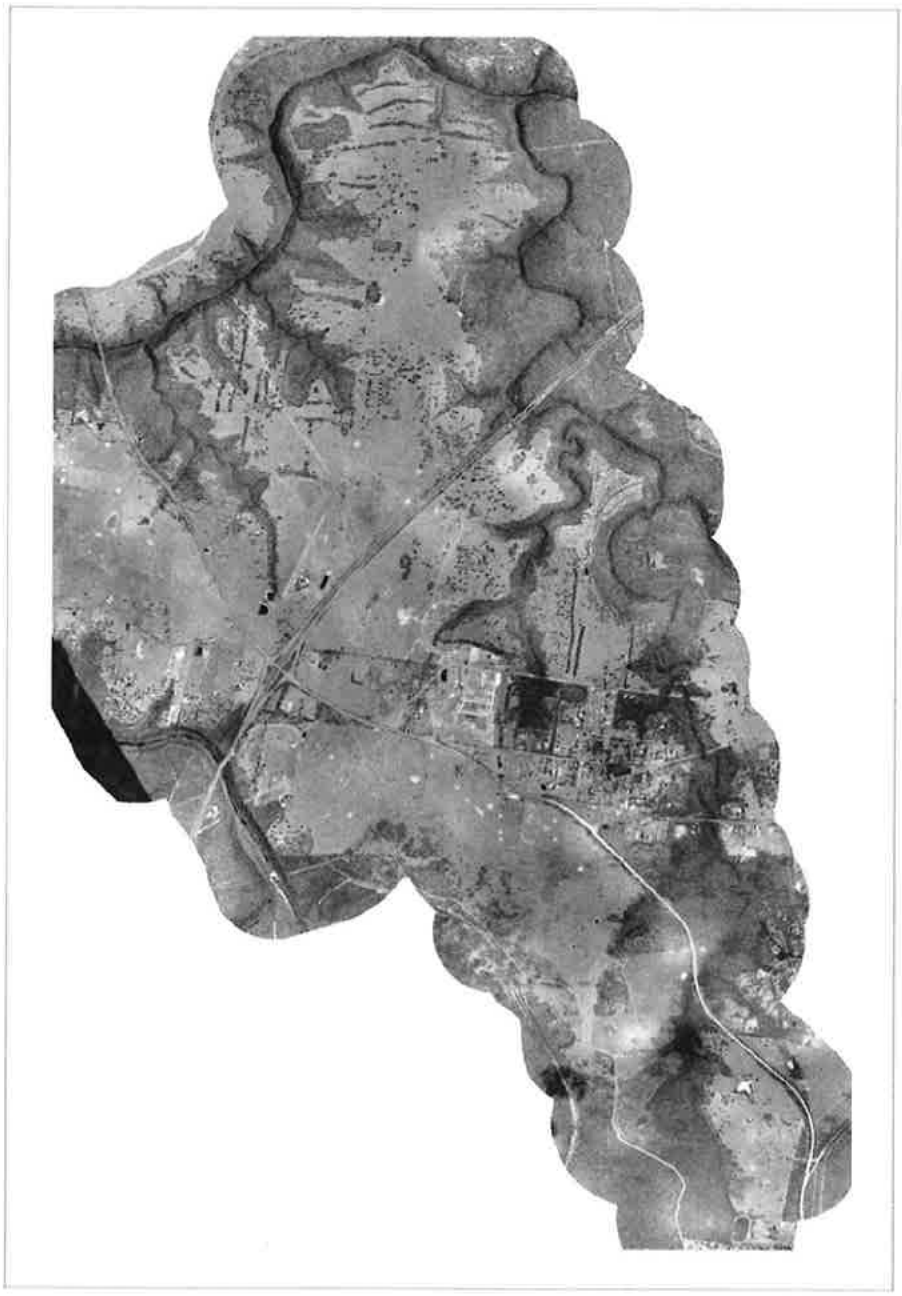


Appendix C

Quadrat and Transect Data (SLR Consulting)

NOTES

- Data collected by Fiona Iolini and Jamie Kankunnen of SLR Ecology.
- Refer to maps attached to this Appendix for locations of quadrats and transects.
- Quadrats and Transects were collected during summer/autumn 2013 and autumn 2014:
  - Sample Sites 1 to 6 (in Area A1) – 05 February 2013
  - Sample Sites 7 to 13 (in Area A1) – 06 February 2013
  - Sample Sites 14 to 18 (in Area A2) – 05 March 2013
  - Sample Sites 19 to 21 (in Area A2) – 07 March 2013
  - Sample Sites 22 to 24 (in Area B and C) – 31 July 2013
  - Sample Sites 25 to 35 (supplementary) – 30 April and 01 May 2014
- Quadrats involved the collection of Braun-Blanquet Cover Abundance data for each species recorded within a 20m x 20m ($400m^2$) area.
- The following Braun-Blanquet Cover Abundance scale was used: 1 (<5% uncommon), 2 (<5% common), 3 (5-25%), 4 (25-50%), 5 (50-75%), 6 (75-100%).
- Transects involved the collection of Braun-Blanquet Cover Abundance data for each species within an approximated 5m x 5m radius (for groundcover) and 10m x 10m radius (for understorey and canopy) at 10m intervals along a 60m measuring tape taken from the corner of the quadrats outward.
- Unknown specimens were sampled and identified using the online PlantNet database (Botanic Gardens Trust 2013), as well as the following field books:
  - *Field Guide to the Native Plants of Sydney* (Robinson 1991)
  - *Weeds of the South-east, An Identification Guide for Australia* (Richardson & Shephard 2007)
  - *Field Guide to Eucalypts, Volume 1 South-eastern Australia* (Brooker & Kleinig 2006)
  - *Grasses of Temperate Australia* (Lamp et al. 2001)
  - *Guide to the Grasses of Sydney* (Van Klaphake 2010)
- Identification was made that day or within two weeks of the sample date. Any unknown specimens or specimens that were possible "*threatened species*" were pressed and sent to the Botanic Gardens identification unit in Sydney for further identification.
- Nomenclature (*ie* species names and common names) used in this Appendix is sourced from PlantNet (BGT 2014).

KEY

Symbol	Description
*	Exotic species
**	Noxious species
C	Species listed as "*characteristic*" in the *Final Determination* (Scientific Committee 2014) for the Cumberland Plain Woodland (CPW) community – listed as a "*critically endangered ecological community*" (CEEC) in the *Threatened Species Conservation Act 1995* (TSC Act) and the *Environment Protection & Biodiversity Conservation Act 1999* (EPBC Act)
S	Species listed as "*characteristic*" within the *Final Determination* (Scientific Committee 2014) for the Shale Sandstone Transition Forest (SSTF) community – listed as an "*endangered ecological community*" (EEC) in the TSC Act

Sample Site 1 For location, see Figures D1, D2 and D4

Status	Species name	Common name	Q	0	10	20	30	40	50	60
C	*Aristida ramosa*	Purple Wire Grass	1							
C S	*Aristida vagans*	Three-awn Spear Grass							3	
C	*Asperula conferta*	Common Woodruff	1							1
	Calotis dentex	-			1			1	1	
C S	*Cheilanthes sieberi*	Poison Rock Fern	1			1	1			
C	*Cymbonotis lawsonii*	Bears-ear	1							
C	*Cyperus gracilis*	Slender Flat-sedge	1							
C	*Dichondra repens*	Kidney Weed	3	1	1	1		2	1	1
C	*Einadia polygonoides*	-	3							
C S	*Einadia trigonos*	Fishweed		2						
C S	*Eucalyptus crebra*	Narrow-leaved Ironbark						1		
C S	*Eucalyptus moluccana*	Grey Box	3	2						
C S	*Eucalyptus terticornis*	Forest Red Gum	3					2	3	2
C S	*Glycine clandestina*	-	3	1	1	1	2			
C	*Glycine tabacina*	-						1		
S	*Leucopogon juniperinus*	Prickly Beard-heath						1		
S	*Lomandra filiformis* subsp. *coriacea*	Wattle Mat-rush					1	2		2
C S	*Microlaenea stipoides*	Weeping Grass	5	4	4	3	5	3	3	4
C	*Oxalis perennans*	-	1							
*	*Pennisetum clandestinum*	Kikuyu Grass	1							
*	*Plantago lanceolata*	Lamb's Tongue	2						1	
*	*Senecio madagascariensis*	Fireweed	3			1	1			1
C S	*Solanum prinophyllum*	Forest Nightshade	1		1					
	Total native species	20								
	Total exotic species	3								
	Total CPW species	16								
	Total SSTF species	11								

Quadrat 1

Transect 1

Sample Site 2 For location, see Figures D1, D2 and D4

Status	Species name	Common name	Q	0	10	20	30	40	50	60
S	*Acacia decurrens*	Black Wattle					1			
	Anisopogon avenaceus	Oat Spear Grass	1							
C S	*Aristida vagans*	Three-awn Spear Grass	2		2					
	Astroloma humifusum	Native Cranberry	1			1	1	1	2	
	Calotis dentex	-	2	3	1	2		1	1	1
C S	*Cheilanthes sieberi*	Poison Rock Fern	2		1	2		2		
	Cyathochaeta diandra	-	2							
C	*Dichondra repens*	Kidney Weed						2	3	2
C	*Echinopogon ovatus*	Forest Hedgehog Grass			2					
	Entolasia marginata	Bordered Panic			1	2	2	2		2
S	*Entolasia stricta*	Wiry Panic	3	3	3					
C S	*Eucalyptus fibrosa*	Broad-leaved Ironbark	4							
C S	*Eucalyptus moluccana*	Grey Box								2
C S	*Eucalyptus paniculata*	Grey Ironbark		4	3	3	3	3	4	
	Eucalyptus piperita	Sydney Peppermint	1							
	Eucalyptus sideroxylon	Mugga Ironbark	1							
S	*Eucalyptus sparsifolia*	Narrow-leaved Stringybark								1
C S	*Glycine clandestina*	-	1						1	1
S	*Hibbertia aspera*	Rough Guinea Flower	1							
S	*Hibbertia diffusa*	Wedge Guinea Flower	2	1	1					
	Imperata cylindrica	Blady Grass	2							
S	*Kunzea ambigua*	Tick Bush	3	5	4	3		3	3	3
	Lepidosperma gunnii	-	1				4			
S	*Lepidosperma laterale*	-	2							
	Lissanthe strigosa	Peach Heath	2		4					
C	*Lomandra multiflora*	Many-flowered Mat-rush	3		1	2				
	Melaleuca erubescens	-	3							
C S	*Microlaenea stipoides*	Weeping Grass	2	2				2	3	3
S	*Persoonia linearis*	Narrow-leaved Geebung			1					
S	*Pomax umbellata*	-	2	2		1				
C	*Pultenaea microphylla*	-	2				1			
C S	*Solanum prinophyllum*	Forest Nightshade	2				1	1		1
C	*Veronica pleibea*	Trailing Speedwell	1							
	Total native species	33								
	Total exotic species	0								
	Total CPW species	13								
	Total SSTF species	17								

Quadrat 2

Transect 2

Sample Site 3 For location, see Figures D1, D2 and D4

Status	Species name	Common name	Q	0	10	20	30	40	50	60
	Acacia mearnsii	Black Wattle	1							
	Acmena smithii	Lilly Pilly						2	2	2
S	*Allocasuarina littoralis*	Black She-oak	2			2	2	3	3	4
C S	*Angophora bakeri*	Narrow-leaved Apple	2							
	Astrotricha latifolia	-								1
C	*Brunoniella australis*	Blue Trumpet					2			
C S	*Bursaria spinosa*	Blackthorn	3	1	2	3		2		2
	Calotis dentex	-	1							
	Cassinia quinquefaria	-	1							
	Ceratopetalum gummifera	Christmas Bush							2	
C S	*Cheilanthes sieberi*	Poison Rock Fern	2		2		2			
	Correa reflexa	Common Correa	5	2	1				3	3
	Dianella revoluta var. *revoluta*	-	1							
C	*Dichondra repens*	Kidney Weed			1					
C	*Echinopogon caespitosus*	Bushy Hedgehog Grass	1							
S	*Entolasia stricta*	Wiry Panic	4			2		2	2	2
C S	*Eucalyptus crebra*	Narrow-leaved Ironbark		2						
C S	*Eucalyptus paniculata*	Grey Ironbark	2		3	3				
C S	*Eucalyptus punctata*	Grey Gum	4				4	3		
S	*Eucalyptus sparsifolia*	Narrow-leaved Stringybark	2							
	Goodenia heterophylla subsp. *eglandulosa*	-	2							
	Grevillea speciosa	Red Spider Flower	1							
S	*Hibbertia aspera*	Rough Guinea Flower	2							
	Hovea longifolia	Rusty Pods	1							
	Lepidosperma gunnii	-	2							
S	*Lepidosperma laterale*	-	2		2	3			3	3
	Leptospermum parvifolium	-	2	4		3	2			
S	*Leptospermum trinervium*	Flaky-barked Tea-tree	2			3		2	2	
S	*Lomandra filiformis* subsp. *coriacea*	Wattle Mat-rush	3	1						
S	*Lomandra longifolia*	Spiny-headed Mat-rush								1
C	*Lomandra multiflora*	Many-flowered Mat-rush					1			
	Lomandra obliqua	-	2							
	Notelaea longifolia	Large Mock-olive	1							
	Panicum simile	Two-colour Panic			1					
S	*Persoonia linearis*	Narrow-leaved Geebung	2							2
	Podolobium ilicifolium	Prickly Shaggy Pea	5							
S	*Pomax umbellata*	-	2							
	Prostanthera rhombea	Sparkling Mint-bush	2	4		3	2	3	4	3
C S	*Rytidosperma tenuius*	Wallaby Grass	2				2			
	Schoenus melanostachys	Black Bog-rush						3		
C S	*Solanum prinophyllum*	Forest Nightshade			1					
	Zieria smithii	Sandfly Zieria								1
	Total native species	42								
	Total exotic species	0								
	Total CPW species	12								
	Total SSTF species	18								

Quadrat 3

Transect 3

Sample Site 4 For location, see Figures D1, D2 and D4

Status	Species name	Common name	Q	0	10	20	30	40	50	60
C	*Asperula conferta*	Common Woodruff	2	1						
C	*Brunoniella australis*	Blue Trumpet	1				1		1	
*	*Cirsium vulgare*	Spear Thistle	1							
C	*Cyperus gracilis*	Slender Flat-sedge	3	2		2	2			
C	*Dichondra repens*	Kidney Weed	3			2	2	1	3	3
C S	*Einadia trigonos*	Fishweed	3	2	2	2		2	2	1
C S	*Eucalyptus moluccana*	Grey Box	3	3		2	1	2	2	2
C S	*Eucalyptus terticornis*	Forest Red Gum	2							
C	*Geranium solanderi*	Native Geranium		1						
C S	*Glycine clandestina*	-	2			1	1			
C S	*Microlaenea stipoides*	Weeping Grass	4	4	4	3	3	2	3	3
*	*Modiola carolina*	Red-flowered Mallow	1							
C	*Oxalis perennans*	-	3		1			1		
*	*Plantago lanceolata*	Lamb's Tongue	2	1	3	2	1			
	Rumex sp.	-	1			3				
C S	*Rytidosperma tenuius*	Wallaby Grass						3		
C S	*Solanum prinophyllum*	Forest Nightshade	2							2
	Total native species	14								
	Total exotic species	3								
	Total CPW species	13								
	Total SSTF species	7								

Quadrat 4

Transect 4

Sample Site 8 For location, see Figures D1, D2 and D4

Status	Species name	Common name	Q	0	10	20	30	40	50	60
C	*Aristida ramosa*	Purple Wire Grass					3	3	2	3
C S	*Aristida vagans*	Three-awn Spear Grass	2							
C	*Asperula conferta*	Common Woodruff	1							
	Calotis dentex	-	1		1					
C S	*Cheilanthes sieberi*	Poison Rock Fern	1					1		1
C	*Chloris ventricosa*	Plump Windmill Grass	1							
C S	*Daviesia ulicifolia*	Gorse Bitter Pea	1							
	Dianella revoluta var. *revoluta*	-	1							
C	*Dichelachne micrantha*	Short-hair Plume Grass	2							
C	*Dichondra repens*	Kidney Weed	3	1	2	2	2	2		1
C	*Eragrostis leptostachya*	Paddock Love Grass	1							
C S	*Eucalyptus paniculata*	Grey Ironbark	4	2	3	2	2	4	2	3
C S	*Glycine clandestina*	-	2				1	2		
S	*Hibbertia diffusa*	Wedge Guinea Flower	1							
*	*Hypericum perforatum*	St. John's Wort				1				
	Lepidosperma gunnii	-				1				
S	*Leucopogon juniperinus*	Prickly Beard-heath	1						2	2
	Lissanthe strigosa	Peach Heath				2	2	1		
S	*Lomandra filiformis* subsp. *coriacea*	Wattle Mat-rush	2							
C	*Lomandra multiflora*	Many-flowered Mat-rush	2						3	1
C S	*Microlaenea stipoides*	Weeping Grass	3		1		1			1
C	*Oxalis perennans*	-	1							
	Pittosporum multiflorum	Orange Thorn			1					
*	*Plantago lanceolata*	Lamb's Tongue	3	1	2	2	2	2	2	
C	*Plectranthus parviflorus*	Cockspur Flower		2						
C	*Pultenaea microphylla*	-							1	1
C S	*Rytidosperma tenuius*	Wallaby Grass	3	3	3	3	3			2
*	*Senecio madagascariensis*	Fireweed			1					
C S	*Solanum prinophyllum*	Forest Nightshade	2							
	Total native species	26								
	Total exotic species	3								
	Total CPW species	18								
	Total SSTF species	11								

Quadrat 5

Transect 5

Sample Site 6 For location, see Figures D1, D2 and D4

Status	Species name	Common name	Q	0	10	20	30	40	50	60
	Acacia floribunda	White Sally Wattle						3		
	Acacia mearnsii	Black Wattle	3							
	Acmena smithii	Lilly Pilly	4	5	5	3	3			3
	Adiantum sp.	Mainderhair Fern	1							
C S	*Bursaria spinosa*	Blackthorn	1					1		
	Calotis dentex	-	2							
	Cassinia quinquefaria	-	2							
	Cayratia clematidea	Native Grape	2							
	Centella cordifolia	-	2							
C	*Commelina cyanea*	Wandering Jew	2							
	Correa reflexa	Common Correa	2				2	1		
C	*Cyperus gracilis*	Slender Flat-sedge	2							
	Dianella caerulea	Blueberry Lily	1							
C	*Dichondra repens*	Kidney Weed	2							
	Entolasia marginata	Bordered Panic	2							
S	*Entolasia stricta*	Wiry Panic	3		2		3	2		1
	Eucalyptus piperita	Sydney Peppermint	3							
C S	*Eucalyptus punctata*	Grey Gum	3			2	2	2	3	
S	*Exocarpos strictus*	Pale-fruit Ballart	1							
	Hovea longifolia	Rusty Pods	1							
S	*Kunzea ambigua*	Tick Bush					1			
S	*Lepidosperma laterale*	-	2	1			2			1
	Lindsaea microphylla	Lacy Wedge Fern	1							
S	*Lomandra longifolia*	Spiny-headed Mat-rush	2	1		3				2
	Maytenus silvestris	Narrow-leaved Orangebark							2	2
	Melaleuca linariifolia	Flax-leaved Paperbark	3	3	3	3		2		1
C S	*Microlaenea stipoides*	Weeping Grass	1							
	Notelaea longifolia	Large Mock-olive	2	1			2	1		
S	*Ozothamnus diosmifolius*	White Dogwood	1							
	Pellaea falcata	Sickle Fern	2	1		3				
S	*Persoonia linearis*	Narrow-leaved Geebung						1		
C	*Plectranthus parviflorus*	Cockspur Flower	2							
	Podolobium ilicifolium	Prickly Shaggy Pea	1							
	Pyrrosia rupestris	Rock Felt Fern	2							
C S	*Rytidosperma tenuius*	Wallaby Grass	2							
	Zieria smithii	Sandfly Zieria	2					1		
	Total native species	36								
	Total exotic species	0								
	Total CPW species	8								
	Total SSTF species	11								

Quadrat 6

Transect 6

Sample Site 7 For location, see Figures D1, D2 and D4

Status	Species name	Common name	Q	0	10	20	30	40	50	60
	Anisopogon avenaceus	Oat Spear Grass						1		
C	*Bothriochloa macra*	Red Grass	1							
*	*Cirsium vulgare*	Spear Thistle	2							
*	*Conyza bonariensis*	Flaxleaf Fleabane				1				
C	*Cyperus gracilis*	Slender Flat-sedge	1							1
C	*Dichondra repens*	Kidney Weed	2						1	
C	*Einadia polygonoides*	-	1						1	
C S	*Einadia trigonos*	Fishweed	1	1						
*	*Eleusine tristachya*	Goose Grass	1							
C	*Eragrostis leptostachya*	Paddock Love Grass	1							
C S	*Eucalyptus paniculata*	Grey Ironbark		3						
C S	*Eucalyptus terticornis*	Forest Red Gum						1	5	
C	*Juncus usitatus*	-	1							
**	*Lycium ferocissimum*	African Boxthorn		2	2				3	
C S	*Microlaenea stipoides*	Weeping Grass	3			4	3	4	2	4
*	*Modiola carolina*	Red-flowered Mallow	2							
C	*Oxalis perennans*	-	1							
*	*Paronychia brasiliana*	Chilean Whitlow Wort		1						
*	*Paspalum dilatatum*	Paspalum	2			3	3			
*	*Pennisetum clandestinum*	Kikuyu Grass	4	5	4				2	
*	*Plantago lanceolata*	Lamb's Tongue	2			1			1	
*	*Senecio madagascariensis*	Fireweed	2							2
*	*Sida rhombifolia*	Paddy's Lucerne	1						3	
C S	*Sporobolus creber*	Western Rat-tail Grass	1							
	Total native species	13								
	Total exotic species	11								
	Total CPW species	12								
	Total SSTF species	5								

Quadrat 7

Transect 7

Sample Site 8 For location, see Figures D1, D2 and D4

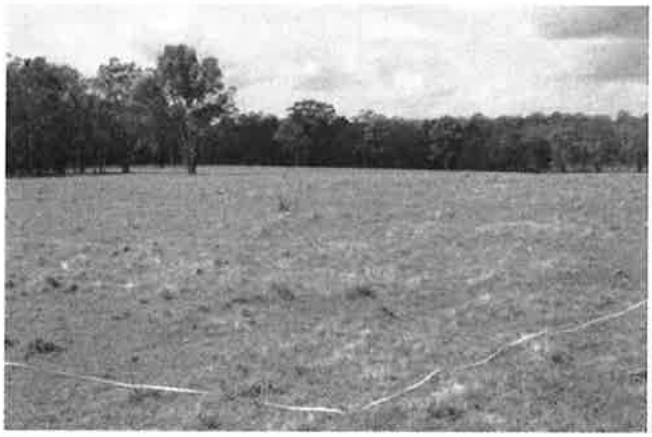
Status	Species name	Common name	Q	0	10	20	30	40	50	60
C	*Cyperus gracilis*	Slender Flat-sedge	1							
*	*Gamochaeta purpurea*	Purple Cudweed		1						
*	*Hypochaeris radicata*	Cats-ear						1		
C S	*Microlaenea stipoides*	Weeping Grass	3	3	3	3	3	3	3	4
C	*Oxalis perennans*	-	1	1						
*	*Paspalum dilatatum*	Paspalum	4	4	3	4	3	3	4	2
*	*Plantago lanceolata*	Lamb's Tongue	1							
*	*Senecio madagascariensis*	Fireweed	3		1	2	2	1	1	1
C S	*Sporobolus creber*	Western Rat-tail Grass	1							
	Total native species	4								
	Total exotic species	5								
	Total CPW species	4								
	Total SSTF species	2								

Quadrat 8

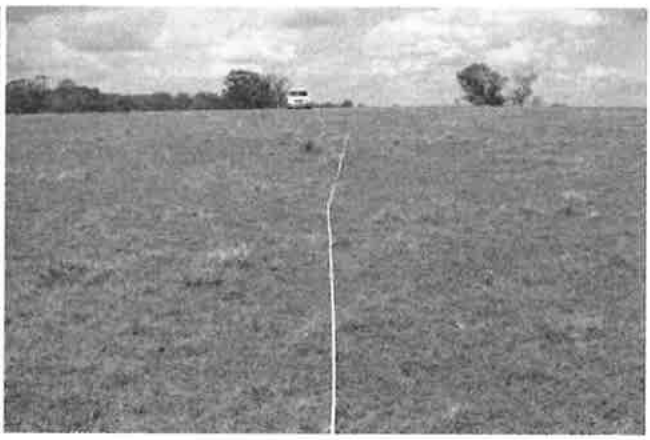
Transect 8

Sample Site 13 For location, see Figures D1, D2 and

Status	Species name	Common name	Q	0	10	20	30	40	50	60
C	*Dichondra repens*	Kidney Weed	1							
C	*Eragrostis leptostachya*	Paddock Love Grass	1							
C	*Juncus usitatus*	-	1							
C S	*Microlaenea stipoides*	Weeping Grass	6	5	6	6	6	4	5	6
*	*Paspalum dilatatum*	Paspalum	1	1				3		1
*	*Senecio madagascariensis*	Fireweed	1							
	Total native species		4							
	Total exotic species		2							
	Total CPW species		4							
	Total SSTF species		1							



Quadrat 9



Transect 9

Sample Site 10 For location, see Figures D1, D2 and D4

Status	Species name	Common name	Q	0	10	20	30	40	50	60
C	*Bothriochloa macra*	Red Grass					1	1		
C S	*Cheilanthes sieberi*	Poison Rock Fern	2							
*	*Cirsium vulgare*	Spear Thistle	1							
C	*Cyperus gracilis*	Slender Flat-sedge	1						1	
C	*Dichondra repens*	Kidney Weed	1						1	
C S	*Einadia trigonos*	Fishweed	1							
C	*Eragrostis leptostachya*	Paddock Love Grass	1							
*	*Gamochaeta purpurea*	Purple Cudweed	1							
C	*Geranium solanderi*	Native Geranium		1						
*	*Hypochaeris radicata*	Cats-ear					1		1	1
C	*Juncus usitatus*	-	1							
C S	*Microlaenea stipoides*	Weeping Grass	3	3	3	2		1	2	3
C	*Oxalis perennans*	-	1							1
*	*Paspalum dilatatum*	Paspalum	3	3	3	5	5	6	5	5
*	*Plantago lanceolata*	Lamb's Tongue	2	2	1				1	2
	Schoenus apogon	Common Bog-rush								2
*	*Senecio madagascariensis*	Fireweed	2							
*	*Sida rhombifolia*	Paddy's Lucerne	1							
C S	*Sporobolus creber*	Western Rat-tail Grass	3				1			
*	*Verbena bonariensis*	Purpletop	1		2			1	1	1
*	*Vulpia myuros*	Rat's Tail Fescue				1		2	2	
	Total native species	12								
	Total exotic species	9								
	Total CPW species	10								
	Total SSTF species	4								

Quadrat 10

Transect 10

cumberland ecology

9 November 2016

Gerry Beasley
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FURTHER ADDITIONAL INFORMATION FOR PROPOSED DEVELOPMENT ON WALKER CORPORATION LANDS AT WILTON (OPTION C)

Dear Gerry,

The purpose of this letter is to provide additional information in response to the latest discussions held with the NSW Office of Environment and Heritage (OEH) about the proposed development of Walker Corporation lands at Wilton. The residual matters outlined by OEH relate to the following:

- Amendments to the development footprint;
- Assessment of grassland;
- Assessment of red flag areas; and
- Assessment of the Koala in relation to the latest report released by Wollondilly Shire Council.

