3 Native vegetation

The following section documents the methods used to identify and map the extent of native vegetation within the development site. Plant Community Types (PCTs) are classified based on the NSW Vegetation Information System (VIS) Classification database (Office of Environment and Heritage, 2014c)

3.1 Methods

3.1.1 Background research

A background review of existing information was undertaken to identify the existing environment of the development site and locality. The review focussed on database searches, relevant ecological reports pertaining to the study area, property boundaries, and relevant GIS layers. Relevant databases and literature included:

- OEH vegetation information system (VIS) database (Office of Environment and Heritage, 2014c) (Office of Environment and Heritage 2014)
- The federal Bureau of Meteorology's Atlas of Groundwater Dependent Ecosystems (GDE) (Bureau of Meteorology, 2016)
- DPI's database for aquatic TECs (Department of Primary Industries, 2016)
- EPBC Act protected matters search tool (Department of the Environment, 2014)
- Available regional vegetation mapping including The native vegetation of the Cumberland Plain, western Sydney: systematic classification and field identification of communities (Tozer, 2003)and the Native Vegetation of Southeast NSW: A Revised Classification and Map for the Coast and Eastern Tablelands (NSW National Parks & Wildlife Service, 2004).
- Geology of the Penrith 1:100,000 Sheet 9030 (Clarke and Jones, 1991)
- Soil landscapes of the Penrith 1:100,000 Sheet 9030 (Hazelton et al., 1989)
- Western Sydney Airport EIS Biodiversity Assessment (GHD, 2016).

3.1.2 Vegetation Surveys

The vegetation surveys were completed using field survey methods in line with Chapter 5 of the FBA and implementing the guidelines for *Threatened Biodiversity Survey and Assessment: Guidelines for Developments and Activities (Working Draft)* (Department of Environment and Conservation, 2004). The field surveys were undertaken over a period of 11 days from 2 September 2015 to 4 February 2016 (not inclusive).

Rapid reconnaissance survey

During the initial stages of the assessment, the study area was visited to verify and refine the PCTs identified from the desktop assessment. Transects/plots were undertaken in representative examples of each PCT and variations in vegetation structure and quality were noted to inform the stratification of PCTs into vegetation zones.

Plot-based floristic survey

The plot-based full floristic survey focused on these five strata using a series of 20 x 20 metre quadrats nested inside a 20 x 50 metre transect. The plots / transects were completed to record the following information:

- Stratum & layer - in which each species occurs
- Growth form - for each recorded species
- Species name - above ground vascular plant species were identified to the lowest taxonomic order possible using nomenclature consistent with PlantNet NSW
- Cover - a measure or estimate of the appropriate cover measure for each recorded species; recorded from 1–5 per cent and then to the nearest 5 per cent. If the cover of a species is less than 1 per cent and the species is considered important, then the estimated cover should be entered (e.g. 0.4)
- Abundance rating – A relative measure of the number of individuals or shoots of a species within the plot. The following intervals were used; numbers above about 20 are estimates only: 1,2,3,4,5,6,7,8,9,10,20,50,100,500,1000. Numbers between 20 and 1000 individuals were estimated only as it is not possible to accurately count large numbers of some species in the plot.

Assessment site value (vegetation condition)

The following site attributes were assessed at each transect/plot to obtain a quantitative measure of vegetation condition to be applied for each vegetation zone within the study area:

- Native species richness (measured in a 20 × 20 metre quadrat)
- Native overstorey cover (measured along a 50 metre line transect
- Native midstorey cover (measured along a 50 metre line transect)
- Native ground cover (grasses) (measured along a 50 metre line transect)
- Native ground cover (shrubs) (measured along a 50 metre line transect)
- Native ground cover (other) (measured along a 50 metre line transect)
- Exotic plant cover (measured along a 50 metre line transect)
- Number of trees with hollows (estimated by counting the number of trees with hollows visible from the ground in the 50 x 20 metre plot)
- Proportion of over-storey species occurring as regeneration (assessed across the entire vegetation zone)
- Total length of fallen logs (the total length of woody material greater than 10 centimetres in diameter within the 50 x 20 metre plot).

These 10 site attributes listed above were ranked against benchmark data for the relevant PCT and a site value score for each vegetation zone was determined in accordance with subsection 5.3.3 of the FBA. Additionally, identification of any noxious weeds was undertaken at each transect/plot.

The minimum number of transects/plots required per vegetation zone area were completed according to the FBA (see Table 3.1).

Table 3.1: Comparison of number of transects/plots required and completed per zone area

Vegetation zone	Vegetation zone code	Vegetation zone area (ha)	FBA plot requirements (minimum no. transects/plots)	Number of plots completed
1	Grey Box - Forest Red Gum grassy woodland on flats of the Cumberland Plain, Sydney Basin Bioregion 849 - Moderate/ Good	13.89	3	11
2	Forest Red Gum - Rough-barked Apple grassy woodland on alluvial flats of the Cumberland Plain, Sydney Basin Bioregion 835 - Moderate/ Good	3.24	2	4
3	Grey Box - Forest Red Gum grassy woodland on shale of the southern Cumberland Plain, Sydney Basin Bioregion 850 – Moderate/Good	25.12	4	8
4	Grey Box - Forest Red Gum grassy woodland on flats of the Cumberland Plain, Sydney Basin Bioregion 849 – Moderate/Good_Poor	10.17	3	3
5	Grey Box - Forest Red Gum grassy woodland on shale of the southern Cumberland Plain, Sydney Basin Bioregion 850 – Moderate/Good_Poor	13.38	3	3
6	Forest Red Gum - Rough-barked Apple grassy woodland on alluvial flats of the Cumberland Plain, Sydney Basin Bioregion 835 - Moderate/Good_Poor	10.30	3	5
7	Grey Box - Forest Red Gum grassy woodland on shale of the southern Cumberland Plain, Sydney Basin Bioregion 850 - Moderate/Good_High	7.33	3	4
8	Derived grasslands on shale hills of the Cumberland Plain (50-300m asl) 806 – Moderate/Good_Derived grassland	49.78	4	4
9	*Phragmites australis* and *Typha orientalis* coastal freshwater wetlands of the Sydney Basin Bioregion 1071 – Moderate/Good_Other	12.92	3	3

Vegetation zone	Vegetation zone code	Vegetation zone area (ha)	FBA plot requirements (minimum no. transects/plots)	Number of plots completed
10	Grey Box - Forest Red Gum grassy woodland on shale of the southern Cumberland Plain, Sydney Basin Bioregion 850 – Moderate/Good_Medium	2.00	1	1

Identification of Plant Community Types

The extent of native vegetation within the development site was firstly mapped in a GIS using digital aerial photography captured in 2015. Broad scale vegetation mapping of the area including the *Native vegetation of the Cumberland Plain, western Sydney: systematic classification and field identification of communities* (Tozer, 2003) and the *Native Vegetation of Southeast NSW: A Revised Classification and Map for the Coast and Eastern Tablelands* (NSW National Parks & Wildlife Service, 2004) were used to inform the identification of PCTs. The *Geology of the Penrith 1:100,000 Sheet 9030* (Clarke and Jones, 1991) and *Soil landscapes of the Penrith 1:100,000 Sheet 9030* (Hazelton et al., 1989) were also used in the identification of PCTs. Topography was examined in a GIS using a shaded relief raster (hillshade) created from an elevation layer.

Once an initial examination of PCTs had been conducted within the GIS, the PCTs were verified and refined with the detailed floristic assessment collected in the field. Once the PCTs had been finalised, each PCT was then further divided into vegetation zones (an area of native vegetation on the development site that is the same PCT and has a similar broad condition state).

The PCTs within the study area are outlined in Section 3.2.

Assessment of vegetation zones

The regional vegetation mapping accessed from the desktop review (NSW National Parks & Wildlife Service, 2004, Tozer, 2003) was used in conjunction with aerial photography, broad scale soil mapping (Hazelton et al., 1989), geology mapping (Clarke and Jones, 1991) and a hillshade model (black and white shaded relief) to stratify the vegetation in the study area into preliminary PCTs and vegetation zones.

The preliminary vegetation mapping was then rapidly ground-truthed during the preliminary rapid site assessment phase where PCTs and vegetation zones were refined. Plant Community Types and vegetation zones were further refined as the survey progressed and data from the plot/transect assessments was examined. Plant Community Types and vegetation zones within the study area were finalised using a GIS.

The field surveys were designed to assess the environmental variation within the development site and any areas with gaps in existing mapping and site information to determine vegetation zones. The condition of PCTs for the development site was assessed in accordance with Chapter 5 of the FBA and vegetation zones assigned by comparing the dominant species, the general description of location, soil type and other attributes as described in the VIS classification database (Office of Environment and Heritage 2014).

Ten vegetation zones were identified on the development site (labelled 1 to 10) (see Table 3.2). The vegetation zones assigned as Moderate to Good were further classified into a sub-condition class based on observable differences as follows:

- Moderate/Good – Poor: the PCTs in this vegetation zone (PCT 835, PCT 849 and PCT 850) are in poor condition as evidenced by a lack of habitat attributes (i.e. no hollow bearing trees, little woody debris in the ground layer, little to no canopy species regeneration), missing structural layers, and dominance of exotic species in the midstorey and/or ground layer. These vegetation zones were often heavily grazed or otherwise impacted by agriculture. While in poor condition, these vegetation zones were not able to be classified as Low condition.
- Moderate/Good – Other: this vegetation zone possesses native vegetation in moderate to good condition in man-made dams and other waterbodies. Only PCT 1071 occurs in this vegetation zone. This PCT is not naturally occurring so was classified as Moderate/Good – Other.
- Moderate/Good – Derived grassland: this vegetation zone occurs where the canopy of PCT 850 has been removed leaving only the native ground layer and regenerating shrubs. Only the Derived grasslands on shale hills of the Cumberland Plain (50-300m ASL) PCT (PCT 806) occurs in this vegetation zone.
- Moderate/Good – Medium: PCT 850 contains an area on an eroded watercourse (now a gully) where the midstorey is heavily infested with Olea europaea subsp. cuspidata. The condition of this area is unlike any other in the development site so has been placed in a separate vegetation zone.
- Moderate/Good: PCTs in this vegetation zone had predominantly native species in all structural layers but possessed a moderate abundance and cover of exotic species in the ground layer. Three PCTs occur in this vegetation zone (PCT 849, PCT 835 and PCT 850).
- Moderate/Good – High: The study area contains some patches of PCT 850 that are considered to be in high condition. This vegetation zone is composed of predominantly native species in all layers including a native ground layer, the highest native species richness was found in this vegetation zone with very few exotic species found in any stratum. This vegetation zone is high quality.

Table 3.2: Vegetation zones within the study area

Vegetation zone	PCT name	PCT number	Condition*	Area (ha) in the study area
1	Grey Box - Forest Red Gum grassy woodland on flats of the Cumberland Plain, Sydney Basin Bioregion	849	Moderate/Good	13.89
2	Forest Red Gum - Rough-barked Apple grassy woodland on alluvial flats of the Cumberland Plain, Sydney Basin Bioregion	835	Moderate/Good	3.24
3	Grey Box - Forest Red Gum grassy woodland on shale of the southern Cumberland Plain, Sydney Basin Bioregion	850	Moderate/Good	25.12

Vegetation zone	PCT name	PCT number	Condition*	Area (ha) in the study area
4	Grey Box - Forest Red Gum grassy woodland on flats of the Cumberland Plain, Sydney Basin Bioregion	849	Moderate/Good_Poor	10.17
5	Grey Box - Forest Red Gum grassy woodland on shale of the southern Cumberland Plain, Sydney Basin Bioregion	850	Moderate/Good_Poor	13.38
6	Forest Red Gum - Rough-barked Apple grassy woodland on alluvial flats of the Cumberland Plain, Sydney Basin Bioregion	835	Moderate/Good_Poor	10.30
7	Grey Box - Forest Red Gum grassy woodland on shale of the southern Cumberland Plain, Sydney Basin Bioregion	850	Moderate/Good_High	7.33
8	Derived grasslands on shale hills of the Cumberland Plain (50-300m asl)	806	Moderate/Good_Derived grassland	49.78
9	*Phragmites australis* and *Typha orientalis* coastal freshwater wetlands of the Sydney Basin Bioregion	1071	Moderate/Good_Other	12.92
10	Grey Box - Forest Red Gum grassy woodland on shale of the southern Cumberland Plain, Sydney Basin Bioregion	850	Moderate/Good_Medium	2.00

Notes: * = Vegetation in Moderate/Good condition is all native vegetation that is not in low condition. Vegetation in Low condition is defined as:

a) woody native vegetation with native over-storey percent foliage cover less than 25% of the lower value of the over-storey percent foliage cover benchmark for that vegetation type, and where either:
- – less than 50% of ground cover vegetation is indigenous species, or
- – greater than 90% of ground cover vegetation is cleared

OR

b) native grassland, wetland or herbfield where either:
- – less than 50% of ground cover vegetation is indigenous species, or
- – more than 90% of ground cover vegetation is cleared.

3.1.3 Limitations

The vegetation field survey was able to provide good spatial coverage and survey effort of the development site, meeting the requirements of the FBA. However, the field survey was constrained by landowner permissions and restricted access in some areas. Some properties within the broader study area were not able to be accessed for the survey, including some areas of higher quality habitat (such as the habitat in the unmade road between Kings Hill Road and Longview Road at Mulgoa). Hence, the location of transects/plots, while stratified to the greatest extent possible, were constrained by limited access in some areas and not all areas of vegetation were able to be surveyed. Where property access was not granted, the vegetation was viewed from the roadside or public areas where possible to verify the PCT and vegetation condition. The majority of the development footprint was able to be surveyed. After detailed design and prior to the finalisation of the offset package for the Project, surveys of these areas will be undertaken and new calculations performed as necessary.

The vegetation within the study area has been assigned to a PCT as listed in the VIS database based on the observed species composition, landscape position, and underlying geology and soils. In some instances the mapped PCTs may not directly correlate to published

broad scale regional mapping projects for the area as the mapping for this project has been done at a much finer scale and is supported by on ground observations and quantitative data. The boundaries of some PCTs (e.g. PCT 1071: *Phragmites australis* and *Typha orientalis* coastal freshwater wetlands of the Sydney Basin Bioregion) change frequently based on the amount of rainfall in any given period. As such, the boundaries of PCT 1071 have been mapped as they were observed during the field survey and it is possible the boundaries of this PCT have changed with time. Likewise, the boundaries of PCT 806: Derived grasslands on shale hills of the Cumberland Plain (50-300m asl) may also be subject to frequent change based on level of grazing pressure, whether the paddock has been cultivated or ploughed since the field survey, or subsequent pasture improvement or weed invasion. As such, the boundaries of PCT 806 have been mapped as they were observed during the field survey and it is possible the boundaries of this PCT have changed with time.

The list of species recorded in each PCT during this study should not be seen to be fully comprehensive, but rather an indication of the species present at the time of the survey. A period of several seasons or years is needed to identify all the species present in an area, especially as some species are only apparent at certain times of the year (e.g. orchids, annual herbs and grasses). Some species require specific weather conditions for optimum detection. The optimal seasonal timing for flora survey in western Sydney is during summer to autumn (December to April). Due to the rain dependent nature of the vegetation, (the Cumberland Plain is a rainshadow coastal valley); many plant species will not be present above ground during winter and in dry years. The vegetation survey was undertaken during spring to summer (2 September 2015 to 4 February 2016) and rainfall for the study area has been good (average winter 2015 rainfall at Badgery's Creek was 48.2 mm, spring rainfall was 44.7 mm, and average summer rainfall was 56 mm). Total rainfall in January 2016 was 145 mm. Conditions for flora survey on the Cumberland Plain during the survey period were good in terms of rainfall which is important for the rain dependent groundcover vegetation.

The conclusions of this report are based upon available data and the field surveys and are therefore indicative of the environmental condition of the study area at the time of the survey. It should be recognised that conditions, including the presence of threatened species, could change with time. To address this limitation, a precautionary approach has been used which aimed to identify the presence and suitability of the habitat for threatened species.

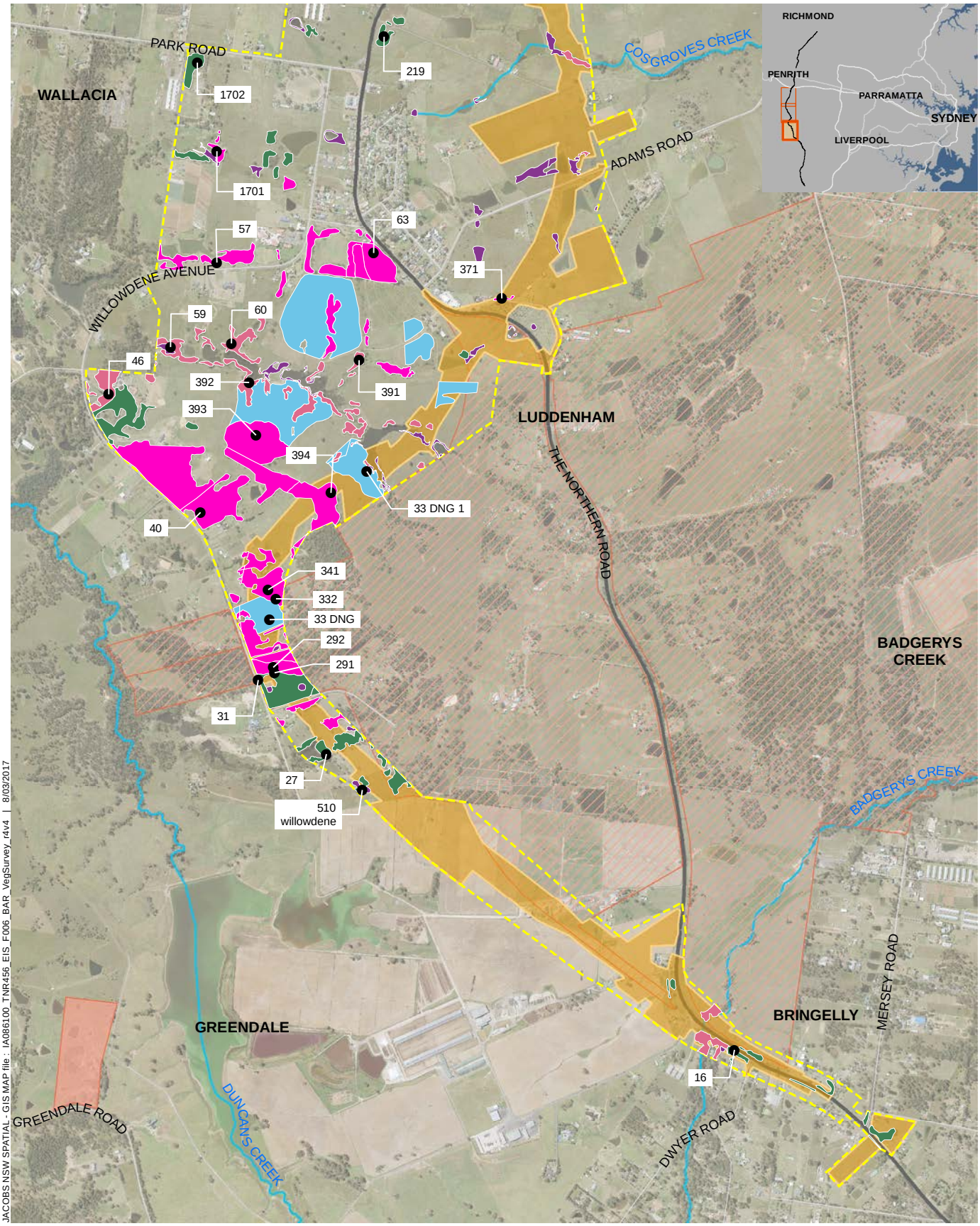


Figure 3-1 | Vegetation survey locations

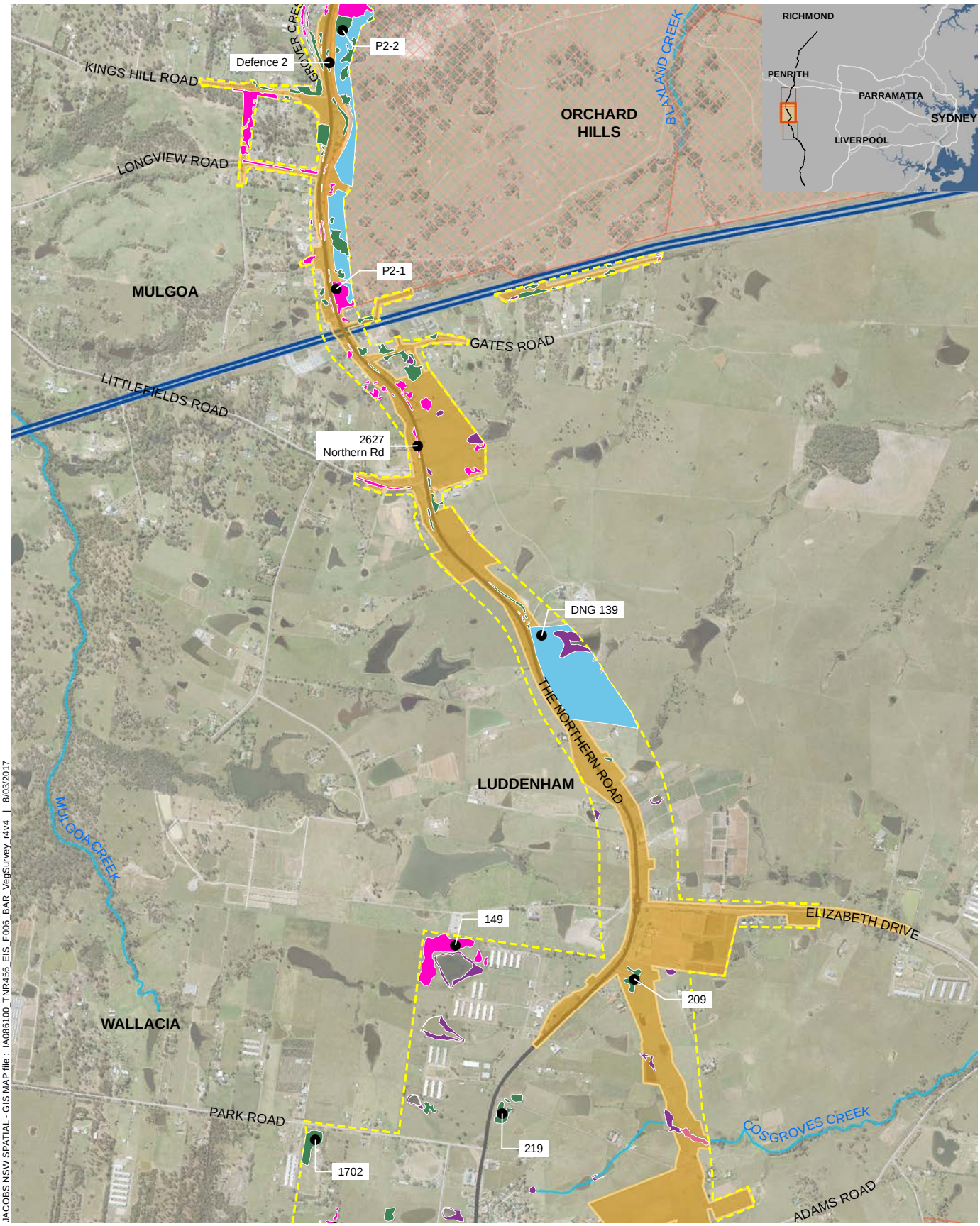


Figure 3-1 | Vegetation survey locations

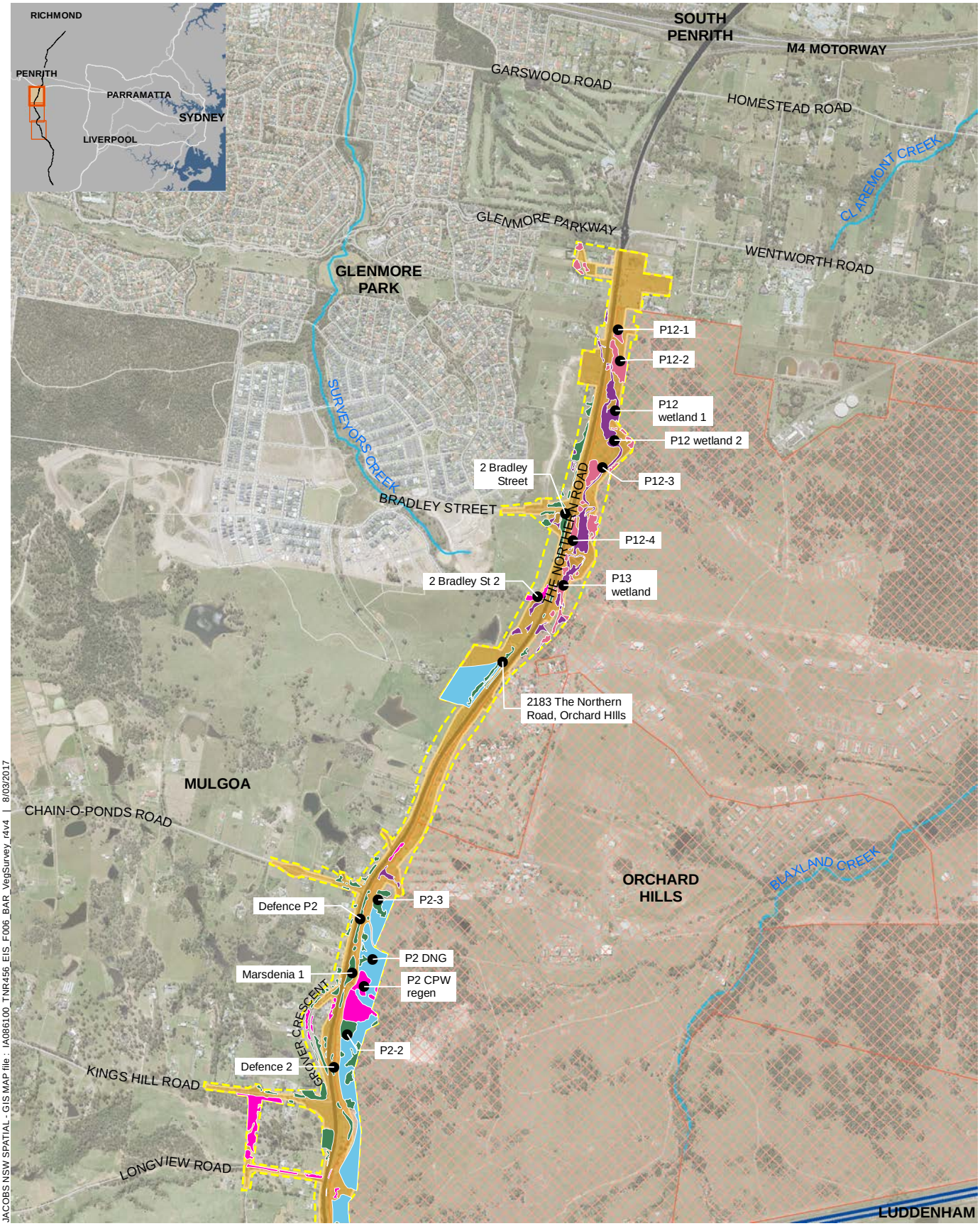


Figure 3-1 | Vegetation survey locations

3.2 PCT descriptions

A description of each PCT and assigned vegetation zone is provided in this section. Table 3.3 summarises each PCT and vegetation zone including the corresponding threatened ecological community and site value score. A vegetation condition assessment table is provided in Appendix A.

