scrub regions – Good			54.6	995	639

PCT ID	Vegetation zone – condition	Exhibited BDAR area (ha)	Exhibited BDAR ecosystem credits required	Updated BDAR area (ha)	Updated BDAR ecosystem credits required	Additional credits for prescribed impacts
	Narrow-leaved Ironbark - White Cypress pine woodland on slopes and flats in the Coonabarabran - Pilliga Scrub regions – Good, fire affected			11.1	102	70
397		**15.78**	**303**	**17.79**	**342**	**197**
	Poplar Box - White Cypress Pine shrub grass tall woodland of the Pilliga - Warialda region, Brigalow Belt South Bioregion – Good			17.79	342	197
398		**369.78**	**8444**	**382.30**	**9,000**	**6,167**
	Narrow-leaved Ironbark - White Cypress Pine - Buloke tall open forest on lower slopes and flats in the Pilliga Scrub and surrounding forests in the central north Brigalow Belt South Bioregion – Good			373.88	8844	6,058
	Narrow-leaved Ironbark - White Cypress Pine - Buloke tall open forest on lower slopes and flats in the Pilliga Scrub and surrounding forests in the central north Brigalow Belt South Bioregion (Moderate, shrubs removed)			8.4	156	109
399		**53.71**	**1105**	**54.83**	**1161**	**674**
	Red gum - Rough-barked Apple +/- tea tree sandy creek woodland (wetland) in the Pilliga - Goonoo sandstone forests, Brigalow Belt South Bioregion – Good			54.83	1161	674
404		**23.05**	**544**	**25.1**	**481**	**332**
	Red Ironbark - White Bloodwood +/- Burrows Wattle heathy woodland on sandy soil in the Pilliga forests – Good			25.1	481	332
406		**2.3**	**49**	**2.4**	**51**	**35**
	White Bloodwood - Motherumbah - Red Ironbark shrubby sandstone hill woodland / open forest mainly in east Pilliga forests – Good			2.4	51	35
409		**0.82**	**15**	**0.76**	**14**	**9**
	Dirty (Baradine) Gum - White Bloodwood - White Cypress Pine - Motherumbah shrubby woodland on sandy soils in the Pilliga Scrub and surrounding region, Brigalow Belt South Bioregion			0.76	14	9
411	*Buloke - White Cypress Pine woodland on outwash plains in the Piliga Scrub and Narrabri regions, Brigalow Belt South Bioregion*	***8.76***	***327***	***0***	***0***	

PCT ID	Vegetation zone – condition	Exhibited BDAR area (ha)	Exhibited BDAR ecosystem credits required	Updated BDAR area (ha)	Updated BDAR ecosystem credits required	Additional credits for prescribed impacts
414		**7.32**	**153**	**7.3**	**79**	**55**
	White Mallee - Dwyer's Red Gum mallee heath on sands in the Goonoo - Pilliga region, Brigalow Belt South Bioregion – Good, fire affected			7.3	79	55
435		**6.11**	**305**	**5.38**	**148**	
	White Box – White Cypress Pine shrub grass hills woodland in the Brigalow Belt South bioregion and Nandewar bioregion – DNG			5.1	129	
	White Box – White Cypress Pine shrub grass hills woodland in the Brigalow Belt South bioregion and Nandewar bioregion – Good			0.3	19	
436	*Derived Kurrajong grassy open woodland / isolated trees in the Brigalow Belt South Bioregion and Nandewar Bioregion*	***5.98***	***0***	***0***	***0***	
444		**1.11**	**37**	**1.75**	**72**	
	Silver-leaved Ironbark grassy tall woodland on clay-loam soils on plains in the Brigalow Belt South Bioregion – Good			1.75	72	
469		**0**	**0**	**0.98**	**14**	
	White Cypress Pine - Narrow-leaved Ironbark - Buloke grassy open forest of the Dubbo region, southern Brigalow Belt South Bioregion – Good			0.98	14	
473		**15.26**	**318**	**20.1**	**400**	
	Red gum - Rough-barked Apple - Narrow-leaved Ironbark - cypress pine grassy open forest on flats and drainage lines in the Goonoo and surrounding forests, southern Brigalow Belt South Bioregion – DNG			0.9	0	
	Red gum - Rough-barked Apple - Narrow-leaved Ironbark - cypress pine grassy open forest on flats and drainage lines in the Goonoo and surrounding forests, southern Brigalow Belt South Bioregion – Good			19.2	400	
589		**1.23**	**27**	**1.05**	**22**	**6**
	White Box - White Cypress Pine - Silver-leaved Ironbark grassy woodland on mainly clay loam soils on hills mainly in the Nandewar Bioregion – Moderate, logged			1.05	22	6

PCT ID	Vegetation zone – condition	Exhibited BDAR area (ha)	Exhibited BDAR ecosystem credits required	Updated BDAR area (ha)	Updated BDAR ecosystem credits required	Additional credits for prescribed impacts
599		**2.21**	**64**	**3.04**	**117**	
	Blakely's Red Gum - Yellow Box grassy tall woodland on flats and hills in the Brigalow Belt South and Nandewar bioregions – Good			3.04	117	
619	***Derived Wire Grass grassland of the NSW Brigalow Belt South Bioregion and Nandewar Bioregion***	***326.26***	***4067***	***0***	***0***	
746		**2.12**	**36**	**2.12**	**36**	
	Brown Bloodwood - cypress - ironbark heathy woodland in the Pilliga region of the Brigalow Belt South Bioregion – good			2.12	36	
1384		**8.77**	**415**	**8.85**	**352**	**255**
	White Cypress Pine - Bulloak - ironbark woodland of the Pilliga area of the Brigalow Belt South Bioregion – Good			8.85	352	255
Grand Total		**1731.82**	**34820**	**1,791**	**39,427**	**9,625**