Appendix A provides our response to these matters. If you have any queries regarding our response, please do not hesitate to contact either myself or

Yours sincerely

Dr David Robertson
Director

Appendix A

Response to OEH Matters

A.1 Introduction

The purpose of this letter is to provide a response to the latest discussions held with the NSW Office of Environment and Heritage (OEH) about the proposed development of Walker Corporation lands at Wilton (the 'subject land'). The residual matters outlined by OEH relate to the following:

- Amendments to the development footprint;
- Assessment of grassland;
- Assessment of red flag areas; and
- Assessment of the Koala in relation to the latest report released by Wollondilly Shire Council.

Each section below addresses the latest matters raised by OEH in their discussions held with Walker Corporation. Figures referred to in the following sections are contained within **Appendix B**.

A.2 Amendments to the Development Footprint

An amendment to the development footprint has been proposed by Walker Corporation following advice from OEH. **Figure 1** shows the location of the amended development footprint. The amendments have been designed to maximise the retention of highly connected woodland/forest vegetation, including along the corridor located in the south eastern portion of the subject land and additional Cumberland Shale Plains Woodland.

The proposed amendments will increase the width of a highly connected corridor, as well as increase the width through rehabilitation of adjoining grassland areas (**Figure 1**, point A). In addition to these amendments, and similar to the previous development footprint, a peninsular of vegetation to the west of the corridor will be partially retained to create a riparian corridor (**Figure 1**, point B).

Table 1 summarises the extent of vegetation clearing and modification for the amended development footprint, including the number of credits required under BCAM. The development footprint shown in **Figure 1** incorporates the required asset protection zones (APZs). The amended footprint will retain an additional 11.35 ha of Cumberland Plain Woodland (woodland form) and 0.83 ha of Cumberland Shale Sandstone Transition Forest within the conservation area. Approximately 75% of Cumberland Shale Plains Woodland (woodland form) occurring within the subject land will be retained within the conservation area. Approximately 99% of Cumberland Shale Sandstone Transition Forest occurring within the subject land will be retained within the conservation area.

Table 1 Vegetation communities and credit values for the amended development footprint and conservation area

Vegetation Community	Subject Land (ha)	Development Footprint (ha)	% Cleared/Modified within Subject Land	Conservation Area (ha)	Credits Required for Development Footprint and APZ	Credits Generated within Conservation Area
Cumberland Shale Plains Woodland	59.41	14.80	24.91	44.62	439	362
Cumberland Shale Sandstone Transition Forest	84.81	0.71	0.83	84.10	22	716
Sydney Hinterland Transition Woodland	19.12	0.02	0.13	19.10	1	158
Hinterland Sandstone Gully Forest	6.17	0.00	0.00	6.17	0	62
Derived Native Grassland*	8.04	6.50	80.75	1.55	95	17
Low Diversity Native/Exotic Grassland	252.53	248.74	98.50	3.80	0	0
TOTAL	430	271	63	159	557	1,315

** Due to absence of plot data collected using field survey methodologies described within BCAM, indicative data has been used for Derived Native Grassland based on data provided by Anne Clements & Associates.*

A.3 Assessment of Grassland

In areas where the original forest has been cleared for farming mapping of the subject land has delineated a map unit that is a mixture of derived native grassland and exotic grassland vegetation. OEH has requested that this mapping be refined and if necessary split to indicate the extent of derived native grassland. It is our understanding that a new method for identifying derived native grassland has been developed, however such methodology has not been provided to assess the grasslands within the subject land. As such, refinement of the mapping of these areas has utilised quadrat data collected by Cumberland Ecology and Anne Clements & Associates (ACA) (see **Appendix C**), and vegetation notes collected by Cumberland Ecology during traverses of the subject land.

The subject land occurs within a landscape that has been cleared or modified historically for agricultural purposes. Much of the grassland within the subject land is modified to varying degrees by past clearing and ongoing agricultural practices for grazing. However, additionally, the land has been used for irrigation using saline waters from underground mining and this has

helped to produce an unusual and simplified (depauperate) grassland flora. Consequently, most areas of grassland contain a very low diversity of native species with many areas dominated by exotic species or co-dominated by a few hardy native grasses and exotic pasture grasses, with such plants as native daisies, lilies, orchids and other plants completely absent.

In the latest analysis of vegetation within the subject land, the grassland and agricultural areas have been re-mapped into the following categories (see **Figure 1**):

- Derived Native Grassland (8.04 ha); and
- Low Diversity Native/Exotic Grassland (252.53 ha).

As is shown on **Figure 2**, Low Diversity Native/Exotic Grassland dominates the grassland areas within the subject land.

Derived Native Grassland has been assessed as a grassland form of Cumberland Shale Plains Woodland. The grassland form of this community is included within the listing of the community as a critically endangered ecological community under the NSW *Threatened Species Conservation Act 1995*. Whilst agricultural practices have been undertaken in the mapped extent of Derived Native Grassland, they occur in proximity to woodland patches that could provide a seed source for trees, shrubs and other species.

Low Diversity Native/Exotic Grassland is not considered to conform to any threatened ecological communities listed under the TSC Act. Based on the results of this assessment, including review of historic aerials and analysis of survey data, this map unit is not considered to be capable of natural regeneration. For the majority of areas within this map unit, the natural soil and associated seed bank has been highly modified as a result of land use practices, including irrigation with saline mine waters. Notable factors that have had a significant negative influenced the capability for natural regeneration include soil disturbance and soil enrichment, both of which has occurred within the subject land. There are some areas within Low Diversity Native/Exotic Grassland where native grasses dominate, however surveys have indicated that these areas contain few native non-grass species.

Table 2 summarises the key descriptors for these two grassland units.

Table 2 Key descriptors for grassland units

Map Unit	Key Descriptors
Derived Native Grassland	Typically adjoining intact or regenerating woodland
	Dominated by native grasses such as *Themeda triandra*
	Diversity of native grass and non-grass species in the ground layer
	Contain evidence or canopy and/or understorey regeneration
	Low exotic plant cover
Low Diversity Native/Exotic	Pasture improved land with limited proximity to intact woodland

Table 2 Key descriptors for grassland units

Map Unit	Key Descriptors
Grassland	Land currently used for grazing and until recent times used for irrigation with saline mine waters.
	Dominated or co-dominated by exotic grasses such as *Paspalum dilatatum* and *Phalaris aquatica*
	Dominated or co-dominated by native grasses such as *Bothriochloa macra* and *Microlaena stipoides*
	Few native understorey species and often in low abundances
	Canopy only present in the form of widely scattered paddock trees
	Few logs and cut stumps

A.4 Consideration of Red Flag Areas

A.4.1 Introduction

Should development of the subject land be assessed using the *Biodiversity Certification Assessment Methodology* (BCAM), there would be a requirement to address red flag matters. Red flag matters are biodiversity constraints of significance that prevent development and offsetting unless the red flag is varied with the consent of the Director General of OEH.

Two of the vegetation communities occurring within the subject land, namely Cumberland Shale Plains Woodland (woodland form) and Cumberland Shale Sandstone Transition Forest, are red flag areas as they both comprise:

- A vegetation type that is greater than 70% cleared as listed in the Vegetation Types Database (that is, has 30% or less remaining of its estimated distribution in the catchment management authority (CMA) area before the year 1750), and the vegetation is not in low condition; and
- A critically endangered or endangered ecological community listed under the TSC Act or EPBC Act, and the vegetation is not in low condition.

Conferral of biodiversity certification can occur within land that directly impacts biodiversity values within red flag areas provided that the Director General is satisfied, following consideration of specific criteria, that the impacts on the red flag area are offset in accordance with the rules and requirements. The criteria that need to be considered by the Director General include the following:

- Section 2.4.1 of BCAM: Feasibility of options to avoid impacts on red flag area(s) where biodiversity certification is conferred; and

- Section 2.4.2 of BCAM: Additional assessment criteria for vegetation types.

A discussion of how these criteria may be addressed should the project proceed using BCAM is provided below.

A.4.2 Feasibility of Avoidance Measures

The subject land forms part of the planning proposal for the Wilton Junction New Town Project which was initiated between four landowners following a Council resolution in May 2012. The masterplan developed for the Wilton Junction New Town Project is designed to deliver high quality new housing, jobs close to home, social and utilities infrastructure and services, and a range of complementary land uses (including open space and biodiversity conservation). Subsequent to the initiation of the planning proposal, the NSW Department of Planning and Environment released the *Greater Macarthur Preliminary Land Release Strategy*, which includes the Greater Macarthur Land Release Investigation Area within which the subject land occurs.

Any avoidance measures proposed within the subject land are required to take into account the masterplan for the Wilton Junction New Town Project. Whilst some portions of the red flag areas are contained within 'open space' areas on the masterplan, there are a number of areas designated for urban development, including the provision of road infrastructure. Despite this, proposed amendments to the layout of the development footprint within the subject land, have sought to avoid, where possible, highly connected areas of Cumberland Shale Plains Woodland and Cumberland Shale Sandstone Transition Forest. The amended footprint will retain an additional 11.35 ha of Cumberland Plain Woodland (woodland form) and 0.83 ha of Cumberland Shale Sandstone Transition Forest within the conservation area.

Despite the need to clear some red flag areas, large areas of Cumberland Shale Plains Woodland and Cumberland Shale Sandstone Transition Forest would be retained and conserved under the amended development footprint.

A.4.3 Additional Assessment Criteria

i. Viability of the Red Flag Area

The subject land is currently zone RU2 Low Density Residential under the *Wollondilly Local Environment Plan 2011*. The red flag areas within the subject land adjoin extensive areas of land that have been subject to agricultural practices. As noted above, a masterplan has been developed for the Wilton Junction New Town Project, which encompasses the subject land. Additionally, the subject land forms part of the Greater Macarthur Land Release Investigation Area.

In making an assessment that the viability of biodiversity values in the red flag area is low or not viable, the Director General must be satisfied that one of the factors outlined in Section 2.4.2.1 of BCAM is met. The below sections outline which of the criteria is considered satisfied for Cumberland Shale Plains Woodland and Cumberland Shale Sandstone Transition Forest.

a. Cumberland Shale Plains Woodland

The red flag area most impacted by the proposed development of the subject land is Cumberland Shale Plains Woodland. This community occurs in both woodland and grassland form, however the grassland form has been assessed as low condition (site value score <34) and therefore does not form a red flag area. This assessment of the viability of the Cumberland Shale Plains Woodland red flag area impacted by the development considers that the following criterion applies:

> *a) The current or future uses of land surrounding the red flag area where biodiversity certification is to be conferred reduce its viability or make it unviable. Relatively small areas of native vegetation surrounded or largely surrounded by intense land uses, such as urban development, can be unviable or have low viability because of disturbances from urbanisation, including edge effects.*

Due to the location of Cumberland Shale Plains Woodland on the more favourable farming areas of the subject land, the occurrence of the woodland form of the community is either in fragmented patches or patches that have a higher edge-to-area ratio. As a result of the proximity to agricultural areas, in conjunction with increased edge-to-area ratios, the viability of the Cumberland Shale Plains Woodland vegetation within the subject land has been reduced. Ongoing agricultural activities under the current land zoning have the potential to further reduce the viability of this community within the subject land.

Of the Cumberland Shale Plains Woodland within the subject land, the portions of proposed to be cleared or modified represent the most disturbed areas of this community. Approximately 45 ha of Cumberland Shale Plains Woodland will be retained and managed within the conservation area in the subject land.

b. Cumberland Shale Sandstone Transition Forest

This assessment of the viability of the Cumberland Shale Sandstone Transition Forest red flag area impacted by the development considers that the following criterion applies:

> *d) The area of a vegetation type in a red flag area on land where biodiversity certification is conferred is minor relative to the area containing that vegetation type on land subject to proposed conservation measures.*

The other red flag area within the subject land comprises Cumberland Shale Sandstone Transition Forest. This community is somewhat buffered from the agricultural land by other native vegetation. The area of Cumberland Shale Sandstone Transition Forest to be removed/modified within the subject land (0.71 ha) is minor relative to the area of the community within the conservation lands (84.10 ha).

ii. Contribution to Regional Biodiversity Values

Mapping by Tozer et al (2011) was examined to determine the extent of Cumberland Shale Plains Woodland and Cumberland Shale Sandstone Transition Forest within the region, which includes the CMA subregion in which the subject land occurs and any adjoining CMA

subregions. The subject land is located within the Cumberland CMA subregion and is adjoined by Burrgorang, Pittwater, Sydney Cataract, Wollemi and Yengo CMA subregions. Whilst Tozer et al (2011) mapping does not cover the entirety of these subregions, there is sufficient data to provide an indication of the regional abundance of the relevant vegetation types and percent remaining in the region.

Table 3 summarises the extent of Cumberland Shale Plains Woodland and Cumberland Shale Sandstone Transition Forest within the region. Cumberland Shale Plains Woodland occupies at least 6,763 ha within the region, of which 0.219% will be cleared/modified within the subject land. Cumberland Shale Sandstone Transition Forest occupies at least 9,632 ha within the region, of which 0.007% will be cleared/modified within the subject land. The percent native vegetation remaining of all woody native vegetation cover in the region is high, with only 0.003% being cleared/modified within the subject land.

Table 3 Extent of red flag communities within the region*

Vegetation Types	Cumberland Subregion	Burragorang Subregion	Pittwater Subregion	Sydney Cataract Subregion	Wollemi Subregion	Yengo Subregion	Grand Total in Region	Cleared / Modified within Subject Land	% Cleared / Modified in Region
Cumberland Shale Plains Woodland	6,574	4		9	0	176	6,763	14.80	0.219
Cumberland Shale Sandstone Transition Forest	6,859	453	15	585	117	1,604	9,632	0.71	0.007
All Woody Vegetation Types	43,348	192,557	36,624	130,225	136,749	24,398	563,901	15.53	0.003

** Values do not include extents that occur outside mapping prepared by Tozer et al (2011)*

A.5 Assessment of the Koala

A recent baseline study of Koalas was undertaken within the Wollondilly Shire by Coleman (2016). The study included surveys of the Koala over four nights in April and May 2016, with both direct (spotlighting) and indirect (habitat assessment, scratches, scats) methods utilised. A total of 58 sites were surveyed, with direct records of the Koala at six sites, indirect records of the Koala at five sites, and two records off site. The study also documented the extent of habitat within the Wollondilly Shire based on vegetation communities. By extrapolating the number of records by the extent of habitat, it is estimated that the 41,313 ha of habitat within the Wollondilly Shire could support approximately 2,623 Koalas.

A total of five sites were surveyed within the Wilton area (extent not defined within report). No Koalas were detected at these sites. One record of the Koala is mapped as occurring to the

south of the subject land within the Upper Nepean State Conservation Area, however it is not known if this record represents a direct or indirect record.

Amendments to the layout of the development footprint within the subject land have been proposed, which has altered the extent of potential Koala habitat impacted. **Table 4** summarises the extent of Koala habitat within the subject land as defined by Coleman (2016). A total of 169.52 ha of habitat is mapped as occurring within the subject land, of which 15.53 ha will be cleared/modified by the proposed development.

Colman (2016) indicates that vegetated corridors within the Wollondilly Shire are likely candidates for the movement of Koalas across the landscape. The report refers to an example of the woodland corridors in Wilton; however it does not specifically indicate the location on a map. The amended development footprint has sought to maximise the retention of highly connected woodland/forest vegetation along the corridor location in the south eastern portion of the subject land.

The findings of the study are not considered to result in a change in the assessment of Koalas within the subject land. As previously reported, the subject land provides potential habitat for the Koala. The amendments to the development footprint have increased the width of the potential movement corridor in the south east of the subject land, which occurs within the mapped extent of Koala Habitat Linkage by OEH.

Table 4 Extent of Koala habitat within the subject land as defined by Coleman (2016)

Vegetation Community	Area within Wollondilly Shire	Area within Walker Corporation Lands (ha)	Area Cleared / Modified within Walker Corporation Lands (ha)	% Cleared / Modified within Walker Corporation Lands	% Cleared / Modified within Wollondilly Shire
Cumberland Shale Plains Woodland	222	59.41	14.80	24.91	6.67
Cumberland Shale Sandstone Transition Forest	5,106	84.81	0.71	0.83	0.01
Sydney Hinterland Transition Woodland	15,414	19.12	0.02	0.13	0.00
Hinterland Sandstone Gully Forest	15,136	6.17	0.00	0.00	0.00
Other	5,434*	0.00	0.00	0.00	0.00
TOTAL	41,313	169.52	15.53	9.16	0.04

A.6 Conclusion

The Walker Corporation lands at Wilton contain 430 ha of which approximately 59% is cleared and is proposed for development. The remaining 41% contain 169.52 ha of native woodland/forest vegetation (both connected and fragmented), most of which will be retained and managed for in perpetuity within a conservation area. The amended development footprint will result in the loss of 9.16% of the woodland/forest vegetation within the subject land. However this loss will be from areas which, if retained, would suffer from significant exposure due to edge effects.

The current masterplan for the Wilton Junction New Town Project would result in a development footprint that reduces the width of a vegetated corridor extending along the eastern boundary of the subject land and retaining a pocket of vegetation to the west of this corridor that is completely surrounded by development. The proposed amendments to the development footprint have sought to maximise the retention of highly connected woodland/forest vegetation along the corridor location in the south eastern portion of the subject land and additional areas of Cumberland Shale Plains Woodland (woodland form). The amended footprint will retain an additional 11.35 ha of Cumberland Plain Woodland (woodland form) and 0.83 ha of Cumberland Shale Sandstone Transition Forest within the conservation area.

Whilst the majority of the amended development footprint comprises Low Diversity Native/Exotic Grassland, some areas of Cumberland Shale Plains Woodland, Cumberland Shale Sandstone Transition Forest and Derived Native Grassland will be impacted. Both Cumberland Shale Plains Woodland and Cumberland Shale Sandstone Transition Forest would be required to be assessed as red flag areas under the rules of BCAM. Due to the potential future reduction in viability of Cumberland Shale Plains Woodland and the minimal amount of Cumberland Shale Sandstone Transition Forest being removed compared to the extent being retained, it is considered that an application for a red flag variation can be made to the Director General of OEH.

The findings of the recent study of the Koala within the Wollondilly Shire are not considered to result in a change in the assessment of Koalas within the subject land. The amendments to the development footprint have increased the width of the potential movement corridor in the south east of the subject land, which occurs within the mapped extent of Koala Habitat Linkage by OEH.

A.7 References

Coleman, N. J. (2016) *Baseline Survey of Koalas in Wollondilly Shire*

DECCW (2011) *Biodiversity Certification Assessment Methodology.* Department of Environment, Climate Change and Water NSW, Sydney South

Tozer, M. G., Turner, K., Keith, D. A., Tindall, D., Pennay, C., Simpson, C., MacKenzie, B., Beukers, P. and Cox, S. (2010). "*Native vegetation of southeast NSW: a revised classification and map for the coast and eastern tablelands.*" Cunninghamia 11(3): 359-406.

Appendix B

Figures

Figure 1. Location of amended development footprint

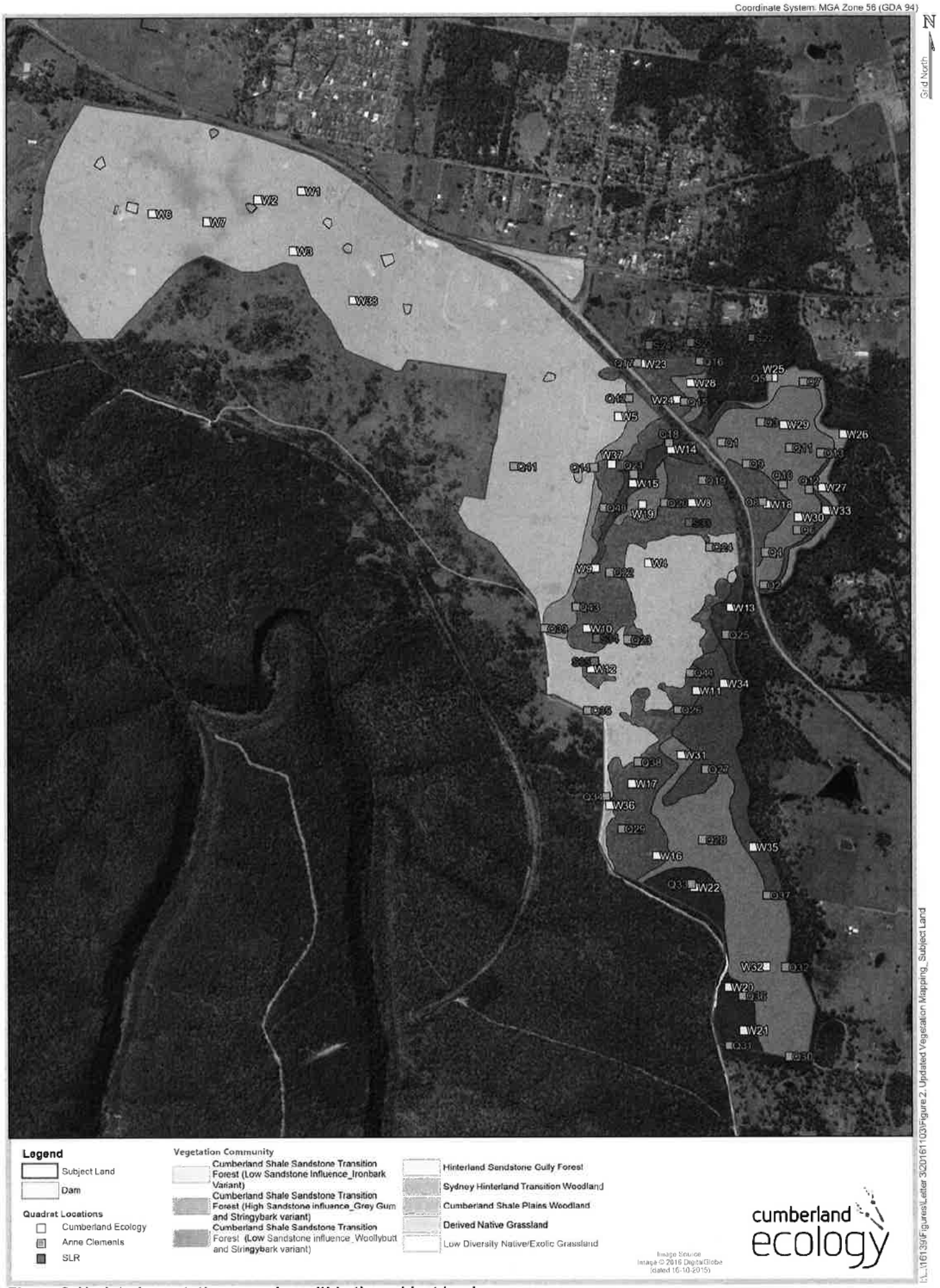

Figure 2. Updated vegetation mapping within the subject land

Appendix C

Grassland Quadrat Data

Table 5 Cumberland Ecology grassland quadrat data

Family	*	Scientific Name	Common Name	W01	W02	W03	W04	W05	W06	W07	W38	W38
				C/A	C/A	C/A	C/A	C/A	C/A	C/A	C	A
Non-grass Herbs (dicots)												
Asteraceae	*	*Cirsium vulgare*	Spear Thistle	1		1	1				0.25	1
Asteraceae	*	*Conyza bonariensis*	Flaxleaf Fleabane	2			1		1	1	0.5	100
Asteraceae	*	*Gamochaeta americana*	-	1				1				
Asteraceae	*	*Hypochaeris glabra*	Smooth Cats-ear				1	5				
Asteraceae	*	*Hypochaeris radicata*	Cats-ear	2	1	2			2	1	0.5	50
Asteraceae	*	*Senecio madagascariensis*	Fireweed	5	4	1			1	1	0.25	2
Clusiaceae		*Hypericum gramineum*	Small St. John's Wort	1								
Clusiaceae	*	*Hypericum perforatum*	St. John's Wort					2				
Convolvulaceae		*Dichondra repens*	Kidney Weed				1					
Fabaceae	*	*Trifolium subterraneum*	Subterranean Clover				1					
Gentianaceae	*	*Centaurium tenuiflorum*	-	1	1	1	1	2		1		
Haloragaceae		*Gonocarpus tetragynus*	Common Raspwort				1					
Malvaceae	*	*Modiola caroliniana*	Red-flowered Mallow	1								
Malvaceae	*	*Sida rhombifolia*	Paddy's Lucerne	1								
Myrsinaceae	*	*Anagallis arvensis*	Scarlet Pimpernel	1	1		1	1				
Oxalidaceae		*Oxalis perennans*	-	1		1		1	1	1	0.25	1
Phyllanthaceae		*Poranthera microphylla*	Small Poranthera				1					