Table 3.3 Plant Community Types and vegetation zones

Vegetation zone	Vegetation zone code	Plant community type (PCT)	Threatened ecological community?	Site value score / 100	Extent in study area (ha)
1	849 - Moderate/ Good	Grey Box - Forest Red Gum grassy woodland on flats of the Cumberland Plain, Sydney Basin Bioregion	Cumberland Plain Woodland in the Sydney Basin Bioregion	55.56	13.89
2	835 - Moderate/ Good	Forest Red Gum - Rough-barked Apple grassy woodland on alluvial flats of the Cumberland Plain, Sydney Basin Bioregion	River-Flat Eucalypt Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions	53.65	3.24
3	850 – Moderate/Good	Grey Box - Forest Red Gum grassy woodland on shale of the southern Cumberland Plain, Sydney Basin Bioregion	Cumberland Plain Woodland in the Sydney Basin Bioregion	57.97	25.12
4	849 – Moderate/Good_Poor	Grey Box - Forest Red Gum grassy woodland on flats of the Cumberland Plain, Sydney Basin Bioregion	Cumberland Plain Woodland in the Sydney Basin Bioregion	15.94	10.17
5	850 – Moderate/Good_Poor	Grey Box - Forest Red Gum grassy woodland on shale of the southern Cumberland Plain, Sydney Basin Bioregion	Cumberland Plain Woodland in the Sydney Basin Bioregion	24.64	13.38
6	835 - Moderate/Good_Poor	Forest Red Gum - Rough-barked Apple grassy woodland on alluvial flats of the Cumberland Plain, Sydney Basin Bioregion	River-Flat Eucalypt Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions	43.23	10.30

Vegetation zone	Vegetation zone code	Plant community type (PCT)	Threatened ecological community?	Site value score / 100	Extent in study area (ha)
7	850 - Moderate/Good_High	Grey Box - Forest Red Gum grassy woodland on shale of the southern Cumberland Plain, Sydney Basin Bioregion	Cumberland Plain Woodland in the Sydney Basin Bioregion	74.64	7.33
8	806 – Moderate/Good_Derived grassland	Derived grasslands on shale hills of the Cumberland Plain (50-300m asl)	Cumberland Plain Woodland in the Sydney Basin Bioregion	19.05	49.78
9	1071 – Moderate/Good_Other	*Phragmites australis* and *Typha orientalis* coastal freshwater wetlands of the Sydney Basin Bioregion	Not listed man made	34.06	12.92
10	850 – Moderate/Good_Medium	Grey Box - Forest Red Gum grassy woodland on shale of the southern Cumberland Plain, Sydney Basin Bioregion	Cumberland Plain Woodland in the Sydney Basin Bioregion	25.85	2.00
				Total	**148.13**

Forest Red Gum - Rough-barked Apple grassy woodland on alluvial flats of the Cumberland Plain, Sydney Basin Bioregion – Moderate/Good

Vegetation formation: Forested Wetlands

Vegetation class: Coastal Floodplain Wetlands

PCT: 835 **BVT:** HN526

Other mapping sources: Cumberland Riverflat Forest (Tozer *et al.* 2010), Alluvial Woodland (Tozer 2003)

Conservation status: Listed as endangered under the TSC Act as River-Flat Eucalypt Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions

Estimate of percent cleared: 95 per cent cleared in Hawkesbury/Nepean

Condition: Moderate/Good

Extent in the study area: 3.24 hectares

Plots completed in vegetation zone: 4 plots (P12-1, P12-2, P12-3, P12-4)

Structure	Average height and height range (m)	Average cover and cover range	Typical species
Trees	18.7 m (10-35 m)	21.4 % (16-24.5 %)	*Eucalyptus amplifolia, Eucalyptus tereticornis*, *Eucalyptus moluccana, Eucalyptus crebra,* (*Angophora floribunda* present outside of plots)
Small trees	6.8 m (1-8 m)	1.2 % (0-5 %)	*Eucalypt* regeneration, *Acacia parramattensis, Olea europaea*,* (*Casuarina glauca* outside of plots)
Shrubs	1.5 m (1-2 m)	1.2 % (0-5 %)	*Bursaria spinosa, Olea europaea**
Ground covers	0-1 m	97.5 % (92-100 %)	*Microlaena stipoides, Dichondra repens, Centella asiatica, Sida rhombifolia*, Bidens pilosa*, Eragrostis curvula*, Hypochaeris radicata*, Einadia* spp.
Vines & climbers	0-2 m	<5 %	*Glycine tabacina, Araujia sericifera**

Description: As per VIS description: An open eucalypt forest situated on broad alluvial flats of the Hawkesbury and Nepean river systems. It also forms narrower ribbons alongside streams and creeks that drain the Cumberland Plain. Typically, the canopy includes one of *Angophora floribunda* or *Angophora subvelutina* and one or both of *Eucalyptus tereticornis* and *Eucalyptus amplifolia*. However there are a wide variety of other interesting eucalypts that are highly localised. The understorey within this riverflat forest is characterised by an occasional sparse to open small tree stratum of *Melaleuca* spp. and *Acacia* spp. A sparse lower shrub layer features *Bursaria spinosa* at most sites. The ground layer is characterised by an abundant cover of grasses with small herbs and ferns. It occurs at altitudes between one and 160 metres above sea level.

Within the study area the most intact and highest quality examples (Moderate/Good condition vegetation zone) occur on the Defence Site Orchard Hills on the low lying land which contains the quaternary alluvial soils of the South Creek soil landscape (gravel, silt, sand, clay) as described by Hazelton *et al.* (1989) which overly the Cranebrook Formation. A patch of this vegetation zone also occurs in the southern point of the study area along Badgerys Creek

where fine-grained sand, silt and clay of quaternary alluvium (South Creek soil landscape) occurs. Altitude of the plots varies from 64 to 71 metres above sea level.

While disturbed by historic landuse and construction of the Defence Site Orchard Hills drainage system this PCT still possesses the characteristic species compliment for PCT 835. *Eucalyptus amplifolia* and *Eucalyptus tereticornis* are dominant in discreet stands (a result of past clearing and subsequent regrowth from trees that were left in the landscape. *Eucalyptus moluccana, Eucalyptus crebra* and *Angophora floribunda* are also present. There are typically one or two large trees surrounded by many smaller trees forming a lower tree layer. The shrub layer is sparse to absent and where present contains *Bursaria spinosa* and *Acacia parramattensis* with the occasional exotic *Olea europaea**. One area contains *Hakea sericea, which* is common in large numbers on the Defence Site Orchard Hills forming dense shrublands (likely a result of planting as this species is not a feature of the Cumberland Plain vegetation). The ground layer is typified by *Microlaena stipoides, Dichondra repens, Centella asiatica* and *Einadia* spp. with a high abundance and cover of exotic species including *Bidens pilosa*, Sida rhombifolia*, Eragrostis curvula*,* and *Hypochaeris radicata**. Climbers including *Glycine tabacina* and *Araujia sericifera** are common.

Photograph 1: Forest Red Gum - Rough-barked Apple grassy woodland on alluvial flats of the Cumberland Plain, Sydney Basin Bioregion – Moderate/Good taken at the Defence Site Orchard Hills (Plot P12-2)

Forest Red Gum - Rough-barked Apple grassy woodland on alluvial flats of the Cumberland Plain, Sydney Basin Bioregion – Moderate/Good_Poor

Vegetation formation: Forested Wetlands

Vegetation class: Coastal Floodplain Wetlands

PCT: 835 **BVT:** HN526

Other mapping sources: Cumberland Riverflat Forest (Tozer *et al.* 2010), Alluvial Woodland (Tozer 2003)

Conservation status: Listed as endangered under the TSC Act as River-Flat Eucalypt Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions

Estimate of percent cleared: 95% cleared in Hawkesbury/Nepean

Condition: Moderate/Good_Poor

Extent in the study area: 10.30 hectares

Plots completed in vegetation zone: 5 plots (59, 60, 391, 392, 46)

Structure	Average height and height range (m)	Average cover and cover range	Typical species
Trees	21.3 m (10-30 m)	19.5 % (13-28.5 %)	*Eucalyptus tereticornis, Eucalyptus moluccana, Angophora floribunda, Eucalyptus eugenioides, Casuarina glauca*
Small trees	5 m (2-8 m)	<5 %	*Olea europaea**
Shrubs	2.7 m (1-6 m)	12.4 % (2.7-33 %)	*Bursaria spinosa, Olea europaea*, Acacia implexa, Acacia parramattensis, Dillwynia sieberi*
Ground covers	0-1 m	87.2 % (66-100 %)	*Microlaena stipoides, Dichondra repens, Scaevola albida* var. *albida, Themeda triandra, Cynodon dactylon, Pennisetum clandestinum*, Senecio madagascariensis*,*
Vines & climbers	0-2 m	<5 %	*Clematis glycinoides* var. *glycinoides, Glycine clandestina, Convolvulus erubescens, Araujia sericifera*, Vicia sativa**

Description: As per VIS description provided for PCT 835 above. Within the study area the poorer quality examples of this PCT (Moderate/Good_Poor vegetation zone) occur as small fragmented patches of vegetation left in the landscape after clearing for agriculture and the flooding of small valleys and drainage lines during creation of farm dams. Patches of this vegetation zone occur on the Defence Site Orchard Hills on the low lying land which contains the quaternary alluvial soils of the South Creek soil landscape (gravel, silt, sand, clay) which overly the Cranebrook Formation. Small patches of this vegetation zone occur throughout the study area associated with small ephemeral drainage lines including Cosgroves Creek, and fringing the dams on the unnamed tributaries in Luddenham that flow west into Duncans Creek. A small patch of this vegetation zone also occurs in the southern point of the study area along Badgerys Creek where fine-grained sand, silt and clay of quaternary alluvium (South Creek soil landscape) occurs. Altitude of the plots varies from 73 to 91 metres above sea level.

While disturbed by historic landuse including construction of the Defence Site Orchard Hills drainage system and numerous farm dams along small drainage lines this PCT still possesses

the characteristic species compliment for PCT 835 (although in some cases highly modified). *Eucalyptus tereticornis* is dominant in the canopy with *Eucalyptus moluccana, Eucalyptus eugenioides, Angophora floribunda* and *Casuarina glauca* also present. A lower tree layer is generally absent but occasionally contains the exotic *Olea europaea**. The shrub layer is variable in density and contains species including *Bursaria spinosa, Acacia implexa, Acacia parramattensis, Dillwynia sieberi* and *Olea europaea**. The ground layer is typified by *Microlaena stipoides, Dichondra repens, Scaevola albida* var. *albida, Themeda triandra,* and *Cynodon dactylon* with a high abundance and cover of exotic species including *Pennisetum clandestinum** and *Senecio madagascariensis**. Climbers including *Clematis glycinoides* var. *glycinoides, Glycine clandestina, Convolvulus erubescens, Araujia sericifera** are common.

Photograph 2: Forest Red Gum - Rough-barked Apple grassy woodland on alluvial flats of the Cumberland Plain, Sydney Basin Bioregion – Moderate/Good_Poor at Plot 59

Grey Box - Forest Red Gum grassy woodland on flats of the Cumberland Plain, Sydney Basin Bioregion – Moderate/Good

Vegetation formation: Grassy Woodlands

Vegetation class: Coastal Valley Grassy Woodlands

PCT: 849 **BVT:** HN528

Other mapping sources: Cumberland Shale Plains Woodland (Tozer *et al.* 2010), Shale Plains Woodland (Tozer 2003)

Conservation status: Listed as critically endangered under the TSC Act as Cumberland Plain Woodland in the Sydney Basin Bioregion. Some patches meet thresholds for the EPBC Act listed critically endangered Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest ecological community

Estimate of percent cleared: 95% cleared in Hawkesbury/Nepean

Condition: Moderate/Good

Extent in the study area: 13.89 hectares

Plots completed in vegetation zone: 11 plots (16, 27, 291, P2-2, Marsdenia 1, Defence 2, Defence P2, P2-3, 2183 TNR, 2 Bradley street, 170-2)

Structure	Average height and height range (m)	Average cover and cover range	Typical species
Trees	16.6 m (10-30 m)	18.7 % (3.5-41 %)	*Eucalyptus moluccana, Eucalyptus tereticornis, Eucalyptus crebra,* (rare *Eucalyptus fibrosa*)
Small trees	12.5 m (10-15 m)	<5 %	*Eucalypt* regrowth, *Exocarpos cupressiformis*
Shrubs	2.9 m (1-8 m)	4.6 % (0-19.5 %)	*Bursaria spinosa, Acacia parramattensis, Acacia falcata, Dodonaea viscosa, Dillwynia sieberi, Daviesia ulicifolia, Olea europaea*, Lycium ferocissimum*, Lantana camara**
Ground covers	0.1 m (0-0.2 m)	86.5 % (52-100 %)	*Themeda triandra, Aristida* spp., *Microlaena stipoides, Chloris ventricosa, Dichondra repens, Brunoniella australis, Commelina cyanea, Eragrostis curvula*, Chloris gayana*, Ehrharta erecta*, Bidens pilosa*, Sida rhombifolia**
Vines & climbers	0-2 m	<5 %	*Hardenbergia violacea, Glycine tabacina, Araujia sericifera*, Marsdenia viridiflora* subsp. *viridiflora*

Description: As per VIS description: The gentle topography associated with the shale plains of western Sydney carries an open grassy woodland dominated by *Eucalyptus moluccana*, *Eucalyptus tereticornis* and *Eucalyptus crebra*/*Eucalyptus fibrosa*. Cumberland Shale Plains Woodland is the second of the grassy woodlands that comprise the Cumberland Plain Woodland in the Sydney Basin Bioregion Critically Endangered Ecological Community listed under the NSW TSC Act. Like the related community Cumberland Shale Hills Woodland, it is typified by a sparse to moderate cover of shrubs and a high cover of grasses and forbs.

Tozer *et al.* (2010) define the primary habitat for the community as occurring at elevations less than 150 meters above sea level with some sites occurring at higher elevations where the landscape remains gently inclined.

Within the study area the most intact and highest quality examples (Moderate/Good condition vegetation zone) occur on the gently undulating land underlain by Bringelly Shale (Wianamatta group) and the associated Luddenham soil landscape as mapped by Hazelton *et al.* (1989). These patches are located on properties at the corner of Willowdene Avenue and Vicar Park Lane at Luddenham. Some smaller patches of this vegetation zone also occur in the north on and around the Defence Site Orchard Hills and in the south near Badgerys Creek on the Blacktown soil landscape. In these areas, the remnants are located beside the existing Northern Road. Altitude of the plots varied from 68 to 100 metres above sea level.

The construction of the current Northern Road and agricultural activities has altered the structure and composition of this PCT considerably. However, this PCT still possesses the characteristic species compliment for PCT 849. *Eucalyptus moluccana* is dominant with some areas possessing *Eucalyptus tereticornis* as a co-dominant to sub-dominant. *Eucalyptus crebra* and *Eucalyptus fibrosa* occur infrequently and do not form a dominant component of the PCT. The canopy is generally composed of relatively young trees of less than 30 cm diameter at breast height. In some areas, the canopy is patchy which is typical of open grassy woodland. The lower tree layer is generally absent but where present contains regrowth of canopy species and *Exocarpos cupressiformis*. The shrub layer is sparse to moderately dense and dominated by a range of species including *Bursaria spinosa, Acacia parramattensis, Acacia falcata, Dodonaea viscosa, Dillwynia sieberi, Daviesia ulicifolia* and exotic shrubs including *Olea europaea*, Lycium ferocissimum** and *Lantana camara**. The ground layer is typified by native grasses and herbs including *Themeda triandra, Aristida* spp., *Microlaena stipoides, Chloris ventricosa, Dichondra repens, Brunoniella australis,* and *Commelina cyanea* with exotic species including *Eragrostis curvula*, Chloris gayana*, Ehrharta erecta*, Bidens pilosa*,* and *Sida rhombifolia**. Climbers including *Hardenbergia violacea, Glycine tabacina* and the exotic *Araujia sericifera** are common. The threatened population of the climber *Marsdenia viridiflora* subsp*. viridiflora* is also present within this vegetation zone.

Photograph 3: Grey Box - Forest Red Gum grassy woodland on flats of the Cumberland Plain, Sydney Basin Bioregion – Moderate/Good at Plot 291

Grey Box - Forest Red Gum grassy woodland on flats of the Cumberland Plain, Sydney Basin Bioregion – Moderate/Good_Poor

Vegetation formation: Grassy Woodlands

Vegetation class: Coastal Valley Grassy Woodlands

PCT: 849 **BVT:** HN528

Other mapping sources: Cumberland Shale Plains Woodland (Tozer *et al.* 2010), Shale Plains Woodland (Tozer 2003)

Conservation status: Listed as critically endangered under the TSC Act as Cumberland Plain Woodland in the Sydney Basin Bioregion

Estimate of percent cleared: 95% cleared in Hawkesbury/Nepean

Condition: Moderate/Good_Poor. The PCT in this vegetation zone scores less than 17 for site score

Extent in the study area: 10.17 hectares

Plots completed in vegetation zone: 3 plots (209, 219, 510 Willowdene)

Structure	Average height and height range (m)	Average cover and cover range	Typical species
Trees	20 m (15-25 m)	18.8 % (13.5-32.5 %)	*Eucalyptus moluccana, Eucalyptus tereticornis*
Small trees	NA	NA	None
Shrubs	1.3 m (1-2 m)	0.8 % (0-2.5 %)	*Lycium ferocissimum**
Ground covers	0.1 m (0-1 m)	94 % (86-98 %)	*Pennisetum clandestinum*, Cirsium vulgare*, Senecio madagascariensis*, Sida rhombifolia, Solanum linnaeanum*, Paspalum dilatatum*, Dichondra repens*
Vines & climbers	NA	NA	None

Description: As per VIS description provided for PCT 849 above.

Within the study area this vegetation zone is located in small narrow patches alongside the current Northern Road and on heavily grazed agricultural land. This vegetation zone has a site score less than 17. This vegetation zone is heavily modified and the vegetation was assigned to this PCT based on a combination of landscape position, canopy species composition and existing regional mapping. This vegetation zone occurs on the gently undulating land underlain by Bringelly Shale (Wianamatta group) and the associated Blacktown soil landscape as mapped by Hazelton *et al.* (1989). Altitude of the plots varied from 98 t o106 m above sea level.

The vegetation zone possesses old remnant canopy trees (*Eucalyptus moluccana* and *Eucalyptus tereticornis*) which contain a number of hollows. A small tree layer is absent and no regeneration of canopy species is evident due to grazing pressure. The native shrub layer is absent. The exotic species *Lycium ferocissimum** is present in the shrub layer in some instances. The ground layer is highly modified and dominated by pasture species and pasture weeds including *Pennisetum clandestinum*, Cirsium vulgare*, Senecio madagascariensis**,

Sida rhombifolia, Solanum linnaeanum,* and *Paspalum dilatatum*.* The ground layer contains few native species.

Photograph 4: Grey Box - Forest Red Gum grassy woodland on flats of the Cumberland Plain, Sydney Basin Bioregion – Moderate/Good_Poorat Plot 209

Grey Box - Forest Red Gum grassy woodland on shale of the southern Cumberland Plain, Sydney Basin Bioregion - Moderate/Good_High

Vegetation formation: Grassy Woodlands

Vegetation class: Coastal Valley Grassy Woodlands

PCT: 850 **BVT:** HN529

Other mapping sources: Cumberland Shale Hills Woodland (Tozer *et al.* 2010), Shale Hills Woodland (Tozer 2003)

Conservation status: Listed as critically endangered under the TSC Act as Cumberland Plain Woodland in the Sydney Basin Bioregion. This vegetation zone meets the thresholds for the EPBC Act listed critically endangered Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest ecological community

Estimate of percent cleared: 90% cleared in Hawkesbury/Nepean

Condition: Moderate/Good_High

Extent in the study area: 7.33 hectares

Plots completed in vegetation zone: 4 plots (P2 CPW regen, 341, 332, 393)

Structure	Average height and height range (m)	Average cover and cover range	Typical species
Trees	20.5 m (10-30 m)	13.2 % (3-24 %)	*Eucalyptus tereticornis, Eucalyptus moluccana, Eucalyptus eugenioides, Eucalyptus crebra*
Small trees	4.5 m (3-6 m)	8% (0-40%)	Canopy species regeneration
Shrubs	2.7 m (1-6 m)	12.4% (0-27 %)	*Bursaria spinosa, Acacia falcata, Olea europaea*, Lantana camara*, Lycium ferocissimum**
Ground covers	0.3 m (0-1 m)	95 % (92-100 %)	*Aristida* spp., *Themeda triandra, Cymbopogon refractus, Chloris ventricosa, Cheilanthes sieberi, Microlaena stipoides, Dichondra repens, Sida rhombifolia*, Conyza bonariensis**
Vines & climbers	0-2 m	<5 %	*Glycine tabacina, Glycine clandestina, Desmodium varians*

Description: As per VIS description: Cumberland Shale Hills Woodland is one of two widespread grassy woodland communities which together are recognised as the Cumberland Plain Woodland n the Sydney Basin Bioregion, a Critically Endangered Ecological Community. It is an open woodland of *Eucalyptus moluccana* and *Eucalyptus tereticornis* with *Eucalyptus crebra* also common. *Acacia implexa* occurs amongst the small tree layer, often amongst regrowth stands. This species is one of the more distinctive floristic attributes that helps distinguish between the two components of the EEC. Other features are similar in that the two woodland units are characterised by an open shrub layer and a grassy ground cover. Fire history can have an important influence on the abundance of shrubs with density of *Bursaria spinosa* increasing with time since fire. The community occupies higher elevations associated with the hills and rises south from Prospect. It is most extensive in Campbelltown and Liverpool local government areas. It extends west across the Razorback range and once dominated the southern half of the Cumberland Plain. It is restricted to elevations between 50 and 350 metres above sea level (Tozer *et al*. 2010).

Within the study area this vegetation zone (Moderate/Good_High) represents the areas of highest quality native vegetation which can be considered some of the best on offer in the locality. This vegetation zone is limited to three patches on private property at Luddenham between the Northern Road and Willowdene Avenue. The rolling hills in this area possess the Luddenham soil landscape that overlies the Bringelly Shale. A small patch of this vegetation zone is also present at the Defence Establishment Orchard Hills. Altitude of the plots varies from 83 to 105 metres above sea level.

This vegetation zone possesses the suite of characteristic species compliment for PCT 850 and is situated correctly in the landscape. The canopy of this vegetation zone is dominated by *Eucalyptus tereticornis* and *Eucalyptus moluccana* with occasional *Eucalyptus eugenioides* and *Eucalyptus crebra* present in some areas (but not common). This vegetation zone possesses some of the largest and oldest canopy trees within the study area and contains a considerable proportion of canopy regrowth. The shrub layer is variable (typical for a grassy woodland) and in some areas is absent. Other areas possess dense patches of mature *Bursaria spinosa* shrubs and pioneer species including *Acacia falcata*. Weeds including *Olea europaea*, Lantana camara*,* and *Lycium ferocissimum** are present in low abundance in the shrub layer of this vegetation zone. The ground layer is the highest quality of any vegetation zone within the study area and is characterised by a dense cover of native species dominated by *Aristida* spp., *Themeda triandra, Cymbopogon refractus, Chloris ventricosa, Cheilanthes sieberi, Microlaena stipoides,* and *Dichondra repens*. Common groundcover weeds including *Sida rhombifolia** and *Conyza bonariensis** are present in low abundance. Climbers including *Glycine tabacina, Glycine clandestina* and *Desmodium varians* are common.

Photograph 5: Grey Box - Forest Red Gum grassy woodland on shale of the southern Cumberland Plain, Sydney Basin Bioregion – Moderate/Good_High at Plot 393

Grey Box - Forest Red Gum grassy woodland on shale of the southern Cumberland Plain, Sydney Basin Bioregion - Moderate/Good

Vegetation formation: Grassy Woodlands

Vegetation class: Coastal Valley Grassy Woodlands

PCT: 850 **BVT:** HN529

Other mapping sources: Cumberland Shale Hills Woodland (Tozer *et al.* 2010), Shale Hills Woodland (Tozer 2003)

Conservation status: Listed as critically endangered under the TSC Act as Cumberland Plain Woodland in the Sydney Basin Bioregion. Parts of this vegetation zone meet the thresholds for the EPBC Act listed critically endangered Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest ecological community

Estimate of percent cleared: 90 per cent cleared in Hawkesbury/Nepean

Condition: Moderate/Good

Extent in the study area: 25.12 hectares

Plots completed in vegetation zone: 8 plots (2 Bradley St 2, P2-1, 2627 Northern Rd, 57, 63, 40, 149, 31)

Structure	Average height and height range (m)	Average cover and cover range	Typical species
Trees	18 m (10-25 m)	17.5 % (11-24.5 %)	*Eucalyptus tereticornis, Eucalyptus moluccana, Eucalyptus eugenioides, Eucalyptus crebra, Eucalyptus fibrosa*
Small trees	8 m	<5 %	*Brachychiton populneus, Olea europaea**
Shrubs	1 m (0-2 m)	7.4 % (0-23%)	*Bursaria spinosa, Acacia parramattensis, Daviesia ulicifolia, Indigofera australis, Olea europaea*, Lycium ferocissimum**
Ground covers	0.3 m (0-1 m)	92 % (76-100 %)	*Themeda triandra, Aristida* spp., *Microlaena stipoides, Chloris ventricosa, Cynodon dactylon, Oplismenus aemulus, Dichondra repens, Brunoniella australis, Eragrostis curvula*, Chloris gayana*, Ehrharta erecta*, Lolium perenne*, Pennisetum clandestinum*, Senecio madagascariensis**
Vines & climbers	0-2 m	<5 %	*Glycine tabacina, Geitonoplesium cymosum, Marsdenia viridiflora* subsp. *viridiflora, Clematis glycinoides* var. *glycinoides, Asparagus asparagoides**

Description: As per VIS description provided for PCT 850 above.