Table O3 Changes to species credit obligation

Species	Exhibited BDAR impact area (ha)	Exhibited BDAR species credits required	Updated BDAR impact (ha)	Updated BDAR species credits required	Total including credits for prescribed impacts
Flora species					
Bluegrass (*Dichanthium setosum*)	0	0	3.5	174	174
Coolabah Bertya (*Bertya opponens*)	4 (individuals)	8	0	0	0
Commersonia procumbens	565.14	16,431	572.9	16,738	16,738
Cyperus conicus	0	0	50.8	1,164	1,164
Keith's Zieria (Zieria ingramii)	0	0	48.6	1,605	1,605
Pine Donkey Orchid (*Diuris tricolor*)	629.97	13,639	388.2	7,176	7,176
Silky Swainson-pea (*Swainsona sericea*)	0	0	78.9	2,472	2,472
Spiny Peppercress (*Lepidium aschersonii*)	10.27	259	338.8	8,232	8,232

Species	Exhibited BDAR impact area (ha)	Exhibited BDAR species credits required	Updated BDAR impact (ha)	Updated BDAR species credits required	Total including credits for prescribed impacts
Winged Peppercress (*Lepidium monoplocoides*)	194.29	3,353	175.8	3,710	3,710
Native Milkwort (*Polygala linariifolia*)	565.86	16,258	263.2	6,023	6,023
Cobar Greenhood (*Pterostylis cobarensis*)	193.04	5,631	442.6	11,256	11,256
Scant Pomaderris (*Pomaderris queenslandica)*	0	0	9.1	267	267
Slender Darling Pea (*Swainsona murrayana*)	43.58	978	50.1	2,021	2,021
Tylophora linearis	582.5	16,902	87.8	2,885	2,885
Fauna species					
Barking Owl (*Ninox connivens*)	24.29	687	258.4	7,448	10,289
Bush Stone-curlew (*Burhinus grallarius*)	337.29	8,992	237.4	15,165	24,152
Eastern Pygmy-possum (*Cercartetus nanus*)	707	20,696	835.5	22,801	38,201
Glossy Black-cockatoo (*Calyptorhynchus lathami*)	30.55	975	324.7	9,296	9,493
Koala (*Phascolarctos cinereus*)	718.26	20,562	260.4	7,293	20,127
Little Eagle (*Hieraaetus morphnoides*)	15.9	376	465.8	9,765	9,949
Masked Owl (*Tyto novaehollandiae*)	7.25	189	185.8	5,543	7,516
Pale-headed Snake (*Hoplocephalus bitorquatus*)	206.7	6,128	286.4	8,277	19,291
Rufous Bettong (*Aepyprymnus rufescens*)	244.35	7,109	357.9	10,600	26,395
Square-tailed Kite (*Lophoictinia isura*)	35.09	765	407.3	8,586	8,743
Squirrel Glider (*Petaurus norfolcensis*)	688.3	20,483	651.0	17,622	35,741
Grand Total		**86,962**		**188,470**	**280,854**

Table O4 Changes to EPBC Act species credit obligations

Species	Exhibited BDAR area of impact	Exhibited BDAR credits required	Updated BDAR area of Impact	Updated BDAR credits required
Commersonia procumbens	565.14 hectares of potential habitat	16,431	572.9	16,738
Dichanthium setosum	0 hectares of potential habitat	0	3.5 hectares of potential habitat	174
Lepidium monoplocoides	194.29 hectares of potential habitat	3,353	175.8 hectares of potential habitat	3,710
Tylophora linearis	582.52 hectares of potential habitat	16,902	37.9 hectares of known habitat	1,236
Koala	718.26 hectares of important habitat	20,562	260.4 hectares of known habitat	7,293 (20,127 with prescribed impacts)
Zieria ingramii	0 hectares of potential habitat	0	48.6 hectares of potential habitat	1,605

Table O5 Changes to EPBC Act ecosystem credit obligations

Species	Exhibited BDAR area of impact	Exhibited BDAR credits required	Updated BDAR area of impact	Updated BDAR ecosystem credits
Corben's Long-eared Bat	1,125 hectares (total area of known and potential habitat). Hollow-bearing trees provide roosting and breeding habitat for this species.	24,545	1,107.4 hectares (total area of known and potential habitat). Hollow-bearing trees provide roosting and breeding habitat for this species.	24,497 33,377 with prescribed impacts
Painted Honeyeater	1,125 hectares (total area of potential habitat). Preferred habitat would include areas with higher densities of mistletoes.	24,545	1,107.4 hectares (total area of potential habitat). Preferred habitat would include areas with higher densities of mistletoes.	24,497
Pilliga Mouse	630 hectares of potential habitat. This includes 29 hectares of Broombush habitat and 457 hectares of PCTs that contain *Acacia burrowii* and *Corymbia trachyphloia.*	13,399	647.1 hectares of potential habitat. This includes 30 hectares of Broombush habitat and 452 hectares of PCTs that contain *Acacia burrowii* and *Corymbia trachyphloia.*	13,932 23,571 with prescribed impacts

Species	Exhibited BDAR area of impact	Exhibited BDAR credits required	Updated BDAR area of impact	Updated BDAR ecosystem credits
Regent Honeyeater	1,125 hectares (total area of potential habitat). 479 hectares containing preferred feed trees would be removed, much of this in the Pilliga.	10,508	286.8 hectares containing preferred feed trees would be removed, much of this in the Pilliga.	6,549
Swift Parrot (possible significant impact)	717 hectares of potential foraging habitat containing preferred feed species for this species, of which 511 hectares is in the Pilliga	15,018	732.9 hectares containing preferred feed trees would be removed, much of this in the Pilliga.	15,269