Table 5 Cumberland Ecology grassland quadrat data

Family	*	Scientific Name	Common Name	W01	W02	W03	W04	W05	W06	W07	W38	W38
				C/A	C/A	C/A	C/A	C/A	C/A	C/A	C	A
Plantaginaceae	*	*Plantago lanceolata*	Lamb's Tongue				5	2	1			
Polygalaceae	*	*Polygala virgata*	-								0.25	1
Polygonaceae		*Rumex brownii*	Swamp Dock						1	1		
Verbenaceae	*	*Verbena bonariensis*	Purpletop						1			
Herbs (monocots)												
Cyperaceae		*Carex appressa*	Tall Sedge					1				
Cyperaceae		*Carex inversa*	Knob Sedge	1	2	1			1	2	1	500
Cyperaceae		*Fimbristylis dichotoma*	Common Fringe-sedge				1					
Juncaceae		*Juncus subsecundus*	Finger Rush	1	5		1	1				
Linaceae	*	*Linum trigynum*	French Flax				1	1				
Poaceae		*Aristida vagans*	Threeawn Speargrass					1				
Poaceae	*	*Axonopus fissifolius*	Narrow-leaved Carpet Grass				2	1				
Poaceae		*Bothriochloa macra*	Red-leg Grass	5			1	2	5	5	2	100
Poaceae	*	*Bromus molliformis*	-	1								
Poaceae		*Cymbopogon refractus*	Barbed Wire Grass				1					
Poaceae	*	*Cynodon dactylon*	Common Couch	2			1	1		1		

cumberland ecology

Table 5 Cumberland Ecology grassland quadrat data

Family	*	Scientific Name	Common Name	W01	W02	W03	W04	W05	W06	W07	W38	W38
				C/A	C/A	C/A	C/A	C/A	C/A	C/A	C	A
Poaceae	*	*Eragrostis curvula*	African Lovegrass						2			
Poaceae		*Eragrostis leptostachya*	Paddock Lovegrass						1		2	100
Poaceae		*Lachnagrostis filiformis*	Blown Grass				1		1			
Poaceae	*	*Lolium rigidum*	-	1	1	1						
Poaceae		*Microlaena stipoides*	Weeping Grass	2	5	5		1	2	2	30	2000
Poaceae	*	*Paspalum dilatatum*	Paspalum	7	7	25	4	4	6	5	45	2000
Poaceae	*	*Phalaris aquatica*	Harding Grass				5				1	50
Poaceae		*Rytidosperma racemosum*	-	5						1	0.5	50
Poaceae	*	*Setaria parviflora*	Slender Pigeon Grass								5	200
Poaceae		*Sporobolus creber*	Western Rat-tail Grass	1	2	2	1	5		1	0.25	20
Poaceae	*	*Stenotaphrum secundatum*	Buffalo Grass	1	25							
Poaceae		*Themeda triandra*	Kangaroo Grass			5	1	5		1	2	100
Poaceae	*	*Vulpia bromoides*	Brome Fescue	1								
Vines/Climbers												
Fabaceae		*Desmodium varians*	-					1				
Fabaceae		*Glycine tabacina*	-				1		1			
Rosaceae	*	*Rubus fruticosus*	Blackberry	2								

Botanical name	Common name	Sampling location																					
		Q24	Q25	Q26	Q27	Q28	Q29	Q30	Q31	Q32	Q33	Q34	Q35	Q36	Q37	Q38	Q39	Q40	Q41	Q42	Q43	Q44	A	B
1. Pteridophytes																								
Adiantaceae																								
Adiantum aethiopicum	Common Maidenhair Fern				2			1						2										X
Adiantum hispidulum	Rough Maidenhair Fern																						X	
Aspleniaceae																								
Asplenium flabellifolium	Necklace Spleenwort, Necklace Fern																						X	
Blechnaceae																								
Blechnum cartilagineum	Gristle Fern																						X	
Doodia aspera	Prickly Rasp Fern		2																					
Dennstaedtiaceae																								
Pteridium esculentum	Bracken		1		2																		X	
Dicksoniaceae																								
Calochlaena dubia	Rainbow Fern, False Bracken																						X	
Osmundaceae																								
Todea barbara	King Fern																						X	
Sinopteridaceae																								
Cheilanthes sieberi	Rock Fern		2	1	1			2	2	1	3	4		3	2	2		2			4	4		
3. Dicotyledons																								
Acanthaceae																								
Brunoniella australis	Blue Trumpet, Blue Yam		1	4			4		2		3			1		4					4	2		
Brunoniella pumilio	Dwarf Blue Trumpet				2	2		1							2									
Pseuderanthemum variabile	Pastel Flower		1					1															X	
Apiaceae																								
Centella asiatica	Indian Pennywort																							
* Cyclospermum leptophyllum	Slender Celery																							
Daucus sp.																1								
Hydrocotyle peduncularis														1										X
Hydrocotyle tripartita	Pennywort																							
Xanthosia tridentata	Rock Xanthosia																							
Apocynaceae																								
Parsonsia straminea	Common Silkpod, Monkey Rope																							

Botanical name	Common name	Sampling location																					
		Q24	Q25	Q26	Q27	Q28	Q29	Q30	Q31	Q32	Q33	Q34	Q35	Q36	Q37	Q38	Q39	Q40	Q41	Q42	Q43	Q44	A	B
Asclepiadaceae																								
Marsdenia suaveolens	Scented Milkvine																						X	
Tylophora barbata	Bearded Tylophora		3						1															
Asteraceae																								
* Arctotheca calendula	Capeweed												2											
Cassinia sp.																								
* Cirsium vulgare	Black Thistle, Spear Thistle	3										1	2			2		2		1		2		
* Conyza sumatrensis	Tall Fleabane																		1	2				
Coronidium scorpioides	Button Everlasting																							
Cotula australis	Common Cotula												2											
Cymbonotus lawsonianus	Bear's-ear																							
Euchiton involucratus	Star Cudweed												2											
Euchiton sp.		2																						
Euchiton sphaericus																								
* Facelis retusa		3																1	2	2		1		
* Gamochaeta pensylvanica	Spike Cudweed	1																						
* Gamochaeta spicata	Spike Cudweed	2											2					1	4	1				
* Hypochaeris radicata	Catsear, False Dandelion	3										2	1				2		4	2		2		
* Lactuca serriola	Prickly Lettuce, Compass Plant																							
Lagenophora gracilis	Slender Bottle-daisy		1		3	3	1	3	4	2	2			3	4	1		1				1		
Olearia microphylla						1																		
Olearia viscidula	Wallaby Weed, Sticky Daisy-bush		4						1					2										
Ozothamnus diosmifolius	White Dogwood		1						1															
Podolepis hieracioides									1															
Senecio hispidulus SYN var. hispidulus	Hill Fireweed, Rough Fireweed																							
* Senecio madagascariensis	Fireweed, Madagascar Ragwort	4		3			1					2	3	3		2	3		4	4		3	X	
Senecio quadridentatus	Cotton Fireweed				1																			
Senecio vagus subsp. eglandulosus	Saw Groundsel																							
Solenogyne dominii							1																	
* Soliva sessilis	Bindii, Bindi-eye, Jo-Jo																							
* Sonchus asper	Prickly Sow-thistle, Rough Milk-thistle	3											1			1	1					1		
* Sonchus oleraceus	Common Sow-thistle, Milk-thistle	4										1	2							2				
* Taraxacum officinale	Dandelion																							
Vernonia cinerea									1		1													
Vittadinia sp.	Fuzzweed											1												

Botanical name	Common name	Sampling location																					
		Q24	Q25	Q26	Q27	Q28	Q29	Q30	Q31	Q32	Q33	Q34	Q35	Q36	Q37	Q38	Q39	Q40	Q41	Q42	Q43	Q44	A	B
Campanulaceae																								
Wahlenbergia gracilis	Sprawling Bluebell		1		1		1					2		3					1			1	X	
Caryophyllaceae																								
* Paronychia brasiliana	Chilean Whitlow-wort																							
* Petrorhagia nanteuilii	Proliferous Pink												2											
* Polycarpon tetraphyllum	Four-leaf Allseed																							
* Silene gallica	French Catchfly	1										1	1											
Casuarinaceae																								
Allocasuarina littoralis	Black She-Oak		3		4	3				1	1	2			2	1					1	2		
Allocasuarina torulosa	Forest She-oak		2		3					2													X	
Chenopodiaceae																								
Einadia hastata	Berry Saltbush											1												
Einadia trigonos	Fishweed											1												
Clusiaceae																								
Hypericum gramineum	Small St Johns-wort					1					1						3		2	3				
* Hypericum perforatum	St Johns-wort																		3					
Convolvulaceae																								
Dichondra repens	Kidney-weed, Mercury Bay Weed	2		4			3	2	4		4	4		4										
Dichondra sp. A	Hairy Kidney Weed															4					2	2		
Crassulaceae																								
Crassula sieberiana	Australian Stonecrop																							
Cunoniaceae																								
Ceratopetalum gummiferum	NSW Christmas Bush																						X	
Dilleniaceae																								
Hibbertia aspera	Rough Guinea-flower		2	3	1	3		4	1	3	4			2		2		2				3		
Hibbertia diffusa	Guinea-flower		1		1	1									1	2		2			2	1		
Hibbertia riparia	Erect Guinea-flower																							
Elaeocarpaceae																								
Elaeocarpus reticulatus	Blueberry Ash			1	1																		X	
Ericaceae Styphelioideae																								
Astroloma humifusum	Cranberry Heath			1		1												1						
Leucopogon juniperinus	Long-flowered Beard-heath		4			4					1			3				1			1	2		

Botanical name	Common name	Sampling location																				
		Q24	Q25	Q26	Q27	Q28	Q29	Q30	Q31	Q32	Q33	Q34	Q35	Q36	Q37	Q38	Q39	Q40	Q41	Q42	Q43	Q44	A	B
Lissanthe strigosa	Peach Heath					1												1						
Monotoca scoparia	Prickly Broom-heath				1																			
Euphorbiaceae																								
Phyllanthus gunnii			2		1																		X	
Phyllanthus hirtellus	Thyme Spurge		1		2	3				3					3									
Poranthera microphylla	Small Poranthera		1	1	1							3		2				4			2	4		
Fabaceae Faboideae																								
Bossiaea obcordata	Spiny Bossiaea				1																			
Bossiaea prostrata	Creeping Bossiaea			1												2						2		
Daviesia ulicifolia	Gorse Bitter-pea					1					1													
Desmodium gunnii	Slender Tick-trefoil															1								
Desmodium varians	Slender Tick-trefoil											1				2						2		
Glycine clandestina	Twining Glycine		2	1	1	1	4	3	4		3	4		4		4		4			3	4		
Glycine microphylla																								
Glycine tabacina				2							3		1									1		
Hardenbergia violacea	False Sarsaparilla		1		2			1			1													
Hovea linearis	Narrow-leaf Hovea				1																			
Kennedia rubicunda	Dusky Coral-pea																							
* Lotus angustissimus	Slender Birdsfoot Trefoil												1											
* Lotus corniculatus	Birds-foot Trefoil												3											
* Medicago sp.	Medic												1											
Podolobium ilicifolium	Native Holly, Prickly Shaggy-pea																						X	
Pultenaea microphylla	Spreading Bush-pea														1									
* Trifolium dubium	Yellow Suckling Clover						1					1												
* Trifolium fragiferum	Strawberry Clover												1											
* Trifolium repens	White Clover	4																						
* Trifolium sp.	Clover																1		4					
* Trifolium subterraneum	Subterranean Clover												3						1					
Fabaceae Mimosoideae																								
Acacia decurrens	Black Wattle																							
Acacia floribunda	White Sally																						X	
Acacia implexa	Hickory Wattle		1																					
Acacia irrorata	Green Wattle													2										
Acacia longifolia	Sydney Golden Wattle		1																					
Acacia parramattensis	Parramatta Green Wattle		4	1	1	1	2	3	3	2	1		1		4	1		4			4	2		
Acacia sp.																								

Botanical name	Common name	Sampling location																					
		Q24	Q25	Q26	Q27	Q28	Q29	Q30	Q31	Q32	Q33	Q34	Q35	Q36	Q37	Q38	Q39	Q40	Q41	Q42	Q43	Q44	A	B
Acacia terminalis subsp. angustifolia	Sunshine Wattle																							
Acacia ulicifolia	Prickly Moses, Prickly Wattle					1																		
Gentianaceae																								
* Centaurium erythraea	Common Centaury																		1	2				
Geraniaceae																								
Geranium homeanum	Rainforest Cranesbill			1										1										
Pelargonium inodorum	Kopata		1																		1			
Goodeniaceae																								
Dampiera purpurea	Purple Dampiera																							
Goodenia hederacea	Ivy Goodenia					2				1	1													
Goodenia heterophylla subsp. eglandulosa	Variable Goodenia						1														2			
Scaevola aemula	Fairy Fan-flower																							
Haloragaceae																								
Gonocarpus tetragynus	Common Raspwort					2				1				1								1		
Gonocarpus teucrioides																							X	
Haloragis heterophylla	Raspwort																							
Lamiaceae																								
Ajuga australis	Native Bugle, Australian Bugle																							
Mentha diemenica	Slender Mint																							
Plectranthus parviflorus			1																					
Lauraceae																								
Cassytha glabella								1																
Cassytha pubescens	Devil's Twine, Dodder-laurel																						X	
Linaceae																								
* Linum trigynum	French Flax	2											2				4		3	4				
Lobeliaceae																								
Pratia purpurascens	Whiteroot		2			4	2	2	3	1	4	1		4										
Loganiaceae																								
Logania albiflora	Narrowleaf Logania																						X	
Logania pusilla	Tiny Logania					2																		
Loranthaceae																								
Muellerina eucalyptoides	Creeping Mistletoe																							

Botanical name	Common name	Sampling location																					
		Q24	Q25	Q26	Q27	Q28	Q29	Q30	Q31	Q32	Q33	Q34	Q35	Q36	Q37	Q38	Q39	Q40	Q41	Q42	Q43	Q44	A	B
Malvaceae																								
* Modiola caroliniana	Red-flower Mallow	1		1								1						1						
Meliaceae																								
Melia azedarach	White Cedar, Persian Lilac																							
Myrsinaceae																								
Myrsine variabilis	Muttonwood				1																			
Myrtaceae																								
Angophora floribunda	Rough-barked Apple		2															1						
Callistemon linearis	Narrow-leaved Bottlebrush														1									
Callistemon pinifolius	Pine-leaved Bottlebrush									3														X
Corymbia gummifera	Red Bloodwood				3	4				2					4									
Eucalyptus agglomerata	Blue-leaved Stringybark																							
Eucalyptus beyeriana	Beyer's Ironbark			3		1																1		
Eucalyptus crebra	Narrow-leaved Ironbark																					1		
Eucalyptus fibrosa	Red Ironbark					3					3													
Eucalyptus globoidea	White Stringybark			3		4	1	4	1	2	4			2	3	3		3			4	3		
Eucalyptus longifolia	Woollybutt						4	3	4		4			4										
Eucalyptus moluccana	Grey Box																							
Eucalyptus paniculata	Grey Ironbark					4		4	4					4										
Eucalyptus pilularis	Blackbutt		4		4										4								X	
Eucalyptus piperita	Sydney Peppermint																						X	
Eucalyptus punctata	Grey Gum		1		1	2		4		4					4									
Eucalyptus sclerophylla	Scribbly Gum																							
Eucalyptus tereticornis	Forest Red Gum			1			1					3				3		1			4	1		
Kunzea ambigua	Tick-bush		2					2		3	1			2	1			2			1	1		X
Leptospermum polygalifolium	Yellow Tea-tree, Tantoon Tea-Tree				2			1		2														X
Leptospermum trinervium	Slender Tea-tree									3														
Melaleuca decora	White Cloud Tree										2													
Melaleuca linariifolia	Flax-leaved Paperbark				2			1		1	1			1										X
Melaleuca thymifolia	Thyme Honey-myrtle									1														
Tristaniopsis laurina	Water Gum, Kanuka Box																						X	
Oleaceae																								
* Ligustrum lucidum	Broad-leaved Privet, Glossy Pribet																							
Notelaea longifolia	Mock-olive																						X	

Botanical name	Common name	Sampling location																					
		Q24	Q25	Q26	Q27	Q28	Q29	Q30	Q31	Q32	Q33	Q34	Q35	Q36	Q37	Q38	Q39	Q40	Q41	Q42	Q43	Q44	A	B
Oxalidaceae																								
Oxalis exilis	Creeping Oxalis		3					3	3		2											2		X
Oxalis perennans							1							3		2	1		2					
Phytolaccaceae																								
* Phytolacca octandra	Inkweed											2												
Pittosporaceae																								
Billardiera scandens	Hairy Apple Berry		3		2	1		1							2	1								
Bursaria spinosa	Australian Boxthorn		2	3			1		1			4	1			1		4	1		4	1	X	
Pittosporum revolutum	Yellow Pittosporum		1																					
Plantaginaceae																								
* Plantago lanceolata	Plantain, Ribwort	3		2								2	3			1	4		3	3		2		
Veronica plebeia	Creeping Speedwell		1					1	1					2										
Polygonaceae																								
Rumex brownii	Slender Dock	1																						
Primulaceae																								
* Anagallis arvensis	Pimpernel	4	1									2	4				1		2	2				
Proteaceae																								
Hakea sericea	Needlebush, Silky Hakea																							
Lomatia silaifolia	Crinkle Bush				1																			
Persoonia levis	Broad-leaved Geebung				1																			
Persoonia linearis	Narrow-leaf Geebung		1		4	1				1					1								X	
Xylomelum pyriforme	Woody Pear				3																			
Ranunculaceae																								
Clematis aristata	Traveller's Joy, Old Man's Beard		1		1			1															X	
Clematis glycinoides	Headache Vine, Traveller's Joy, Old Ma				1			3	4															
Rhamnaceae																								
Pomaderris andromedifolia																								
Pomaderris intermedia										1													X	X
Pomaderris lanigera	Velvety Pomaderris																							
Rosaceae																								
* Rosa sp. (unidentified)																								
Rubus parvifolius	Native Raspberry, Small-leaf Bramble		1																					

Botanical name	Common name	Sampling location																					
		Q24	Q25	Q26	Q27	Q28	Q29	Q30	Q31	Q32	Q33	Q34	Q35	Q36	Q37	Q38	Q39	Q40	Q41	Q42	Q43	Q44	A	B
Rubiaceae																								
Asperula conferta	Common Woodruff																1		1	1				
Galium binifolium			2									1											X	
Galium liratum																								
Morinda jasminoides	Morinda																						X	
Opercularia aspera	Coarse Stinkweed																						X	
Opercularia diphylla	Stinkweed			2		4	4	4	3	1	4	3		1	1	2		2			4	3		
Opercularia hispida	Hairy Stinkweed		3	3	3			1		1								2				1		
Pomax umbellata	Pomax		1		1	2				1					2						1			X
* Sherardia arvensis	Field Madder																							
Rutaceae																								
Boronia polygalifolia																								
Correa reflexa	Native Fuchsia																						X	
Eriostemon australasius	Wax Plant																							
Zieria smithii	Sandfly Zieria, Stinkwood							3																
Santalaceae																								
Exocarpos strictus	Pale-fruited Ballart				1										1	1								
Leptomeria acida	Sour Currant Bush														1									
Sapindaceae																								
Dodonaea triquetra	Hopbush		4		3					2					1									
Solanaceae																								
Solanum americanum	Blackberry Nightshade, Glossy Nightsh											1												
* Solanum nigrum	Blackberry Nightshade																							
Solanum prinophyllum	Forest Nightshade		1				1	1	1	1	1	2		1	1			1			3	1	X	
* Solanum pseudocapsicum	Jerusalem Cherry																							
* Solanum seaforthianum	Brazilian Nightshade																							
Stackhousiaceae																								
Stackhousia viminea	Slender Stackhousia					2									1									
Sterculiaceae																								
Lasiopetalum ferrugineum var. cordatum					1										1									
Thymelaeaceae																								
Pimelea linifolia	Slender Rice Flower				1			1							1									

Botanical name	Common name	Sampling location																				
		Q24	Q25	Q26	Q27	Q28	Q29	Q30	Q31	Q32	Q33	Q34	Q35	Q36	Q37	Q38	Q39	Q40	Q41	Q42	Q43	Q44	A	B
Violaceae																								
Hybanthus monopetalus	Slender Violet-bush		1		1			1	2						1									
Viola hederacea	Native Violet, Ivy-leaved Violet							1																
4. Monocotyledons																								
Anthericaceae																								
Arthropodium milleflorum	Pale Vanilla Lily		3																					
Laxmannia gracilis	Slender Wire Lily														1							1		
Sowerbaea juncea	Vanilla Lily														1									
Tricoryne elatior	Yellow Rush Lily																1	1			1	2		
Asparagaceae																								
* Asparagus asparagoides	Bridal Creeper, Florists' Smilax																							
Cyperaceae																								
Carex appressa	Tall Sedge																							
Carex breviculmis											1			2		1	3		2	1				
Carex inversa	Knob Sedge																							
Carex longebrachiata	Drooping Sedge																2		4					
Cyathochaeta diandra						2				2					1									
Fimbristylis dichotoma																			1	1				
Gahnia aspera	Rough-leaved Saw-sedge			1																				
Gahnia radula	Thatch Saw-sedge																							
Lepidosperma gunnii	Little Sword-sedge													1							1			
Lepidosperma laterale	Variable Sword-sedge		2		2	3		2	2	4	4			4	2								X	X
Lepidosperma viscidum	Sticky Sword-sedge		1																					
Ptilothrix deusta																								
Schoenus apogon	Fluke Bog-rush, Common Bog-rush												1											
Schoenus brevifolius	Zigzag Bog-rush																							
Schoenus melanostachys	Black Bog-rush				2					1					1								X	X
Iridaceae																								
Patersonia glabrata	Native Iris, Leafy Purple-flag														1									
Patersonia sericea	Native Iris, Silky Purple-flag				2					1					1									
* Romulea rosea	Onion Grass	2															4		4	4		3		
* Sisyrinchium sp. aff. S. micranthum	Scourweed																		1			1		
Juncaceae																								
Juncus sp.	Rush																							

Botanical name	Common name	Sampling location																						
		Q24	Q25	Q26	Q27	Q28	Q29	Q30	Q31	Q32	Q33	Q34	Q35	Q36	Q37	Q38	Q39	Q40	Q41	Q42	Q43	Q44	A	B
Juncus subsecundus	Finger Rush											1												
Lomandraceae																								
Lomandra confertifolia subsp. rubiginosa			3		3					4					3								X	
Lomandra cylindrica	Needle Mat-rush									1					1									
Lomandra filiformis subsp. coriacea	Wattle Mat-rush	1		3	1	3	2	4	1	2	2			3	1						4	4		
Lomandra filiformis subsp. filiformis	Wattle Mat-rush		1	1	3	1		2	1						1	4		4			1	1		X
Lomandra fluviatilis										1											1			
Lomandra longifolia	Spiny-headed Mat-rush		2		1			1		4				2									X	X
Lomandra micrantha	Small-flowered Mat-rush		1		1	1		1	1	1					3	2								
Lomandra multiflora	Many-flowered Mat-rush		2	1	2	4		3	2	2	3			1	4						3	1		
Lomandra obliqua					1																			
Orchidaceae																								
Acianthus fornicatus	Gnat Orchid				2	1		2															X	
Chiloglottis reflexa	Autumn Bird Orchid																							
Chiloglottis sp.																								
Cryptostylis sp.																								
Dendrobium speciosum	Rock Orchid, Rock-lily																						X	
Liparis reflexa																							X	
Pterostylis acuminata	Sharp Greenhood Orchid								1															
Pterostylis concinna	Trim Greenhood					1		2						1									X	X
Pterostylis longifolia	Long-leaf Greenhood Orchid									1														
Pterostylis nana	Dwarf Greenhood														1									
Pterostylis nutans	Nodding Greenhood Orchid				1			1															X	
Pterostylis parviflora	Tiny Greenhood Orchid																							
Thelymitra sp.	Sun Orchid					1																		
Philesiaceae																								
Eustrephus latifolius	Wombat Berry																							
Phormiaceae																								
Dianella caerulea	Blue Flax-lily		2		1											1							X	
Dianella revoluta	Blue Flax-lily, Spreading Flax-lily						2					1				1								
Poaceae																								
* Andropogon virginicus	Whisky Grass												1				4		1	2				
Aristida ramosa	Wiregrass																	1				1		
Aristida vagans	Threeawn Speargrass	2	1	4		4	4	3	4	4	4	4		4	3	4	4	4	2	4	3	4		
Austrodanthonia laevis				2			4				3							1	1					