Within the study area, this vegetation zone is located in varying large to small patches generally on private property off Willowdene Avenue. The vegetation near the church at Luddenham also fits into this vegetation zone. There are also some patches of this vegetation zone on the Defence Establishment Orchard Hills and linear remnants along the Northern Road.

This vegetation zone is categorised as Moderate/Good condition. The canopy layer is intact. Where present the shrub layer is in good condition. The groundcover has a good cover and diversity of native species but weed invasion is prevalent. Some areas of this vegetation zone are currently grazed. The rolling hills in this area possess the Blacktown and Luddenham soil

landscapes that overlie the Bringelly Shale. Altitude of the plots varied from 71 to 115 m above sea level.

This vegetation zone possesses the characteristic species compliment for PCT 850 and is situated correctly in the landscape. The canopy of this vegetation zone is dominated by *Eucalyptus tereticornis* and *Eucalyptus moluccana* with occasional *Eucalyptus eugenioides, Eucalyptus crebra* and *eucalyptus fibrosa*. The shrub layer is variable (typical for a grassy woodland) and in some areas is absent. Other areas possess dense patches of mature *Bursaria spinosa* shrubs with *Acacia parramattensis, Daviesia ulicifolia,* and *Indigofera australis* also common. Weeds including *Olea europaea** and *Lycium ferocissimum** are relatively common in the shrub layer of this vegetation zone but do not dominate the vegetation. The groundcover vegetation possesses a variety of native species dominated by

Themeda triandra, Aristida spp., Microlaena stipoides, Chloris ventricosa, Cynodon dactylon, Oplismenus aemulus, Dichondra repens, and *Brunoniella australis*. Weeds including *Eragrostis curvula*, Chloris gayana*, Ehrharta erecta*, Lolium perenne*, Pennisetum clandestinum*,* and *Senecio madagascariensis** are also common. Vines and climbers including *Glycine tabacina, Geitonoplesium cymosum,* and *Clematis glycinoides* var. *glycinoides* are common as is the weed *Asparagus asparagoides**. The threatened population of the climber *Marsdenia viridiflora* subsp. *viridiflora* is also present within this vegetation zone in a patch along the Northern Road.

Photograph 6: Grey Box - Forest Red Gum grassy woodland on shale of the southern Cumberland Plain, Sydney Basin Bioregion – Moderate/Good at Plot 40

Grey Box - Forest Red Gum grassy woodland on shale of the southern Cumberland Plain, Sydney Basin Bioregion - Moderate/Good_Medium

Vegetation formation: Grassy Woodlands

Vegetation class: Coastal Valley Grassy Woodlands

PCT: 850 **BVT:** HN529

Other mapping sources: Cumberland Shale Hills Woodland (Tozer *et al.* 2010), Shale Hills Woodland (Tozer 2003)

Conservation status: Listed as critically endangered under the TSC Act as Cumberland Plain Woodland in the Sydney Basin Bioregion. This vegetation zone meets the thresholds for the EPBC Act listed critically endangered Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest ecological community

Estimate of percent cleared: 90% cleared in Hawkesbury/Nepean

Condition: Moderate/Good_Medium (individual zone based on density of *Olea europaea**)

Extent in the study area: 2.00 hectares

Plots completed in vegetation zone: 1 plot (29-2)

Structure	Average height and height range (m)	Average cover and cover range	Typical species
Trees	22.5 m (20-25m)	1%	*Eucalyptus tereticornis, Eucalyptus moluccana*
Small trees	NA	NA	None
Shrubs	4.5 m (1-8 m)	62 %	*Olea europaea*, Bursaria spinosa, Cestrum parqui**
Ground covers	0.5 m (0-1 m)	100 %	*Microlaena stipoides, Dichondra repens, Oplismenus aemulus, Cynodon dactylon*
Vines & climbers	NA	NA	None

Description: As per VIS description provided for PCT 850 above.

Within the study area, this vegetation zone is located in two discreet areas: near the church at Luddenham, and in a heavily eroded drainage line on private property off Willowdene Avenue. This vegetation zone is characterised by PCT 850 with a dense shrub layer of the weed *Olea europaea**. This vegetation zone occurs on the Blacktown and Luddenham soil landscapes that overlie the Bringelly Shale. Altitude of the plot was not recorded.

This vegetation zone possesses characteristic species for PCT 850 and is situated correctly in the landscape. The canopy of this vegetation zone is dominated by a sparse cover of *Eucalyptus tereticornis* and *Eucalyptus moluccana.* The shrub layer is dominated by the weed species *Olea europaea** with some *Bursaria spinosa* also present. Despite the dominance of weeds in the shrub layer, the ground cover is dominated by native species including *Microlaena stipoides, Dichondra repens, Oplismenus aemulus,* and *Cynodon dactylon* which are species adapted to wetter shaded environments. Vines and climbers were absent from the sample plot.

Photograph 7: Grey Box - Forest Red Gum grassy woodland on shale of the southern Cumberland Plain, Sydney Basin Bioregion – Moderate/Good_Medium at Plot 29-2

Grey Box - Forest Red Gum grassy woodland on shale of the southern Cumberland Plain, Sydney Basin Bioregion - Moderate/Good_Poor

Vegetation formation: Grassy Woodlands

Vegetation class: Coastal Valley Grassy Woodlands

PCT: 850 **BVT:** HN529

Other mapping sources: Cumberland Shale Hills Woodland (Tozer *et al.* 2010), Shale Hills Woodland (Tozer 2003)

Conservation status: Listed as critically endangered under the TSC Act as Cumberland Plain Woodland in the Sydney Basin Bioregion. Some areas of this vegetation zone meet the thresholds for the EPBC Act listed critically endangered Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest ecological community

Estimate of percent cleared: 90% cleared in Hawkesbury/Nepean

Condition: Moderate/Good_Poor

Extent in the study area: 13.38 hectares

Plots completed in vegetation zone: 3 plots (394, 371, 170-1)

Structure	Average height and height range (m)	Average cover and cover range	Typical species
Trees	22.5 m (20-25 m)	21.7 % (4.7-39.5 %)	*Eucalyptus tereticornis, Eucalyptus moluccana*
Small trees	0-8 m	<5 %	*Exocarpos cupressiformis*
Shrubs	3.3 m (1-4 m)	24.5% (0.2-65.5 %)	*Bursaria spinosa, Olea europaea*, Lycium ferocissimum**
Ground covers	0.4 m (0-1.2 m)	98.6 % (96-100%)	*Paspalum dilatatum*, Setaria gracilis*, Pennisetum clandestinum*, Senecio madagascariensis*, Ehrharta erecta*, Eragrostis curvula*, Chloris gayana*, Themeda triandra Dichondra repens*
Vines & climbers	0.1 m	<5 %	*Glycine tabacina*

Description: As per VIS description provided for PCT 850 above.

Within the study area, this vegetation zone is predominantly located to the south of the Luddenham town centre but is also found as linear roadside patches along the northern road. This vegetation zone is in poor condition overall but the site score is high enough to avoid this vegetation zone being classed as Low condition.

This vegetation zone possesses characteristic species for PCT 850 and is situated correctly in the landscape. The canopy of this vegetation zone is dominated by *Eucalyptus tereticornis* and *Eucalyptus moluccana. Exocarpos cupressiformis* is present in the lower tree layer in some areas. Where present, the shrub layer is dominated by *Bursaria spinosa* and the weeds *Olea europaea** and *Lycium ferocissimum**. Weeds are dominant in the ground layer with species including *Paspalum dilatatum*, Setaria gracilis*, Pennisetum clandestinum*, Senecio madagascariensis*, Ehrharta erecta*, Eragrostis curvula*,* and *Chloris gayana** composing most of the ground layer biomass. Native species including *Themeda triandra* and *Dichondra repens* occur occasionally. Vines and climbers were generally absent from the sample plots but *Glycine tabacina* was occasionally found in low abundance.

Photograph 8: Grey Box - Forest Red Gum grassy woodland on shale of the southern Cumberland Plain, Sydney Basin Bioregion – Moderate/Good_Poor at Plot 394

Derived grasslands on shale hills of the Cumberland Plain (50-300m asl)

Vegetation formation: Grasslands

Vegetation class: Not listed in VIS database

PCT: 806 **BVT:** HN627

Other mapping sources: None, no mapping of this PCT is available

Conservation status: Listed as critically endangered under the TSC Act as Cumberland Plain Woodland in the Sydney Basin Bioregion. Some areas of this vegetation zone meet the thresholds for the EPBC Act listed critically endangered Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest ecological community

Estimate of percent cleared: Not identified in the VIS database

Condition: Moderate/Good_Derived grassland

Extent in the study area: 49.78 hectares

Plots completed in vegetation zone: 4 plots (P2 DNG, 139 DNG, 33 DNG, 39 DNG)

Structure	Average height and height range (m)	Average cover and cover range	Typical species
Trees	NA	NA	None
Small trees	NA	NA	None
Shrubs	1 m	<5 %	*Eucalyptus tereticornis* regrowth
Ground covers	0-0.5 m	100%	*Themeda triandra, Aristida* spp., *Cynodon dactylon, Sporobolus creber, Briza subaristata*, Axonopus fissifolius*, Paspalum dilatatum**
Vines & climbers	0.1 m	<5 %	*Glycine clandestina*

Description: Grassland derived from PCT 850 dominated by *Themeda triandra*.

Photograph 9 and 10: Derived grasslands on shale hills of the Cumberland Plain (50-300m asl) within the study area

***Phragmites australis* and *Typha orientalis* coastal freshwater wetlands of the Sydney Basin Bioregion**

Vegetation formation: Freshwater Wetlands

Vegetation class: Coastal Freshwater Lagoons

PCT: 1071 **BVT:** HN630

Other mapping sources: None, man-made wetlands not mapped in study area

Conservation status: This PCT is not listed as endangered under the TSC Act. Artificial wetlands created on previously dry land specifically for purposes such as sewerage treatment, stormwater management and farm production, are not regarded as part of the Freshwater Wetlands on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions TEC (NSW Scientific Committee, 2004)

Estimate of percent cleared: 70 per cent

Condition: Moderate/Good_Other (classed as other as they are man-made wetlands)

Extent in the study area: 12.92 hectares

Plots completed in vegetation zone: 3 plots (P12 wetland 1, P12 wetland 2, P13 wetland)

Structure	Average height and height range (m)	Average cover and cover range	Typical species
Trees	12.5m (10-15m)	<5%	*Casuarina glauca* (sporadic individuals)
Ground covers	1.5m (0-3m)	98.7% (98-100%)	*Juncus acutus*, Juncus usitatus, Typha orientalis, Paspalum distichum, Ludwigia peploides* subsp. *montevidensis, Persicaria* spp., *Damasonium minus, Cynodon dactylon, Phragmites australis*

Description: A rushland with sub-stratum growth forms of forbs, herbs, grass and aquatics. Dominated by the exotic *Juncus acutus** with native wetland species and occasional *Casuarina glauca*. Occurs fringing man-made water bodies, drainage lines and depressions across the study area. Also associated with sites of poor drainage where *Phragmites australis* becomes dominant.

Photograph 11 and 12: *Phragmites australis* and *Typha orientalis* coastal freshwater wetlands of the Sydney Basin Bioregion on the Defence Establishment Orchard Hills

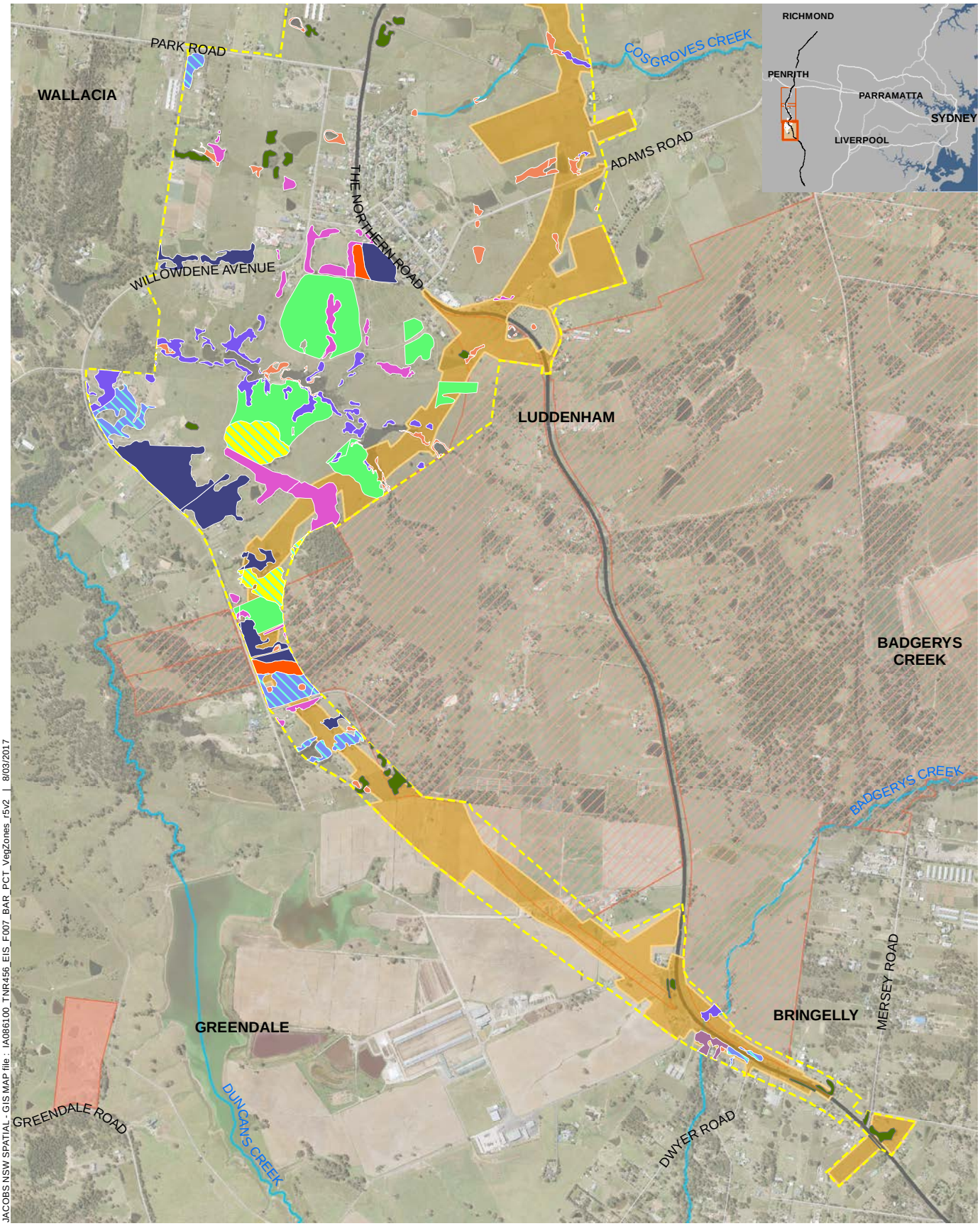
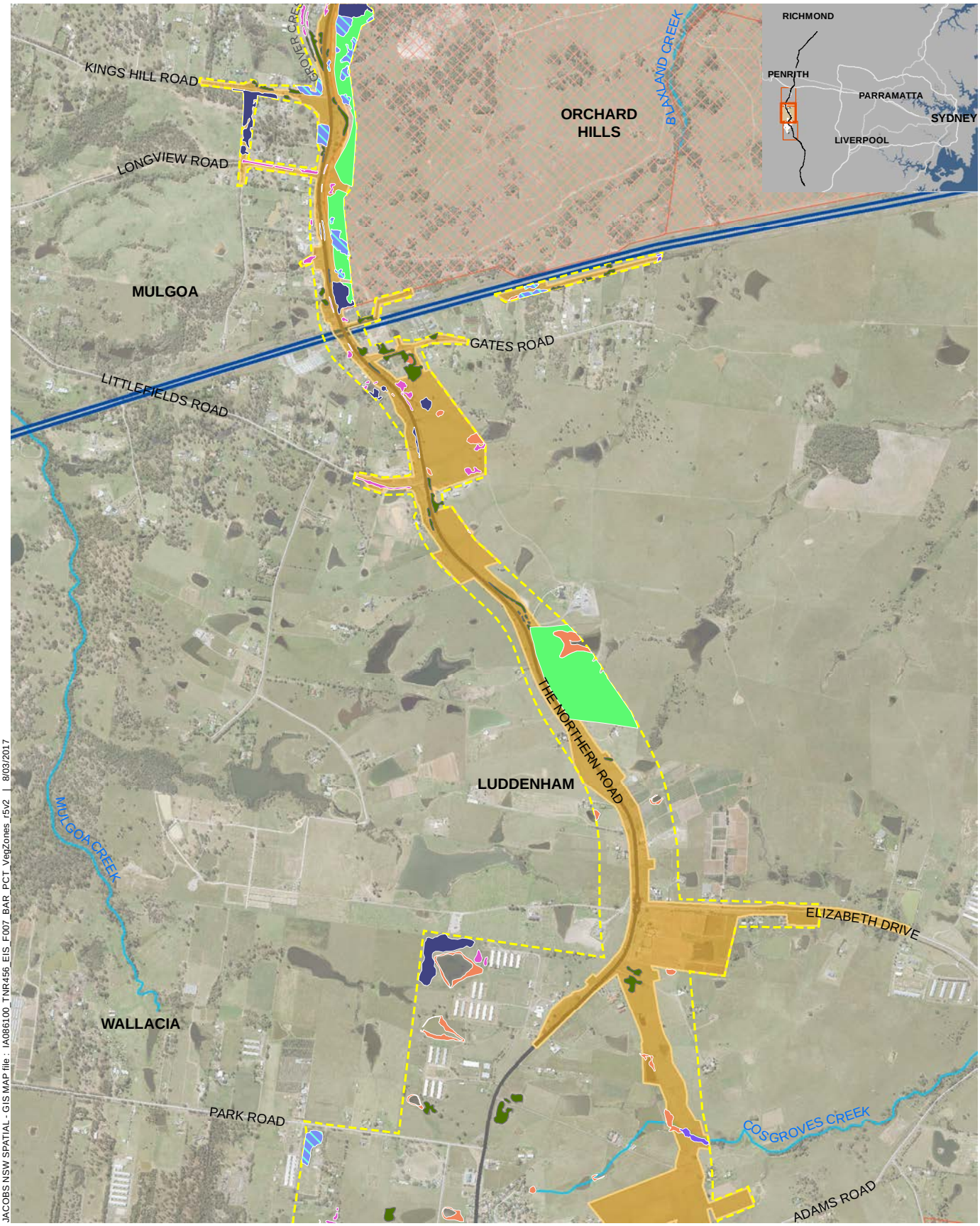


Figure 3-2 | Plant community types and vegetation zones



JACOBS NSW SPATIAL - GIS MAP file : IA086100_TNR456_EIS_F007_BAR_PCT_VegZones_r5v2 | 8/03/2017

The Northern Road (Existing)
WaterNSW supply pipelines
Development site boundary
Ecology study area
Western Sydney Airport site (Commonwealth Land)
Defence Establishment Orchard Hills (Commonwealth Land)
Commonwealth Lands

0 0.5 1 km

N

Vegetation zones

- Derived grasslands on shale hills of the Cumberland Plain (50-300m asl) - Moderate/Good - Derived Grassland
- Forest Red Gum - Rough-barked Apple grassy woodland on alluvial flats of the Cumberland Plain, Sydney Basin Bioregion - Moderate/Good
- Forest Red Gum - Rough-barked Apple grassy woodland on alluvial flats of the Cumberland Plain, Sydney Basin Bioregion - Moderate/Good - Poor
- Grey Box - Forest Red Gum grassy woodland on flats of the Cumberland Plain, Sydney Basin Bioregion – Moderate/Good – Poor
- Grey Box - Forest Red Gum grassy woodland on flats of the Cumberland Plain, Sydney Basin Bioregion - Moderate/Good
- Grey Box - Forest Red Gum grassy woodland on shale of the southern Cumberland Plain, Sydney Basin Bioregion - Moderate/Good
- Grey Box - Forest Red Gum grassy woodland on shale of the southern Cumberland Plain, Sydney Basin Bioregion - Moderate/Good - High
- Grey Box - Forest Red Gum grassy woodland on shale of the southern Cumberland Plain, Sydney Basin Bioregion - Moderate/Good - Medium
- Grey Box - Forest Red Gum grassy woodland on shale of the southern Cumberland Plain, Sydney Basin Bioregion - Moderate/Good - Poor
- Phragmites australis and Typha orientalis coastal freshwater wetlands of the Sydney Basin Bioregion - Moderate/Good - Other

3
2
1

Figure 3-2 | Plant community types and vegetation zones

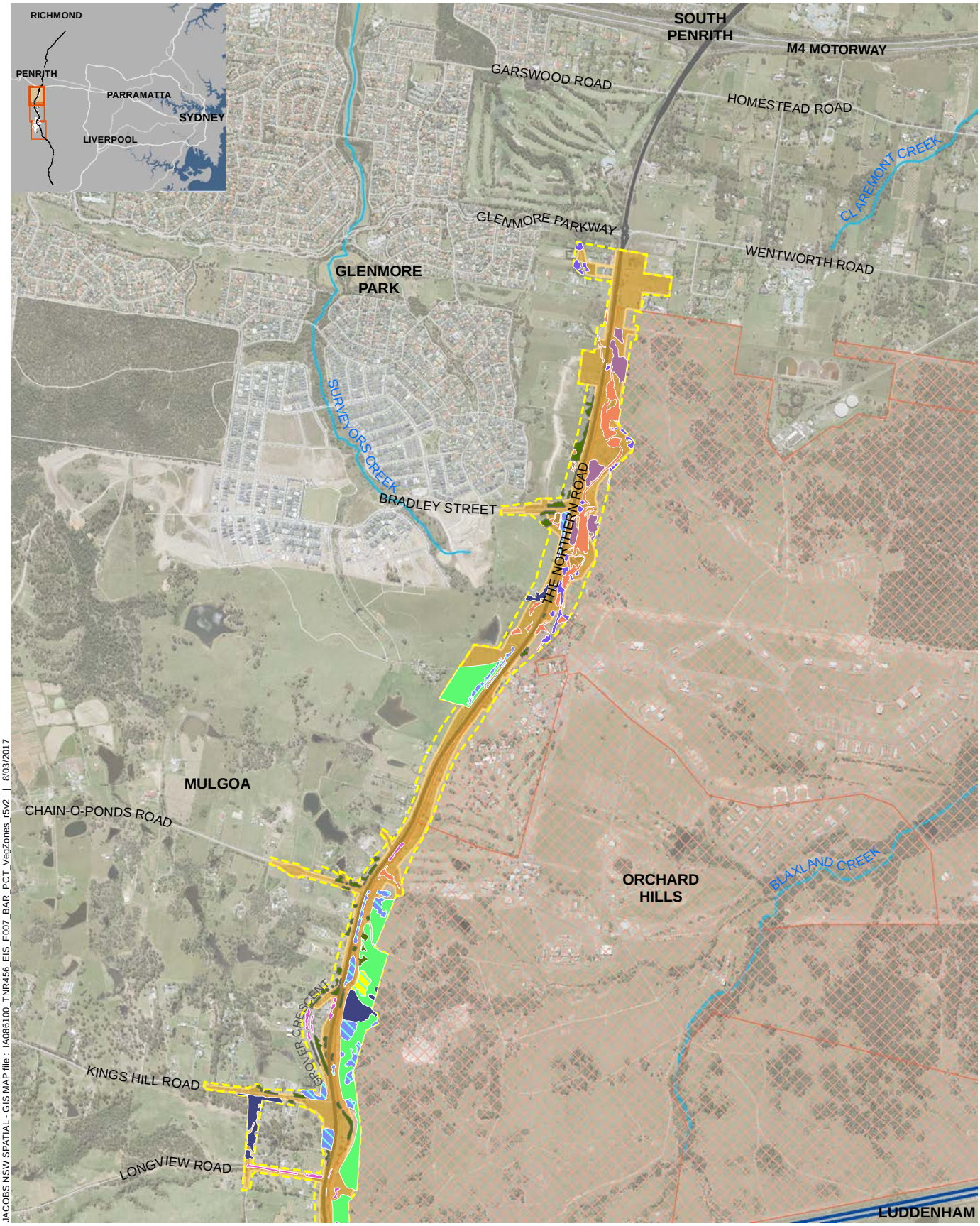


Figure 3-2 | Plant community types and vegetation zones

3.3 Threatened ecological communities

The field survey identified two threatened ecological communities (TECs) as listed under the TSC Act within the study area (see Table 3.4).

One TEC listed under the EPBC Act was also identified in the study area: Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest (critically endangered). This TEC is discussed in detail in Section 5.4.1.