Botanical name	Common name	Sampling location																					
		Q24	Q25	Q26	Q27	Q28	Q29	Q30	Q31	Q32	Q33	Q34	Q35	Q36	Q37	Q38	Q39	Q40	Q41	Q42	Q43	Q44	A	B
Austrodanthonia pilosa var. pilosa	Velvet Wallaby Grass																1							
Austrodanthonia racemosa	Wallaby Grass	2		2			3		1		1	3	3	3		1			4	1				
Austrodanthonia sp.	Wallaby Grass																	1						
Austrodanthonia tenuior	Wallaby Grass																	1						
Austrostipa pubescens	Speargrass					4		4	1	2					3									
Austrostipa rudis			2	1	2		1	1	3		2			3		1		1			1	1		
Austrostipa setacea	Corkscrew Grass																					1		
* Avena sativa	Oats	1														2	1	3				1		
* Axonopus fissifolius	Narrow-leaved Carpet Grass			1													4	1	4	3		1		
Bothriochloa macra	Redleg Rass			1									1			1			3	3				
* Bromus catharticus	Prairie Grass																							
Cymbopogon refractus	Barbed Wire Grass		1	4			1		1		1			1		3				1				
Cynodon dactylon	Couch, Bermuda Grass	2											2				1		3	2				
Dichelachne inaequiglumis														1										
Dichelachne micrantha	Shorthair Plumegrass	3		1			2				2	1	3	2		1	3	1	4	4		2		
Dichelachne sieberiana									1															
Digitaria parviflora	Smallflower Finger Grass		3												1									
Digitaria ramularis							1	1																
Echinopogon caespitosus	Tufted Hedgehog Grass																							
Echinopogon ovatus	Forest Hedgehog Grass			1			1	1	1		1	1		3		1		1						
Entolasia marginata	Bordered Panic																							
Entolasia stricta	Wiry Panic		4	3	4	4	3	3	4	4	3	3		4	4			3			4	2	X	X
Eragrostis brownii	Brown's Lovegrass				1						1				1			1	1	1				
Eragrostis leptostachya	Paddock Lovegrass	2		2			4						2	1		1			4					
* Festuca elatior	Tall Fescue	1											1											
Imperata cylindrica	Blady Grass		2		2					1					2									X
Joycea pallida	Red-anther Wallaby Grass					1				1														
* Lolium perenne	Perennial Ryegrass	3		1												1						1		
Microlaena stipoides	Weeping Grass, Meadow Rice-grass	3	3	4	2	4	4	4	4	4	4	4	3	4	4	4	4	4	4	4	4	4	X	X
* Nassella trichotoma	Serrated Tussock																							
Oplismenus aemulus	Broad-leaved Basket Grass																							
Panicum effusum	Hairy Panic	2																1	1	1				
Panicum simile	Two-colour Panic				1	1		3	1	1	2			1	2									
* Paspalum dilatatum	Paspalum	1											2				4		4	4				
* Pennisetum clandestinum	Kikuyu Grass	2											2											
* Phalaris aquatica	Phalaris	3											3											
Poa affinis																								
* Poa annua	Winter Grass																							

Botanical name	Common name	Sampling location																				
		Q24	Q25	Q26	Q27	Q28	Q29	Q30	Q31	Q32	Q33	Q34	Q35	Q36	Q37	Q38	Q39	Q40	Q41	Q42	Q43	Q44	A	B
* Poa pratensis	Kentucky Bluegrass																							
Poa sieberiana	Snow Grass, Fine-leaf Tussock Grass													1										
* Setaria gracilis	Slender Pigeon Grass												1											
* Sporobolus africanus	Rat-tail Grass, Parramatta Grass																1			2				
Sporobolus creber	Slender Rat's-tail Grass	3					1										3	1	4	4		1		
Themeda australis	Kangaroo Grass	3	1	4		1	3	1		3	4			1		4	4	4	2	4	3	4		
Smilacaceae																								
Smilax glyciphylla	Sweet Sarsaparilla																						X	
Xanthorrhoeaceae																								
Xanthorrhoea concava	Grass-tree														1									

APPENDIX D

ADDITIONAL INFORMATION PROVIDED TO THE COMMITTEE

Wollondilly
Shire Council

PROTECTION OF OUR UNIQUE, DISEASE-FREE KOALA COMMUNITY

BRIEFING PAPER

State and Federal Issues Briefing Paper

Title: **Protection of our unique Disease free Koala Community**

Date: July 2018

Key issues *(What problem/issue needs to be resolved?)*
• The largest disease free koala population in NSW is not currently protected by an Integrated Regional Koala Conservation Plan that conserves habitat corridors across the region. In the absence of these protective measures this Koala population will be adversely effected. • The rezoning of Wilton South East will bisect the regionally significant Allens Creek koala habitat corridor and ignores the advice of the Office of Environment and Heritage (OEH) and independent consultants. • The area was rezoned before the koala habitat corridor survey and mapping work had been completed by OEH and the biocertification of the Wilton and Greater Macarthur Growth Areas had been completed by the Department of Planning and Environment (DPE). • The New South Wales Koala Strategy needs to be amended to recognise the state and national significance of this koala population. • The review of the State Environmental Planning Policy 44 – Koala Habitat Protection needs to be finalised and to adopt the amended koala food tree species list used in the certification and mapping of koala habitat corridors.

Action sought	**Timeframe**
Agree to oppose the current rezoning decision of South East Wilton until it protects this crucial koala population's habitat. To work collaboratively with the State and Community stakeholders to create an integrated framework for the protection of koalas. Preservation of local and regional corridors	August 2018 Representation to State Parliament

Contact for telephone discussion (if required)

Name	Position	Telephone direct line	after hours	Suggested first contact
Alexandra Stengl	Manager Environmental Outcomes	02 4677 9577	0437 805 850	☐
Damion Stirling	Environment Officer	02 4677 9522		

The Briefing note:

The South Western Sydney Koala population is estimated to exceed 700 individuals throughout the eastern portion of the Wollondilly Shire and throughout Campbelltown.

Research and survey work carried out by Professor Rob Close, University of Western Sydney, and the Office of Environment and Heritage (OEH) for the Wollondilly Koala Conservation Plan (WKCP) has confirmed this is the largest disease free population in NSW that is expanding with numerous breeding females being identified throughout the corridors.

Eighteen months of survey work for the WKCP has confirmed that the Allen's Creek corridor at Wilton is a primary habitat for breeding and is a critical movement corridor for koalas between the continuous Southern Highlands, Wollondilly and Campbelltown populations. Koalas have been recorded within the Allens Creek corridor since 1991.

Wollondilly Shire Council is very concerned that the recently rezoned South East Precinct at Wilton New Town by the NSW Government bisects the Allen's Creek corridor and completely ignores recommendations made by independent experts and the work carried out by OEH for the WKCP to protect this vital koala habitat.

Council believes that the recent rezoning by Department of Planning and Environment of the South East Precinct at Wilton is premature and will likely result in substantial adverse impacts to the local koala population, as well as the movement of this species within the Greater Macarthur Area. These corridors would also facilitate the connectivity of a large number of native species, many of which are endangered and vulnerable (over 520 fauna species).

In addition to this, Council has previously raised concerns that little consideration has been given to the protection of koala habitats from the impacts of development associated with the overall Wilton New Town proposal.

The NSW State government has produced the NSW Koala Strategy which has not identified this population of koalas for protection and therefore compromising long term protection strategies that could be implemented through land use planning frameworks.

Given that the rezoning of the Wilton South East Precinct has already occurred and the intention of the NSW Department of Planning & Environment to proceed with the rezoning of other large land precincts within the Wilton and Greater Macarthur Priority Growth Areas, Council believe it is imperative that a South Western Sydney Integrated Regional Koala Conservation Plan is prepared and adopted before any further progress of the growth areas occurs.

Purpose of briefing

The purpose of the briefing is to inform the Government and Community that Council has concerns over the lack of protection of the Koala Corridor both through landscape and over major arterial roads and road corridors.

Executive Summary

- The Council does not support the rezoning at Wilton South East that bisects the Allens Creek Koala habitat corridor.

  The recommendations are:

  - That the southern portion of the Allens Creek Koala habitat corridor be protected and restored between the north western and south eastern culverts of Allens Creek that flow under Picton Road, providing a koala corridor linkage to the Upper Nepean State Conservation Area.
  - That the NSW government defer any further release of land within the Greater Macarthur Growth Area and the Wilton Priority Growth Area until a South Western Sydney Integrated Regional Koala Conservation Plan is finalised.
  - That the State Environmental Planning Policy 44 – Koala Habitat Protection review be finalised including the adoption of the updated koala food tree species list to be used in determining core koala habitat corridors.

Overview of the issue

- The Department of Planning and Environment rezoned Wilton South East that will effectively bisect the Allens Creek Koala Habitat corridor, ignoring advice from the Office of Environment and Heritage.
- The Department of Planning and Environment rezoned the south west precinct without considering new research that has demonstrated that the rezoning in particular is an important core habitat Koala Corridor. This rezoning has also highlighted that at a regional level there is no South Western Sydney Integrated Regional Koala Conservation Plan covering the Wilton and Greater Macarthur Growth Areas and surrounds. Council has been successful in obtaining over 13,000 signatures from the community in support

of the #saveourkoalas campaign seeking to have the issue debated in the NSW parliament.

- If the rezoning progresses as is currently proposed it will bisect the regionally significant Allens Creek koala habitat corridor linking the Nepean River to the Nepean Conservation Area. Breeding koalas have been recorded using the corridor since 1991. This will have an impact on the Koala corridor and there is a proposal to upgrade Picton road to a 6 lane highway with no overpasses for fauna proposed as the State is ignoring the significance of the corridor and therefore has no wildlife protection proposals in place for this area.
- The koala is an iconic species and the first reported European siting of a koala was in the Wollondilly Shire in 1798. The koalas of Wilton and Appin through to Campbelltown are the largest disease free koala population in NSW and hence have state and national significance. The corridor exists between 6 Local Government area of Liverpool, Campbelltown, Wollondilly, Wingecarribee, Sutherland and Wollongong.
- The southern portion of the Allens Creek corridor was identified as a primary koala corridor in 2007 as part of the "Threatened and Pest Animals of Greater Southern Sydney" report published by the Department of Environment and Climate Change. This has been confirmed by recent survey work undertaken by the Office of Environment and Heritage for the WKCP. The reports prepared and supplied for the rezoning do not consider the new data and have not comprehensively addressed or acknowledged the habitat or corridors.
- For the last 18 months the Office of Environment Heritage have been undertaking field work and monitoring of Koalas under the Saving Our Species program, surveying both koalas and their habitat. This work has confirmed the presence of breeding koalas within and around the Allens Creek Corridor.
- By not acknowledging the presence of the breeding koala population will compromise the long term expansion and connectivity of this species in the landscape. There are only 2 culverts linking the koala corridor from north to south under Picton Road that are suitable for safe koala crossings and the Wilton South East rezoning will effectively cut one of those linkages.

What are the risks or ramifications of not resolving the issue?

- Development will proceed without adequate consideration of the Koalas and their habitat. The result is that Koalas may become isolated and restricted from moving through the corridor.

What references exist to inform this issue:

- Peer Review – Koala Survey, Wilton prepared by HWR Ecological PTY LTD, prepared by Professor Robert Close, November 2005.
- Threatened and pest animals of Greater Southern Sydney report, Department of Environment and Climate Change, September 2007.
- Conserving koalas in Wollondilly and Campbelltown LGA's report, the Office of Environment and Heritage, September 2017.

Council Resolutions

Wollondilly Shire Council is extremely committed to the protection of our unique koala populations and their habitat which is reflected in the resolution at the Extraordinary Meeting of Council held on 30 April 2018.

The NSW Government defer any further release of land within the Greater Macarthur Growth Area and Wilton Priority Growth Area until the NSW Government prepares and finalises a South Western Sydney Koala Conservation Strategy that protects koalas and their habitat corridors throughout the region. The Conservation Strategy should:

I. *Be underpinned by an approved and integrated Comprehensive Koala Plans of Management for Wollondilly, Campbelltown, Liverpool, Wingecarribee and Wollongong Local Government Areas in accordance with Schedule 1 and Part 3 of the State Environmental Planning Policy (SEPP) 44 - Koala Habitat Protection.*
II. *Include Koala habitat and corridors with reference to the updated Koala food tree species list that has been provided by OEH for the current review of SEPP 44 and we request that the review of SEPP 44 be finalised.*

And further council requests:

The rezoning of that portion of the Wilton South East Precinct that forms part of the Allen's Creek Primary Koala habitat corridor be repealed by the Minister of Planning.

That the draft petition to the Speaker and Members of the NSW Legislative Assembly seeking that Parliament debate the repeal of the rezoning of the South East Precinct as tabled at the Extra Ordinary Meeting, be endorsed by Council for circulation immediately following the meeting. That upon 10,000 signatures being received, Council formally requests that Jai Rowell MP, Member for Wollondilly, presents the petition to the NSW Legislative Assembly.

Further that this petition be incorporated into a Koala habitat preservation campaign as part of the "A GREAT New Town or NO town at all' campaign. This petition should also be sent to

LGA's and community groups that neighbour the last disease free Sydney Koala habitat requesting support for the petition.

Following are Council Resolutions in relation to this topic:

36/2017; 14/2017; 105/2018; 81/2018; 55/2018; 85/2018;

Cr Strategic Planning Day 20/03/2018

Community views on the issue (CSP)

- The community is concerned that the rezoning has gone ahead without transport and koala corridors being resolved.
- Currently over 13,000 signatures have been received from the community supporting councils #saveourkoalas petition which has been tabled in the NSW state parliament.
- The community cannot understand why the broader planning issues such as koala/wildlife corridors and transport (M9) and public transport have not been improved or resolved and further residential rezoning's are occurring.

Lobbyist's/Submitters' views on the proposal

- Wilton Action Group and the community oppose the development.
- Developers support the proposal.

State Government view on the issue

- Department of Planning and Environment believe that the issues have been addressed.
- Council believes that the rezoning is premature and has not considered transport, wildlife corridors namely the impact on koala population.
- The Department of Planning and Environment claims that they have resolved the issues. Council claims that there has been no final documents prepared prior to the rezoning and Council and that the works and planning mechanisms are not adequate and not enough has been done to date.

Actions

Council resolved to write to the State and Federal Ministers to alert them to the issues.

To table a petition at the NSW Legislative Assembly to highlight the issues raised by the Community and Council.

To undertake a Koala Summit and raise awareness of the issue.

To collaboratively work with both Local Government, State Government and community stakeholders to create an integrated framework for the protection for koalas.

Ibrahim Muharrem

From: Gina Metcalfe <
Sent: Friday, 13 April 2018 3:30 PM
To: Brett Whitworth; Alex Graham; Susan Harrison; Liza Schaeper; Marnie Stewart; Bruce Colman; Wil Robertson; Laura Torrible; Fiona Morrison; Gwenda Kullen; saul.deane ; Julie.RAVALLION ; Steve Hartley; 'CLARK Owen T'; bazpat ; Damion Stirling; Nicola Wass; Alexandra Stengl; 'Alexandra Cave'; 'Angela Taylor'; Blake Edwick; Renae Hockey; 'SCULLY Edward J'; 'Steve Phillips'; 'Mathew Crowther'; 'AMOS Paul M'; Enhua Lee; 'Saul Deane'; Wesley Folitarik
Subject: Koala conservation meeting notes
Attachments: Koala conservation round table summary.pdf; Koala round table_OEH.pdf; Introduction to Strategic Biocertification Presentation - KOALA workshop.pdf; Koala workshop.pdf

Dear all

Thank you very much for participating in last week's koala round table. A copy of the presentation and meeting notes are attached for your information.
We will be in contact to arrange a follow up session in coming weeks.

Regards

Gina

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Strategic Planning and Programs
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-----Original Appointment-----
From: Gina Metcalfe
Sent: Monday, 5 March 2018 12:53 PM
To: Gina Metcalfe; Brett Whitworth; Alex Graham; Susan Harrison; Liza Schaeper; Marnie Stewart; Bruce Colman; Wil Robertson; Laura Torrible; Fiona Morrison; Gwenda Kullen; saul.deane ; Julie.RAVALLION@ ; Steve Hartley; CLARK Owen T; bazpat ; Damion Stirling; Nicola Wass; David Henry; Alexandra Stengl; Alexandra Cave; Angela Taylor; Blake Edwick
Cc: Saul Deane; AMOS Paul M; Kate Wilson; Gregory Summerell; Jeremy Black; BEIRNE Brendon; SCULLY Edward J; Renae Hockey; Mike Fleming; Mathew Crowther; Enhua Lee; Martin Predavec; Steve Phillips
Subject: Regional Koala Strategy
When: Thursday, 5 April 2018 1:30 PM-4:00 PM (UTC+10:00) Canberra, Melbourne, Sydney.
Where: Level 5 10 Valentine Avenue Parramatta

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Thank you for advising that you are available to participate in a meeting to discuss a regional approach to the protection of koalas in Greater Macarthur.

Please join us on 5 April for lunch at 1.30 before the meeting starts at 2pm. If you have any catering requirements please let me know

At the meeting OEH will present the results of their current research. We'd like to discuss our proposed application of this research to planning for the region.

We hope to discuss where your research and observations are consistent with the OEH research and where there are issues that may need further consideration or evidence.

We will send an agenda ahead of the meeting.

Regards
Gina

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Koala conservation round table

5 April 2018

The Department of Planning and Environment convened a meeting to discuss conservation of koalas in the context of the Greater Macarthur and Wilton Growth Areas. The aim of the round table discussion was to hear from stakeholders after sharing research by the Office of Environment and Heritage, outline the approach to strategic assessment of biodiversity and land use planning within the growth areas.

The following is a summary of goals stated by participants of the round table.

Stakeholders' long-term goals for koalas

Produce a plan that protects and enhances koala colonies at the heart not simply a land development plan.

Provide the greatest protection possible for bushland and wildlife (including koala corridors).

Achieve connectivity between Nepean and Georges River corridors/habitat and Bargo to Cataract Rivers and Blue Mountains National Park.

Ensure long-term sustainability of koalas through appropriate planning, understanding that development in inevitable.

Manage and maintain the viability of the Koala population.

Minimise road traffic impact on koala population through coordination with other agencies and integrating transport and precinct planning.

Share research to provide the best regional position for koala (movement and habitat).

Deal with issues in the long term and achieve alignment of issues from large to small scale.

Integrated biodiversity conservation with overall planning.

Take a stewardship approach in development and achieve an exemplary /benchmark outcome.

The following is a summary of issues raised by participants following presentations (supplied separately). The summary does not represent agreed or positions or meeting outcomes.

Key issues raised by stakeholders

Corridors have been identified based on current state at the time of mapping and research. The potential for these to be enhanced and linked should be considered.

Corridors between rivers and the Georges River and Nepean are likely to be valuable for long term genetic diversity and ability to recover from stochastic events.

It appears that koalas are being killed more frequently than before. Hot spots have been identified based on overall numbers and is not time based. Additional data would be useful including which direction koalas are attempting to travel when being hit.

The interpretation of the percentage of time koalas dwell in particular trees may need a more fine-grained analysis of the vegetation and relative abundance of the trees species in parts of the region. Specifically, koalas may be using acacia as feed trees are in the immediate environs.

Viable patch sized based on male koala home ranges discounts importance of smaller patches of vegetation. Koalas will move across cleared patches to get to remnant patches.

The view was expressed that replanting areas is supported but it could be a 20 to 30-year exercise and the carrying capacity is relatively low. This is important when we are comparing importance of primary and secondary habitat.

An assessment of the physical impediments to the animals' capacity to move through the landscape, – for example the canal, may be useful.

South 32's planned rubbish dumping emplacement area could restrict the proposed north south corridor.

Support for the strategic biodiversity certification process but need more data collection before moving on to conservation measures.

'Like-for-like' conservation/ offsets is critical – Wollondilly is one of the few areas with Shale Sandstone Transition Forest. Need to consider the unique needs of koala when implementing this.

8 to 12 percent of Cumberland Plain vegetation remaining. Measures need to be a mix of protection locally or in other locations. Restoration is a different approach again. Conservation will include some offsetting, use of public lands and restoration.

The conservation of koalas needs to be understood and resolved before further rezonings occur. Appropriate development and density needs to be considered.

Support the concept of connectivity and the idea of folding in Georges River parkway.

In relation to east west corridors, it is not a case of either/or as the east west corridors have significance to connect with populations in the Blue Mountains. Need to determine whether the linkages further south between rivers is sufficient.

Need to be clear about how privately-owned land east of Appin Road would be managed and ensuring that conservation sites have the appropriate statutory protection in terms of zoning and biobanking status.

RMS has examined the potential for crossings between Rosemeadow and Beualah. The footprint for an overpass is significant and would involve the loss of a large amount of vegetation including land under conservation management. There is reluctance to introduce koalas into a hostile environment or remnant bushland that is effectively a sink.

The capacity of this corridor to provide physical access to Nepean River either now (given impediments such as the Upper Canal or later (once the residential subdivision is in place) are crucial factors in determining whether investment in connectivity would benefit koalas in this location.

Fencing, supported by grids at access points along the eastern side of Appin road, is currently under consideration. This would effectively exclude koalas from the secondary corridor near Rosemeadow and would direct koalas along a north south alignment.

A Review of Environmental Factors (REF) has been prepared for the Rosemeadow to Beulah widening of Appin Road and will go on exhibition. Options for connectivity south of Beualah are still under consideration and are not part of the REF that will be placed on display.

There are significant opportunities to reduce current koala road kill and connect core koala habitat corridors (as defined by OEH) along Picton Road in Wollondilly Local Government Area. Multiple existing suitable culverts exist under Picton Road and augmenting their effectiveness through fencing (which funnels the koalas to the culvert) should be a key consideration for Roads and Maritime in any future upgrade of Picton Road and for Department of Planning and Environment (as part of the Wilton priority precinct planning).

Campbelltown Council has adopted a position and wants to facilitate east west movement with widened corridors widths within Campbelltown LGA.

If fencing Appin Road the movement of koalas west to east and cluster mortality at the edges needs to be addressed.

Disease status of animals needs to be further understood. It has been asserted that the northern population is chlamydia free but it may be present. It was acknowledged that the Wedderburn population is recovering, dispersing to the south and west and will inevitably come into contact with wild populations that have chlamydia. An ecologically naïve population can be devastated by chlamydia.

Wollondilly's research has shown that koalas are using Rivers to move but coming up to the clay soils to feed. Some koalas are coming across the Broughton Gorge. What was formerly dispersal habitat is now breeding habitat. Allens Creek links to the Nepean. There is connectivity to Nepean through this. Vegetation to the east is not habitat but is connected.

Would be value in releasing a documenting where we have got to including the road kill data.

The issue needs to be considered at an appropriate regional scale instead of by local government area. A summary to put all issues into context would be useful.

Need a good understanding of what is happening on Nepean River and require access to private landholdings to achieve this.

Potential to apply software to inform an objective recommendation on corridors. Ability to consider the impacts of large infrastructure and include patch size, roads, costs for dispersal.

Next steps

The Department of Planning and Environment, Office of Environment and Heritage and Roads and Maritime Services will consider stakeholder feedback and update participants via a future round table forum. At a later stage a draft Land Use and Infrastructure Implementation Plan will be released for public exhibition.

Wilton Council Workshop

Meeting Minutes

Details

Name	**Wilton Workshop**
Location	Wollondilly Shire Council
Date/Time	Tuesday, 11 June 2018, 3pm
Chairperson	Reza Ahmed
Members Attending	**Department of Planning and Environment (DPE) from Office of Open Space and Parklands (OSAP)** Reza Ahmed (RA) – Senior Open Space Designer Ranine Hammed (RH) – Student Landscape Architect **Wollondilly Shire Council (WSC)** David Henry (DH) – Environmental Assessment Planner Ibrahim Muharrem (IM) – Sustainability Coordinator Edith Barnes (ED) – Executive Planner – Growth Areas Toni Averay (TA) Director of Planning Brittany Madeley (BM) – Strategic Planner – Growth Mary-Anne Madden (MM) – Senior Strategic Planner - Growth Lauren Ackerly (LA) – Facilities and Recreation Planner Christopher Browne (CB) – Senior Strategic Health Planner
Minutes	Reza Ahmed (RA)

Wilton Council Workshop

Meeting Minutes

Minutes

No.

1 The Chair introduced the meeting and thanked attendees for sitting on the Program Control Group.

Reza delivered presentation.

Agenda Item	Discussion	Agreed Actions
1	**Introduction**	
	RA providing introduction and objectives of the Green Plan for Wilton Growth Area	Noted
2	**Green Plan General**	
	Effluent treated lake is not endorsed by the Council due to the maintenance issues, public health concerns, and potential environmental impacts.	Noted Green plan to reassess appropriateness of regional open space *if* Lake does not go ahead
	WSC What is the funding strategy for the Green Plan. OSAP note Funding will need to be a partnership approach between various stakeholders.	**OSAP** team will investigate funding mechanisms including SIC.
	WSC will not endorse the Green Plan until finalized, however thus far agrees with the principles.	Noted **OSAP** to provide mapping for comment
	WSC – DPE to engage developers to inform them about the Green Plan outcomes.	Noted

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3	**Biodiversity**	
	WSC – The open space on the north west Wilton (previously classified as Regional Open Space) is not appropriate for open space due to potential impacts of activities extending into the conversation area such as exposure to dogs, motorbikes, mountain biking, litter etc.	Noted – **OSAP** to discuss with Biodiversity team for biobanking potential for the site and omit from plans
	WSC Appropriate widths of Koala Corridors are not reflected in the Green Plans. A minimum of 450m wide koala corridor will need to be implemented within identified pinch points. DPE will need to coordinate. OSAP note Green Plan does not set the parameters on the widths of Koala Corridors.	**OSAP** to confirm with Biodiversity and Sustainability team that minimum widths have been achieved.
	WSC: There is a need to integrate mapping within the Green Plan to mapping within the Cumberland Conservation Plan as well as Council's Koala Plan of Management. The review of this integration by WSC cannot occur in the absence of detailed mapping	OSAP: There is integration but further discussions will occur with the Biodiversity and Sustainability Team.
	WSC – are there case studies for successful Koala Lookout treatment. Number of other similar look our type projects have failed.	Noted, **DPE** to investigate.
4	**DCP**	
	WSC - Alignment of principles of the Green Plans with the DCP.	Noted – **OSAP** to follow up with planning team and Biodiversity and Sustainability team and review relative documents.