Table 3.4: Threatened ecological communities listed under the TSC Act present within the study area

Threatened ecological community	Status TSC Act	Corresponding PCT	Study area (ha)
Cumberland Plain Woodland in the Sydney Basin Bioregion	Critically endangered	849 850 806	121.7 (includes 49.78 hectares of derived native grasslands)
River-Flat Eucalypt Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions	Endangered	835	13.54

3.3.1 Cumberland Plain Woodland in the Sydney Basin Bioregion

The critically endangered Cumberland Plain Woodland in the Sydney Basin Bioregion ecological community (Cumberland Plain Woodland) is the name given to the ecological community in the Sydney Basin bioregion associated with clay soils derived from Wianamatta Group geology, or more rarely alluvial substrates, on the Cumberland Plain, a rainshadow area to the west of Sydney's Central Business District (NSW Scientific Committee, 2009).

A detailed description of Cumberland Plain Woodland is provided by the NSW Scientific Committee (2009). Briefly, the community is characterised by an upper-storey that is usually dominated by *Eucalyptus moluccana* and *Eucalyptus tereticornis*, often with *Eucalyptus crebra*, *Eucalyptus eugenioides*, *Corymbia maculata* or other less frequently occurring eucalypts, including *Angophora floribunda, Angophora subvelutina, Eucalyptus amplifolia* and *Eucalyptus fibrosa* (NSW Scientific Committee, 2009). This description is typical of PCT 849 and PCT 850 within the study area. The Cumberland Plain Woodland in the Sydney Basin Bioregion ecological community is directly composed of two closely related PCTs: PCT 849 and PCT 850 (see section 3.2 for detailed descriptions of these PCTs). These two PCTs are present on the shale plains and the hills and rises throughout the study area.

Importantly, the NSW Scientific Committee (2009) does not exclude patches of vegetation from the listing based on condition or structure thresholds. The community includes poorer condition patches and 'derived' native grasslands which result from removal of the woody strata from the woodlands and forests (NSW Scientific Committee, 2009). As such, all areas of PCT 806 in the study area are considered Cumberland Plain Woodland.

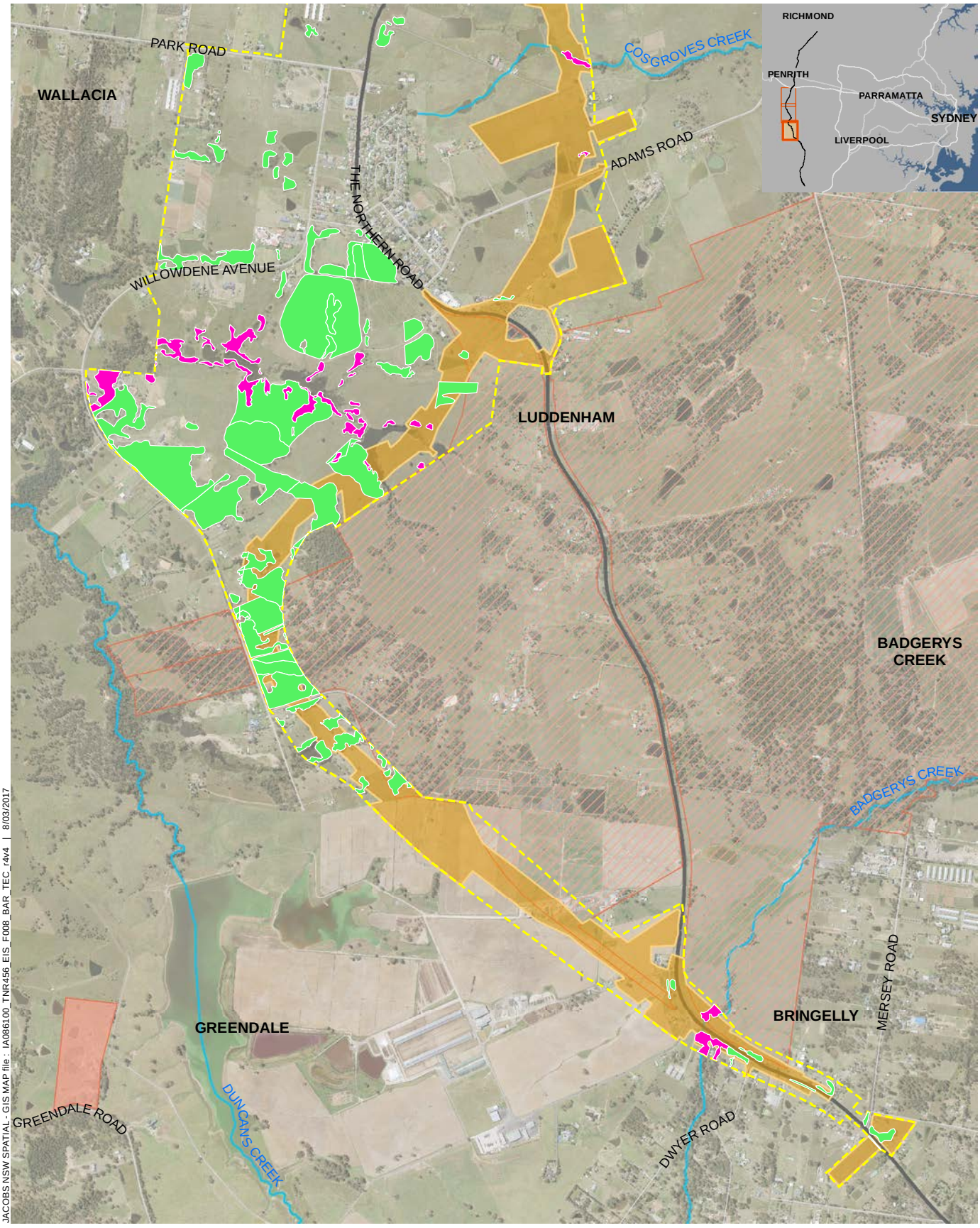
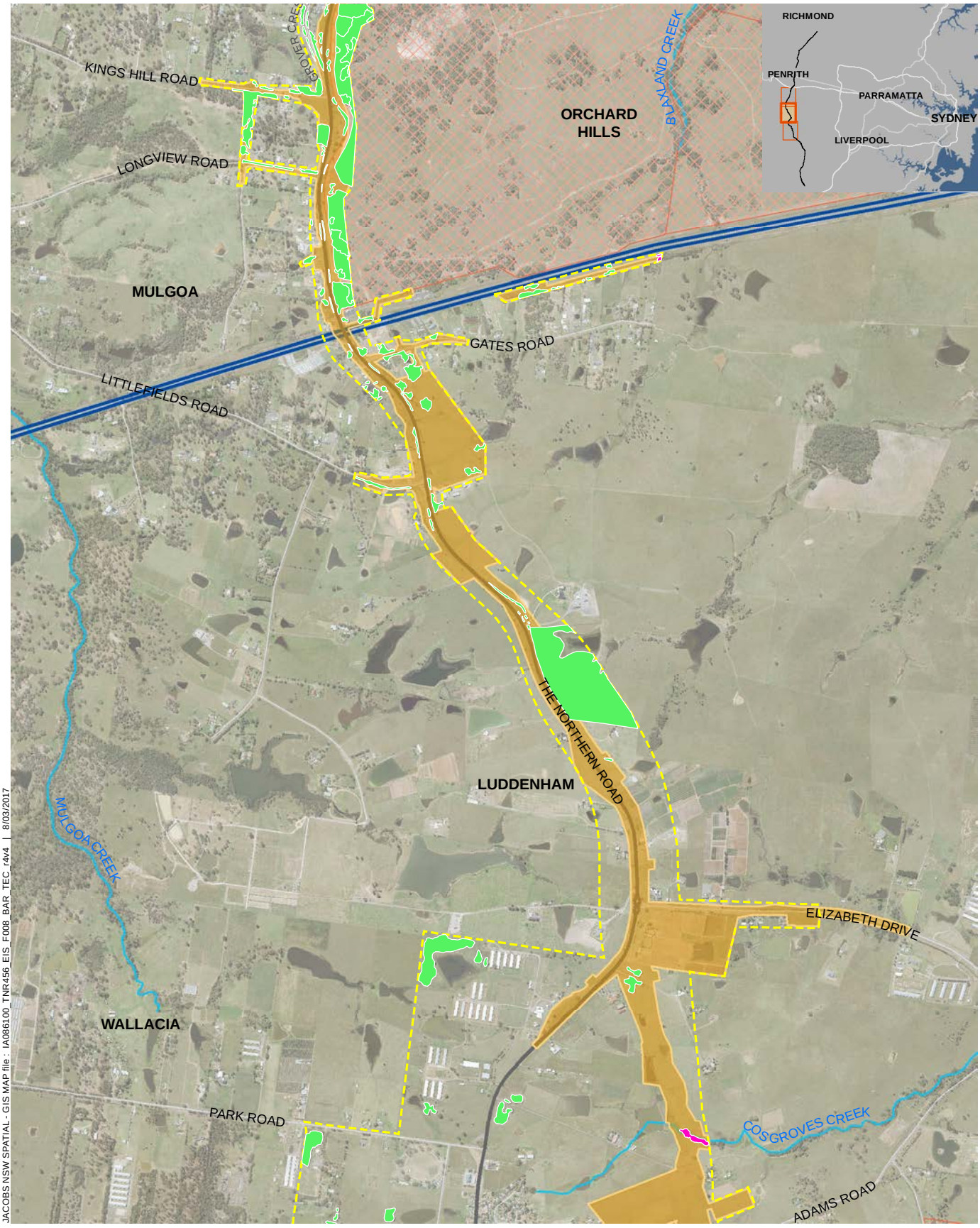


Figure 3-3 | Threatened ecological communities



The Northern Road (Existing)
WaterNSW supply pipelines
Development site boundary
Ecology study area
Western Sydney Airport site (Commonwealth Land)
Defence Establishment Orchard Hills (Commonwealth Land)
Commonwealth Lands

0 0.5 1 km

N

Threatened ecological communities

Cumberland Plain Woodland in the Sydney Basin Bioregion

River-Flat Eucalypt Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions

3
2
1

Figure 3-3 | Threatened ecological communities

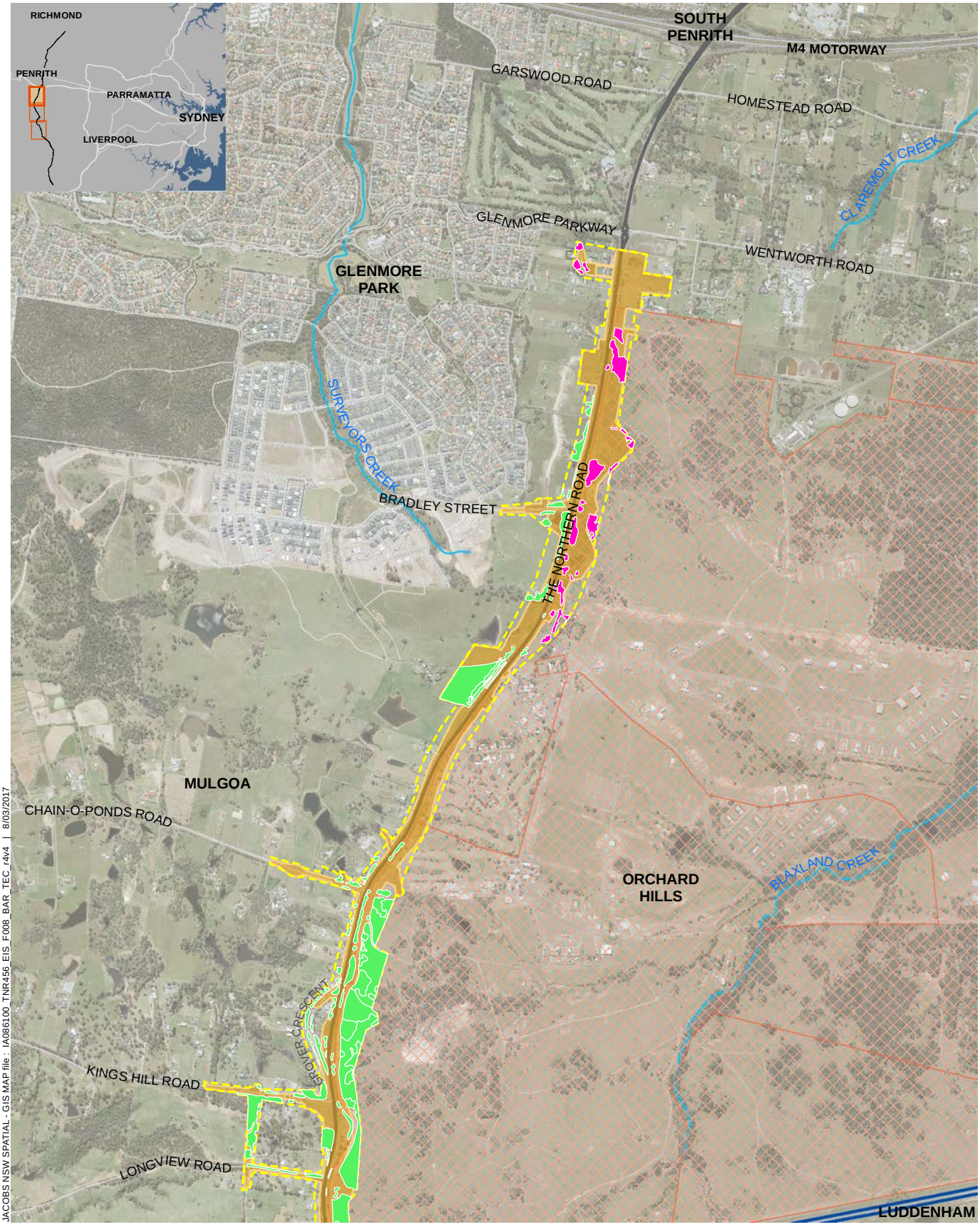


Figure 3-3 | Threatened ecological communities

3.3.2 River-Flat Eucalypt Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions

River-Flat Eucalypt Forest on Coastal Floodplains of the NSW North Coast, Sydney Basin and South East Corner bioregions (River-Flat Eucalypt Forest on Coastal Floodplains) is the name given to the ecological community associated with silts, clay-loams and sandy loams, on periodically inundated alluvial flats, drainage lines and river terraces associated with coastal floodplains (NSW Scientific Committee, 2005). River-Flat Eucalypt Forest on Coastal Floodplains generally occurs below 50 m elevation, but may occur on localised river flats up to 250 m above sea level in the Sydney Basin Bioregion (NSW Scientific Committee, 2005).

The composition of River-Flat Eucalypt Forest on Coastal Floodplains is primarily determined by the frequency and duration of waterlogging and the texture, nutrient and moisture content of the soil. Composition also varies with latitude and the structure of the community may vary from tall open forests to woodlands, although partial clearing may have reduced the canopy to scattered trees (NSW Scientific Committee, 2005). This indicates that highly disturbed and poor quality vegetation remnants, such as those found within the study area, still form part of this community.

River-Flat Eucalypt Forest on Coastal Floodplains has a tall open tree layer of eucalypts with composition of the tree stratum varying considerably. The most widespread and abundant dominant trees include *Eucalyptus tereticornis*, *Eucalyptus amplifolia*, *Angophora floribunda* and *Angophora subvelutina* (NSW Scientific Committee, 2005). PCT 835 is recognised in the VIS as part of the River-Flat Eucalypt Forest on Coastal Floodplains community. A detailed description of PCT 835 as it occurs in the study area is provided above in Section 3.2.

3.4 Groundwater dependent ecosystems

This BAR uses the definition of a groundwater dependent ecosystem (GDE) as outlined by Serov *et al.* (2012) which is an ecosystem which has its species composition and natural ecological processes wholly or partially determined by groundwater. The location of GDEs within the within the Hawkesbury Nepean Catchment Management Authority (CMA) area is mapped by Kuginis *et al.* (2012). No high probability GDEs are mapped within or near the study area by Kuginis *et al.* (2012). However, PCT 850 and PCT 849 are identified as having a high probability of being a GDE. Additionally, PCT 835 is considered by Kuginis *et al.* (2012) to be a high probability groundwater dependent wetland community.

Chapter 7 of the EIS and the soils, water and contamination technical paper (Jacobs, 2016b) suggests that a shallow groundwater system exists in the study area. The conceptual hydrogeological model created for the study area suggests that the shallow groundwater system consists of low permeability weathered shale with an expected shallow water table ranging from 5 to 30m below ground level (Jacobs, 2016b). The shallow aquifer is expected to contain clay lenses that may act as localised zones of decreased permeability leading to perched water table resting above the lens (Jacobs, 2016b). There may also be local colluvial/alluvial lenses that could represent localised zones of higher permeability (Jacobs, 2016b). The Wianamatta Shale is a low permeability formation and therefore the contribution of this aquitard to baseflow in surface water courses is expected to be minor to negligible (Jacobs, 2016b).

Within the study area, PCT 850, PCT 849, PCT 1071, PCT 806 and PCT 835 are considered unlikely to be GDEs given their location in the landscape. In the case of PCT 850, 849, and 806 these communities are classed as vadophytic vegetation with no apparent groundwater dependency. PCT 835 and PCT 1071 within the study area are not part of a river baseflow system and are situated along losing stream reaches (streams that 'lose' surface water to ground water). The dams are man-made and fed by surface water. The flow regimes of the streams within the study area are ephemeral (or would have naturally been ephemeral prior to

damming). Ephemeral streams flow only in direct response to precipitation, and the stream channel is above the water table at all times. The majority of watercourses within the study area are ephemeral and most flow events occur in direct response to major rainfall. These systems are not considered to support GDEs (Serov et al., 2012). There is no evidence of baseflow feeding any of the streams within the study area. As such, none of the riparian zones within the study area are considered to be GDEs.

4 Threatened species

4.1 Candidate species

The candidate species for assessment in the BAR were largely identified via the BioBanking credit calculator. However, the following database searches were undertaken:

- BioNet- the website for the Atlas of NSW Wildlife (Office of Environment and Heritage, 2015b)
- OEH BioBanking Threatened Species Profile Database
- NSW Department of Primary Industries (DPI) Fisheries Fish Records Viewer
- The federal Department of Environment and Energy's Protected Matters Search Tool
- Critical habitat register.

Existing reports from near the study area including the *Defence Establishment Orchard Hills: Biodiversity Monitoring Report - Spring 2013* (Sinclair Knight Merz, 2014) and *Western Sydney Airport EIS Biodiversity Assessment* (GHD, 2016) were also reviewed. All species credit species with a moderate to high likelihood of occurrence, that have been identified as requiring survey in the BBCC, or that have been recorded during the surveys are considered candidate species. Thirty-Six threatened flora species and 24 threatened fauna species were identified as candidate species and formed the target of the threatened species survey.

4.2 Threatened species survey

4.2.1 Terrestrial flora surveys

The targeted flora surveys were undertaken by Lukas Clews, an ecologist with strong botanical skills gained from a combination of academic qualifications (Master of Scientific Studies with specialisation in botany) and 11 years of field experience in New South Wales, Queensland, and Victoria with a particular emphasis on the Sydney Basin.

The targeted flora surveys followed the methods described in the *Threatened Biodiversity Survey and Assessment Guidelines for Developments and Activities – Working Draft 2004* (Department of Environment and Conservation, 2004). The survey timing adhered to the months detailed in the BioBanking credit calculator for each candidate flora species. The targeted flora surveys were completed prior to the release of the *NSW Guide to Surveying Threatened Plants* (Office of Environment and Heritage, 2016). However, a systematic approach was taken to the survey including targeting the species at the optimal time of year, identifying potential habitats, and then undertaking a survey using parallel field traverses.

Targeted surveys were completed for all identified candidate flora species with suitable habitat. The BioBanking credit calculator was first used to generate a list of threatened plant species that required survey. Past specimen records from the locality that indicate a species presence were then investigated for accuracy. The list of candidate species was then further refined based on the presence or absence of key habitat features including associated PCTs and taxa, topographic, soil and geological preferences, microhabitats (e.g. damp areas, table drains), and disturbance regime of the habitat in the study area. The survey effort expended for threatened flora species is outlined in Table 4.1.

For cryptic species (i.e. *Pimelea spicata*) that are known form the locality in the PCTs within the study area (i.e. potential habitat was present), the field survey included visiting reference populations to ensure visibility in the study area during the survey period. Three *Pimelea spicata* reference sites were surveyed in January 2016 including the Mt Annan Botanic

Gardens, Camden Golf Course bushcare site, and a site in the Western Sydney Parklands. *Pimelea spicata* was flowering and visible at all three reference sites during the survey period.

Table 4.1 Targeted flora survey details

Common Name *(Scientific Name)*	TSC Act	EPBC Act	Minimum survey requirements (Office of Environment and Heritage 2016)	Survey completed
Dillwynia tenuifolia	V	-	*Dillwynia tenuifolia* is a reasonably large non-cryptic shrub that can be readily detected year round within suitable habitats. The recommended approach is the parallel field traverse (i.e. parallel transects) as used by Cropper (1993). As a medium shrub the maximum distance between transects in open vegetation is 20 m, in dense vegetation is 10 m. In open vegetation, field traverse length is 0.5 km per hectare of potential habitat in open vegetation. With about 60 hectares of potential habitat in the study area, survey time is 6.25 hours in open vegetation.	Detailed floristic plots and traverses by foot and vehicle throughout the study area failed to record *Dillwynia tenuifolia*. Particular survey effort was expended in the vegetation on the Defence Establishment Orchard Hills. Parallel field traverses undertaken by two observers were used to survey for this species in areas which appeared to provide suitable habitat. The field surveys were undertaken over a period of 11 days from 2 September 2015 to 4 February 2016 (not inclusive). Surveys targeted PCT 849 and PCT 850. Derived grasslands were also surveyed. Surveys for this species can be undertaken year round. Floristic plots were undertaken in PCT 849 (14 plots), PCT 850 (16 plots) and PCT 806 (4 plots) which lasted on average 1 hour each with two observers. This equates to 68 person hours of detailed floristic survey in potential habitat for *Dillwynia tenuifolia*. Each floristic plot was accompanied by a traverse throughout the adjacent habitat lasting a minimum of 0.5 hours duration undertaken by two observers. This resulted in an additional 34 person hours of traverse-based survey in habitat for *Dillwynia tenuifolia*. In total, 102 person hours were expended on survey for *Dillwynia tenuifolia* within the study area. Existing records of this species from near the study area were checked. The record of *Dillwynia tenuifolia* from the Defence Establishment Orchard Hills near the dam south of the golf course was checked and it is erroneous. The record located on Park Road Wallacia about 1.3 km west of the intersection of the Northern Road and Park Road is no longer valid as it was checked and no plants were found. The record of *Dillwynia tenuifolia* at 2161-2177 Elizabeth Drive Luddenham is also erroneous as this record belongs to the Elizabeth Drive Waste Management Site.
Downy Wattle (*Acacia pubescens*)	V	V	*Acacia pubescens* is a reasonably large non-cryptic shrub that can be readily detected year round in suitable habitats. The recommended approach is the parallel field traverse (i.e. parallel transects) as used by Cropper (1993).	Detailed floristic plots and traverses by foot and vehicle throughout the study area failed to record *Acacia pubescens.* This species has a distinctive habit that can be seen via fast moving vehicle where it is present. Parallel field traverses undertaken by two observers were used to survey for this species in areas which appeared to provide suitable habitat. The field surveys were undertaken over a period of 11 days from 2 September 2015 to 4 February 2016 (not inclusive). Surveys targeted PCT 849 and PCT 850. Derived grasslands were also

Common Name *(Scientific Name)*	TSC Act	EPBC Act	Minimum survey requirements (Office of Environment and Heritage 2016)	Survey completed
			As a medium shrub the maximum distance between transects in open vegetation is 20 m, in dense vegetation is 10 m. In open vegetation, field traverse length is 0.5 km per hectare of potential habitat in open vegetation. With about 60 hectares of potential habitat in the study area, survey time is 6.25 hours in open vegetation.	surveyed. Surveys for this species can be undertaken year round. Floristic plots were undertaken in PCT 849 (14 plots), PCT 850 (16 plots) and PCT 806 (4 plots) which lasted on average 1 hour each with two observers. This equates to 68 person hours of detailed floristic survey in potential habitat for *Acacia pubescens*. Each floristic plot was accompanied by a traverse throughout the adjacent habitat lasting a minimum of 0.5 hours duration undertaken by two observers. This resulted in an additional 34 person hours of traverse-based survey in habitat for *Acacia pubescens*. In total, 102 person hours were expended on survey for *Acacia pubescens* within the study area. There are no records of *Acacia pubescens* in the study area. The nearest records of this species are from 8 km to the east at Kemps Creek.
Juniper-leaved Grevillea (*Grevillea juniperina* subsp. *juniperina*)	V	-	*Grevillea juniperina* subsp. *juniperina* is a reasonably large non-cryptic shrub that can be readily detected year round in suitable habitats. The recommended approach is the parallel field traverse (i.e. parallel transects) as used by Cropper (1993). As a medium shrub the maximum distance between transects in open vegetation is 20 m, in dense vegetation is 10 m. In open vegetation, field traverse length is 0.5 km per hectare of potential habitat in open vegetation. With about 60hectares of potential habitat in the study area, survey time is 6.25 hours in open vegetation.	Detailed floristic plots and traverses by foot and vehicle throughout the study area failed to record *Grevillea juniperina* subsp. *juniperina*. Particular survey effort was expended in the Defence Establishment Orchard Hills. Parallel field traverses undertaken by two observers were used to survey for this species in areas which appeared to provide suitable habitat. The field surveys were undertaken over a period of 11 days from 2 September 2015 to 4 February 2016 (not inclusive). The study area lies beyond the south western boundary of the known occurrence of this species (however some outliers from 1915, 1954 and 1995 occur in the locality but these records are inaccurate). There is a large population of *Grevillea juniperina* subsp. *juniperina* on and around the Defence Establishment Orchard Hills. There is a record close to the study area on Lot 14 Park Rd Wallacia (this site was checked and it is no longer valid). Surveys targeted PCT 849 and PCT 850. Derived grasslands were also surveyed. Surveys for this species can be undertaken year round. Floristic plots were undertaken in PCT 849 (14 plots), PCT 850 (16 plots) and PCT 806 (4 plots) which lasted on average 1 hour each with two observers. This equates to 68 person hours of detailed floristic survey in potential habitat for *Grevillea juniperina* subsp. *juniperina.* Each floristic plot was accompanied by a traverse throughout the adjacent habitat lasting a minimum of 0.5 hours duration undertaken by two observers. This resulted in an additional 34 person hours of traverse-based survey in habitat for *Grevillea juniperina* subsp. *juniperina*. In total, 102 person hours were expended on survey for *Grevillea juniperina* subsp. *juniperina* within the study area.