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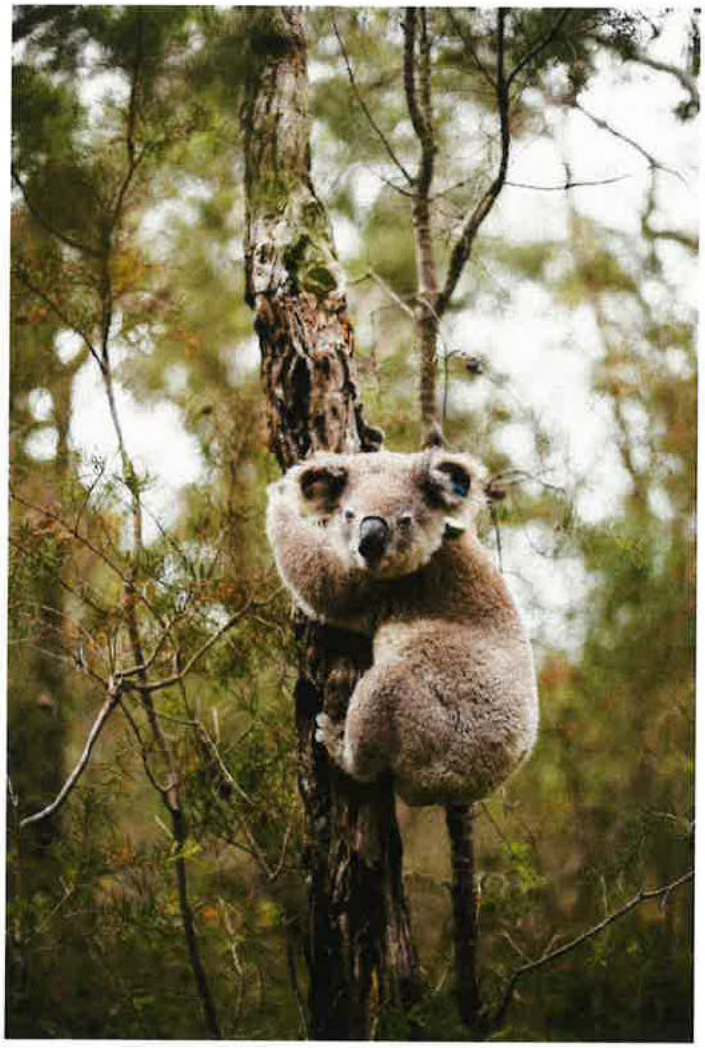
	DCP should also refer to the Green Plan principles to assist in delivering the outcomes	Noted – **OSAP** to follow up with the planning team
	WSC – ~~concerns over~~Agrees with the 40% canopy targets especially considering the lot sizes will potentially not fit a tree in the back yard. Consideration needs to be given to the infrastructure design to accommodate the development of trees long term.	**OSAP** to review DCP in relation to guidelines of development of individual lots and tree specifications.
	WSC prefer public consultation to occur once the Green Plan is finalized	Noted – **OSAP** to investigate.

NSW GOVERNMENT

DEPARTMENT OF PLANNING, INDUSTRY & ENVIRONMENT

Conserving Koalas in the Wollondilly and Campbelltown Local Government Areas



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Cover photo: Koala (*Phascolarctos cinereus*). Bear Hunt Photography

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ISBN 978 1 922317 36 0
EES 2019/0573
October 2019

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1. Summary

This report identifies high-quality koala habitat, core koala habitat, koala movement corridors and koala roadkill hotspots in the Wollondilly and Campbelltown Local Government Areas (LGAs). Existing data were used, along with new data collected in the eastern part of the Wollondilly LGA as part of the Wollondilly Koala Conservation Project. An estimate for koala densities in core koala habitat calculated from the Wollondilly Koala Conservation Project is provided, along with extrapolated koala numbers potentially supported in movement corridors in the Wollondilly and Campbelltown LGAs. A categorisation for the relative importance of different corridors is also provided. Areas of high-quality koala habitat, core koala habitat, koala movement corridors and koala roadkill hotspots form the basis for DPIE's management recommendations in the Wollondilly and Campbelltown LGAs. Key koala conservation principles are coupled with known areas of koala habitat to provide specific recommendations for the conservation of the regional koala population extending from Campbelltown through Wollondilly to Wingecarribee.

Information and recommendations outlined in this report are communicated in the context of residential and urban development in the Wilton and Greater Macarthur Growth Areas (GAs). Information on core koala habitat and koala movement corridors is essential knowledge when planning for development in south-west Sydney. Data collection for koalas in the Wollondilly and Campbelltown areas is ongoing. Data used in this report represents the best available information to inform management decisions related to future development. Previous information for koala habitat and movement corridors (Department of Environment and Climate Change (DECC) 2007) was compiled for a regional scale and is not appropriate for use at the scale needed for the Wilton and Macarthur GAs.

2. Introduction

The NSW Government recently began funding koala research and on-ground management actions under the *Saving our Species* (SoS) conservation program. As part of the SoS program, the Department of Industry, Planning and Environment – Environment, Energy and Science (DPIE–EES) initiated the Wollondilly Koala Conservation Project. This project is collecting new information on koala distribution, abundance, movement, and habitat usage within the Wollondilly Local Government Area (LGA). Work began in March 2016 and data collection and analyses are ongoing.

The Wollondilly and adjacent Campbelltown areas are earmarked for development as part of the Wilton and Greater Macarthur Growth Areas (GAs), with projected development expected to support thousands of new dwellings, town centres and associated infrastructure. DPIE–EES has prepared this document to inform government and non-government stakeholders of priority areas for koala conservation, and key actions required to avoid and minimise impacts and threats from these new developments. This information is essential to ensure that future urban growth does not compromise the viability of the koalas in the area, and the wider regional koala population extending from Campbelltown through Wollondilly to Wingecarribee.

This report combines existing data from a range of sources, including the NSW BioNet database, and new data from the Wollondilly Koala Conservation Project. Core koala habitat, as defined in this report, and koala movement corridors in the Wollondilly and Campbelltown LGAs, specifically southern Campbelltown, Appin and Wilton, are identified at a local scale (approximately 1:10,000). Core koala habitat and koala movement corridors are both critical to the long-term persistence of the regional koala population.

The focus area is the Wilton and Greater Macarthur GAs. However, koala habitat and corridors in the GAs link to important koala habitat and metapopulations (groups of spatially separated populations connected by dispersal) to the north and south. Therefore, mapping was undertaken for a larger area than the GAs, from the Georges River north of Holsworthy to Colo Vale in the Wingecarribee Shire.

Information collected to date for the Wollondilly Koala Conservation Project has improved our understanding of the regional koala population. The data updates existing koala habitat and corridor mapping done at a regional scale (Department of Environment and Climate Change (DECC) 2007) from south Campbelltown to Appin and across to the Wilton area. The new mapping will allow us to prioritise management actions within these areas.

The scientific methods, areas recommended for protection and mitigation measures identified have been peer reviewed by two recognised koala scientists, Associate Professor Mathew Crowther and Dr Stephen Phillips. Their reviews in Appendices 1 and 2 indicate that the conservation areas and measures recommended in this report represent the minimum requirements for koala conservation in the area.

The use of best available information is crucial to understand what is required to maintain the regional koala population, and specifically the metapopulations in the Wollondilly and Campbelltown areas. As more information becomes available, it will be used to refine outcomes.

3. Methods

A number of data input layers were used to identify or validate koala habitat and movement corridors. These are referred to throughout this section and include:

- Koala Linkage (Department of Environment and Climate Change (DECC) 2007)
- Koala habitat model (DECC 2007)
- Koala records and presence–absence spotlighting data (downloaded from BioNet November 2017; Office of Environment and Heritage (OEH) 2017a)
- Koala habitat assessment 20 x 20 metre vegetation plots (downloaded from the BioNet Vegetation Information System November 2017; OEH 2017b)
- Preferred koala-use trees for Wollondilly (OEH unpublished data)
- Native vegetation of the Sydney Metropolitan Area (OEH 2013)
- Native vegetation of the Woronora, O'Hares and Metropolitan Special Areas (National Parks and Wildlife Service (NPWS) 2003)
- Cumberland Plain Native Vegetation Mapping (Tozer 2003)
- Native Vegetation of the Nattai and Bargo Reserves (Department of Environment and Conservation (DEC) 2004).

Other layers referred to but not formally used to derive or validate koala habitat and movement corridors included:

- Cumberland Plain Priority Conservation Lands (Department of Environment, Climate Change and Water (DECCW) 2011)
- Cumberland Subregion Biodiversity Investment Opportunities Map (BIO Map) (OEH 2015)
- Campbelltown Council Biodiversity Corridors (Campbelltown Council 2017)
- Eco Logical Australia (ELA) wildlife corridors for Mt Gilead and surrounds (ELA 2017).

In addition, data used to validate high-quality koala habitat (see Section 3.4) were derived from the Wollondilly Koala Conservation Project using. Only data from the eastern part of the Wollondilly Local Government Area (LGA); i.e. the area bordered by the Wollondilly LGA boundaries in the north, east and south, and Remembrance Drive in the west, were used. This area encompasses the Wilton and Greater Macarthur Growth Areas.

3.1 Using fine-scale vegetation mapping

The vegetation in the Wollondilly and Campbelltown areas has been mapped to a fine and very fine scale, and plant communities are well known. As such, maps for core koala habitat and koala movement corridors were based on these fine-scale vegetation maps. Vegetation communities reflect the geology of the region, with shale, shale-transition and sandstone-derived soils influencing the proportion of koala feed trees in each community.

North from Wedderburn, the vegetation map used was the Native Vegetation of the Sydney Metropolitan Area (OEH 2013). This validated vegetation map of NSW Plant Community Types (PCTs) was developed in-line with the NSW Native Vegetation Interim Type Standards (DECCW 2010). It was produced at a scale of 1:8000 and has very accurate line work and attribution of vegetation communities.

For the remainder of the study area a mosaic of vegetation maps were used, including the Cumberland Plain Native Vegetation Map (Tozer 2003), Native Vegetation of the Nattai and Bargo Reserves (DEC 2004) and the Native Vegetation of the Woronora, O'Hares and Metropolitan Catchments (NPWS 2003) (all at a scale of 1:25,000). These maps are limited by the accuracy of the aerial photography available at the time. Wherever possible, line-work has been updated (using high-resolution ASD40 2014 aerial photography) to improve line-work accuracy and excise new areas of clearing. Areas that had been under-scrubbed or semi-cleared since the mapping was undertaken were reattributed. Although still fine-scale compared to most vegetation maps, the different accuracies of the underlying mapping between the south and the north is a limitation of the final maps.

3.2 State Environmental Planning Policy 44 definitions

State Environmental Planning Policy (SEPP) 44 definitions of 'core koala habitat' were not used in this report because of the high number of known local feed trees used by koalas, particularly for the Wollondilly LGA, that are not listed in SEPP 44. Core koala habitat for the purpose of this report is defined in the Glossary.

3.3 Defining koala habitat

In the Campbelltown and Wollondilly LGAs, there is a long-established association between the presence of koalas and vegetation that grows on higher fertility soils, such as shale or shale-transition soils (e.g. Prevett et al. 2001; Phillips and Callaghan 2002; Ward 2002; Lunney et al. 2010). Koalas favour vegetation growing on fertile soils due to the increased nutrient availability in the eucalypt leaves (Moore et al. 2010). Therefore, all shale and shale-enriched vegetation types with a dominant eucalypt canopy were classified as being high-quality habitat (HQH). HQH patches greater than 100 hectares were identified as 'core koala habitat'.

Eucalypt-dominated riparian sandstone communities, rainforest communities on shale with some eucalypts present and regenerating acacia scrubs on shale were classified as medium-quality habitat (MQH). Low-fertility sandstone vegetation communities including heaths, heathy woodlands, swamps and rocky woodlands were classified as low-quality habitat (LQH).

Table 1 lists mapped vegetation communities, their soil classification and their assigned habitat quality based on the vegetation community descriptions listed in the relevant vegetation map (Tozer 2003; DEC 2004; OEH 2013; NPWS 2003).

Table 1 **Vegetation communities within the study area, soil classification and koala habitat quality**

Vegetation community	Soil classification	Koala habitat quality
Cumberland Plain alluvial woodland	Shale	High-quality habitat (HQH)
Cumberland Plain shale hills woodland	Shale	HQH
Cumberland Plain shale plains woodland	Shale	HQH
Cumberland Plain shale sandstone transition forest (high sandstone influence)	Shale transition	HQH
Cumberland Plain shale sandstone transition forest (low sandstone influence)	Shale transition	HQH
Eastern gully forest	Sandstone	Medium-quality habitat (MQH)
Exposed sandstone scribbly gum woodland	Sandstone	MQH
Highlands shale tall open forest: form C tall open variant	Shale	HQH
Moist shale woodland	Shale	HQH
Nattai sandstone river peppermint forest	Sandstone	MQH
Nepean enriched sandstone woodland	Shale-enriched	HQH
Nepean Gorge moist forest	Sandstone	MQH
O'Hares Creek shale forest	Shale transition	HQH
Riparian forest	Shale transition	HQH
Riparian scrub	Sandstone	Low quality habitat (LQH)
Rock pavement heath	Sandstone	LQH
Rock plate heath-mallee	Sandstone	LQH
Sandstone gully apple-peppermint forest	Sandstone	MQH
Sandstone gully peppermint forest	Sandstone	MQH
Sandstone heath-woodland	Sandstone	LQH
Sandstone ridgetop woodland	Sandstone	LQH
Sandstone riparian scrub	Sandstone	LQH
Sheltered sandstone blue-leaved stringybark forest	Sandstone	MQH
Transitional shale dry ironbark forest	Shale transition	HQH
Transitional shale open blue gum forest	Shale transition	HQH
Transitional shale stringybark forest	Shale transition	HQH
Upland swamps: banksia thicket	Sandstone	LQH
Upland swamps: fringing eucalypt woodland	Sandstone	LQH
Upland swamps: sedgeland-heath complex	Sandstone	LQH
Upland swamps: tea-tree thicket	Sandstone	LQH

Vegetation community	Soil classification	Koala habitat quality
Upper Georges River sandstone woodland	Shale-enriched	HQH
Western sandstone gully forest	Shale-enriched	HQH
Western Sydney dry rainforest	Shale	MQH
Woronora tall mallee-heath	Sandstone	LQH
Regenerating vegetation		LQH/MQH
Weeds and exotics		LQH
Exposed rock		LQH

3.4 Validating high-quality habitat

High-quality koala habitat was subject to a series of validation steps using four independent datasets obtained from the Wollondilly Koala Conservation Project.

3.4.1 Floristic validation

The draft high-quality habitat map was validated using floristic plot data collected as part of the Wollondilly Koala Conservation Project. A total of 143 20 x 20-metre full floristic plots were completed within the study area and used to validate HQH. Tree species recorded in vegetation plots were used to confirm the presence and association of koala-use trees with mapped HQH. These plots have been entered into the OEH Vegetation Information System (VIS) (OEH 2017b). The plots were not used to develop the vegetation mapping used to assign koala habitat quality and are therefore a suitable validation dataset.

3.4.2 Systematic presence–absence spotlighting data

The correlation between the presence of koalas and shale, shale-transition and shale-enriched vegetation types (e.g. Prevett et al. 2001; Phillips and Callaghan 2002; Ward 2002; Lunney et al. 2010) was assessed using systematic presence–absence spotlighting data (OEH 2017a). Between 2014 and 2018, over 800 systematic, two-hectare spotlighting surveys were undertaken as part of the Wollondilly and Southern Highlands Koala Conservation Projects. For the purposes of this report, spotlighting sites within the eastern part of the Wollondilly LGA were used (Figure 2). Survey sites within 500 metres of another site were excluded to promote independence, leaving 173 sites in total.

Spotlighting site data, including koala observations, were overlayed on the HQH map. The number of spotlighting sites and koalas recorded in and out of high-quality habitat was determined using a geographic information system (GIS).

An estimate of density of koalas in each habitat category (high-quality versus non-high-quality) was calculated by dividing the number of koalas observed by the area surveyed. Pearson's Chi-squared test was used to determine whether there was a significant difference in koala density in HQH and non-HQH using R.3.3.0 (R Core Team 2013).

Spotlighting is likely to underestimate koala numbers and densities. It is an imperfect technique and it is possible some koalas within survey areas were not detected.

3.4.3 Incidental koala sightings

The correlation between shale and shale-transition vegetation types and koalas was also assessed using koala sightings for the eastern part of the Wollondilly LGA from the NSW

Atlas of Wildlife (OEH 2017a). Records with an accuracy over 1 kilometre were discarded, leaving 582 valid records. Of these, 500 records (86%) had an accuracy of 100 metres or less.

Koala records were clipped to the map of high-quality and non-high-quality koala habitat with a 100-metre buffer. The buffer was included so that koala records on roads that intersect with HQH were classified as HQH rather than non-HQH. The percentage of records on identified HQH and non-HQH was calculated.

3.4.4 Association with preferred koala-use trees

A list of preferred koala-use trees in the Wollondilly LGA was determined through radio tracking eight collared koalas, as part of the Wollondilly Koala Conservation Project (OEH unpublished data). Weekly diurnal and nocturnal observations of radio-collared koalas were undertaken for up to six months. Tree species, diameter at breast-height and tree height were recorded for each direct koala observation. Individual koalas were observed between 30 and 53 times in the field. Data for two females (named Daenerys and Ellaria) with lower numbers of observations and overlapping home ranges were combined. Data from one koala was excluded due to insufficient data. Trees that were used at least 15% of the time by at least one koala were identified as preferred koala-use trees.

The canopy species for each vegetation community within the study area were listed as described in the associated technical report for each relevant vegetation map (DEC 2004; NPWS 2003; OEH 2013; Tozer et al. 2003). Identified preferred koala-use trees for Wollondilly LGA were highlighted for each vegetation type, and the number of preferred tree species per vegetation type counted. The number of vegetation communities with preferred koala trees and the average number of preferred koala trees was then calculated for sandstone vegetation communities and shale/shale-enriched vegetation communities.

3.5 Delineating koala movement corridors

We identified the most important connections of koala habitat in the region and defined these as primary, secondary and tertiary movement corridors. This was done by joining large patches of HQH areas, including or excluding habitat within or adjacent to these joined patches, then categorising these by the strength of links within and between connections, according to the following rules:

- HQH patches greater than 100 hectares (ha), with known koala feed-tree species and records of koalas, were identified as 'core' habitat. Tracking of koalas in the region has shown that 100 ha is sufficient to support the home range of at least one male koala and multiple females. In this region, the average home-range size of tracked koalas is 94 hectares, with males averaging 114 ha (n = 8) and females averaging 38 ha (n = 3) (unpublished OEH data from the Wollondilly and Southern Highlands Koala Conservation Projects).
- Patches of 'core' habitat separated by more than 1 kilometre (km) by cleared land were excluded from movement corridors. This 1 km threshold was sourced from the maximum distances of open land crossed by tracked koalas during the Wollondilly and Southern Highlands Koala Conservation Project (OEH unpublished data).
- Smaller patches of HQH within 100 metres (m) of 'core' habitat were included as part of movement corridors.
- Patches of MQH or LQH that were between 'core' habitat, or were entirely within 'core' habitat, were included as part of movement corridors.
- MQH or LQH patches peripheral to the corridors were not included in corridors.

- Scattered trees were included when they were completely or largely contained within corridors.
- Scattered trees peripheral to corridors will be used by koalas, but these were identified as 'supporting' habitat and excluded from corridors.
- Strips of HQH less than 200 m wide and less than 2 km long that led into the low-quality sandstone habitat of the Woronora Plateau surrounds were truncated (i.e. not mapped).

Identified corridors were then categorised into primary, secondary, and tertiary rankings.

- Primary corridors were those that contained 'core' koala habitat which were contiguous (gaps between trees less than 100 m) and were greater than 380 ha in size.
- Secondary corridors were those that contained 'core' habitat patches and smaller habitat patches or scattered trees that were separated by more than 100 m (were not contiguous), or were narrow or had pinch points less than 50 m wide and contained between 100 ha and 380 ha of 'core' habitat. Secondary corridors sometimes comprised 'core' habitat that totalled more than 380 ha and were wider than 50 m, but where this was the case, they were classified as secondary corridors if they did not connect to primary corridors on both ends.
- Tertiary corridors were those that contained patches of HQH that were poorly linked to primary corridors, contained between 30 ha and 100 ha of HQH, and did not connect to primary corridors on both ends. Tertiary corridors sometimes contained more than 100 ha of habitat, but where this was the case, they were classified as tertiary corridors if they did not connect to other corridors on both ends.

The corridor network was broken down into sub-catchments and named accordingly; e.g. Georges, Nepean, Cataract, and Allens Creek corridors. In the digital layer, each corridor was attributed its name; classification as a primary, secondary or tertiary corridor; the width of its connection to a primary corridor; its width at the narrowest point; and source layer.

Cleared land was excluded from mapped movement corridors, despite cleared land forming part of movement corridors. Rehabilitation of cleared land is a priority for improving corridor function.

3.6 Validating koala movement corridors

The koala movement corridor map developed for this report was validated by comparing it with a generalised linear model of koala habitat and associated corridor map (DECC 2007). The 2007 corridor habitat model was laid over the newly-defined corridors from this study and correlation between the pathways was identified. The DECC (2007) layer is a computer-based spatial interpolation (S-PLUS and ArcGIS Spatial Analyst) of koala corridors generated from known sightings of koalas modelled with environmental variables (DECC 2007). The layer products cover the Greater Southern Sydney region, which includes the current study area, and were derived at a scale of 1:25,000. These maps and the modelling process have been extensively reviewed, and the habitat model features in a peer-reviewed publication (Lunney et al. 2010). The dataset used to derive the 2007 model was independent from the dataset used to create the current layers; therefore, it is suitable as a validation tool for the current corridor layer.

3.7 Calculating koala numbers and densities in corridors

To demonstrate the relative importance of the individual movement corridors for koalas, we extrapolated koala numbers potentially supported in each of the movement corridors based on the amount of available habitat. Extrapolations were based from a density estimate using data collected from 67 systematic, 2 ha spotlights surveys undertaken within the identified corridors as part of the Wollondilly Koala Conservation Project (Figure 7). Koala density was calculated based on koalas directly observed in the 2 ha survey areas. No indirect calculations via scats, and/or scratches were made. Density was calculated by dividing the total number of koalas observed (7 koalas) by the search area (67 x 2 ha).

Although used by koalas, cleared land, scattered trees and regrowth areas around core koala habitat areas were excluded for these calculations. Therefore, this is a conservative, minimum estimate of koala numbers for corridors. Note that figures for the Georges River corridor were not calculated because this is mostly outside the Wollondilly LGA and there were insufficient presence–absence spotlighting sites to incorporate into this report.

4. Results

4.1 Core koala habitat

Core koala habitat in the Wilton and Greater Macarthur Growth Areas (GAs) is shown in Figure 1. Koalas in the area are living in an increasingly fragmented landscape. Strongholds for the koala metapopulations of the Campbelltown and Wollondilly Local Government Areas (LGAs) are large patches of core habitat on the eastern edge of the Cumberland Plain. The remaining areas of shale sandstone transition forest along the Nepean River and its major tributaries provide the only other core habitat for koalas in these areas. This habitat is more limited in extent and linear in configuration. However, it supports significant numbers of resident koalas and is therefore vital to the persistence of the regional koala population.

Figure 1 **Core and supporting koala habitat in the Wilton and Greater Macarthur Growth Areas. Note that koala records shown are sightings and do not indicate koala densities.**

4.2 Validation of high-quality koala habitat

4.2.1 Floristic validation

High-quality koala habitat validated well against the 143 new floristic plots. There was good agreement between the mapped high-quality habitat (HQH) and the koala feed trees identified in the floristic plots.

4.2.2 Systematic presence–absence spotlighting data

There was a strong correlation between koalas recorded during spotlighting surveys and areas classified as HQH (Table 2 and Figure 2). Of the 173 sites surveyed, 16 koalas were observed and 13 of these were recorded in HQH. Koala densities were significantly higher in mapped HQH than in non-HQH (chi-square = 5.4161, df = 1, p = 0.01995). The other three koalas were recorded in vegetation communities not classified as HQH. However, two of these three koalas were observed 150 metres or less from areas identified as HQH. This is likely to reflect under-mapping of the shale-influenced vegetation types, which is coarser in the southern part of the study area.

Table 2 **Koala density estimates calculated using spotlight data from high-quality and non-high-quality habitat**

	2-hectare Spotlight surveys (n =)	Koalas observed on spotlight (n =)	Estimated koala density/hectare	Estimated koalas per 100 hectares
High-quality habitat	83	13	0.078	7.8
Non-high-quality habitat	90	3	0.017	1.7

4.2.3 Incidental koala sightings

Of the 582 valid koala sighting records, 499 (86%) were recorded in HQH, confirming the results of previous studies in the region (Figure 3). It should be noted that incidental records collated in BioNet are often biased, with an over-representation of records in areas with high human–wildlife interaction or high visibility (i.e. areas where koalas are easier to see). However, koala sightings supported the assumptions underpinning the classification of vegetation communities as HQH or non-HQH for koalas.

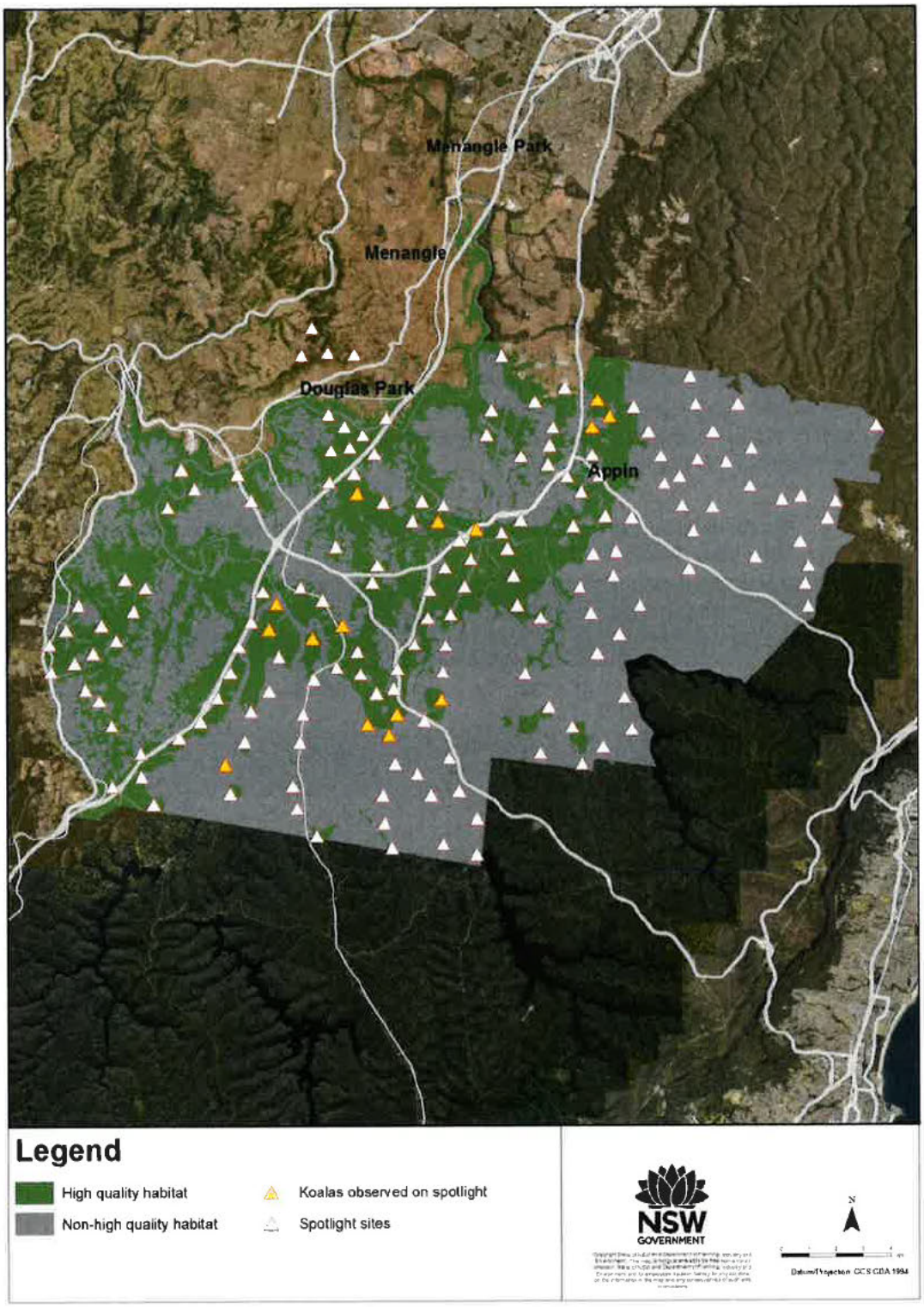

Figure 2 Area. **Spotlighting sites and positive koala records within the Wollondilly East Study**

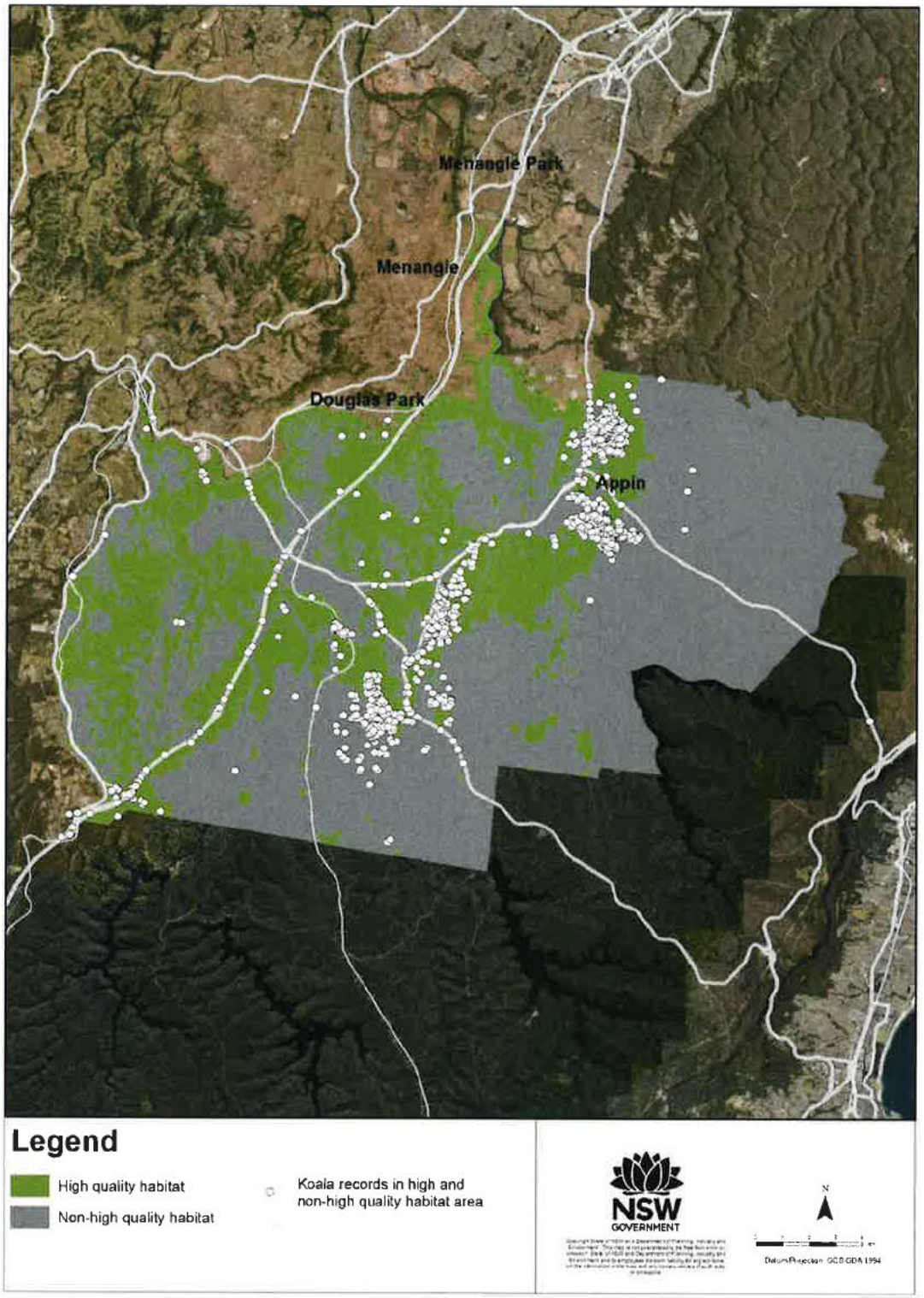

Figure 3 All koala records intersected with high-quality and non-high-quality koala habitat. Note that koala records shown are sightings and do not indicate koala densities.

4.2.4 Association with preferred koala use trees

A total of 243 observations of radio-tracked koalas revealed the animals used 22 different tree species, with each individual using between 5 and 12 species (Table 3). The observations indicate that each radio-tracked koala used two to four preferred tree species (trees used at least 15% of the time by at least one koala). Using this measure, seven preferred koala-use trees have been identified from the koala radio-tracking data (Table 4).

Table 3 Observed and percentage tree-use by individual koalas

	Koala name/s											
	Daenerys/Ellaria		Gendry		Hodor		Ilyn payne		Jon snow		Khal drogo	
Tree species	Obs	%	Obs	%	Obs	%	Obs	%	Obs	%	Obs	%
Acacia (A.) decurrens											8	15.1
A. floribunda											2	3.8
Corymbia gummifera	1	3.2					1	2.6	1	2.6	1	1.9
Eucalyptus (E.) amplifolia											3	5.7
E. beyeriana	2	6.5	1	3.3	3	5.7	1	2.6				
E. bosistoana					1	1.9					3	5.7
E. crebra			1	3.3	1	1.9					3	5.7
E. eugenoides											1	1.9
E. fibrosa	3	9.7	1	3.3	4	7.5	1	2.6				
E. globoidea	3	9.7	5	16.7	5	9.4	8	21.1			12	22.6
E. longifolia	2	6.5	9	30	23	43.4			1	2.6		
E. mollucana			1	3.3								
E. oblonga	2	6.5	3	10			5	13.2				
E. paniculata	5	16.1			1	1.9					3	5.7
E. pilularis	1	3.2							20	52.6		

Tree species	Koala name/s											
	Daenerys/Ellaria		Gendry		Hodor		Ilyn payne		Jon snow		Khal drogo	
	Obs	%	Obs	%	Obs	%	Obs	%	Obs	%	Obs	%
E. piperita							2	5.3			1	1.9
E. punctata	6	19.4	8	26.7	15	28.3	18	47.4	13	34.2	8	15.1
E. quadrangulata	3	9.7										
E. resinifera			1	3.3			1	2.6	1	2.6		
E. sclerophylla	1	3.2					1	2.6				
E. seiberi	2	6.5										
E. tereticornis											8	15.1
Total	**31**		**30**		**53**		**38**		**38**		**53**	

Notes: Orange indicates that more than 15% of observations for an individual koala were recorded in a particular tree species, and associated tree species are highlighted in green.

Table 4 Preferred koala-use trees in the Wollondilly study area

Species	Common name
Eucalyptus (E.) punctata	Grey gum
E. globoidea	White stringybark
E. longifolia	Woollybutt
E. tereticornis	Forest red gum
E. paniculata	Grey ironbark
E. pilularis	Blackbutt
Acacia decurrens	Green wattle

The number of species of preferred koala-use tree (PKT) was calculated for each vegetation community, with a range of between zero and six PKTs identified for each community (Appendix 1). There was a strong correlation between shale-influenced vegetation communities and presence of PKT: 15 of 16 shale-influenced vegetation communities contained at least 1 PKT, with an average of 2.4 PKTs per community. In contrast, 5 of 18 sandstone vegetation communities contained a PKT, with an average of 0.5 PKT per vegetation community.

4.3 Koala movement corridors

The primary, secondary and tertiary koala movement corridors are shown in Figure 4. Koala movement corridors have further been mapped and named according to sub-catchments (Figure 5). Each corridor was ranked as primary, secondary or tertiary, based on the area of core koala habitat it contained, width, and level of connectivity (see Section 3.5 and Table 5).

As for core koala habitat in the area (Figure 1), the primary corridor identified for the persistence of koalas ran continuously along the eastern edge of the Cumberland Plain from Campbelltown through Wedderburn and the eastern part of Appin, crossing Picton Road south of Wilton and skirting the southern edge of the Wilton GA (Figure 4).

The koala movement corridors did not extend into sandstone country, as native vegetation on sandstone derived soils is not considered HQH for koalas. The primary corridor on the east was directly and continuously linked with other primary corridors along the Nepean River, Allens Creek and Cataract Creek north to Menangle. Secondary corridors linked the Nepean corridor with the Georges River across the Greater Macarthur GA.

The configuration of the remaining core habitat in this region presents significant challenges for maintaining connectivity for the population. Residential development in much of the area between core habitats will place significant pressure on the smaller, narrower corridors that link koala populations.

4.4 Validation of koala movement corridors

The koala movement corridors validated well against the independently derived generalised linear model (GLM) of koala habitat/linkage. There was a high degree of overlap (approximately 80%, although this was not formally calculated) between the GLM of koala habitat/linkage and the new corridor map despite different vegetation mapping base layers and koala presence information (Figure 6). Note that the GLM of koala habitat/linkage was completed at a larger scale, so would not include smaller corridors newly mapped.

Table 5 **Extent of core koala habitat within koala movement corridors and rankings for corridors**

Corridor name	Corridor rank	Habitat	Area of core habitat (hectares)
Nepean	Primary	Core	1742.58
Allens	Primary	Core	1235.17
Wallandoola–Cataract	Primary	Core	1193.03
Avon–Nepean	Primary	Core	1089.23
Cordeaux	Primary	Core	628.64
Cascade	Primary	Core	605.28
Cataract	Primary	Core	381.38
Sub-total			**6875.31**
Ousedale–Mallaty	Secondary	Core	390.08
Simpsons–Elladale	Secondary	Core	255.31
Woodhouse–Menangle	Secondary	Core	220.33
Noorumba	Secondary	Core	122.01
Clements	Secondary	Core	107.86
Sub-total			**1095.59**
Stonequarry	Tertiary	Core	124.15
Myrtle	Tertiary	Core	84.48
Strongybark	Tertiary	Core	78.43
Leafs Gully	Tertiary	Core	34.52
Sub-total			**321.58**
Total	**All**		**8292.46**

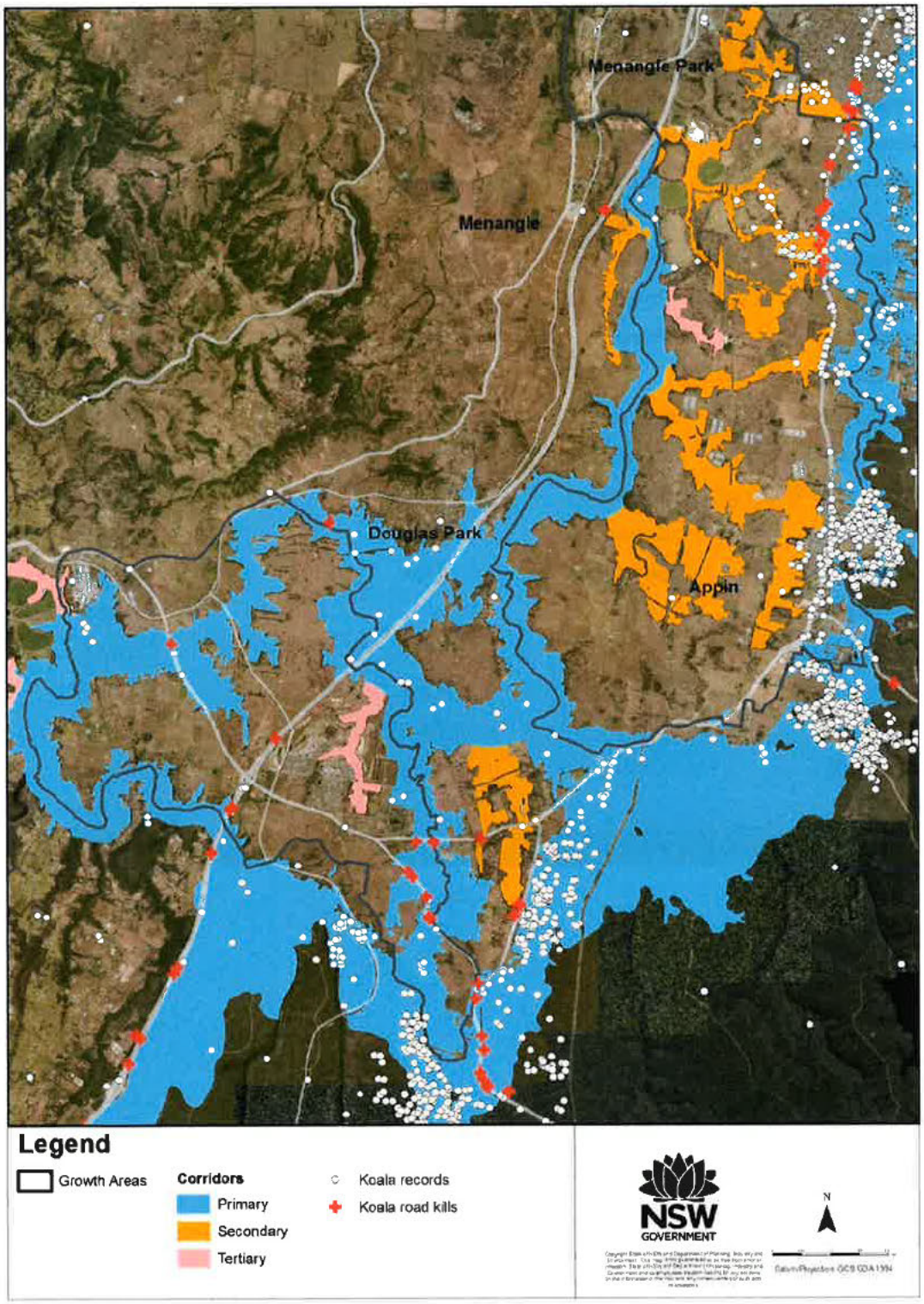

Figure 4 Rankings for koala corridors across the Wilton and Greater Macarthur Growth Areas. Note that koala records shown are sightings and do not indicate koala densities.

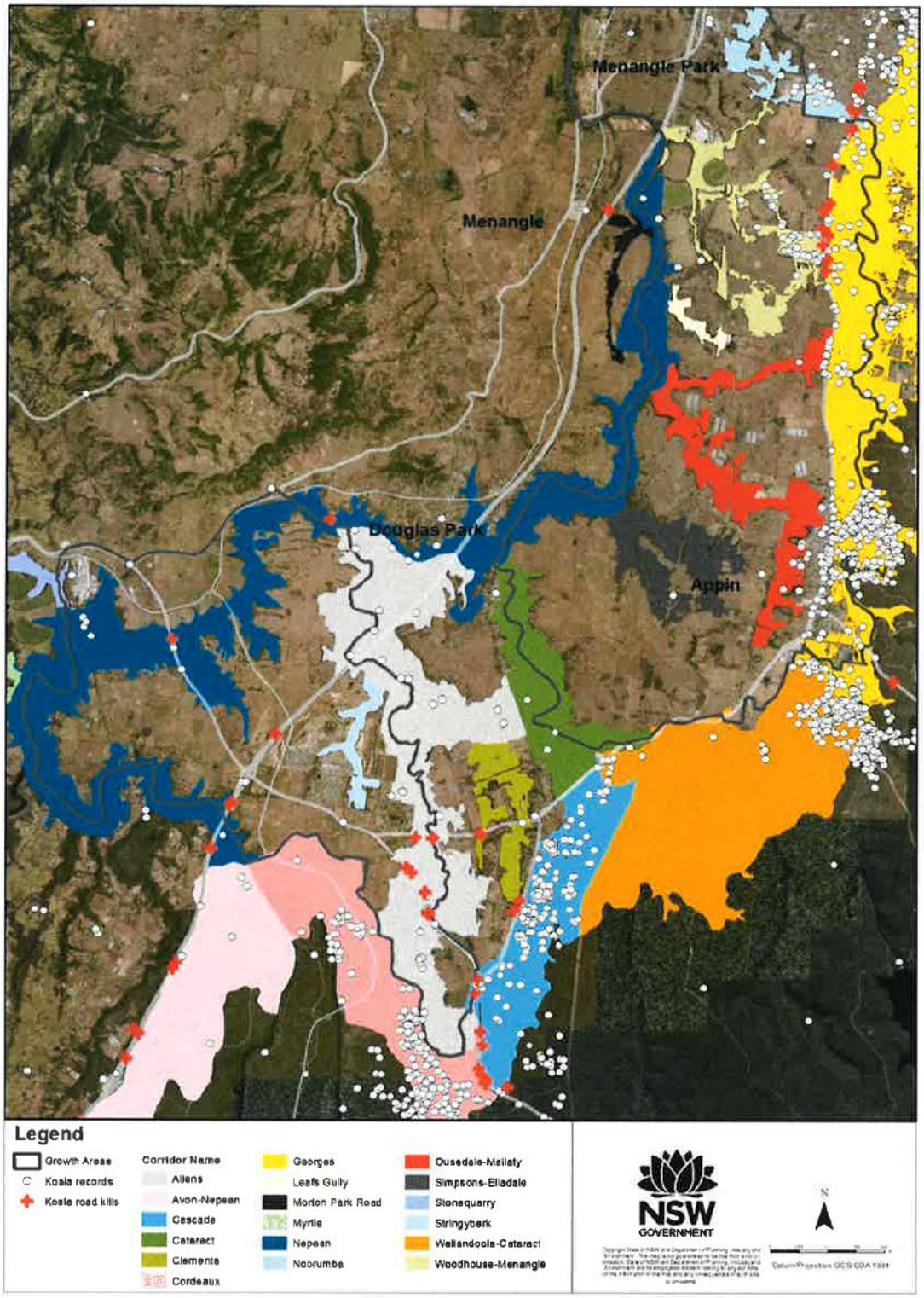

Figure 5 The 17 koala movement corridors across the Wilton and Greater Macarthur Growth Areas. Note that koala records shown are sightings and do not indicate koala densities.

Figure 6 Comparison of the generalised linear model (GLM) of koala habitat/linkage and the new corridor map.

4.5 Koala densities and numbers in corridors

Table 6 lists the amount of core koala habitat and estimates of koala numbers potentially supported by each identified movement corridor based on available habitat and the density estimate (0.052 koalas/hectare) calculated from the spotlight surveys of koalas shown in Figure 7. Primary corridors contained a significant amount of core koala habitat (6,875.31 ha), providing habitat for at least 359 koalas. Secondary and tertiary corridors contained less core koala habitat and therefore lower estimated densities of koalas. Primary corridors are key for the extent and stretches of contiguous habitat they provide. They need to be protected and enhanced for their value in connectivity and as important koala habitat in their own right.

Figure 5 shows the names and locations of the individual koala corridors identified in Table 6. The most important corridor in regard to the amount of core koala habitat, the highest densities of koala potentially supported, and largest and longest link across the GAs was the Nepean corridor (1742.58 ha and 91 koalas). The Allens Creek and Cataract corridors, which are key links between the Nepean corridor and intact bushland to the east (towards the Cordeaux, Cascade, and Wallandoola–Cataract corridors), also contained large amounts of core koala habitat and potentially supported 64 and 20 koalas, respectively. Although this analysis was not undertaken on the Georges corridor, this corridor is known to be important as a key component of the main north–south corridor which links the known Campbelltown koala population with the Wollondilly koala population and the Southern Highlands population further south.

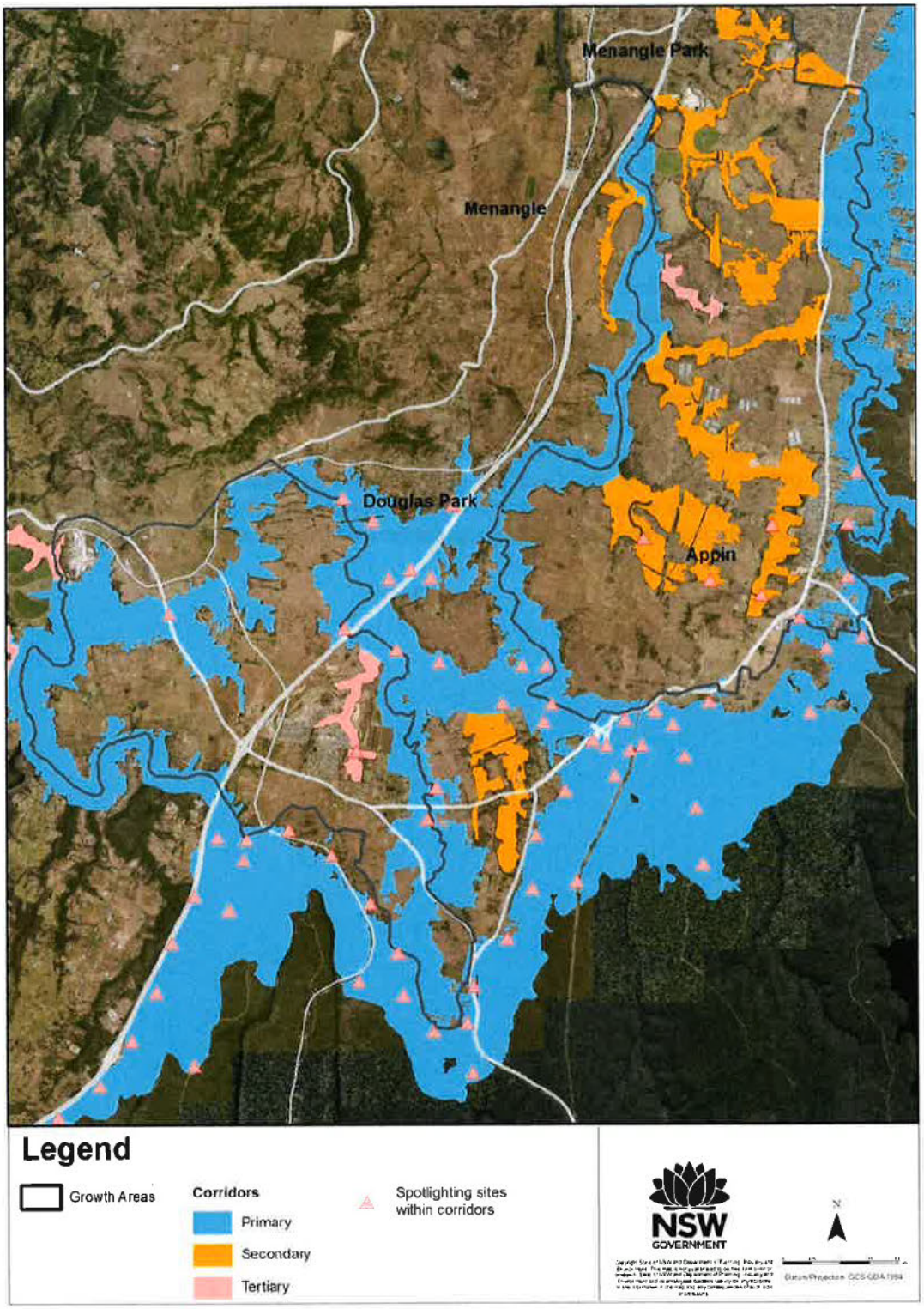

Figure 7 Map of systematic spotlight surveys for koalas within the corridors of the Wilton and Greater Macarthur Growth Areas used to estimate koala densities and extrapolate koala numbers.