Common Name *(Scientific Name)*	TSC Act	EPBC Act	Minimum survey requirements (Office of Environment and Heritage 2016)	Survey completed
Marsdenia viridiflora subsp. *viridiflora* in the Bankstown, Blacktown, Camden, Campbelltown, Fairfield, Holroyd, Liverpool and Penrith local government areas	EP	-	*Marsdenia viridiflora* subsp. *viridiflora* was flowering and fruiting during the survey in early October. However, the flowers are relatively inconspicuous and this species is readily located by the foliage. The recommended approach is the parallel field traverse (i.e. parallel Transects) as used by Cropper (1993). As a climber the maximum distance between transects in open vegetation is 10 m, in dense vegetation is 5 m. In open vegetation, field traverse length is 1 km per hectare of potential habitat in open vegetation. With about 85 hectares of potential habitat in the study area, survey time is 12.5 hours in open vegetation.	Traverses of known locations along the fence of the Defence Site Orchard Hills recorded this species in previously known areas. This species was also recorded in other locations in the roadside habitats along the northern road. Parallel field traverses undertaken by two observers were used to survey for this species in areas which appeared to provide suitable habitat. The field surveys were undertaken over a period of 11 days from 2 September 2015 to 4 February 2016 (not inclusive). Surveys targeted PCT 835, PCT 849 and PCT 850. Derived grasslands were also surveyed. Surveys for this species can be undertaken year round. Floristic plots were undertaken in PCT 835 (9 plots), PCT 849 (14 plots), PCT 850 (16 plots) and PCT 806 (4 plots) which lasted on average 1 hour each with two observers. This equates to 86 person hours of detailed floristic survey in potential habitat for *Marsdenia viridiflora* subsp. *viridiflora.* Each floristic plot was accompanied by a traverse throughout the adjacent habitat lasting a minimum of 0.5 hours duration undertaken by two observers. This resulted in an additional 43 person hours of traverse-based survey in habitat for *Marsdenia viridiflora* subsp. *viridiflora*. In total, 129 person hours were expended on survey for *Marsdenia viridiflora* subsp. *viridiflora* within the study area. The endangered *Marsdenia viridiflora* subsp. *viridiflora* population was recorded in four locations (all relatively disturbed) adjacent to the current Northern Rd alignment (two locations on the Defence Establishment Orchard Hills fence, and roadside vegetation adjacent to 2509 Northern Road, and 2627 Northern Road).
Spiked Rice-flower (*Pimelea spicata*)	E	E	The recommended approach is the parallel field traverse (i.e. parallel transects) as used by Cropper (1993). As a herb the maximum distance between transects in open vegetation is 10 m, in dense vegetation is 5 m. In open vegetation, field traverse length is 1 km per hectare of potential habitat in open vegetation. With about 60 hectares of potential habitat in the study area, survey time is 12.5 hours in	Detailed floristic plots and traverses on foot throughout the study area failed to record *Pimelea spicata*. Survey was prioritised within the higher quality habitats but lower condition woodland and Derived Native Grasslands were also surveyed. Surveys targeted PCT 849 and PCT 850. Derived grasslands were also surveyed. Parallel field traverses undertaken by two observers were used to survey for this species in areas which appeared to provide suitable habitat. The field surveys were undertaken over a period of 11 days from 2 September 2015 to 4 February 2016 (not inclusive). Floristic plots were undertaken in PCT 849 (14 plots), PCT 850 (16 plots) and PCT 806 (4 plots) which lasted on average 1 hour each with two observers. This equates to 68 person hours of detailed floristic survey in potential habitat for *Pimelea spicata*. Each floristic plot was accompanied by a traverse throughout the adjacent habitat lasting a minimum of 0.5 hours duration undertaken by two

Common Name *(Scientific Name)*	TSC Act	EPBC Act	Minimum survey requirements (Office of Environment and Heritage 2016)	Survey completed
			open vegetation.	observers. This resulted in an additional 34 person hours of traverse-based survey in habitat for *Pimelea spicata*. In total, 102 person hours were expended on survey for *Pimelea spicata* within the study area. According to the BioBanking credit calculator, surveys for this species can be undertaken year round. However, as this species is very small and easily missed when not in flower, surveys were undertaken during the flowering period in summer after rainfall. To gauge detectability, three reference sites were checked during the survey period to check flowering status. *Pimelea spicata* was flowering at all three reference sites during the survey period. Flowering conditions were optimal during the survey.
White-flowered Wax Plant (*Cynanchum elegans*)	E	E	The recommended approach is the parallel field traverse (i.e. parallel Transects) as used by Cropper (1993). As a climber the maximum distance between transects in open vegetation is 10 m, in dense vegetation is 5 m. In open vegetation, field traverse length is 1 km per hectare of potential habitat in open vegetation. With about 85 hectares of potential habitat in the study area, survey time is 12.5 hours in open vegetation.	Detailed floristic plots and traverses on foot throughout the study area failed to record *Cynanchum elegans*. Parallel field traverses undertaken by two observers were used to survey for this species in areas which appeared to provide suitable habitat. The field surveys were undertaken over a period of 11 days from 2 September 2015 to 4 February 2016 (not inclusive). Surveys targeted PCT 835, PCT 849 and PCT 850. Derived grasslands were also surveyed. No suitable dry rainforest habitat is present in the study area. Surveys for this species can be undertaken year round. Floristic plots were undertaken in PCT 835 (9 plots), PCT 849 (14 plots), PCT 850 (16 plots) and PCT 806 (4 plots) which lasted on average 1 hour each with two observers. This equates to 86 person hours of detailed floristic survey in potential habitat for *Cynanchum elegans.* Each floristic plot was accompanied by a traverse throughout the adjacent habitat lasting a minimum of 0.5 hours duration undertaken by two observers. This resulted in an additional 43 person hours of traverse-based survey in habitat for *Cynanchum elegans*. In total, 129 person hours were expended on survey for *Cynanchum elegans* within the study area. A nearby record of *Cynanchum elegans* exists at Bringelly recorded in 1992 in PCT 850. Habitat for *Cynanchum elegans* may be present in PCT 835, 849 and 850. However, habitat for *Cynanchum elegans* on the Cumberland Plain is thought to be restricted to small isolated remnant patches of dry rainforest.
Pultenaea parviflora	E	V	The recommended approach is the parallel field traverse (i.e. parallel Transects) as used by Cropper (1993).	Traverses of roadside habitats along the Northern Road were successful in recording three *Pultenaea parviflora* plants in two locations. Searches of adjacent habitats did not record this species.

Common Name *(Scientific Name)*	TSC Act	EPBC Act	Minimum survey requirements (Office of Environment and Heritage 2016)	Survey completed
			As a medium shrub the maximum distance between transects in open vegetation is 20 m, in dense vegetation is 10 m. In open vegetation, field traverse length is 0.5 km per hectare of potential habitat in open vegetation. With about 60 hectares of potential habitat in the study area, survey time is 6.25 hours in open vegetation.	Particular survey effort was expended in the in the vegetation on the Defence Establishment Orchard Hills. Surveys targeted PCT 849 and PCT 850. Derived grasslands were also surveyed. Parallel field traverses undertaken by two observers were used to survey for this species in areas which appeared to provide suitable habitat. Surveys for this species can be undertaken year round. The field surveys were undertaken over a period of 11 days from 2 September 2015 to 4 February 2016 (not inclusive). Floristic plots were undertaken in PCT 849 (14 plots), PCT 850 (16 plots) and PCT 806 (4 plots) which lasted on average 1 hour each with two observers. This equates to 68 person hours of detailed floristic survey in potential habitat for *Pimelea spicata*. Each floristic plot was accompanied by a traverse throughout the adjacent habitat lasting a minimum of 0.5 hours duration undertaken by two observers. This resulted in an additional 34 person hours of traverse-based survey in habitat for *Pimelea spicata*. In total, 102 person hours were expended on survey for *Pimelea spicata* within the study area.

4.2.2 Terrestrial fauna surveys

The list of potential threatened fauna species reported from the BioBanking credit calculator is displayed in Table 4.2. It was intended to target the species identified as having a moderate to high likelihood of occurring in the study area. A number of combined 'species credit and ecosystem credit' species for the Hawkesbury / Nepean sub-region were not identified in the Biobanking Credit Calculator and were considered to have potential to occur. This includes the Eastern Bentwing-bat (*Miniopterus schreibersii* subsp. *oceanensis*), as well as the Australasian Bittern (*Botaurus poiciloptilus*), which were targeted during the field survey.

The survey approach and methods were designed to address the methods described in the *Threatened Biodiversity Survey and Assessment Guidelines for Developments and Activities – Working Draft 2004* and the following guidelines:

- Amphibians – Threatened species survey and assessment guidelines: field survey methods for fauna – Amphibians (2009). http://www.environment.nsw.gov.au/resources/threatenedspecies/09213amphibians.pdf
- Threatened bats – Survey Guidelines for Australia's Threatened Bats, Commonwealth of Australia (2010). http://www.environment.gov.au/epbc/publications/threatened-bats.html
- Threatened birds – Survey Guidelines for Australia's Threatened Birds, Commonwealth of Australia (2010) http://www.environment.gov.au/system/files/resources/107052eb-2041-45b9-9296-b5f514493ae0/files/survey-guidelines-birds.pdf
- Threatened frogs – Survey Guidelines for Australia's Threatened Frogs, Commonwealth of Australia (2011). http://www.environment.gov.au/system/files/resources/ff3eb752-482d-417f-8971-f93a84211518/files/survey-guidelines-frogs.pdf.

Habitat Assessment

Rapid habitat assessments were conducted at vegetation plot sites to gather information on the type and condition of the fauna habitats present with a focus on identifying the suitability of the habitat for the list of predicted threatened species generated from the BioBanking Calculator (refer Table 4.2). At each survey site, an assessment was made of the fauna habitat features including the:

- Type and structure of the vegetation, including an assessment of the 'naturalness' in terms of the presence of remnant vegetation or planted and re-growth areas and the extent of modification
- Presence and frequency of large mature trees, tree hollows, standing dead trees (stags) and logs
- Presence of significant keystone species and critical habitat elements for threatened fauna
- Disturbance regimes, both past and ongoing including grazing and weed abundance
- Density of each vegetation strata (structural diversity)
- Presence and quality of wet areas or waterbodies, significant aquatic habitats where present
- Size of remnant patches and extent of connectivity, movement corridors and refuge value.

The habitat assessment data were used to identify the likelihood for predicted species credit species to occur and inform the detailed survey. The fauna species that were identified from the background review and habitat assessment that were targeted during the survey are discussed in Table 4.2.

Table 4.2 Targeted fauna survey details

Species	Minimum survey requirements	Survey completed
Green and Golden Bell Frog	All surveys should be undertaken within one week of heavy rainfall (>50 mm in seven days) during spring/summer (October – March). Initial habitat assessment - surveys using a combination of call detection, call playback and spotlighting. A minimum of four nights under ideal conditions. Small wetlands (<50 m at greatest length) should be covered in about one hour. Large sites should be sampled systematically.	All dams within 100-200 m of the project corridor where assessed for their habitat value using criteria identified in the literature. Potential habitats identified and each searched for one hour by two ecologists using call detection, call playback and spotlighting. Large series of dams at the Defence site surveyed systematically over four nights. Total survey effort was 6 nights. All surveys were conducted within a week of heavy rainfall, which ranged from 30-90 mm. The nocturnal field surveys were undertaken over a period of 6 nights from 2 September 2015 to 4 February 2016 (not inclusive).
Regent Honeyeater	20 minute surveys of 2 hectare plots per stratification unit. Area and targeted searches in woodland concentrating on flowering Eucalypts and where other nectar feeding birds are evident. 20 hours over 5 days	20 minute dedicated surveys of approx. 2 hectares plots by one ecologist repeated twice at each of four sites (4 mornings) plus opportunistic surveys during all other site activities (about 25 hours over 10 days). Surveys undertaken at four sites across study area, including opportunistic sightings, targeted both PCTs. The field surveys were undertaken over a period of 6 days from 2 September 2015 to 4 February 2016 (not inclusive).
Cumberland Plain Land Snail	*M. corneovirens* can be surveyed year round and it is not necessary to wait until after wet weather. The minimum time required will depend on the size and amount of potential habitat present within the site being assessed.	Habitat assessment undertaken at 50 locations across both PCTs, focused at vegetation plot locations. 10 minute search at each habitat assessment plot and general search around sites identified as moderate to high habitat value.
Australasian Bittern and Black Bittern	Observations of targeted foraging habitat within wetland within early morning or evenings. Detection by observation or solicited calls.	Evening and spotlighting surveys and call playback over 6 evenings / nights by two ecologists. Survey times varied between 0.5 to 2.0 hrs at each site. In total 7 sites were surveyed for bitterns.

Species	Minimum survey requirements	Survey completed
Eastern Bentwing-bat Large-eared Pied Bat	Harp trapping - Four trap nights over two consecutive nights (with one trap placed outside the flyways for one night) per 100 hectares of stratification unit Call detection - Two sound activated recording devices utilised for the entire night (a minimum of four hours), starting at dusk for two nights per 100 hectares of stratification unit	Harp traps – four trap nights over two consecutive nights at four different locations (8 trap nights). Poor flyways in study area so traps placed on tracks where available and on edge of flyway or forest edge. Call detection – Four AnaBat™ II bat detectors used each for two nights and each recording from 1900 hours to 0500 hours.

Stratification and site selection

Fauna surveys and habitat assessment were conducted at stratified sampling locations positioned along the length of the upgrade and prioritising habitat likely to be directly and indirectly impacted by the project. The study area was stratified initially by PCT and then by discrete habitats such as individual farm dams with dense emergent vegetation and higher condition riparian areas. Opportunistic surveys were conducted within cleared and modified grazing land which comprises the majority of the study area. The specific number and location of survey sites is described in the species-specific methods following.

Green and Golden Bell Frog

There are numerous farm dams in the study area with various dimensions and depths, many in isolated locations and others connected along drainage lines. The presence of emergent and surrounding vegetation also varies considerably, from completely absent and unshaded dams to a species rich wetland type environment with abundant emergent vegetation and surrounding tree canopy with grassy understorey. As farm dams may provide potential habitat for the Green and Golden Bell Frog an initial habitat assessment was conducted to stratify the habitat available and target survey effort at sites where habitats appeared most suited to Litoria aurea. To determine this review of literature on the habitat requirements of the species was conducted, namely Pyke and White (1996). These authors document the criteria found most consistently at sites that support breeding and non-breeding populations, this included the following:

- Presence of emergent vegetation providing shelter sites
- Moderate to high level disturbance
- Aquatic plant species present (especially Typha spp.)
- Still or low flowing water
- Run-off urban / industrial / grazing or parkland
- Substrate sand, or rock
- Shallow water depth <50 cm
- Nearby vegetation low, grassland, or shrubland or woodland
- Unshaded or partial shade
- Areas of grass nearby
- No visible signs of pollution
- *Crinia signifera* or *Limnodynastes peronii* present
- *Gambusia holbrooki* absent.

The initial habitat assessment considered all dams within about 100-200 metres of the project footprint that were assessed against the criteria described above. Dams located up-slope from the project and outside of the predicted impact zone were not assessed. In total 38 farm dams or clusters of connected dams were assessed (refer Figure 3.2 for dam locations). The habitat assessment scored each of the habitat criteria as being either, present (1) or absent (0) to provide a total score out of 13. All sites were on clay substrates so scored 0 for criteria f 'substrate sand, or rock'. Dams that scored ≥10 were identified for targeted nocturnal surveys (n = 14). Sites without emergent vegetation providing shelter sites for *L. aurea* and scored less than 10 were considered to have a very low chance of supporting a population and no nocturnal surveys were conducted.

Nocturnal surveys were then conducted at 6 sites over 6 nights, between the 20th January and 2nd February 2016, weather conditions are shown in Table 4.3. A 'site' sometimes consisted of multiple dams in close proximity providing opportunities for movements of Litoria aurea, these were sampled separately to cover the entire area, and resulted in sampling of 14 dams in total (refer Table 4.3). Ponds at the Defence Estate Orchard Hills consisted of five constructed dams connected by a series of narrow vegetated channels over a large area used for treatment of effluent, the survey aimed to sample both the dam and channel habitats over four consecutive nights.

Each dam was searched by two ecologists at least once during the survey period with some dams searched on more than one occasion, the duration of each sampling event extended between 0.5 and 1 hour per site depending on the size of the dam. The survey involved a spotlight search of the entire perimeter of the dam / channel focusing on the upper water column and within emergent vegetation. Call playback was used at each site, which involved playing calls through a 20W loudhailer for 2-5 minutes at each location. Smaller sites involved a single broadcast point, while larger sites and densely vegetated sites used multiple call sites whilst searching the perimeter of the dam. Details of the survey effort are described in Table 4.4.

Table 4.3. Weather and rainfall conditions during nocturnal surveys

Date	Min Temp (^{0}C)	Max Temp (^{0}C)	Wind (3pm)	Rainfall (24 hours)	Total rainfall in 7 days prior to survey
20/01/2016	16.8	38.9	Slight NNW 11 km/hr	0 mm	30.6 mm
21/01/2016	20.6	38.5	Calm NE 7 km/hr	0 mm	48.2 mm
01/02/2016	17.1	26.9	Slight SSW 11 km/hr	0.2 mm	89.6 mm
02/02/2016	13.5	28.6	Calm E 9 km/hr	0.8 mm	89.6 mm
03/02/2016	15.2	32.3	Calm NNW 6 km./hr	0 mm	89.6 mm
04/02/2016	17.8	24.9	Moderate SSE 28 km/hr	2.8 mm	89.6 mm

Table 4.4. Details of survey sites and sampling events for targeted nocturnal surveys

Survey site	Survey nights						Total duration (hours)	No. sampling events
	1	2	3	4	5	6		
1a. Willowdene Rd south	20/01	21/01					1.0	1
1b. Willowdene Rd south	20/01	21/01					2.0	2
2. Northern bridge on xmas tree farm		21/01					1.0	3
3. Adams Road		21/01					0.5	4
4a. Large subdivision property				2/02			0.5	5
4b. Large subdivision property					3/02		0.5	6
4c. Large subdivision property			1/02				0.5	7
4d. Large subdivision property						4/02	0.5	8
5a. DEOH			1/02				1.0	9
5b. DEOH			1/02				1.0	10
5c. DEOH				2/02			1.0	11
5d. DEOH					3/02		1.0	12
5e. DEOH						4/02	1.0	13
6. opposite golf course				2/02			0.5	14
6 sites (14 dams)							11.0 hrs (22 person hrs)	

Australasian Bittern (*Botaurus poiciloptilus*) and Black Bittern (*Ixobrychus flavicollis*)

There is one record of the cryptic Australasian Bittern in the study area, in 2003 to the south of Badgerys Creek, this species and the Black Bittern are considered to have a moderate chance of occurring and were targeted during diurnal habitat assessment for frog sites (n = 38 dams) and by spotlighting and call playback over 6 nights by two ecologists using 50W spotlights and a 20W loudhailer. The survey times varied between 0.5 to 2.0 hours depending on the size of the habitat and concentrated on densely vegetated dams and adjoining riparian habitats and were conducted following the targeted Green and Golden Bell Frog surveys at sites considered suitable for these species. In total 7 sites were surveyed for bitterns consistent with frog sites 1a and 1b, 2, and 4a-4d (refer Table 4.4). Call playback used a single point broadcast for 5 minutes duration at the start of the survey and then quite searching and listening for individuals during the remainder of the survey.

Cumberland Plain Land Snail (*Meridolum corneovirens*)

The Cumberland Plain Land Snail (Meridolum corneovirens) was identified from the desktop research as a key species for consideration. As such, a targeted habitat condition assessment and search for the species was conducted at 50 sites which generally coincided with vegetation plot sites. The location of the Cumberland Plain Land Snail habitat assessment sites is shown on Figure 4.1. The condition of the habitat for this species was determined based on the presence of important habitat features being present, for example the presence and abundance of woody or artificial debris, density of leaf litter or tussock grass and condition of the groundcover vegetation including proportion of exotic plant species such as African Olive and invasive grasses. Landscape values were also considered beyond the plot area and included patch-size and connectivity, and the degree of disturbance and modification to the habitat. Each of these five variables was scored out of 3, with 3 being abundant or well represented and 1 representing absent or poorly represented. The variables assessed and scoring used are described in Table 4.5. The scores were then totalled for the five variables to identify the condition of the habitat at each location based on the following;

- High quality habitat - score ≥12

- Moderate quality habitat - score 8-11
- Low quality habitat - score <8

Following the habitat assessment, searches were conducted at each of the 50 sites for live snails and snail shells and these involved a general traverse for 10 minutes duration in proximity to the habitat assessment point, turning logs and other debris and raking through decaying leaf litter around the base of trees. Habitat condition scores and the results of the targeted searches were used to map the distribution of potential habitat for the species.

Regent Honeyeater (*Anthochaera phrygia*)

A time-based bird survey was repeated at four sites within four hours of sunrise in spring (3 and 30 September 2015), and summer (21-22 January and 3-4 February 2016). This involved replicated 20 minute surveys at each site. The survey was conducted by one observer using a random meander within the habitat patch and recording all birds seen and heard during the survey.

All bird species heard or observed were recorded including those outside the habitat node (i.e. flying over the site). Birds were also recorded opportunistically during all other site visits and field surveys activities. Binoculars were carried in the field at all times to assist in identification.

Microchiropteran bats (Eastern Bentwing-bat and Large-eared Pied Bat)

Standard two-bank 4.2m^2 harp traps were used to survey for microchiropteran bats at four woodland locations in summer (21-23 January and 3-5 February 2016). The siting of suitable trap sites was limited by the high degree of public access and visibility over the study area and lack of suitable positions. Traps were set for two nights in narrow fly-ways along tracks or forest edges. Captured bats were collected early the following morning, identified and measured then soft-released at the capture point using a bat release box.

Two stationary ultrasonic bat call detectors (Anabat II, Titley Electronics) were used with a storage ZCAIM unit to record bat calls at four sites concurrently during the trapping period. Calls were recorded continuously between 1900 and 0500 hours on each occasion. Calls were identified to genus or species level where possible using computer frequency analysis software (i.e. Analook v.4.0).

Table 4.5. Cumberland Plain Land Snail habitat condition variables and scoring applied.

Density of sheltering habitat (woody debris / or artificial)	Score	Density of leaf litter or tussock grass	Score	Naturalness	Score	Patch size / connectivity	Score	Shrub-layer / Ground cover	Score
Abundant >5 logs or scattered building refuse throughout	3	Dense leaf litter around base of most trees, abundant tussock grass across plot	3	Remnant woodland / forest with native understorey, grazing limited or absent	3	>2 hectares with connectivity to other patches	3	>10% open ground with leaf litter, intact understorey dominated by native species	3
Moderate abundance of logs between 2-5 and/or occasional artificial debris	2	Dense leaf litter around base of some trees, tussock sparse or absent	2	Remnant or regrowth trees with modified understorey, moderate to high level grazing	2	1-2 hectare patch with small links to other vegetation in overall fragmented mosaic of woodland patches	2	<10% of ground is open. Moderate density of African Olive and exotic grasses mixed with native species	2
Low abundance (1 log or piece artificial shelter) or completely absent	1	None	1	Modified landscape, plantings, slashed or over grazed	1	Small < 0.5 isolated patch in heavily fragmented or cleared landscape	1	100% cover of dense exotic grasses and weeds and / or high density of African Olive	1

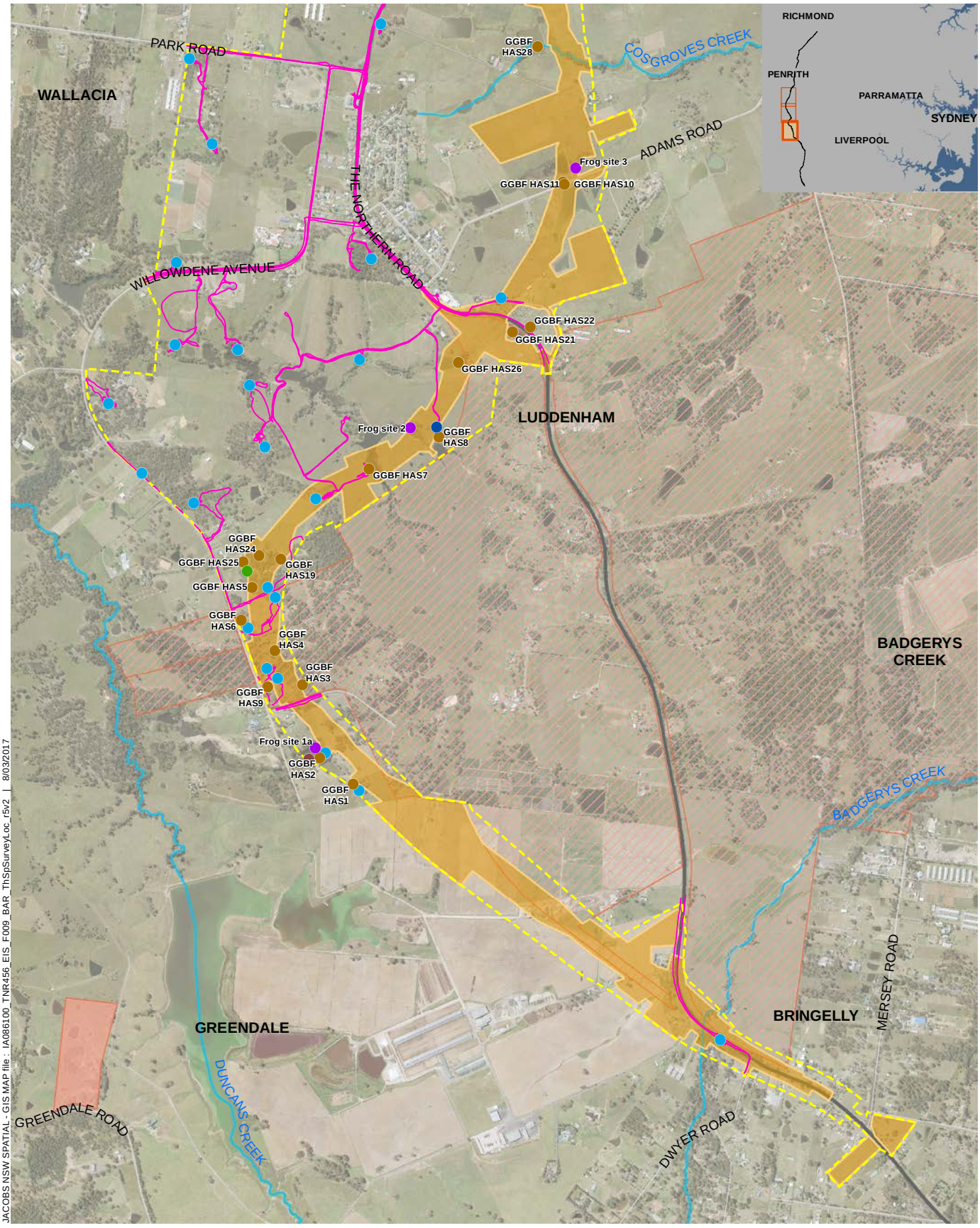
4.2.3 Limitations

The field survey was able to provide good spatial coverage and survey effort of the development site that meets the requirements of the FBA. However, the field survey was constrained by landowner permissions and restricted access. Some properties within the broader study area could not be accessed for the survey, including some areas of higher quality habitat (such as the habitat in the unmade road between Kings Hill Road and Longview Road at Mulgoa). Hence, the location of surveys to target threatened species was constrained by limited access in some areas and not all areas of habitat could be surveyed. Where property access was not granted, the vegetation and habitats were viewed from the roadside or public areas where possible to verify the PCT and vegetation condition. The majority of the development footprint could be surveyed. After detailed design and prior to the finalisation of the offset package for the Project, surveys of these areas will be undertaken and new calculations performed as necessary.

The optimal seasonal timing for flora survey in western Sydney is during summer to autumn (December to April). Due to the rain dependent nature of the vegetation, (the Cumberland Plain is a rainshadow coastal valley); many plant species will not be present above ground during winter and in dry years. The vegetation survey was undertaken during spring to summer (2 September 2015 to 4 February 2016) and rainfall for the study area has been good (average winter 2015 rainfall at Badgery's Creek was 48.2 mm, spring rainfall was 44.7 mm, and average summer rainfall was 56 mm). Total rainfall in January 2016 was 145 mm. Conditions for flora survey on the Cumberland Plain during the survey period were good in terms of rainfall which is important for the rain dependent groundcover vegetation.

The conclusions of this report are based upon available data and the field surveys and are therefore indicative of the environmental condition of the study area at the time of the survey. It should be recognised that conditions, including the presence of threatened species, could change with time. The field surveys were undertaken from summer to autumn so the survey timing was not appropriate to detect some fauna species with specific seasonal movement patters such as the Swift Parrot, which is only present on the mainland during the colder months. The presence of suitable habitat was used as a surrogate for likely species presence where possible.

The targeted surveys for flora and fauna followed the methods described in the *Threatened Biodiversity Survey and Assessment Guidelines for Developments and Activities – Working Draft 2004* (Department of Environment and Conservation, 2004). The survey timing adhered to the months detailed in the BioBanking credit calculator for each candidate threatened species. The targeted flora surveys were completed prior to the release of the *NSW Guide to Surveying Threatened Plants* (Office of Environment and Heritage, 2016). As such, the recommended length and time for field traverses for each species was not known. However, a systematic approach was taken to the survey including targeting the species at the optimal time of year, identifying potential habitats, and then undertaking a survey using parallel field traverses.



JACOBS NSW SPATIAL - GIS MAP file : IA086100_TNR456_EIS_F009_BAR_ThSpSurveyLoc_r5v2 | 8/03/2017

The Northern Road (Existing)
Development site boundary
Ecology study area
Western Sydney Airport site (Commonwealth Land)
Defence Establishment Orchard Hills (Commonwealth Land)
Commonwealth Lands

Field surveys
Survey locations
Bat Detector
Bat Trap
Bird Survey

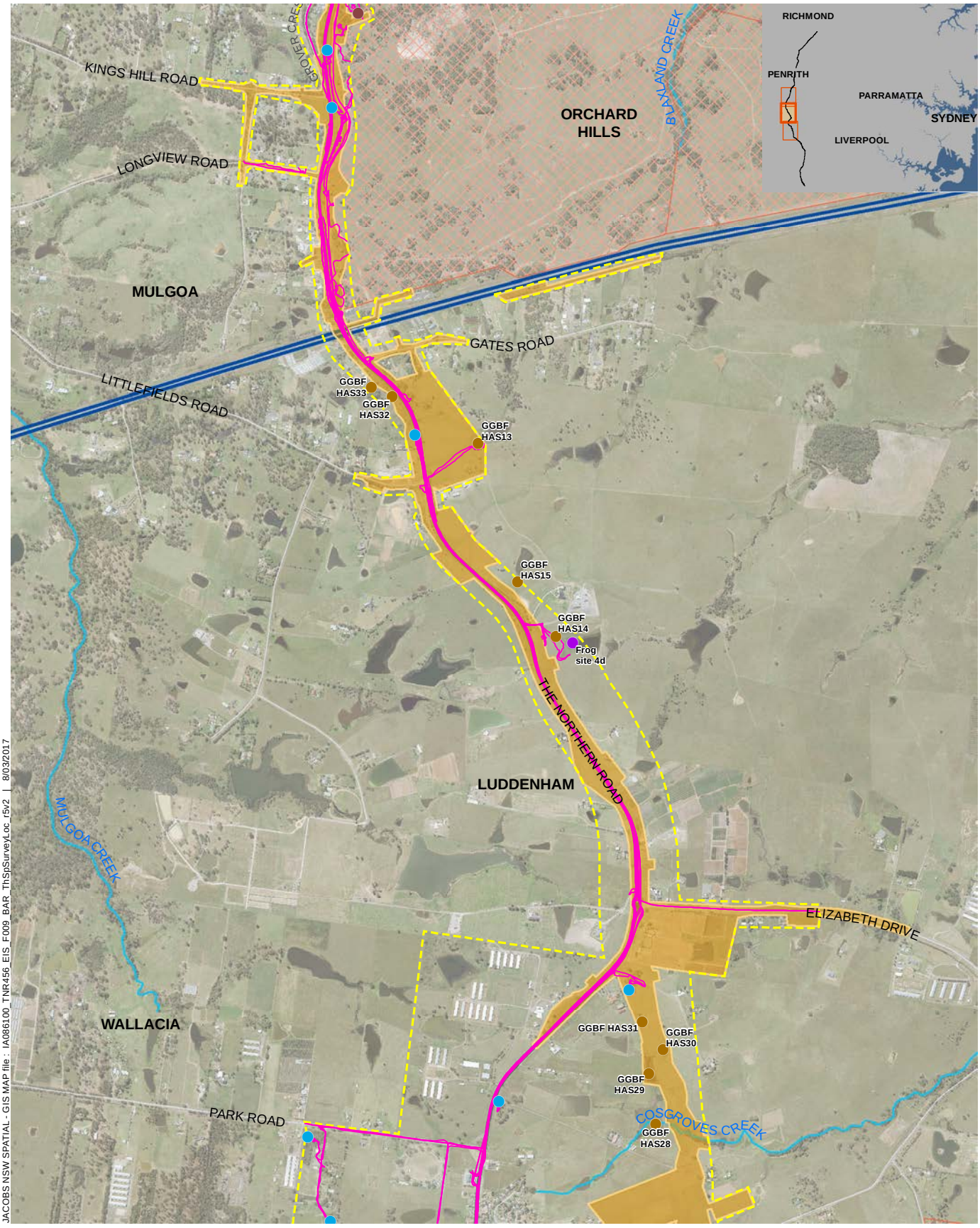
Cumberland Plain Snail Habitat Assessment
GGBF habitat assessment sites (HAS)
GGBF targeted survey sites

0 0.5 1 km

N

3
2
1

Figure 4-1 | Threatened species survey locations



The Northern Road (Existing)
WaterNSW supply pipelines
Development site boundary
Ecology study area
Western Sydney Airport site (Commonwealth Land)
Defence Establishment Orchard Hills (Commonwealth Land)
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Field surveys
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Cumberland Plain Snail Habitat Assessment
GGBF habitat assessment sites (HAS)
GGBF targeted survey sites

0 0.5 1 km

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3
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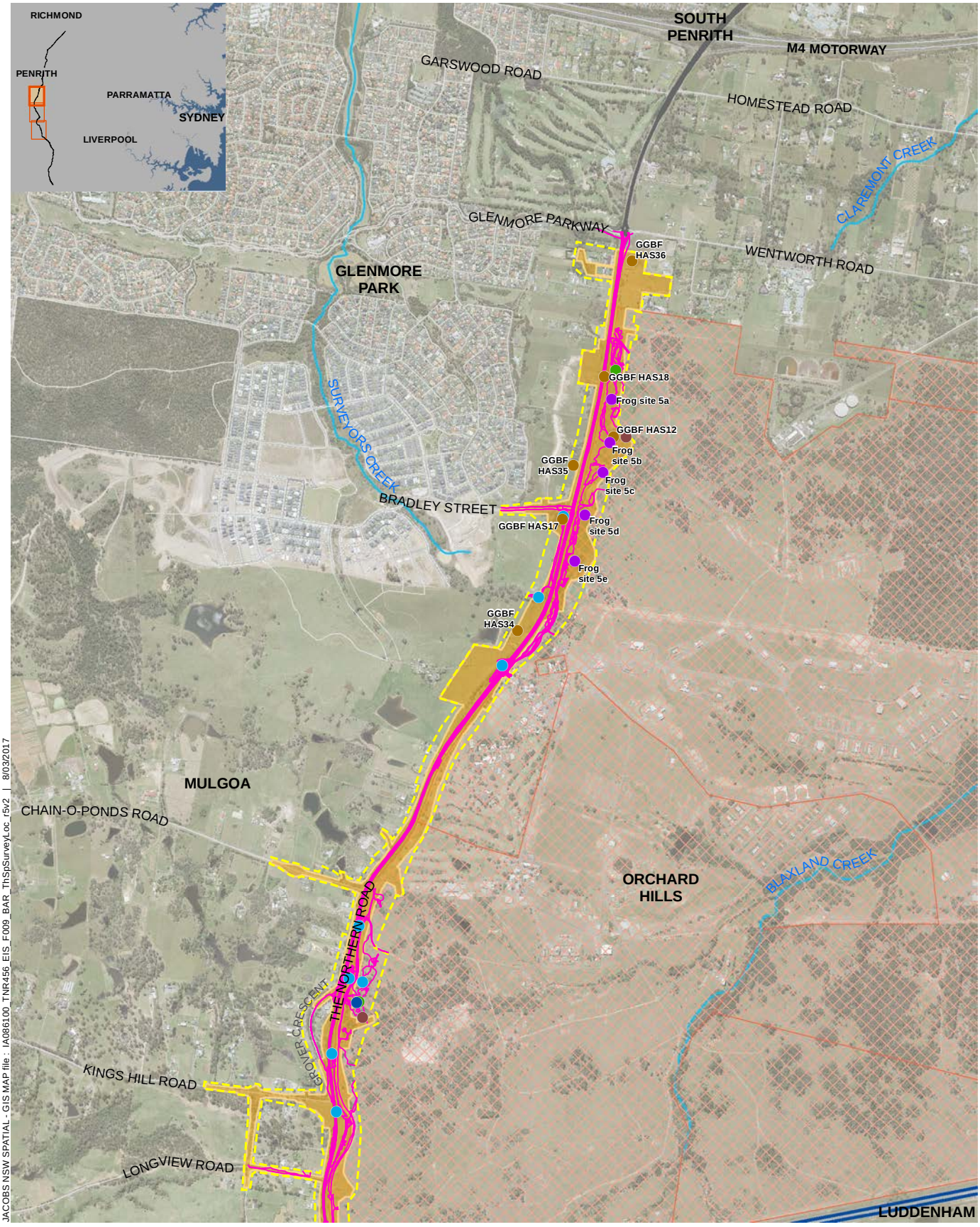
Figure 4-1 | Threatened species survey locations



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GGBF habitat assessment sites (HAS)
GGBF targeted survey sites

0 0.5 1 km

N

3
2
1

Figure 4-1 | Threatened species survey locations

4.2.4 Threatened species results

For many of the threatened species identified by the BioBanking credit calculator, the OEH Atlas and/or the PMST (see Appendix B), the study area does not provide suitable habitat. Appendix B provides the habitat assessment for each identified threatened species.

The field surveys recorded one threatened flora species: *Pultenaea parviflora* (listed as endangered under the TSC Act and vulnerable under the EPBC Act). Four *Pultenaea parviflora* plants were found in the study area. The plants were located in three areas: two locations within the western road reserve of the Northern Road and one location along Kings Hill Road. Two plants are present in the road reserve at 2465 The Northern Road Mulgoa and one plant is present at the top of the road cutting about 420 m south of the first two plants on the western side of the Northern Road at 2509 The Northern Road Mulgoa. One plant was found in the corner of the property at 34 Kings Hill Road. Based on the data from the OEH Atlas of NSW Wildlife, the *Pultenaea parviflora* plants within the study area would represent an extension of the known south western distribution of this species.

No other threatened plant species were recorded during the surveys. Targeted surveys for other listed threatened flora species was undertaken including detailed survey for *Pimelea spicata*. Three *Pimelea spicata* reference sites were surveyed in January 2016 including the Mt Annan Botanic Gardens, Camden Golf Course bushcare site, and Western Sydney Parklands. *Pimelea spicata* was flowering at all three reference sites during the survey period. *Pimelea spicata* was not recorded during the surveys undertaken for the biodiversity assessment despite targeted survey in habitat using parallel transects.

One endangered population listed under the TSC Act: *Marsdenia viridiflora* R. Br. subsp. *viridiflora* population in the Bankstown, Blacktown, Camden, Campbelltown, Fairfield, Holroyd, Liverpool and Penrith local government areas was recorded during the field surveys. This endangered population was recorded in four locations (all relatively disturbed) adjacent to the current Northern Road alignment (two locations on the fence of the Defence Establishment Orchard Hills, and roadside vegetation adjacent to 2509 Northern Road, and 2627 Northern Road).

The Cumberland Plain Land Snail was recorded in the study area. Live snails and shells were found in a variety of habitats from high quality woodland (high quality habitat), to woodland with a heavily grazed understorey (moderate quality habitat). Shells (often heavily bleached) were also found in dense swards of *Eragrostis curvula* on roadsides particularly along Willowdene Avenue. Only moderate to high quality habitats were mapped for Cumberland Plain Land Snail resulting in 13 hectares of suitable habitat being recorded. These areas of habitat have a moderate to high abundance of logs, bark or artificial debris on the ground, dense leaf litter and/or abundant tussock grasses, remnant or regrowth trees with low levels of grazing, habitat patch size of 1 to >2 hectares and generally with connectivity to other vegetation patches, and >10% of the ground cover is open. The ground layer may contain a mix of native and exotic species.

Three threatened insectivorous bats were recorded via Anabat: Eastern Bentwing-bat, Eastern False Pipistrelle, and Eastern Freetail-bat. Foraging habitat for these species is widespread throughout the study area. These species are likely to fly across cleared land to move between habitat patches. Large trees in the study area (e.g. the large old *Eucalyptus tereticornis* tree to the north of the wetlands on the Defence Site Orchard Hills) may provide potential roosting habitat for the Eastern False Pipistrelle, and Eastern Freetail-bat. The Grey-headed Flying-fox was recorded in one location on private property off Willowdene Avenue during spotlight surveys. The Regent Honeyeater is assumed to be present in the study area due to the presence of suitable foraging habitat. Table 4.2 outlines the results of the threatened species surveys.

Table 4.2 Threatened species survey results

Species	Ecosystem or species credit species	Identification method (assumed, recorded, expert report)	Can the species withstand further loss?	Habitat feature/ component
Pultenaea parviflora	Species credit	Recorded	Yes, up to 10% loss where population on the property is > 500 mature plants	PCT 806 Also likely to occur in PCT 849 and PCT 850 although not identified as such in the Threatened Species Profile.
Marsdenia viridiflora subsp. *viridiflora* in the Bankstown, Blacktown, Camden, Campbelltown, Fairfield, Holroyd, Liverpool and Penrith local government areas	Species credit	Recorded	No	PCT 849 and PCT 850
Cumberland Plain Land Snail	Species credit	Recorded	Yes	PCT 835, PCT 849, PCT 850 and PCT 806 Land containing bark or leaf litter accumulation
Eastern Bentwing-bat	Ecosystem and Species credit	Recorded (probable call recording)	No loss of natural breeding or roosting habitat. No more than 10% loss of foraging habitat within 500m of breeding habitat (caves in Karst). No capping of loss of foraging habitat elsewhere.	PCT 835, PCT 849, and PCT 850 Land containing caves or similar structures
Eastern False Pipistrelle	Ecosystem	Recorded (possible call identification)	Up to 10% loss of foraging habitat. Up to 10% loss of hollow bearing trees.	PCT 835, PCT 849, and PCT 850
Eastern Freetail-bat	Ecosystem	Recorded (possible call identification)	Can tolerate temporary loss of up to 10% foraging habitat. No more than 10% loss of hollow bearing trees.	PCT 835, PCT 849, and PCT 850
Grey-headed Flying-fox	Ecosystem	Recorded	No loss of vegetation within 200 m of roosts	PCT 835, PCT 849, and PCT 850 Land within 40 m of rainforest, coastal scrub, riparian or estuarine communities
Regent Honeyeater	Species	Assumed present	Yes, but no loss of breeding in Capertee sub catchment, up to 5% of habitat excluding Swamp Mahogany	PCT 835, PCT 849, and PCT 850

Photos of *Pultenaea parviflora* from the study area showing overall form and detail of flowers

Photos of *Marsdenia viridiflora* subsp. *viridiflora* from the study area showing close up of leaves and flowers and growth habit on an old fence post

Photos of the Cumberland Plain Land Snail from the study area (these two snails were recorded 1.5 m up the trunk of a *Eucalyptus moluccana* tree)