Table 6 **Extent of core koala habitat and estimated koala numbers within corridors based on a density estimate of 0.052 koalas/hectare**

Corridor name	Corridor rank	Habitat	Area of core habitat	Extrapolated koala numbers based on habitat extent
Nepean	Primary	Core	1742.58	91
Allens	Primary	Core	1235.17	64
Wallandoola–Cataract	Primary	Core	1193.03	62
Avon–Nepean	Primary	Core	1089.23	57
Cordeaux	Primary	Core	628.64	33
Cascade	Primary	Core	605.28	32
Cataract	Primary	Core	381.38	20
Sub-total			**6875.31**	**359**
Ousedale–Mallaty	Secondary	Core	390.08	20
Simpsons–Elladale	Secondary	Core	255.31	13
Woodhouse–Menangle	Secondary	Core	220.33	12
Noorumba	Secondary	Core	122.01	6
Clements	Secondary	Core	107.86	6
Sub-total			**1095.59**	**57**
Stonequarry	Tertiary	Core	124.15	6
Myrtle	Tertiary	Core	84.48	4
Strongybark	Tertiary	Core	78.43	4
Leafs Gully	Tertiary	Core	34.52	2
Sub-total			**321.58**	**16**
Total			**8292.46**	**433**

5. Principles and recommendations for koala conservation in Wollondilly and Campbelltown

South-western Sydney is facing large-scale land-use change with the development of the Wilton and Greater Macarthur Growth Areas (GAs). The proposed change from rural to low/medium density residential development across the GAs has significant implications for the koalas of this area.

Notwithstanding the implementation of measures to avoid, minimise and reduce impacts, major residential development in the GAs would result in:

- the direct loss of core and supporting koala habitat, and potentially habitat fragmentation, resulting from the upgrade of existing principal roads into the new residential areas, as well as from new roads and other urban development
- an increased urban interface with koala populations
- increased traffic volumes
- increased indirect impacts to koala habitat through more frequent fire, weed incursion, feral pests, domestic animals, light spill, noise and rubbish dumping.

The direct loss of core and supporting koala habitat and any subsequent habitat fragmentation would have the most significant impact on koalas in the area. It has been demonstrated that as areas of habitat for koalas are reduced, koala population sizes are directly impacted, and the likelihood of local extinction increases. The survival of metapopulations relies on the ability of animals to recolonise habitat patches where a sub-population has become extinct. For koala populations to thrive and maintain genetic biodiversity, habitat must remain intact and available for koalas to disperse.

Increased urban interfaces, traffic volumes, and disturbance would also significantly impact koalas. Higher traffic volumes would result in a greater risk of koala–vehicle collisions and koala roadkill. Increased urban interfaces would lead to a rise in interactions with people, houses, pools, domestic dogs and vehicles, in turn potentially leading to koala stress, injury, or death. Exposure to novel and prolonged stressors, such as those associated with human-induced landscape change, has the potential to suppress immune function in koalas, thereby increasing their susceptibility to diseases such as chlamydia.

The most rapid declines in koala numbers in New South Wales and Queensland have been in the high-density urban and remnant source populations, which are undergoing rapid conversion from agriculture to urban environments (McAlpine et al. 2006a; Adams–Hosking 2017). High rates of mortality associated with development and dogs were found for radio-tracked koalas in an urban area of Queensland (Redlands City; de Oliveira et al. 2013). A Queensland study found that koalas were unable to successfully disperse through urban areas due to attacks by domestic dogs and collisions with vehicles (Dique et al. 2003). McAlpine et al. (2017) found that landscape change influences the susceptibility of koala to disease, and that urbanisation is associated with an increased prevalence of chlamydia. The impact of chlamydia on koala populations may not be evident for several years, until there is a reported impact on reproductive success.

5.1 Principles and recommendations

We have assessed existing and new information on koalas, including the identification of core koala habitat and koala movement corridors in southern Campbelltown, and around Appin and Wilton (Section 3), as well as the relative importance of koala corridors in terms of

their positions in the landscape, estimated koala density and available core koala habitat (Section 4). In combination with this information, an assessment of the known threats to koalas in the area, and the extent of proposed development in the GAs and their impacts, we have designed a strategy to conserve the koala metapopulations in the Wollondilly and Campbelltown Local Government Areas (LGAs).

Underlying the strategy are four key principles:

1. avoid new residential development within core koala habitat and primary corridors
2. separate residential development and koala populations to minimise ongoing threats from domestic dogs and vehicles
3. identify critical revegetation zones that will augment and strengthen core habitat and corridors
4. identify koala roadkill hotspots requiring road-kill mitigation fencing and/or underpasses to allow safe passage of koalas.

These principles generally align with existing koala principles or guidelines, such as the Planning Guidelines for Koala Conservation and Recovery: A Guide to Best Planning Practice (McAlpine et al. 2006b) prepared to help land managers plan for the long-term conservation of koalas. The guidelines recommend that:

- the maintenance and protection of networks of koala habitat patches and corridors linking blocks of koala habitat be of highest priority
- approval bodies ensure development does not further fragment koala habitat areas by removing habitat/linkage areas or imposing significant threats to koalas
- development and roads are separated from koala habitat, and potential conflict between threats such as dogs are minimised – the presence of koalas is greatly reduced by high road densities, especially in areas within or adjacent to koala habitat
- approval bodies for development encourage koala habitat restoration and avoid internal fragmentation of koala habitat patch and linkages, and reductions in tree density
- sufficient structural diversity in koala habitat is maintained – while feed trees, soil fertility and water availability are the most important determinants of koala habitat quality, the presence of factors such as large trees, species diversity, and structure can enhance koala habitat quality
- larger koala habitat patches and wider corridors are better – patches should have low perimeter-to-area ratios to decrease edge effects since for koalas, edge effects may lead to increased predation risk by dogs or increased stress leading to disease
- blocks of koala habitat and corridors linking these be kept free from barriers to koala movement – where there are known black-spot areas, it recommends constructing exclusion fencing.

Next we outline our strategy and management recommendations to conserve the koala metapopulations in the Wollondilly and Campbelltown LGAs in line with the four key principles.

5.1.1 Avoid development within core habitat and primary corridors

All development within core koala habitat and primary corridors should be avoided. As outlined above, the direct loss of core koala habitat and habitat fragmentation would have the biggest impact on koalas in the area. Koala populations operate at the landscape level and require habitat connectivity for animal movement, particularly in the spring breeding season. This connectivity is also important for the dispersal of young animals or animals recolonising areas where a metapopulation has gone extinct.

Development in currently cleared areas adjacent to primary corridors should also be avoided. Primary corridors, particularly to the east of Appin Road adjacent to the Greater

Macarthur GA and in the south-east section of the Wilton GA, are currently mapped adjacent to cleared areas (Figures 5 and 6). These cleared areas have been excised from the primary corridors as they do not currently support core koala habitat and koala records; they have been historically cleared of core koala habitat. Nevertheless, koalas will traverse cleared areas. In this context, cleared areas adjacent to primary koala corridors could be informally considered part of primary corridors (outside of criteria used to categorise corridors). Key areas of cleared land adjacent to primary corridors where development is to be avoided include those to the east of Appin Road along the entire eastern length of the Greater Macarthur GA and in the south-east section of the Wilton GA.

5.1.2 Separate residential development from koala habitat and movement corridors

Residential development poses a suite of direct and indirect threats to koalas. Facilitating koala access into residential areas exposes them to novel and more serious threats such as domestic dogs, cars and swimming pools. These persistent threats inhibit long-term koala survival in proximity to urban settlement. 'Koala-friendly urban design', which has been trialled in other locations, is not recommended.

Keeping koalas out of future residential areas in the GAs is key to minimise the direct and indirect threats associated with residential development. Koalas should be excluded in two ways:

- Firstly, residential subdivision should be designed to limit the interface between core habitat and corridors. The integrity of corridors is increased by increasing width, so avoiding housing infill within primary corridors to provide maximum movement potential and minimal disturbance is critical.
- Secondly, where development proceeds adjacent to core koala habitat and movement corridors, fencing and other barrier solutions should be installed to separate koalas from houses and their occupants. Creating access points for residents to enjoy the bush is important to link communities with their landscape, so identifying a small number of well-considered access points will limit the likelihood of koalas traversing residential settlements.

Figure 8 indicates approximate locations where barriers (residential enclave fence) can be added to separate residential areas/development and core koala habitat/corridors in the Wilton and Greater Macarthur GAs.

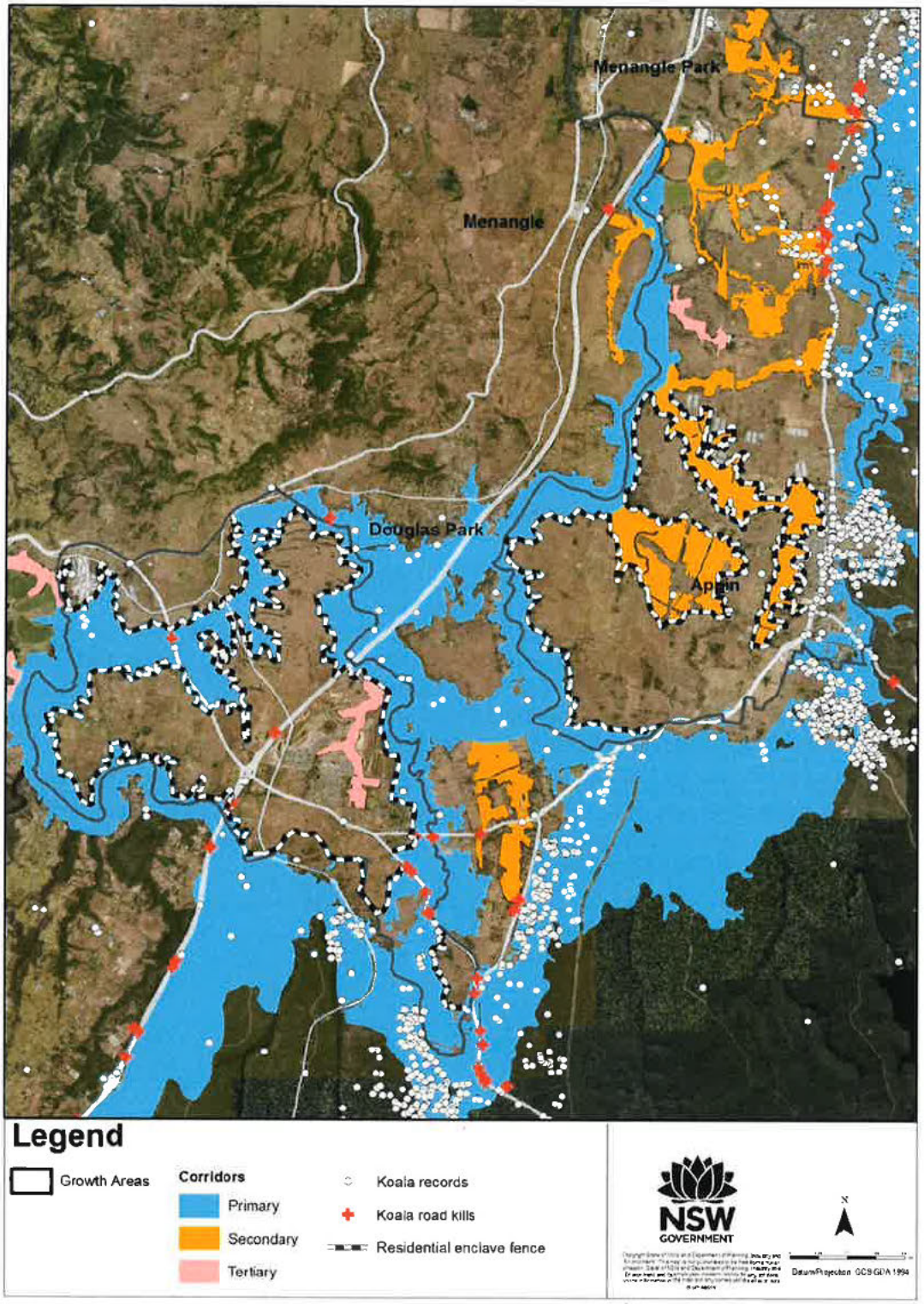

Figure 8 Approximate locations of residential enclave fencing or other barrier solutions where development and core koala habitat/corridors can be separated in the Wilton and Greater Macarthur Growth Areas. Note that koala records shown are sightings and do not indicate koala densities.

5.1.3 Restore and revegetate koala habitat and movement corridors

Wider corridors and larger areas of habitat are superior to narrow corridors and smaller areas of habitat, partly because wider corridors and larger habitat areas have lower perimeter-to-area ratios (less edge effects). Some habitat linkages are compromised or incomplete in some areas due to historical clearing. Some of these areas of core habitat can be augmented and strengthened to widen corridors and increase the area of core habitat. Habitat restoration and revegetation is effective in filling gaps.

When considered along with the principle of separating urban development and koala habitat and corridors, clear priorities for habitat restoration in the Wilton and Greater Macarthur GAs emerge. The highest priority in the Wilton GA is in the south-east section, where core koala habitat surrounds an almost fully enclosed area of cleared land at the beginning of the primary corridor along Allens Creek (Allens corridor) (Figure 9).

Many high-priority restoration areas exist within the Greater Macarthur GA. The most apparent areas are along the length of the eastern side of the GA, to the east of Appin Road, directly adjacent to the Georges River corridor (Figure 9). Additional areas (not shown in Figure 9) include areas to the east of the Ousedale–Mallaty corridor near Appin. Restoring these areas would connect the Ousedale–Mallaty corridor to primary corridors on both ends. The Ousedale–Mallaty corridor is currently connected to a primary corridor (the Nepean corridor) at its western end.

If the identified cleared land was developed rather than restored, this would introduce significant threats and compromise these adjacent corridor values. Conservation of the regional koala population would be greatly enhanced by restoring the cleared areas to HQH, an outcome that would consolidate and double the width of the existing Allens and Georges River primary corridors and result in a far more sensitive urban design. Although it would take time for trees to grow, koalas are known to use saplings. Indeed, the leaves of younger trees often have higher nutrient levels than older trees.

Protection of the vegetation and restoration of the degraded areas could potentially be funded through biodiversity offset arrangements for other developments or major projects in Western Sydney. There is strong demand in the market for biobank/biodiversity stewardship agreement sites in Western Sydney.

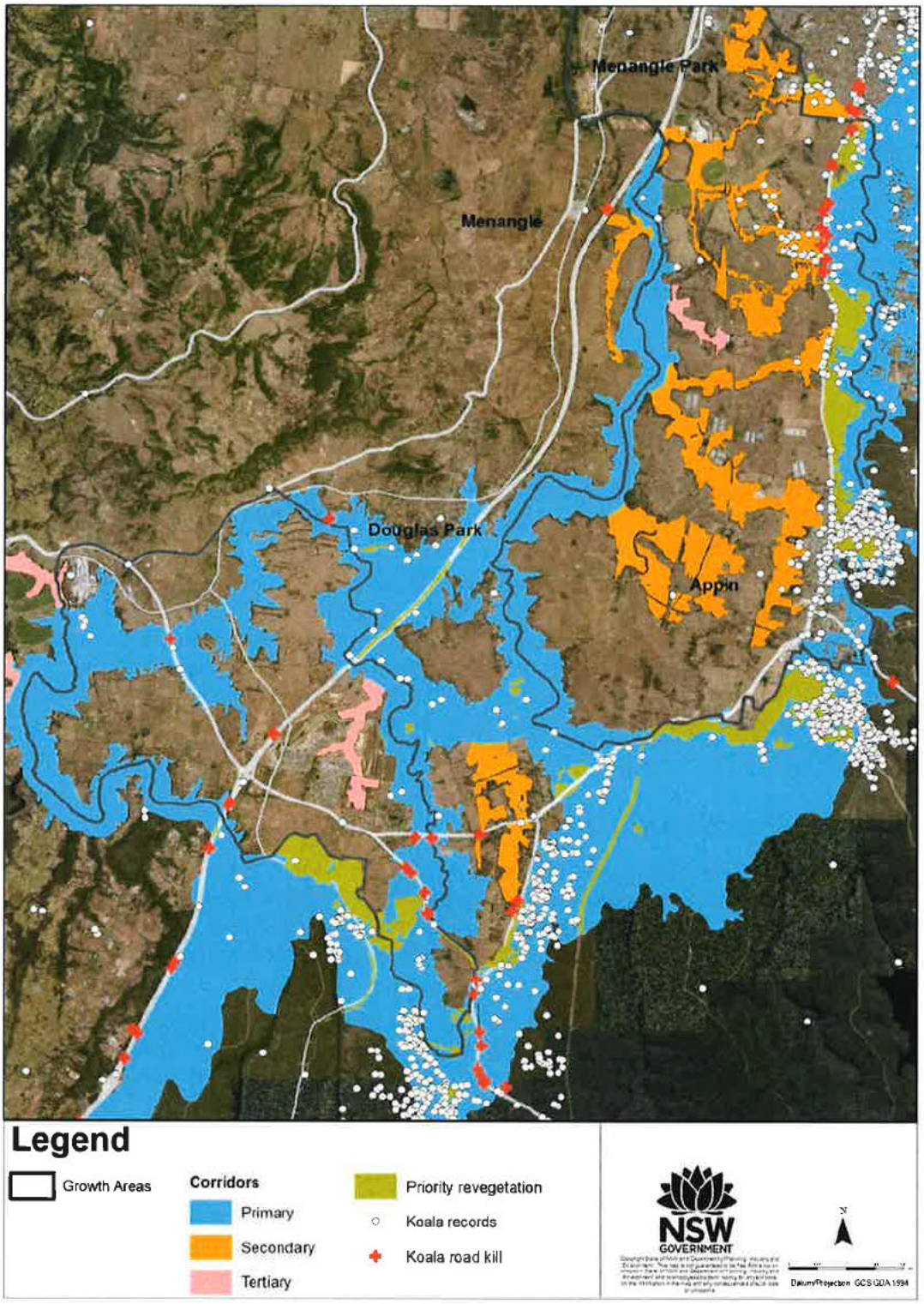

Figure 9 Key areas for restoration in the Wilton and Greater Macarthur Growth Areas. Note that koala records shown are sightings and do not indicate koala densities.

5.1.4 Prevent koala roadkill

Koala roadkill is a highly visible and increasing threat to koalas in the Campbelltown and Wollondilly LGAs. Much of the remaining core koala habitat is intersected by major roads, with the Hume Motorway, Picton Road, Wilton Road, MacArthur Drive and Appin Road all traversing areas of core habitat and primary corridors. Traffic on Picton and Appin Roads has rapidly increased over the last 5 years and with this there has been an increase in the number of koala roadkill incidents. With land-use changes and further increases in traffic, the number of koalas being hit, injured and killed will continue to rapidly increase unless there is significant investment in roadkill mitigation. Increases in koala roadkill will potentially affect the viability of the population. This has been demonstrated in koala populations elsewhere (Polak et al. 2014). Widening and upgrades of major arterial roads provides an opportunity to implement roadkill mitigation measures, which will help slow the decline of koalas in the area (Polak et al. 2014).

Roadkill hotspots have been identified based on collation of records in the NSW Wildlife Atlas (OEH 2017a; Figure 10). Hotspots have been identified as stretches of road with greater than four roadkill koala incidents within a two-kilometre stretch. Hotspots are along Picton Road between Cordeaux Dam and Wilton, MacArthur Drive, the eastern end of Wilton Road, and Appin Road between Appin and Campbelltown. Another important hotspot occurs on the Hume Motorway at the Bargo exit, just south of the Wilton GA. These identified hotspots occur where a major road intersects a primary koala corridor, typically at the headwaters of a watercourse.

Options to reduce koala mortality on these roads include exclusion fencing, with improved road underpasses installed along existing gully line underpasses, such as on Allens Creek, to retain connectivity (Figure 10). Exclusion fences could also be installed on the east side of Appin Road (Figure 10). Exclusion fencing and underpasses would require ongoing maintenance, however, fencing is considered the most effective roadkill mitigation measure on major roads. We do not consider signage an effective roadkill mitigation measure on major roads.

5.2 Predicted outcomes

If management recommendations outlined in Sections 5.1.1 to 5.1.4 are implemented, the extent of core koala habitat would increase and koala movement corridors would be consolidated. Koalas would be separated from future residential areas in the GAs and existing roadkill hotspot locations, reducing the threats associated with residential areas and major roads.

Figure 11 illustrates consolidated koala movement corridors post-revegetation and recommended mitigation measures to minimise threats associated with residential areas and major roads. It is noted that as currently cleared areas adjacent to the Wilton GA were restored, additional exclusion fencing would be required (indicated in Figure 11).

Exclusion fencing progressively built along Appin Road would prevent east–west koala movements across the Greater Macarthur GA. Underpass structures would need to be built to provide east–west access to koalas. However, we do not consider the east–west corridors essential for the long-term survival of the regional koala population. Koalas could continue to move through the landscape via primary movement corridors, rather than via the east–west secondary corridors. The distance from the top of the Georges corridor to the Cataract corridor is approximately 15 kilometres and is within the distance that koalas can disperse. Allowing koalas access to the secondary corridors would expose them to threats associated with residential areas and would be inconsistent with the second key principle of our strategy to conserve these koala populations (to separate koalas from residential areas).

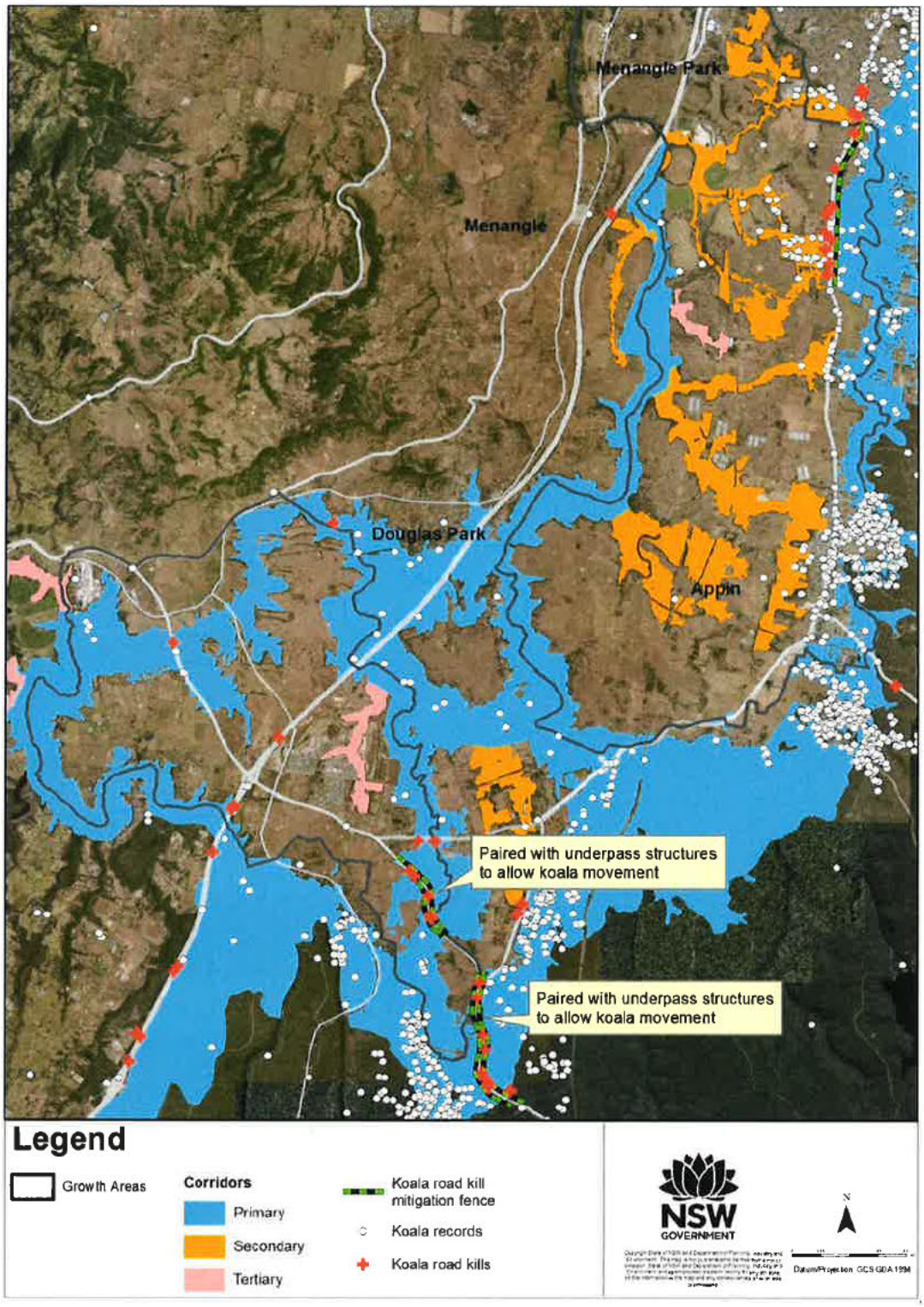

Figure 10 Koala roadkill mitigation infrastructure (fences with some paired with underpass structures) recommended to be implemented in the Wilton and Greater Macarthur Growth Areas. Note that koala records shown are sightings and do not indicate koala densities.