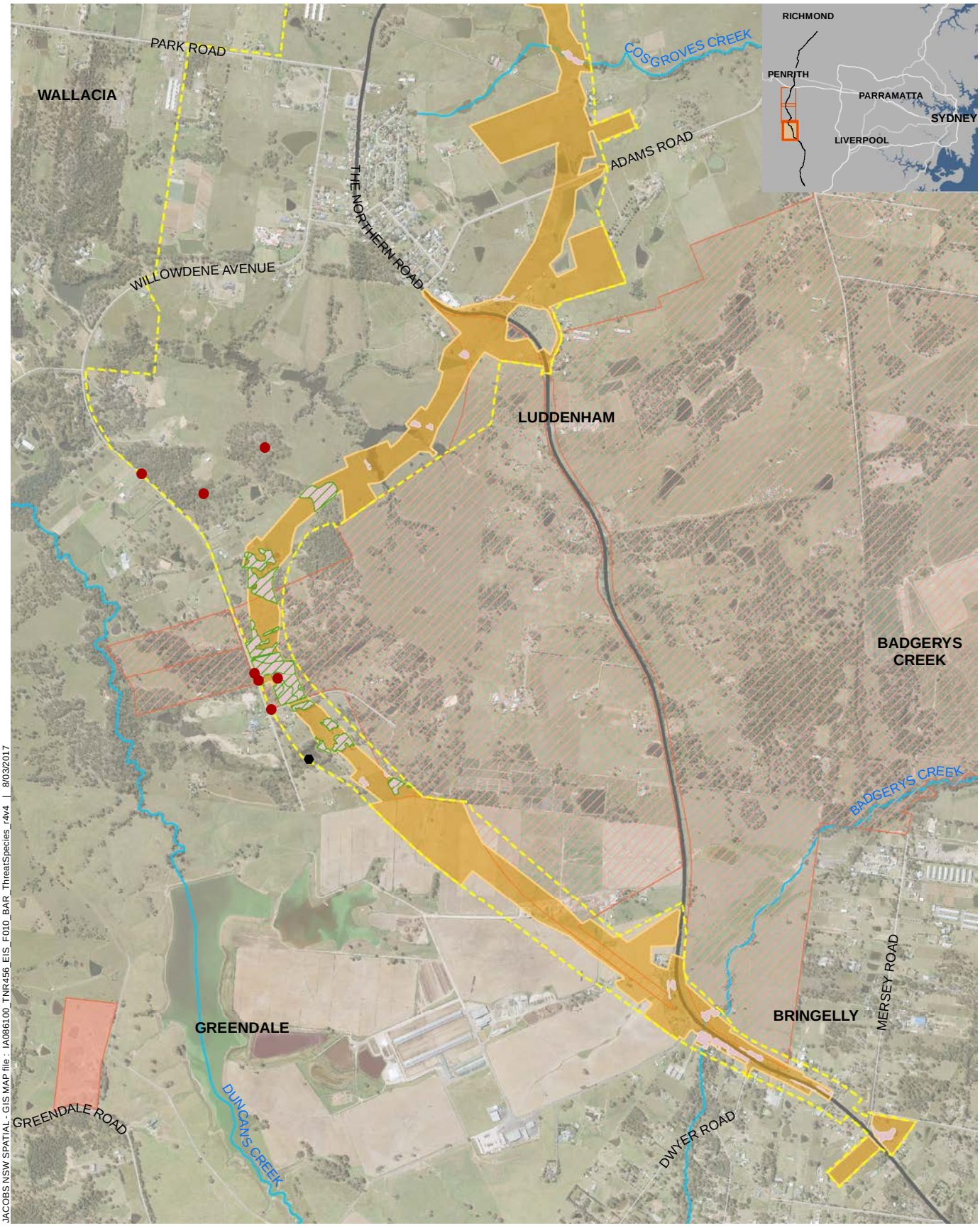

Figure 4-2 | Recorded threatened species

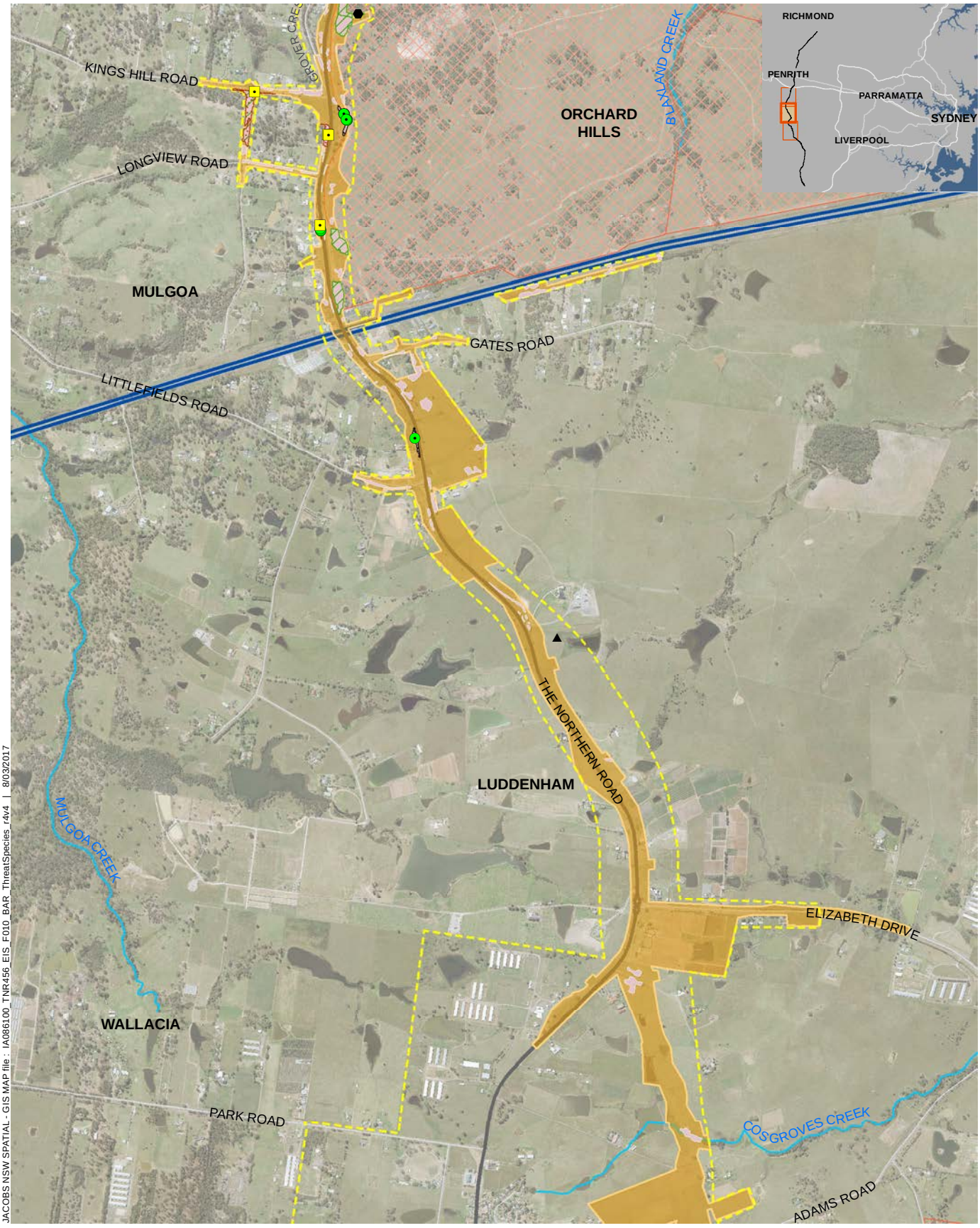

Figure 4-2 | Recorded threatened species

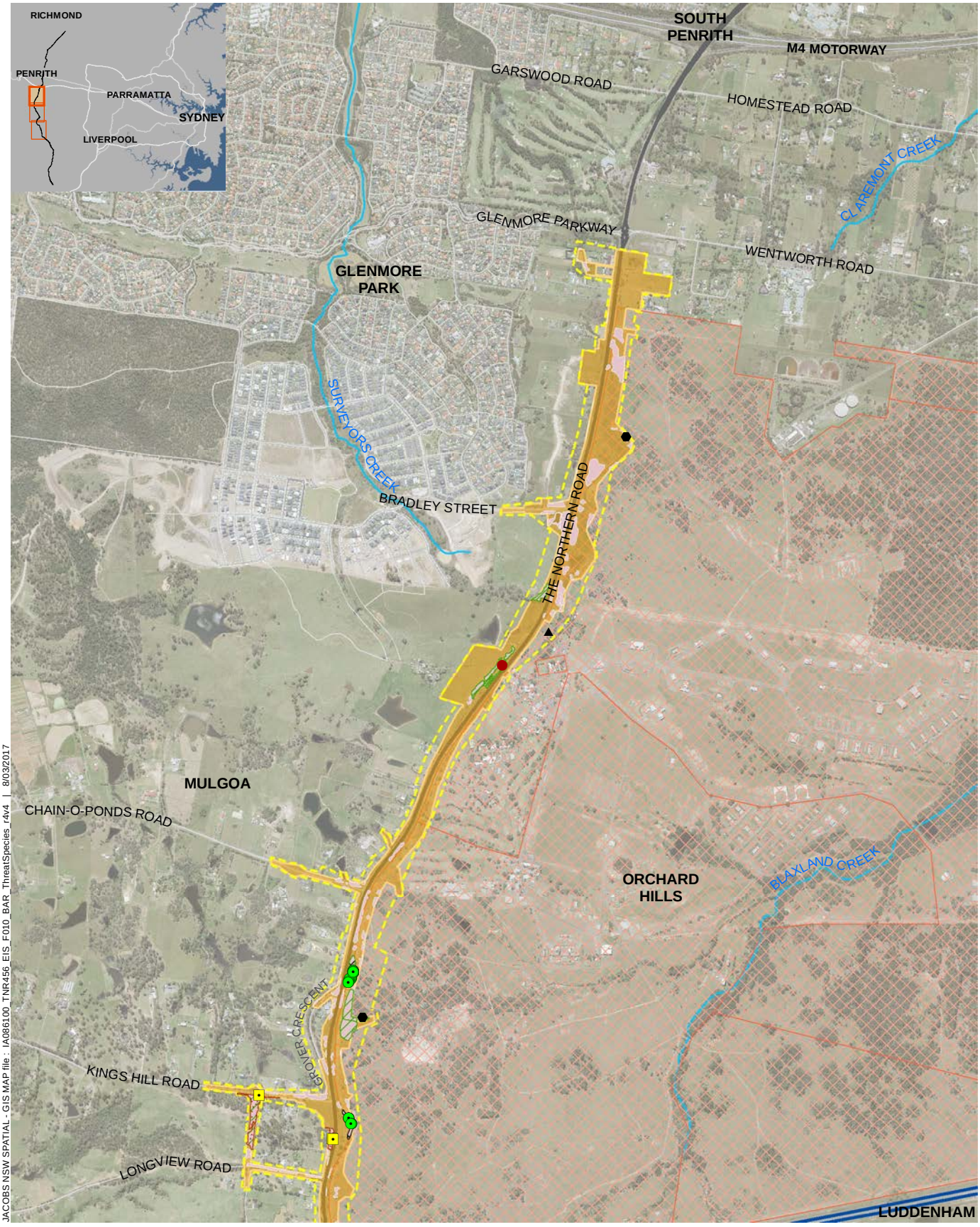

Figure 4-2 | Recorded threatened species

4.3 Aquatic habitat and threatened species

4.3.1 Aquatic surveys

Aquatic habitat assessments were conducted on the 20-22nd February 2016. No watercourses were mapped as Key Fish habitat by DPI Water (2007) however fish habitats were also assessed against the NSW *Department of Primary Industries Policy and Guidelines for Fish Habitat Conservation and Management* (2013) (Table 4.4), and Fish Passage Requirements for Waterway Crossings (Fairfull & Witheridge 2003) (Table 4.5) These guidelines provide information for waterway classification and ways to minimise impacts to fish and other aquatic wildlife from road projects which may improve the survival rate and protect threatened fish species, populations and their habitat. Site inspections were visual only, no fish surveys were undertaken. Due to the low likelihood of threatened fish species present, limited water availability and limited aquatic habitat, fish and macroinvertebrate surveys were deemed unnecessary. Visual inspections allowed the classification of Key Fish Habitat (DPI 2013).

Table 4.4 Key Fish Habitat and associated sensitivity classification scheme (adapted for freshwaters only)

Key Fish Habitat and associated Sensitivity Classification Scheme	
Type 1 - Highly Sensitive Key Fish Habitat Marine park or an aquatic reserve. SEPP 14 Coastal wetlands, wetland recognised under international agreements , or listed in the Directory of Important Wetlands of Australia Freshwater habitats that contain in-stream gravel beds, rocks greater than 500mm in two dimensions, snags greater than 300mm in diameter or 3 metres in length, or native aquatic plants.* Any known or expected threatened species habitat or area of declared 'critical habitat' under the FM Act	Type 2 - Moderately sensitive key fish habitat Aquatic habitat within 100m of a marine park, an aquatic reserve or intertidal protected area. Freshwater habitats other than those defined in Type 1* Weir pools and dams up to full supply level where the weir or dam is across a natural waterway. Type 3 – Minimally sensitive key fish habitat may include: Coastal or freshwater habitats not included in Types 1 or 2* Ephemeral aquatic habitat not supporting native aquatic or wetland vegetation.

*Farm Dams on first and second order streams or unmapped gullies are not considered key fish habitat (Source: DPI 2013)

Table 4.5 Fish habitat classification criteria for watercourses and recommended crossings types

Classification	Characteristics of waterway type
Class 1- Major fish habitat	Major permanently or intermittently flowing waterway (eg river or major creek), habitat of a threatened fish species
Class 2 - Moderate fish habitat	Named permanent or intermittent stream, creek or waterway with clearly defined bed and banks and with semi-permanent to permanent waters in pools or in connected wetland areas. Marine or freshwater aquatic vegetation is present. Known fish habitat and/or fish observed inhabiting the area.
Class 3- Minimal fish habitat	Named or unnamed waterway with intermittent flow and potential refuge, breeding or feeding areas for some aquatic fauna (eg fish, yabbies). Semi-permanent pools form within the waterway or adjacent wetlands after a rain event. Otherwise, any minor waterway that interconnects with wetlands or recognised aquatic habitats.
Class 4 – Unlikely fish habitat	Named or unnamed watercourse with intermittent flow during rain events only, little or no defined drainage channel, little or no free standing water or pools after rain event (eg dry gullies or shallow floodplain depression with no permanent wetland aquatic flora).

(Source: Fairfull & Witheridge, 2003)

4.3.2 Aquatic results

The project lies within the Lower Nepean River Management Zone of the Hawkesbury and Lower Nepean Rivers Water Source. The catchment is relatively flat with gently undulating hills. The project directly traverses Badgery's Creek and Cosgrove Creek. There are a number of other unnamed tributaries/drainage lines and farm dams traversed by the project. The predominant catchment land uses are residential, rural residential and various forms of agriculture. The rural areas are predominantly agriculture including cattle grazing.

The Nepean River is the downstream receiving environment to the project area; however, the project itself is located close to the catchment divide, just west of the eastern boundary. The Nepean River is significant both environmentally and economically and provides for a range of domestic and irrigation uses. Several threatened species including Macquarie Perch (Macquaria australasica), Australian Grayling (*Prototroctes maraena*), Silver Perch (*Bidyanus bidyanus*), Murray Cod (*Maccullochella peelii peelii*) and Trout Cod (M*accullochella macquariensis*) have been recorded within the Hawkesbury-Nepean Catchment; however, habitat for these species is not present within the study area.

No protected or threatened fish species are considered likely to occur within the study area due to the limited water and aquatic habitat present.

Fish habitat classification criteria for watercourses in the project area and recommended crossings types are provided in Table 4.6. All watercourse crossings are designed in accordance with Policy and Guidelines for Fish Friendly Waterway Crossings (Department of Primary Industries, 2004) and Fish Passage Requirements for Waterway Crossings (Fairfull and Witheridge 2003).

Aquatic survey locations and identified key fish habitat are shown in Figure 4.3.

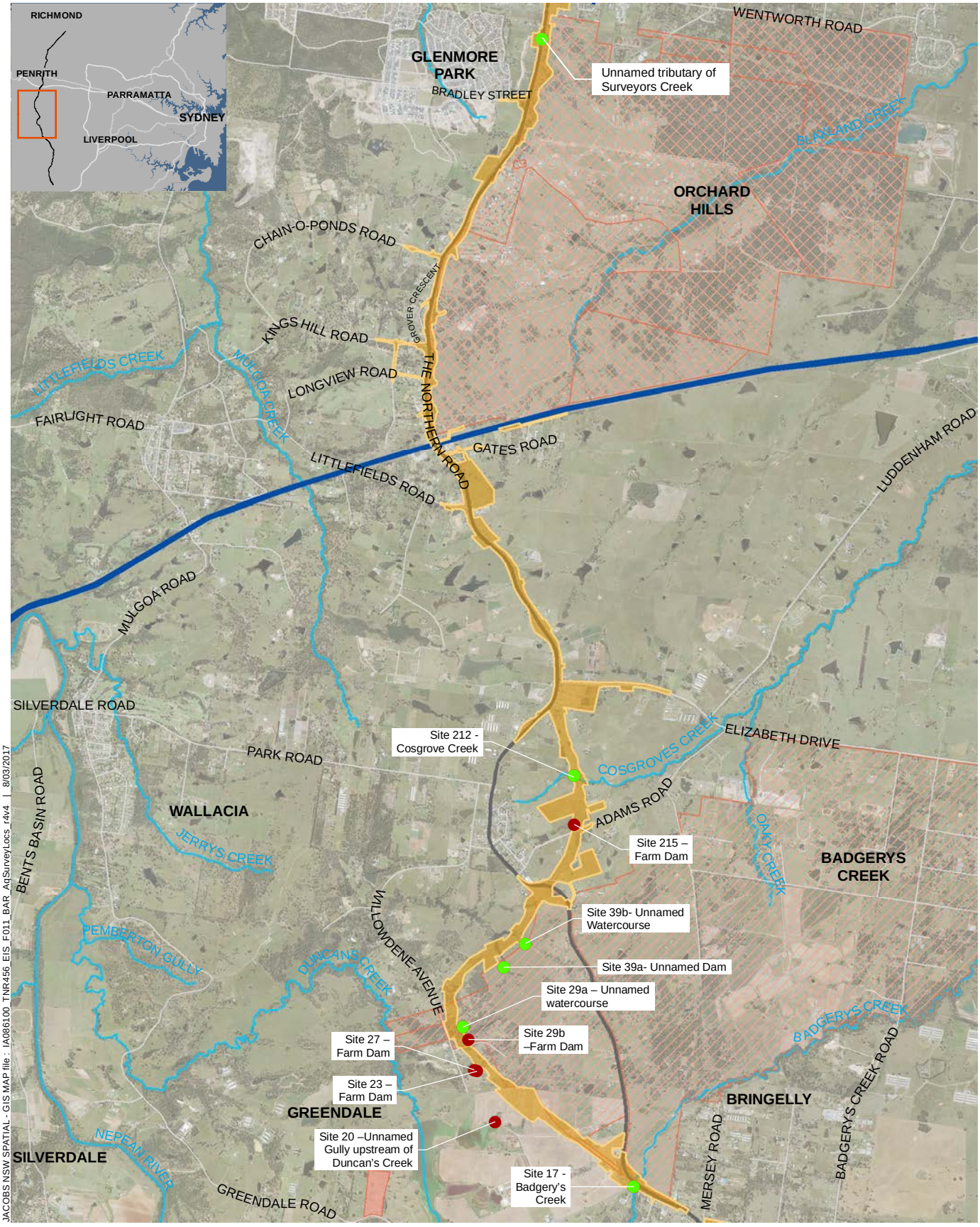

Figure 4-3 | Aquatic survey locations

Table 4.6 Fish habitat classification criteria for watercourses and recommended crossings types

Site	Description	Key Fish Habitat Classification, and Fish Passage Classification	Crossing Type
Site 17 - Badgery's Creek **Location**: 287912.65E / 6244897.30N 	Site 17 is an intermittent stream, Badgery's Creek which is crossed by the project. It contains permanent residual pools which provide refuge habitat for fish. The substrate consists of sand, gravel and clay. A variety of instream macrophytes are present including Cumbungi (*Typha sp.*), *Eleocharis*, *Vallisneria*, Duckweed (*Lemna*), and Water Primrose (*Ludwigia peploides)*. The presence of macrophytes and instream woody snags provides fish habitat, however no threatened or protected fish species are expected to occur within the Creek. Visual inspection sighted the invasive pest species, Gambusia *(Gambusia holbrooki)* within the Creek. Surrounding landuse is agriculture, primarily cattle grazing which has led to some bank degradation. Riparian vegetation is sparse, consisting of both natural and exotic vegetation. Water quality appears moderate, tannin stained with some frothing and instream rubbish. Runoff from surrounding agriculture is likely to impact upon water quality.	**Class :** Class 2 – Key Fish habitat **Key Fish Habitat** – Type 1 – Highly sensitive key fish habitat	Culvert C620
Site 20 –Unnamed Gully upstream of Duncan's Creek **Location**:: 286361.22 E / 6245627.46 N 	Site 20 is an unmapped, unnamed gully associated with Leppington Dam and Duncans Creek. It has minimal channel definition, and no water was present at the time of inspection, despite heavy rainfall in the past 24 hours. No instream aquatic habitat is present. The surrounding land use is agriculture including cattle grazing and various crops. Downstream is a large dam 'Leppington Dam' which forms part of Duncans Creek. Duncans Creek is a perennial stream; however the Leppington Dam is an artificial barrier to fish migration and would affect the natural flow regimes within Duncans Creek. Water quality within the Dam appears poor, with frothing and an extensive green algae bloom (pictured), suggesting high nutrient concentrations are likely to be present and are likely to result in deoxygenation events within the dam. No fish were sighted during visual inspections.	**Class :** Class 4 – Unlikely Key Fish Habitat **Key Fish Habitat:** Type 3 Minimally sensitive key fish habitat.	Culvert C2240

Site	Description	Key Fish Habitat Classification, and Fish Passage Classification	Crossing Type
Site 23 – Farm Dam **Location**: 286157.9E / 6246190.98N 	Site 23 is a farm dam situated immediately downstream of alignment. The dam is part of a series of disconnected ponds situated within an undefined gully. The dam is used for cattle, and has poor water quality, with high turbidity and frothing upon the water surface. Limited aquatic habitat is present and consists of a small density of the aquatic macrophyte Water Primrose (*Ludwigia peploides*). The substrate consists of a relatively even distribution of silt, clay, sand, gravel and pebble. A lot of rubbish such as tiles, bricks and broken glass is also present. No fish were sighted during vidual inspections, and no threatened or protected fish species are expected to occur within the dam.	**Class:** Class 3 – Moderate Key Fish habitat **Key Fish Habitat:** n/a (farm dam)	Culvert C2610
Site 27 – Farm Dam **Location**: 286130.90E / 6246206.89N 	Site 27 is a farm dam, situated immediately downstream of site 23, downstream of the alignment. The dam is part of a series of disconnected ponds situated within an undefined gully. The dam is used for cattle and has poor, stagnant water quality with high turbidity and a thick algal bloom suggesting elevated nutrient concentrations. Substrate is predominantly silt, clay and detritus. Variety of aquatic habitat is present including submerged woody logs, and a variety of aquatic macrophytes including Water Primrose *(Ludwigia peploides*), Nardoo (*Marsilea mutica*), *Eleocharis sp.,* Floating Pondweed (*Potamogeton sulcatus*) and several sedge species (*Cyperus sp.*). Gambusia *(Gambusia holbrooki)* were sighted during visual inspections, however no threatened or protected fish species are expected to occur within the dam.	**Class:** Class 3 – Moderate Key Fish habitat **Key Fish Habitat:** n/a (farm dam)	Culvert C2850

Site	Description	Key Fish Habitat Classification, and Fish Passage Classification	Crossing Type
Site 29a – Unnamed watercourse **Location**: 286000.59 E / 6246680.74N 	Site 29a is an intermittent stream which is crossed by the project. It has low to no flow, despite rainfall occurring within the past 24 hours. The creek will only flow when the dams upstream (including site 29a) overflows. Variety of substrates present including boulder, pebble, gravel, clay, sand and silt. Large quantities of detritus are present within the residual pools. Some instream woody snags are present. Macrophytes present include Water Primrose *(Ludwigia peploides*), Sedge (*Cyperus sp.)* and Watermilfoil (*Myriophyllum sp*.). Water quality appears moderate, with anoxic odour within residual pools, tannin staining and filamentous algae present. Some rubbish such as tyres are present within the site. No fish were sighted during visual inspections, and no threatened or protected fish species are expected to occur within the stream.	**Class:** Class 2 – Moderate Key Fish habitat **Key Fish Habitat:** Type 1	Culvert C3250
Site 29b –Farm Dam **Location**: 286060.62 E / 6246544.14N 	Site 29b is a farm dam immediately upstream of the alignment. Dam acts as a barrier to fish passage, and disrupts the natural hydrology of the creek downstream (site 29a). Water quality appears poor, with an anoxic odour and thick algae present. Substrate consists of an even distribution of silt, clay, sand, gravel and pebble. A thick layer of detritus is present throughout the dam. Macrophytes present include Water Primrose (*Ludwigia peploides*) and Watermilfoil (*Myriophyllum sp*.). No fish were sighted during vidual inspections, and no threatened or protected fish species are expected to occur within the dam.	**Class:** Class 3 – Moderate Key Fish habitat **Key Fish Habitat:** n/a (farm dam)	Culvert C3250

Site	Description	Key Fish Habitat Classification, and Fish Passage Classification	Crossing Type
Site 212 - Cosgroves Creek **Location**: 287247.11E / 6249490.76N 	Site 212 is an intermittent stream, Cosgroves Creek which is crossed by the project. At the time of inspection it consisted of a series of shallow disconnected pools. The bed and banks of the channel are degraded by cattle access. The substrate consists of silt and clay. Water quality appears poor, with thick algae bloom, oily film and frothing present in some of the stagnant pools. Aquatic macrophytes present include *Azolla,* Duckweed (*Lemna*) and Floating Pondweed (*Potamogeton sulcatus*). *Typha* Sedges are present further downstream. A large density of Gambusia (*Gambusia holbrooki)* were sighted during visual inspections, however no threatened or protected fish species are expected to occur within the dam.	**Class:** Class 2 – Moderate Key Fish habitat **Key Fish Habitat:** Type 1	Culvert C6700
Site 215 – Farm Dam **Location**: 287243.33E 6248945.37N 	Site 215 is a series of farm dams which are crossed by the project. It is fed by an undefined gully which only flows when the upstream dams overflow. The bed and banks of the channel are degraded by cattle access. The substrate consists of silt and clay. Aquatic macrophytes present within the site include Cumbungi (*Typha sp*.). No fish were sighted during vidual inspections, and no threatened or protected fish species are expected to occur within the dam.	**Class:** Class 3 – Moderate Key Fish habitat **Key Fish Habitat:** n/a (farm dam)	Culvert C6200. Partially filled.

Site	Description	Key Fish Habitat Classification, and Fish Passage Classification	Crossing Type
Site 39- Unnamed Dam and Watercourse Location: 286460.594 E 6247352.348 and 286698.896E / 6247616.628 	Site 39 is a large farm dam, fed by several minor 1st and 2nd order streams. These streams are ephemeral with minimal channel definition, only flowing when the upstream dams overflow. A variety of aquatic habitat is present including submerged woody logs, and a variety of aquatic macrophytes including Water Primrose *(Ludwigia peploides*), Nardoo (*Marsilea mutica*), *Eleocharis sp.,* Cumbungi (*Typha sp.*), Floating Pondweed (*Potamogeton sulcatus*) and several sedge species (*Cyperus sp.*). No fish were sighted during vidual inspections, however Gambusia (*Gambusia holbrooki*) are likely to be present. No threatened or protected fish species are expected to occur within the dam.	**Class:** Class 2 – Moderate Key Fish habitat **Key Fish Habitat:** Type 1	**Culverts C4460 and C4720**
Unnamed tributary of Surveyors Creek Location: 286887.04 E 6257728.9 N 	The unnamed tributary of Surveyors Creek is an ephemeral stream which is crossed by the project. At the time of inspection, no water was present and the channel was densely populated by *Typha* Sedges. No fish were sighted during vidual inspections, however Gambusia (*Gambusia holbrooki*) are likely to be present. No threatened or protected fish species are expected to occur within the dam.	**Class:** Class 2 – Moderate Key Fish habitat **Key Fish Habitat:** Type 1	

5 Matters of National Environmental Significance

The EPBC Act is the Australian Government's central piece of environmental legislation. The key provisions of the EPBC Act are based on the following treaties:

- World Heritage Convention – The Convention for the Protection of the World Cultural and Natural Heritage 1975
- The Ramsar Convention – The Convention on Wetlands of International Importance especially as Waterfowl Habitat 1975
- The Convention on Biological Diversity 1992
- JAMBA – Japan-Australia Migratory Bird Agreement
- CAMBA – China-Australia Migratory Bird Agreement
- Bonn Convention – Convention on the Conservation of Migratory Species of Wild Animals
- CITES – The Convention on International Trade in Endangered Species of Wild Fauna and Flora 1976.

The EPBC Act provides a legal framework to protect and manage nationally and internationally important flora, fauna, ecological communities and heritage places – defined as matters of national environmental significance as follows (as applicable to the project):

- World heritage properties
- National heritage places
- Wetlands of international importance (often called 'Ramsar' wetlands after the international treaty under which such wetlands are listed)
- Nationally threatened species and ecological communities
- Migratory species.

The EPBC Act also applies to Commonwealth land (for actions outside Commonwealth Land that may impact on the environment on Commonwealth Land) (section 26 and 27A).

The project was referred under the EPBC Act) to the Commonwealth Minister for the Environment and Energy on 2 May 2016. The Minister determined on 21 July 2016 that approval is required as the action has the potential to have a significant impact on listed threatened species and ecological communities and Commonwealth land. The controlled action is considered likely to have a significant impact on the following EPBC Act listed threatened species and ecological communities:

- Critically endangered – Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest (Cumberland Plain Woodlands)
- Critically endangered – *Lathamus discolor* (Swift Parrot)
- Critically endangered – *Anthochaera phrygia* (Regent Honeyeater)
- Vulnerable – *Pultenaea parviflora*
- Vulnerable – *Pteropus poliocephalus* (Grey-headed Flying-fox).

5.1 World heritage properties

There is one world heritage property located within 10 km of the project: the Greater Blue Mountains Area. At its nearest point, the Greater Blue Mountains Area is located about six kilometres west of the project. The project is not predicted to result in any direct or indirect impacts on World Heritage Properties and this MNES is not considered any further in this report.

5.2 National heritage places

There is one national heritage place located within 10 km of the project: the Greater Blue Mountains Area. At its nearest point the Greater Blue Mountains Area is located about six kilometres west of the project. The project is not predicted to result in any direct or indirect impacts on National Heritage Places and this MNES is not considered any further in this report.

5.3 Wetlands of international importance (declared Ramsar wetlands)

There are no Wetlands of International Importance (declared Ramsar wetlands) within the study area or located within 10 km of the project. The project will not result in any direct or indirect impacts on Wetlands of International Importance (declared Ramsar wetlands) and this MNES is not considered any further in this report.

5.4 Listed threatened species and ecological communities

As part of this BAR, EPBC Act listed threatened species and ecological communities have been assessed. A review of existing information and government maintained databases was undertaken as the first stage of the investigation. A 10 kilometre radius around the study area was used when searching databases. The following information was reviewed:

- The Protected Matters Search Tool (PMST) provided under the EPBC Act (Accessed November 2015)
- Atlas of NSW Wildlife, maintained by the NSW Office of Environment and Heritage
- BioBanking credit calculator and associated Threatened Species Profile Database
- NSW Vegetation Information System (VIS)
- Available vegetation mapping including the *Native Vegetation of Southeast NSW: A Revised Classification and Map for the Coast and Eastern Tablelands* (Tozer et al. 2006) and the *Native Vegetation of the Cumberland Plain, western Sydney: systematic classification and field identification of communities* (Tozer 2003).

Field surveys were undertaken within the study area from 2 September 2015 to 4 February 2016.

5.4.1 Listed ecological communities

The field surveys involved detailed floristic surveys in accordance with the methodology outlined in Stage 1 of the FBA (see Section 3). Native vegetation extent within the study area was first mapped and verified in the field during the survey. Native vegetation was stratified into Plant Community Types (PCTs). A plot-based full floristic survey was undertaken (using 400 m^2 plots nested within a larger 1,000 m^2 plot with a central 50 m transect) that was

stratified and targeted to assess the variation in the vegetation (variability assigned as vegetation zones). Any EPBC Act listed threatened ecological communities associated with a PCT were identified.

Eight listed threatened ecological communities (TECs) were identified during desktop searches and include the following:

- Castlereagh Scribbly Gum and Agnes Banks Woodlands of the Sydney Basin Bioregion (endangered)
- Cooks River/Castlereagh Ironbark Forest of the Sydney Basin Bioregion (critically endangered)
- Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest (critically endangered)
- Shale Sandstone Transition Forest of the Sydney Basin Bioregion (critically endangered)
- Temperate Highland Peat Swamps on Sandstone (endangered)
- Turpentine-Ironbark Forest in the Sydney Basin Bioregion (critically endangered)
- Upland Basalt Eucalypt Forests of the Sydney Basin Bioregion (endangered)
- Western Sydney Dry Rainforest and Moist Woodland on Shale (critically endangered).