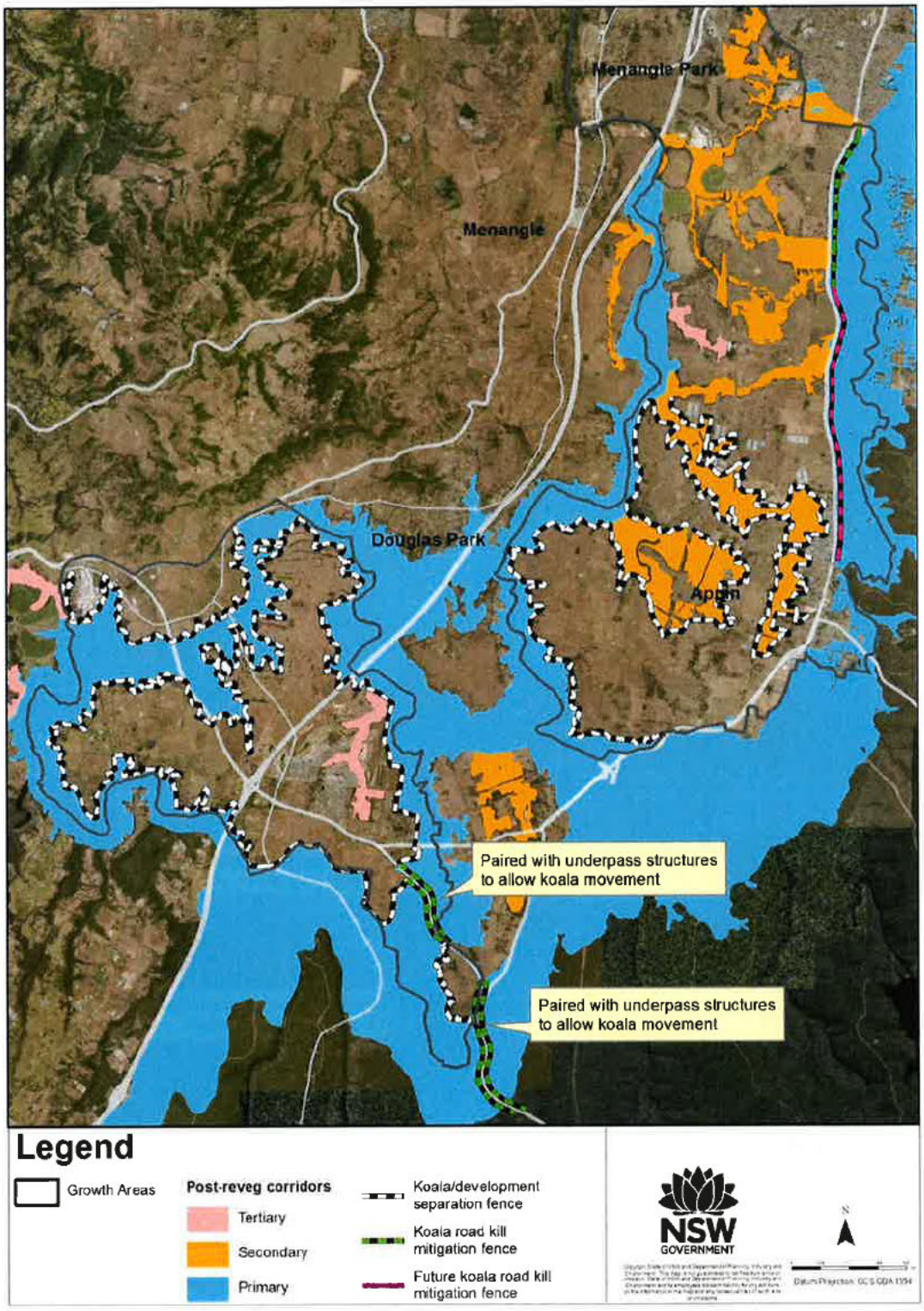

Figure 11 Koala movement corridors post-revegetation and recommended mitigation measures (including separation and roadkill mitigation fences and roadkill mitigation fences paired with underpass structures) in the Wilton and Greater Macarthur Growth Areas.

6. Glossary

High-quality koala habitat: All shale and shale-enriched vegetation types with a dominant eucalypt canopy in the area around the Wilton and Greater Macarthur Growth Areas (GAs).

Medium-quality koala habitat: Eucalypt-dominated riparian sandstone vegetation communities, rainforest vegetation communities on shale with some eucalypts present, and regenerating acacia scrubs on shale in the area around the Wilton and Greater Macarthur GAs.

Low-quality koala habitat: Low-fertility sandstone vegetation communities including heaths, heathy woodlands, swamps and rocky woodlands in the area around the Wilton and Greater Macarthur GAs.

Core koala habitat: Large patches (>100 hectares (ha)) of high-quality koala habitat that contain known koala feed tree species, determined through the Wollondilly and Southern Highlands Koala Conservation Projects, and records of koalas. The SEPP 44 definition of core koala habitat is not used in this document because koalas in the area use a range of tree species not listed in SEPP 44.

Supporting habitat: Scattered trees peripheral to and outside of identified koala movement corridors.

Koala movement corridors: Areas of habitat koalas can move through and potentially use to recolonise other core habitat patches where a metapopulation has gone extinct. Note that koala movement corridors are not necessarily strips of core koala habitat surrounded by cleared areas. Core habitat surroundings may include other intact vegetation that is not favoured by koalas, such as open woodland on sandstone.

Primary corridors: The most important linkages of koala habitat for the koala population in the local area around the Wilton and Greater Macarthur GAs. They contain patches of core koala habitat which are contiguous (gaps between trees are less than 100 metres (m)) and contain over 380 ha of core habitat per named corridor. They are the most important koala habitat in which the bulk of koalas in the area live and breed. The breaking or weakening of primary corridors would have serious ramifications on the long-term viability of koalas in the area, and thereby, the regional koala population.

Secondary corridors: Linkages that contain patches of core koala habitat, smaller habitat patches, and scattered trees separated by more than 100 m (are not contiguous), are narrow or have pinch points of less than 50 m wide, and contain between 100 and 380 ha of core habitat per named corridor. Secondary corridors may include corridors that contain more than 380 ha of habitat or corridors that are more than 50 m wide, if they do not connect to primary corridors on both ends. The retention of secondary corridors is not critical to the long-term viability of the regional koala population; however, enhancement of these corridors would support primary corridors and core koala habitat.

Tertiary corridors: Linkages that contain patches of high-quality koala habitat that are poorly linked to primary corridors, together contain between 30 ha and 100 ha of high-quality habitat per named corridor, and do not connect to primary corridors on both ends. Tertiary corridors may contain corridors that contain more than 100 ha of habitat, but are classified as tertiary corridors if they lead away from other corridors or do not connect to other corridors. Tertiary corridors may be enhanced to provide greater connectivity and habitat for the koalas in the local area around the Wilton and Greater Macarthur GAs, but are the least-valuable connectivity asset to retain for koalas and the regional koala population.

Regional koala population: The single, contiguous koala population extending from Campbelltown through Wollondilly to Wingecarribee.

Metapopulation: A group of spatially separated sub-populations connected by dispersal. In this report, the term is applied to koalas in the Campbelltown and Wollondilly Local Government Areas; i.e. the Campbelltown koala metapopulation and the Wollondilly koala metapopulation.

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8. Appendix 1

Table A.1. Mapped vegetation communities in the study area with details for canopy floristics, preferred koala feed trees, soil classification, koala habitat quality and status

Vegetation community	Hectare extant	Canopy floristic (Preferred koala use trees bolded)	Number of preferred tree species	Soil classification	Habitat quality	Koala habitat status
Cumberland Plain alluvial woodland	445	*E. amplifolia*, ***E. tereticornis***, *A. floribunda, E. deanei, E. eugenioides, A. subvelutina, E. moluccana,* ***E. globoidea, E. punctata***, *E. baueriana, C. maculata, E. elata, E. piperita, E. sclerophylla*	3	Shale	HQH	Core
Cumberland Plain shale hills woodland	809	*E. moluccana,* ***E. tereticornis***, *E. crebra, E. eugenioides, E. amplifolia. A. floribunda, C. maculata, A. subvelutina, E. fibrosa*	1	Shale	HQH	Core
Cumberland Plain shale plains woodland	462	*E. moluccana,* ***E. tereticornis***, *E. crebra, E. eugenioides, E. fibrosa, A. floribunda, A. subvelutina, C. maculata, E. amplifolia,* ***E. punctata***, *E. baueriana,* ***E. globoidea***, *E. longifolia,* ***E. paniculata***	4	Shale	HQH	Core
Cumberland Plain shale sandstone transition forest (high sandstone influence)	5067	***E. punctata***, *E. crebra, E. eximia, E. notabilis, E. beyeriana, E. fibrosa, C. gummifera, A. bakeri, E. eugenioides,* ***E. pilularis***, *C. maculata,* ***E. globoidea***, *A. floribunda, E. oblonga,* ***E. tereticornis***, *A. costata, E. resinifera, E. sclerophylla,* ***E. longifolia,*** *E. moluccana*	5	Shale transition	HQH	Core
Cumberland Plain shale sandstone transition forest (low sandstone influence)	718	***E. tereticornis***, *E. eugenioides, E. crebra, E. fibrosa,* ***E. punctata***, *E. moluccana, A. floribunda,* ***E. globoidea***, *C. maculata, A. bakeri, E. resinifera, C. gummifera,* ***E. pilularis***, *E. saligna, E. sideroxylon*	4	Shale transition	HQH	Core

Eastern gully forest	292	*A. costata, C. gummifera, E. piperita, E. seiberi*	0	Sandstone	MQH	Non-core
Exposed sandstone scribbly gum woodland	8679	*E. Sclerophylla. E. racemosa, E. haemastoma, C. gummifera, E. oblonga, E. seiberi, E. piperita, A. costata*	0	Sandstone	LQH	Non-core
Highlands shale tall open forest: form C tall open variant	17	*E. piperita,* ***E. globoidea****, E. radiata, E. obliqua, E. cypellocarpa, E. quadrangilata, E. elata, E. agglomerata,* ***E. punctata****, E. amplifolia, E. dives, E. smithii, E. ovata*	2	Shale	HQH	Core
Moist shale woodland	348	***E. tereticornis****, E. moluccana, E. crebra, C. maculata*	1	Shale	HQH	Non-core
Nattai sandstone river peppermint forest	47	*E. elata, E. piperita, E. cypellocarpa, E. oreades*	0	Sandstone	LQH	Non-core
Nepean enriched sandstone woodland	302	*C. gummifera,* ***E. globoidea****, E. oblonga, E. eugenoides, E. piperita, E. seiberi,* ***E. punctata***	2	Shale-enriched sandstone	HQH	Core
Nepean Gorge moist forest	6	*E. elata, E. agglomerata,* ***E. punctata****, E. piperita, C. gummifera*	1	Sandstone	MQH	Non-core
O'Hares Creek shale forest	9	***E. globoidea****, E. piperita, A. costata, C. gummifera, E. seiberi*	1	Shale transition	HQH	Core
Riparian forest	184	*E. botryoides, E. benthamii, A. subvelutina, E. elata, A. floribunda, E. baueriana, E. saligna X botryoides,* ***E. tereticornis***	1	Shale transition	HQH	Core
Riparian scrub	133	*A. costata,* ***E. pilularis***	1	Sandstone	LQH	Non-core
Rock pavement heath	2	None	0	Sandstone	LQH	Non-core
Rock plate heath-mallee	19	*E. stricta, E. apiculata, E. multicaulis, E. sclerophylla, E. seiberi, C. gummifera, E. oblonga*	0	Sandstone	LQH	Non-core
Sandstone gully apple-peppermint forest	907	*A. costata, E. piperita, C. gummifera, E. seiberi*	0	Sandstone	MQH	Non-core

Sandstone gully peppermint forest	1022	*E. piperita, C. gummifera, E. seiberi,* ***E. globoidea***	1	Sandstone	MQH	Non-core
Sandstone heath-woodland	37	*E. haemastoma.racemosa, E. seiberi, E. oblonga, C. gummifera*	0	Sandstone	LQH	Non-core
Sandstone ridgetop woodland	766	*C. gummifera, E. sclerophylla,* ***E. punctata,*** *A. costata, E. Oblonga, E. piperita, A. bakeri, E. sieberi,* ***E. globoidea,*** *E. agglomerata, E. haemastoma, E. parramattensis,* ***E. pilularis,*** *E. squamosa,*	3	Sandstone	LQH	Non-core
Sandstone riparian scrub	326	*A. costata, E. piperita,* ***E. punctata, E. pilularis***	2	Sandstone	LQH	Non-core
Sheltered sandstone blue-leaved stringybark forest	1200	*C. gummifera,* ***E. punctata,*** *E. piperita, E. agglomerata*	1	Sandstone	LQH	Non-core
Transitional shale dry ironbark forest	1350	*E. crebra, E. fibrosa,* ***E. paniculata, E. globoidea,*** *E. eugenoides,* ***E. punctata,*** *E. moluccana, E. bosistoana,* ***E. tereticornis, E. longifolia,*** *C. gummifera,* ***E. pilularis,*** *E. oblonga, E. sparsifolia, E. resinfera, E. beyeriana, A. floribunda,*	6	Shale transition	HQH	Core
Transitional shale open blue gum forest	36	*E. salignaXbotryoides*	0	Shale transition	HQH	Core
Transitional shale stringybark forest	252	***E. globoidea,*** *E. eugenoides,* ***E. punctata,*** *C. gummifera, E. crebra, E. piperita, E. sclerophylla*	2	Shale transition	HQH	Core
Upland swamps: banksia thicket	6	*E. racemosa/haemastoma/sclerophylla, E. oblonga, E. seiberi*	0	Sandstone	LQH	Non-core
Upland swamps: fringing eucalypt woodland	264	*E. sclerophylla, C. gummifera, E. seiberi*	0	Sandstone	LQH	Non-core
Upland swamps: sedgeland-heath complex	138	none	0	Sandstone	LQH	Non-core

Upland swamps: tea-tree thicket	7	none	0	Sandstone	LQH	Non-core
Upper Georges River sandstone woodland	3416	***E. punctata***, *C. gummifera*, ***E. globoidea***, *E. oblonga*, *E. racemosa*, *A. costata*, *E. eugenoides*, *E. pierita*, *E. seiberi*, *E. fibrosa*	2	Shale-enriched sandstone	HQH	Core
Western sandstone gully forest	1934	***E. pilularis***, ***E. punctata***, *A. costata*, *C. gummifera*, *E. piperita*, *E. agglomerata*, *A. floribunda*	2	Shale-enriched sandstone	HQH	Core
Western Sydney dry rainforest	73	*C. maculata*, ***E. tereticornis***, ***E. pilularis***	2	Shale	MQH	Non-core
Woronora Tall Mallee-heath	1	*E. luehmanniana*, *C. gummifera*, *E. racemosa*	0	Sandstone	LQH	Non-core
Regenerating vegetation	14				LQH/MQH	Non-core
Weeds and exotics	13				LQH	Non-core
Exposed rock	4				LQH	Non-core

Notes: a = acacia; C = Corymbia; E = Eucalyptus; HQH = high-quality habitat; MQH = medium-quality habitat; LQH = low-quality habitat

9. Appendix 2

Associate Professor Mathew Crowther
School of Life and Environmental Sciences

18 December 2017

Dear Liza Schaeper

Office of Environment and Heritage

RE: Review of Office of Environment and Heritage (OEH) Draft "Conserving koalas in Wollondilly and Campbelltown LGAs – additional justifications"

I have been commissioned by OEH to review provide a scientific review and analysis of Conserving koalas in Wollondilly and Campbelltown LGAs – additional justifications relating to the following two key points:

1. To review and comment on the koala conservation report's key principles and recommendations to conserve the regional koala population, and
2. • To review and comment on the methods used to derive corridors for koalas and koala estimates included in OEH's koala conservation report.

I will first outline my experience and qualifications with koala research, comment on the documents provided and provide my recommendations.

I am an Associate Professor in wildlife ecology and evolution in the School of Life and Environmental Sciences at the University of Sydney. I have researched on koalas in NSW since 2006, including publishing over 10 scientific papers on koalas. I have also contributed to koala management by contributing to the NSW Koala Recovery Plan, and am a current expert advisory member on the NSW Save Our Species Koala Panel. I have a history of reviewing documents concerning koala management. My CV is attached.

In regards to the report's key principals and recommendations to conserve the regional koala population, the document appears sound. The areas considered by the report are being rapidly developed and hence threats to the regional koala population will increase. This does not even take into account the possible impacts of increased urbanisation interacting with the impacts of climate change, such as increased heatwaves and bushfires.

The report is correct in that development needs to be avoided in both core habitat and primary corridors. With increasing development in the area, these core habitat and

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corridor areas need protection. Cleared areas near the corridors also need protection, as koalas spend much of the time on the ground. When koalas are moving areas, they are particularly vulnerable to threats such as dog attack. Hence the recommendations of increasing corridor widths, and the use of barriers to separate koala habitat areas and corridors from residential areas are appropriate.

Habitat restoration and revegetation of cleared areas are essential. Many of the corridors depicted in the maps are very narrow and hence vulnerable to edge effects. Revegetation has to be well planned, and needs a mixture of local shelter trees (often non *Eucalyptus* species) and local feed species. Koalas use a large variety of *Eucalyptus* species in the area, and plantings must be appropriate for soil type. Tree planting is a long-term management action, as trees are not usable by koalas for many years. There are a number of research projects on tree use in this area, both published and unpublished reports and theses, and these need to be consulted for appropriate trees for planting.

The recommendations for mitigation of the impacts of widened roads and increased traffic, although correct, could be made stronger. Effective mitigation of the impacts of roads on koala populations is an expensive exercise, and needs a combination of fencing and underpasses. Signage, as reported, has been shown to be ineffective in mitigating against road deaths. Hence more details on the true cost of development in the area could be emphasised with more details on the fencing and underpasses.

Although briefly mentioned, I think there is more need for mitigation measures from chlamydia. The Campbelltown populations is currently free of chlamydia, while the Southern Highlands has chlamydia within its populations. Introduction of chlamydia to a population that was previously chlamydia-free can result in a rapidly increasing prevalence within a few years. Such a phenomenon was observed on the Liverpool Plains koala population, surrounding the town of Gunnedah, which had an extremely low, if not absent, prevalence of chlamydia a decade ago. There is a risk of corridors actually increasing the movements of chlamydia infected individuals into chlamydia-free areas. Possible mitigation measures for this would be increased veterinary checks of koalas in corridor areas, and possible barriers of certain corridors if they are problematic.

In regards to the determination of corridors for koalas, the methods seem to be sound. Generalised linear models and Geographical Information Systems are well-tested methods in determining habitat. The criteria in determining corridors was also appropriate and had a high overlap with the modelling approach. The details of the modelling and criteria are probably not as important as the quality of the data. The models and corridor criteria are based on very detailed and accurate vegetation mapping, and extensive koala spotlighting data. Hence, the models are likely to have a high predictive power.

Koalas have been VHF and GPS tracked in the local area for the last few years. Movements of some of these animals could be useful in determining koala corridor use, as well as the models and spotlighting data.

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Determining densities and numbers of koalas is extremely difficult. Some reports have based density estimates on scat counts (usually using the SAT procedure), but these estimates are not universally accepted, and can be affected by decay rates and koala densities. The most accurate way of determining koala densities is distance-sampling, where the probability of detection is accounted for, with covariates of weather and habitat, as well as distance away from the observer. Estimates include confidence intervals, which can be quite large. The main issue with distance sampling is the sample size required to get reasonably accurate and precise estimates. These are a minimum of 75 koala observations per area, which is not feasible in some areas. Hence the method employed in this report, with a large number of systematic surveys (67), and being conservative in the area selection (i.e. leaving out cleared areas that koalas used), gives a reasonable minimum of koalas in the area.

In summary, the recommendations for protecting the koala core areas and habitat, as well as mitigating against future declines by roadkill are reasonable. The methods used in determining koala corridors and koala numbers are also reasonable. Future use of distance sampling, plus more details on disease surveillance, would help in providing more robust recommendations in the future.

Sincerely,

Associate Professor Mathew Crowther

10. Appendix 3

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NSW Office of Environment & Heritage
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Senior Team Leader
Ecosystems & Threatened Species
Greater Sydney Branch
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Hurstville NSW 2220

30th January 2018

Re: Review of Revised Draft Report: Conserving koalas in Wollondilly and Campbelltown LGAs.

Dear Liza

Thanks for the opportunity to review and comment on more recent revisions to the draft report.

The revised document provides recommendations for koala conservation in Western Sydney, to which end it is clear that the majority of the areas identified as habitat are appropriately located and essential for koala survival. That the outcomes of the report remain conservative is also a positive aspect and because of this I am comfortable in offering qualified support for the report as it currently reads.

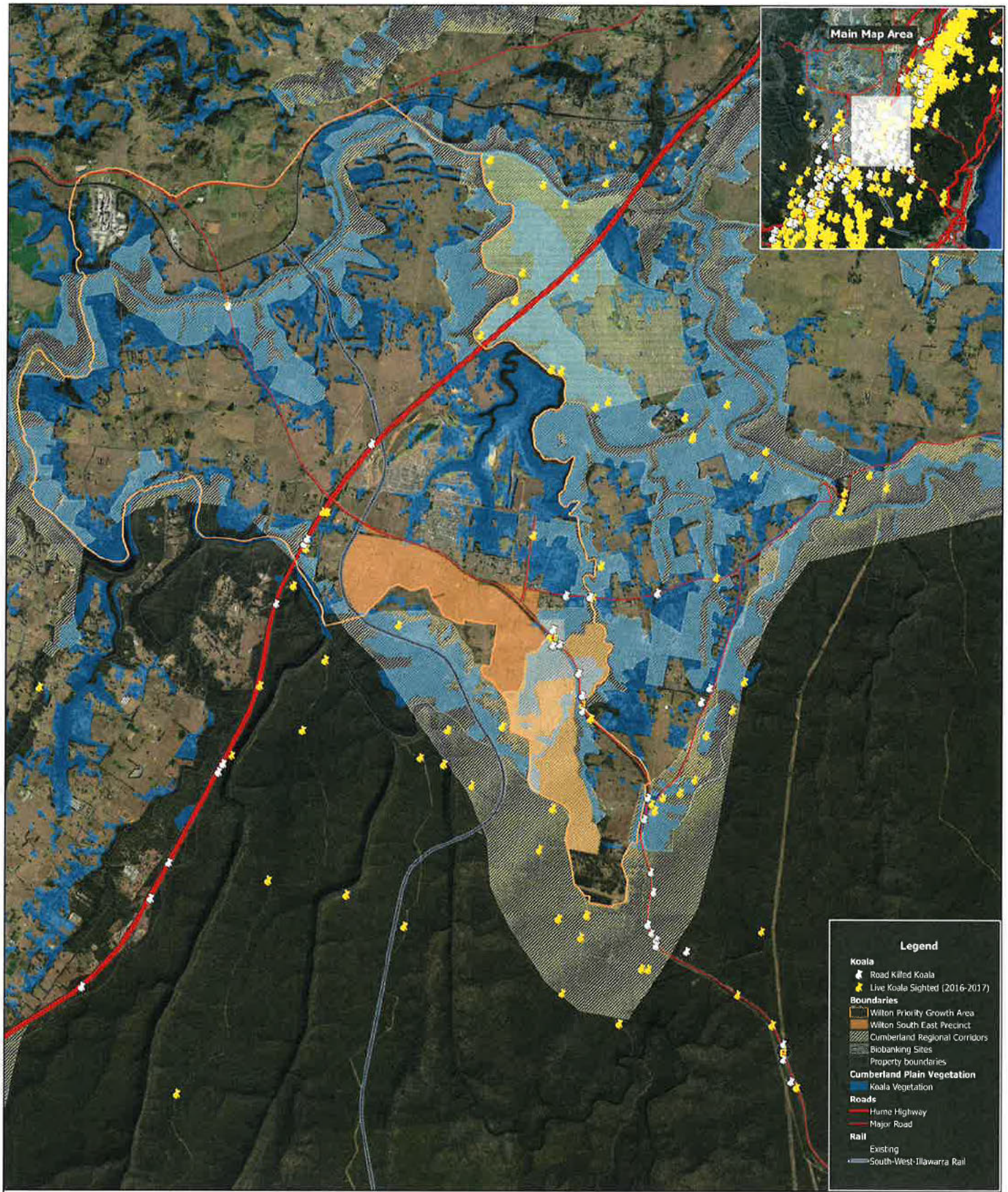
However, while I agree with the principles and application of science that has been used to inform the report, I do remain at odds with some aspects of the terminology and data analyses, especially that which relates to the identification of preferred trees. Consistent with my earlier feedback, I remain of the opinion that further work in this area will be valuable and reiterate my earlier offer of assistance with statistical analyses of the associated data.

The proposed mitigation measures of enclaving, fencing and underpasses are appropriate and reflect best practice measures. Because of the conservative approach that has been taken however, I remain concerned at the longer-term conservation implications of the report should the recommendations proceed without further expansion. Specifically, the recommendations insofar as they relate to the southern habitat areas need to be extended to the north as well (*i.e.* South Campbelltown / Macarthur PGA) where optimal levels of occupancy by koalas have been identified within identified linkage areas and there is an obvious need for east –west connectivity to be maintained, rather than discounted. Because of this I am strongly of the opinion that the report has yet to effectively accommodate the conservation needs of koalas in the Macarthur Priority Growth Area and that further work is required to effectively future-proof this important population. Hence the best-practice concepts articulated so well for the southern population need to be expanded into the northern area to which end measures such as fencing and the inferred lack of provision for connectivity will need to be reviewed.

I hope the preceding comments are of some value. Please don't hesitate to contact me if any of the matters I have raised require further clarification, to which end I am keen to offer any further assistance as may be required to resolve any of the issues that remain outstanding.

Yours Sincerely

Dr. Stephen Phillips
Managing Director / Principal Research Scientist.



Koala Corridors at Wilton South East Precinct

Projection: EPDG 3857
Created by: PWhitten
Date Created: 27-04-18

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