Of these eight listed TECs, only the critically endangered Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest (referred to hereafter as CPWSGTF) is known to occur within the study area. Three PCTs representative of CPWSGTF are present in the study area including:

- Grey Box - Forest Red Gum grassy woodland on flats of the Cumberland Plain, Sydney Basin Bioregion (PCTID 849)
- Grey Box - Forest Red Gum grassy woodland on shale of the southern Cumberland Plain, Sydney Basin Bioregion (PCTID 850).
- Derived grasslands on shale hills of the Cumberland Plain (50-300m asl) (PCTID 806)

Detailed floristic plots were undertaken within the patches of PCT 849, PCT 850 and PCT 806 within the study area to determine vegetation quality. These three PCTs were found to be present in varying levels of condition within the study area. The condition of patches was assessed according to the criteria provided in the *Commonwealth Listing Advice on Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest* (Threatened Species Scientific Committee, 2009) (see Table 5.1). Only the highest quality patches of these PCTs are considered to be consistent with the EPBC Act listing.

In accordance with the condition criteria in Table 5.1, two categories of CPWSGTF are present within the study area:

- Category A - core thresholds that apply under most circumstances: patches with an understorey dominated by natives and a minimum size that is functional and consistent with the minimum mapping unit size applied in NSW
- Category C - patches with connectivity to other large native vegetation remnants in the landscape (this category also includes areas of Derived Native Grasslands where the grasslands are contiguous with the TEC).

Within the study area, the patches of Category A CPWSGTF (patches that meet the core thresholds) are located in two main areas: the southern portion of the Defence Establishment Orchard Hills and on private properties along Willowdene Avenue. There is part of one larger patch (>5 hectares in size) within the study area which is on private property off Willowdene Avenue. An additional Category A patch is present outside of the study area along Willowdene Avenue but will not be impacted by the proposed action.

The Category C patches are lower condition patches of CPWSGTF and Derived Native Grasslands that are contiguous with Category A patches. These Category C patches are located on private property off Willowdene Avenue and on the southern portion of the Defence Establishment Orchard Hills.

Table 5.1 Condition thresholds for patches that meet the description for Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest

Category and rationale	Thresholds
A. Core thresholds that apply under most circumstances: patches with an understorey dominated by natives and a minimum size that is functional and consistent with the minimum mapping unit size applied in NSW	Minimum patch size is ≥0.5 hectares AND ≥50 percent of the perennial understorey vegetation cover is made up of native species
OR	
B. larger patches which are inherently valuable due to their rarity	The patch size is ≥5 hectares AND ≥30 percent of the perennial understorey vegetation cover is made up of native species
OR	
C. Patches with connectivity to other large native vegetation remnants in the landscape	The patch size is ≥0.5 hectares; AND ≥30 percent of the perennial understorey vegetation cover is made up of native species; AND The patch is contiguous with a native vegetation remnant (any native vegetation where cover in each layer present is dominated by native species) that is ≥5 hectares in area
OR	
D. Patches that have large mature trees or trees with hollows (habitat) that are very scarce on the Cumberland Plain	The patch size is ≥0.5 hectares in size; AND ≥30 percent of the perennial understorey vegetation cover is made up of native species; AND The patch has at least one tree with hollows per hectare or at least one large tree (≥80 cm dbh) per hectare from the upper tree layer outlined from the community description.

5.4.2 Listed threatened flora species

The PMST search identified 26 threatened flora species (or their habitats) with habitat in the 10 kilometre search radius around the study area (see likelihood of occurrence in Appendix B).

Targeted surveys were completed for all identified candidate flora species with suitable habitat. The targeted flora surveys followed the methods described in the Threatened Biodiversity Survey and Assessment Guidelines for Developments and Activities – Working Draft 2004 (NSW Department of Environment and Conservation 2004). The survey timing adhered to the months detailed in the BioBanking credit calculator for each candidate flora species. For cryptic species with a potential habitat present (i.e. *Pimelea spicata*), the field survey included visiting reference populations to ensure visibility in the study area during the survey period. The targeted flora surveys were completed prior to the release of the NSW Guide to Surveying Threatened Plants (Office of Environment and Heritage, 2016). However, a systematic approach was taken to the survey including targeting the species at the optimal time of year, identifying potential habitats, and then undertaking a survey using parallel field traverses.

The field surveys recorded one threatened flora species identified in the EPBC Act PMST report: *Pultenaea parviflora* (listed as vulnerable under the EPBC Act). No other threatened plant species were recorded during the surveys. For many of the threatened flora species identified in the PMST report (see Appendix B), the study area does not provide suitable habitat.

Four *Pultenaea parviflora* plants were found during the field surveys. The plants were located in two areas within the western road reserve of the Northern Road and in one location at 34 Kings Hill Road. Two plants are present in the road reserve at 2465 The Northern Road Mulgoa and one plant is present at the top of the road cutting about 420 m south of the first two plants on the western side of the Northern Road at 2509 The Northern Road Mulgoa. One plant was found in the north west corner of the property at 34 Kings Hill Road. Based on the data from the OEH Atlas of NSW Wildlife, the *Pultenaea parviflora* plants within the study area would represent an extension of the known south western distribution of this species in the Sydney Basin Bioregion.

Targeted surveys for other EPBC Act listed threatened flora species was undertaken including detailed survey for *Pimelea spicata*. Three *Pimelea spicata* reference sites were surveyed in January 2016 including the Mt Annan Botanic Gardens, Camden Golf Course bushcare site, and Western Sydney Parklands. *Pimelea spicata* was flowering at all three reference sites during the survey period. *Pimelea spicata* was not recorded in the study area during the surveys undertaken for the biodiversity assessment despite targeted survey in potentially suitable habitat using parallel transects.

5.4.3 Listed terrestrial fauna species

The PMST search identified 19 threatened fauna species with known or modelled habitat in the 10 kilometre search radius around the study area. This included five birds, four frogs, six mammals, one reptile, one invertebrate, and two fish species (see likelihood of occurrence in Appendix B).

Targeted surveys were completed for all identified threatened fauna species that had suitable habitat in the study area. The targeted fauna surveys adhered to the methods described in the *Threatened Biodiversity Survey and Assessment Guidelines for Developments and Activities – Working Draft 2004* (Department of Environment and Conservation, 2004) and the following guidelines:

- *Threatened species survey and assessment guidelines: field survey methods for fauna: Amphibians* (Department of Environment and Climate Change, 2009)
- *Survey Guidelines for Australia's Threatened Frogs - guidelines for detecting frogs listed as threatened under the Environment Protection and Biodiversity Conservation Act 1999* (Department of the Environment Water Heritage and the Arts, 2010a)
- *Survey guidelines for Australia's threatened bats - Guidelines for detecting bats listed as threatened under the EPBC Act* (Department of the Environment Water Heritage and the Arts, 2010b)
- *Survey guidelines for Australia's threatened mammals - Guidelines for detecting mammals listed as threatened under the EPBC Act* (Department of Environment Water Heritage and the Arts, 2011a)
- *Survey guidelines for Australia's threatened birds - Guidelines for detecting birds listed as threatened under the EPBC Act* (Department of Environment Water Heritage and the Arts, 2010).

The nationally listed threatened species identified from the background review and field surveys were considered in terms of their likelihood to occur in the habitats present within the study area based on their identified habitat requirements (see likelihood of occurrence in Appendix B).

Green and Golden Bell Frog (*Litoria aurea*)

There are no reported existing populations of the Green and Golden Bell Frog (Litoria aurea) in the study area. The most recent record of this species nearby is from Gow Park Mulgoa from 1999. Recent targeted surveys conducted for the Badgerys Creek airport site which adjoins the study area (GHD, 2016) did not detect a population. Despite this, suitable habitat does occur and targeted surveys were conducted.

There are numerous 'farm dams' in the study area with various dimensions and depths, many in isolated locations and others along streams and ephemeral drainage lines, as in-stream dams which are common, these were also assessed as 'farm dams'. The presence of emergent and surrounding vegetation also varies considerably, from completely absent and unshaded dams to a species rich wetland type environment with abundant emergent vegetation and surrounding tree canopy with grassy understorey.

The Commonwealth survey guidelines for Australia's threatened frogs (2013) state that 'in some circumstances, the study area of interest will be small enough to allow a comprehensive search of the entire area within a reasonable period of time. If a comprehensive search is feasible, then sampling will not be required and the data collected will be representative of the entire area. In many cases, however, the study area will be too large to permit a complete search within a reasonable time frame, and selective searches or sampling procedures will be required (Royle & Nichols 2003). Many study sites will be comprised of a variety of distinct habitat types, especially if the area is extensive. Some of these habitats may be unsuitable for occupancy by the targeted taxa. An effective strategy to maximise the likelihood of detecting a particular taxon is to concentrate search effort within habitat that is favoured by the targeted taxon (Resources Inventory Committee 1998). This is the approach that was used for the current study.

The sampling strategy focused on searching optimum sites for detection and breeding by the species, because successful breeding activity is essential to long-term persistence of the Green and Golden Bell Frog in an area (Pyke and White 1996).

Habitat Assessment

As farm dams and in-stream ponds may provide potential habitat for the Green and Golden Bell Frog an initial habitat assessment was conducted across the entire project study area to stratify the habitats and identify the sites where the habitat is most suited to *Litoria aurea*. To determine this, a review of literature on the habitat requirements of the species was conducted (Pyke and White 1996). These authors document the criteria found most consistently at sites that support breeding and non-breeding populations, this included the following:

a. Presence of emergent vegetation providing shelter sites
b. Moderate to high level disturbance
c. Aquatic plant species present (especially *Typha* spp.)
d. Still or low flowing water
e. Run-off urban / industrial / grazing or parkland
f. Substrate sand, or rock
g. Shallow water depth <50 cm
h. Nearby vegetation low, grassland, or shrubland or woodland
i. Unshaded or partial shade
j. Areas of grass nearby
k. No visible signs of pollution
l. *Crinia signifera* or *Limnodynastes peronii* present
m. *Gambusia holbrooki* absent.

The initial habitat assessment considered all dams within about 100-200 metres of the project footprint which were assessed against the criteria described above. Dams located up-slope from the proposal and outside of the predicted impact zone were not assessed.

In total 38 farm dams or clusters of connected dams along drainage lines were assessed (refer Figure 5.1). The habitat assessment at each site scored each of the habitat criteria above as being either, present (1) or absent (0) to provide a total score out of 13.

All sites were on clay substrates, this is because clay is the prevailing soil type and no areas of sandy bottom or rocky bottom dams occur (criteria f). This criteria was therefore scored zero for criteria f 'substrate sand, or rock' for all sites, and the stratification did not offer any weighting to this criteria (i.e. there was no exclusion on the basis of soil substrate as only one soil substrate occurs).

In terms of assessing pollution, the assessment closely followed the assessment criteria documented in Pyke and White (1996) for consistency. These authors base their assessment of pollution on a visual scale noting the nature and extent of any obvious evidence of water pollution (e.g., presence of human garbage, water discolouration, and visible signs of eutrophication). They suggest that most sites preferred by *Litoria aurea* have no visible signs of pollution.

With regard to criteria k, the stratification in this study did not focus on pristine sites or non-polluted sites, as it is well known that the species can tolerate pollution. All the farm dams / frog habitats in the study area showed low to moderate levels of visible pollution associated with regular cattle / stock trampling, sedimentation and limited flushing, many in very poor condition which were assessed as 'high level' disturbance (these were shallow, trampled and very turbid or obvious eutrophication). There was also sediment stirring and run-off from vehicle crossings for some dams and drainage lines. The ponds sampled in the DEOH were constructed for the purposes of treating effluent, and these were sampled, as there was low

level turbidity, high oxygen levels and abundant aquatic vegetation, which were considered suitable. Sites were prioritised if they were less obviously polluted and degraded [i.e. 'no visible signs of pollution'] and therefore had a better chance of supporting a stable breeding population that would be impacted by the project.

For consideration of vegetation at a site (criteria h and j), the habitat assessment considered the rationale and conclusions presented in Pyke and White (1996). These authors identify that preferred habitat comprises 'nearby vegetation' such as woodland, providing potential sites for diurnal shelter and that open grassy areas were also important for foraging. Sites that had a combination of both these vegetation types rated highly. In this study, sites that were surrounded by cleared paddocks, or alternatively dense forest, scored lower and sites were rated highly if they had open grassy areas surrounding the water body, and also woodland or debris nearby within 50 metres.

Considering all criteria sites that scored ≥10 were identified as potentially favoured by *Litoria aurea* and were targeted for nocturnal surveys (n = 14 sites). Sites that scored less than 10 were considered to have a very low chance of supporting a population and no nocturnal surveys were conducted. Sites were selected at the habitat assessment site, or adjoining and connected ponds that resembled the habitat assessment site. The results of the habitat assessment scoring is outlined in Table 5.2.

Table 5.2. Results of habitat assessment for Green and Golden Bell Frog

Habitat Assessment Site	Survey Site	Description	a	b	c	d	e	F	g	h	i	j	k	l	m	SCORE
HAS1	-	Very small isolated dam, close to roadside, approximately 20 square metres. Surrounding paddock heavily weed infested, limited pasture, visible signs of eutrophication, water quality very poor, surrounding woodland cover, suffering stress and dieback. Gambusia abundant	0	0	0	1	0	0	1	0	0	0	0	1	0	3
HAS2	Site 1A	Large farm dam on ephemeral drainage lines, approximately 1600 square metres, with standing dead trees. Mix of shaded and open sunny areas surrounding with woodland and open grassy areas. No visible signs of pollution. Margins vegetated with Juncus acutus, no Typha present	1	1	1	1	1	0	1	1	1	1	1	1	0	11
HAS 3, 9, 4	Site 1B	Large farm dams on drainage channel, approximately 5000 square metres and up to 2.5 metres deep. Margins densely vegetated with Juncus acutus and Baumea sp. Mostly shaded, small area of open sun. surrounding vegetation grassy and low woodland	1	1	1	1	1	0	0	1	1	1	1	1	0	10
HAS 5, 6	-	Small Isolated farm dams surrounded woodland patchy, very high weed abundance in the understorey, no grassy habitat surrounding, limited macrophyte vegetation, and visual pollution evident. Gambusia abundant.	0	0	1	1	0	0	0	1	0	0	0	1	0	4
HAS 7, 8	Site 2	Very large and deep instream dam on two drainage lines, proposed bridge site. Fringing aquatic vegetation limited on main dam, although common on smaller branches. Smaller attached dam on tributary of main creek, approximately 1200 square metres, up to 1 metre deep, clay substrate. Margins vegetated with Juncus acutus and Typha.	1	1	1	1	1	0	0	1	1	1	1	1	0	10
HAS9	-	Very small isolated dam, shallow, surrounding woodland is poor condition, some dieback, understorey dominated by weeds, water quality poor, cattle grazing, Gambusia present	0	0	0	1	0	0	1	0	0	0	0	1	0	3
HAS10 and HAS 11	Site 3	Large permanent farm dam 1600 square metres on shall drainage line. Up to 2.0 metres deep with vegetated margins comprising Juncus acutus	1	1	1	1	1	0	0	1	1	1	1	1	0	10
HAS13	Site 4a	Large permanent farm dam 1200 square metres on shallow drainage line and clay substrate. Margins vegetated with Juncus usitatus and Nardoo. Central area comprises dense Baumea. Shallow <1m	1	1	1	1	1	0	1	1	1	1	0	1	0	10
HAS14	Site 4d	Large permanent farm dam 1500m2 on moderately steep drainage line with connectivity downstream. Margins vegetated by frogsmouth and central areas dense Baumea forming islands	1	1	1	1	1	0	0	1	1	1	1	1	0	10

Habitat Assessment Site	Survey Site	Description	a	b	c	d	e	F	g	h	i	j	k	l	m	SCORE
HAS15	Site 4c	Small shallow farm dam <1000m2, on clay substrate. Margins vegetation with Juncus usitatus and central area Baumea. High level of pollution from cattle trampling, visible signs of water pollution	1	1	1	1	1	0	1	1	1	1	0	1	0	10
HAS16	Site 4b	Large permanent farm dam 1000 square metres on shallow drainage line and clay substrate. Margins vegetated with Juncus usitatus and Nardoo. Central area comprises dense Baumea. Shallow <1m	1	1	1	1	1	0	1	1	1	1	0	1	0	10
HAS12, 17, 18, and 35	Site 5a-5e	A series of permanent dams ranging from 1000-2400 m2, part of continuous chain of dams and channels constructed along drainage channel used for water treatment on Defence base with treated effluent disposal. Constant slow flow, ponds likely range in depth from 0.4 to 1 metre deep. Margins densely vegetated with Typha, particularly along the channel sections, also Juncus asiaticus. Surrounding areas open grass and weed and small patches of woodland or alluvial forest along channel	1	1	1	1	1	0	1	1	1	1	0	1	0	10
HAS 19, 20, 24, 25	-	Series of small isolated dams, all shallow with limited intake, surrounding woodland is in poor condition, some dieback of trees, history of grazing and fire, understorey dominated by weeds, water quality poor, cattle grazing, Gambusia present. Some aquatic vegetation present. HAS20 on edge of study area boundary adjacent TO HAS19	1	0	1	1	0	0	1	0	0	0	0	1	0	5
HAS 21, 22	-	Small roadside dams, receiving run-off from road, poor water quality. No woodland surrounding, adjacent areas are grass and weeds. High density of weeds, Gambusia present	0	0	1	1	0	0	1	0	1	1	0	0	0	5
HAS 23, 36, 37	-	Small isolated dams near roadside areas, receiving run-off from road. Visual signs of pollution, disturbance from slashing, weed abundance, nutrient inputs. Limited woodland in surrounding areas and no grassy habitat. HAS 23, and 37 near M4 as part of the TNR stage 3 project	0	0	1	1	0	0	1	0	1	0	0	0	0	4
HAS 26	-	Large deep dam, no aquatic vegetation within edge areas, run-off from chicken farm, no surrounding woodland for cover	0	0	0	1	0	0	0	0	1	1	0	0	1	4
HAS 28	-	Moderate sized in-stream dam on Cosgroves Creek up 200 square metres, very heavily weed infested understorey, no grass surrounding, riparian vegetation absent, Gambusia present. Deep sections. Water quality appears poor, with thick algae bloom, oily fil and frothing present in some of the stagnant pools.	0	0	0	1	1	0	0	0	1	0	0	1	0	4
HAS 27, 29, 30, 31	-	Range of small to medium sized dams, from 200-600 square metres. All in open grazing land, no surrounding woodland in proximity. Grazed, impacts from cattle trampling, very limited to no aquatic vegetation. Gambusia present	0	0	0	1	0	0	1	0	1	0	0	1	0	4

Habitat Assessment Site	Survey Site	Description	a	b	c	d	e	F	g	h	i	j	k	l	m	SCORE
		in the smaller dams														
HAS 32, 33	-	Small isolated farm dams near road, aquatic vegetation present, limited woodland nearby but occurs in wider surrounding areas.no grassy areas surrounding, dominated by dense, tall weeds	1	0	1	1	1	0	0	0	1	0	0	1	0	6
HAS 34	-	Small isolated shallow farm dam, <30 square metres, no aquatic vegetation. Only a small number of trees in sounding areas. Obvious pollution from cattle trampling and road side run-off. Gambusia abundant	0	0	0	1	0	0	1	0	1	0	0	1	0	4
HAS38	Site 6	Adjacent to Glenmore Parkway, under power easement. Large dam, up to 3000 square metres, with dense cover of Typha, located along ephemeral drainage line. Surrounding woodland shaded, and unshaded with abundant logs and sedges for cover. Water quality average.	1	1	1	1	1	0	1	1	1	1	0	1	0	10

Survey approach

Nocturnal surveys were then conducted over 6 nights, between the 20th January and 2nd February 2016, weather conditions are shown in Table 5.3. A 'site' sometimes consisted of multiple dams in close proximity providing opportunities for movements of *Litoria aurea*, these were sampled separately to cover the entire area, and resulted in sampling of 14 dams in total representing 6 sites (refer Table 5.3 and Figure 5-1). Ponds at the Defence Estate Orchard Hills consisted of five constructed dams connected by a series of narrow vegetated channels over a large area used for treatment of effluent, the survey aimed to sample both the dam and channel habitats over four consecutive nights.

Each dam was searched by two ecologists at least once during the survey period with some dams searched on more than one occasion, the duration of each sampling event extended between 0.5 and 1 hour per site depending on the size of the dam. The survey involved a spotlight search of the entire perimeter of the dam / channel focusing on the upper water column and within emergent vegetation. Call playback was used at each site which involved playing calls of the target species through a 20W loudhailer for 2-5 minutes at each location. Smaller sites involved a single broadcast point, while larger sites and densely vegetated sites used multiple call sites whilst searching the perimeter of the dam. Details of the survey effort are described in Table 5.4.

Table 5.3. Weather and rainfall conditions during nocturnal surveys

Survey nights	Date	Min Temp (0C)	Max Temp (0C)	Wind (3pm)	Rainfall (24 hours)	Total rainfall in 7 days prior to survey
1	20/01/2016	16.8	38.9	Slight NNW 11 km/hr	0 mm	30.6 mm
2	21/01/2016	20.6	38.5	Calm NE 7 km/hr	0 mm	48.2 mm
3	01/02/2016	17.1	26.9	Slight SSW 11 km/hr	0.2 mm	89.6 mm
4	02/02/2016	13.5	28.6	Calm E 9 km/hr	0.8 mm	89.6 mm
5	03/02/2016	15.2	32.3	Calm NNW 6 km./hr	0 mm	89.6 mm
6	04/02/2016	17.8	24.9	Moderate SSE 28 km/hr	2.8 mm	89.6 mm

Table 5.4. Details of survey sites and sampling events for targeted nocturnal surveys

Survey site	Survey nights						Total duration (hours)	No. sampling events
	1	2	3	4	5	6		
1a. Willowdene Rd south	20/01	21/01					1.0	1
1b. Willowdene Rd south	20/01	21/01					2.0	2
2. Northern bridge on xmas tree farm		21/01					1.0	3
3. Adams Road		21/01					0.5	4
4a. Large subdivision property				2/02			0.5	5
4b. Large subdivision property					3/02		0.5	6
4c. Large subdivision property			1/02				0.5	7
4d. Large subdivision property						4/02	0.5	8
5a. DEOH			1/02				1.0	9
5b. DEOH			1/02				1.0	10
5c. DEOH				2/02			1.0	11

Survey site	Survey nights						Total duration (hours)	No. sampling events
	1	2	3	4	5	6		
5d. DEOH					3/02		1.0	12
5e. DEOH						4/02	1.0	13
6. opposite golf course				2/02			0.5	14
6 sites (14 dams)							11.0 hrs (22 person hrs)	

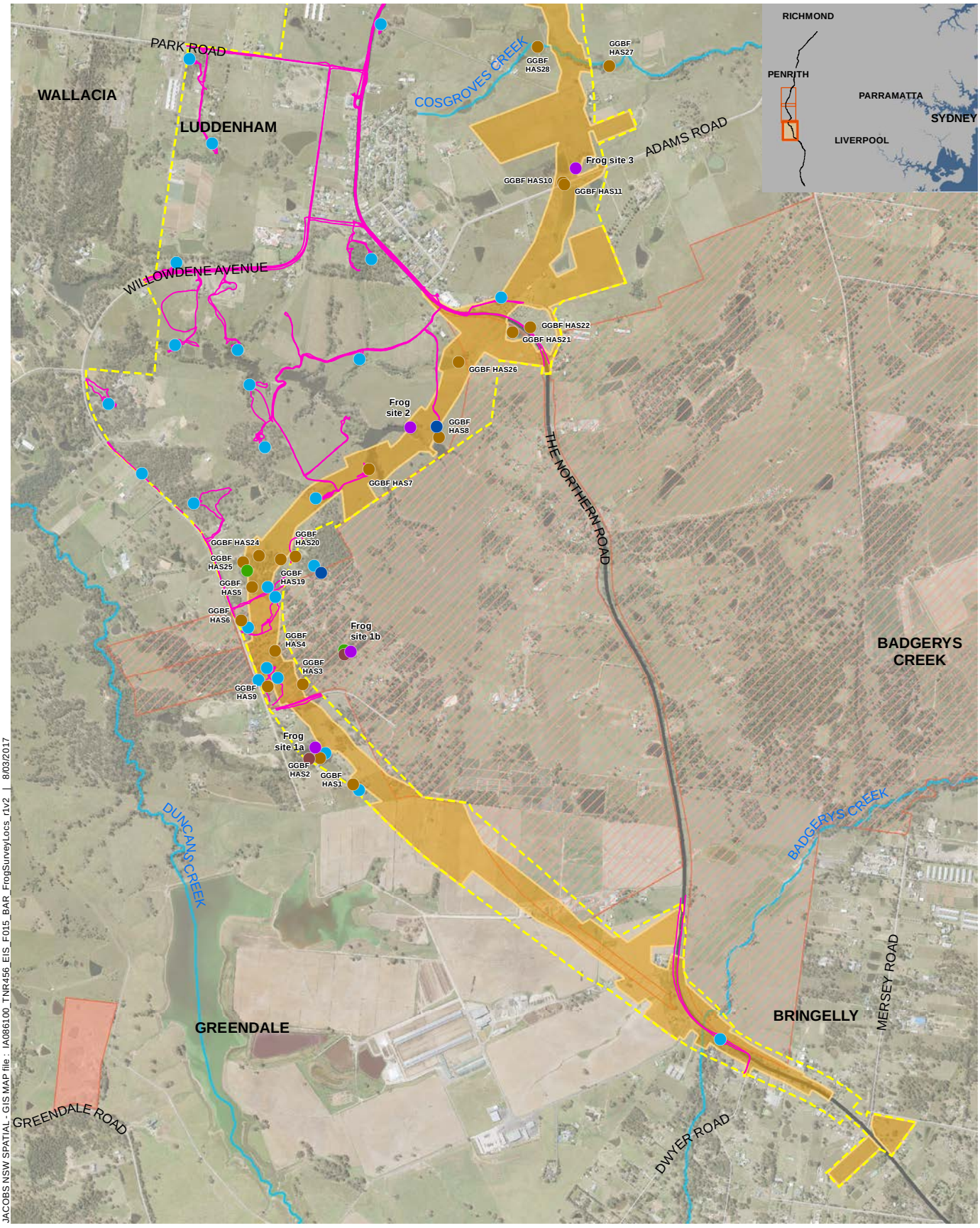

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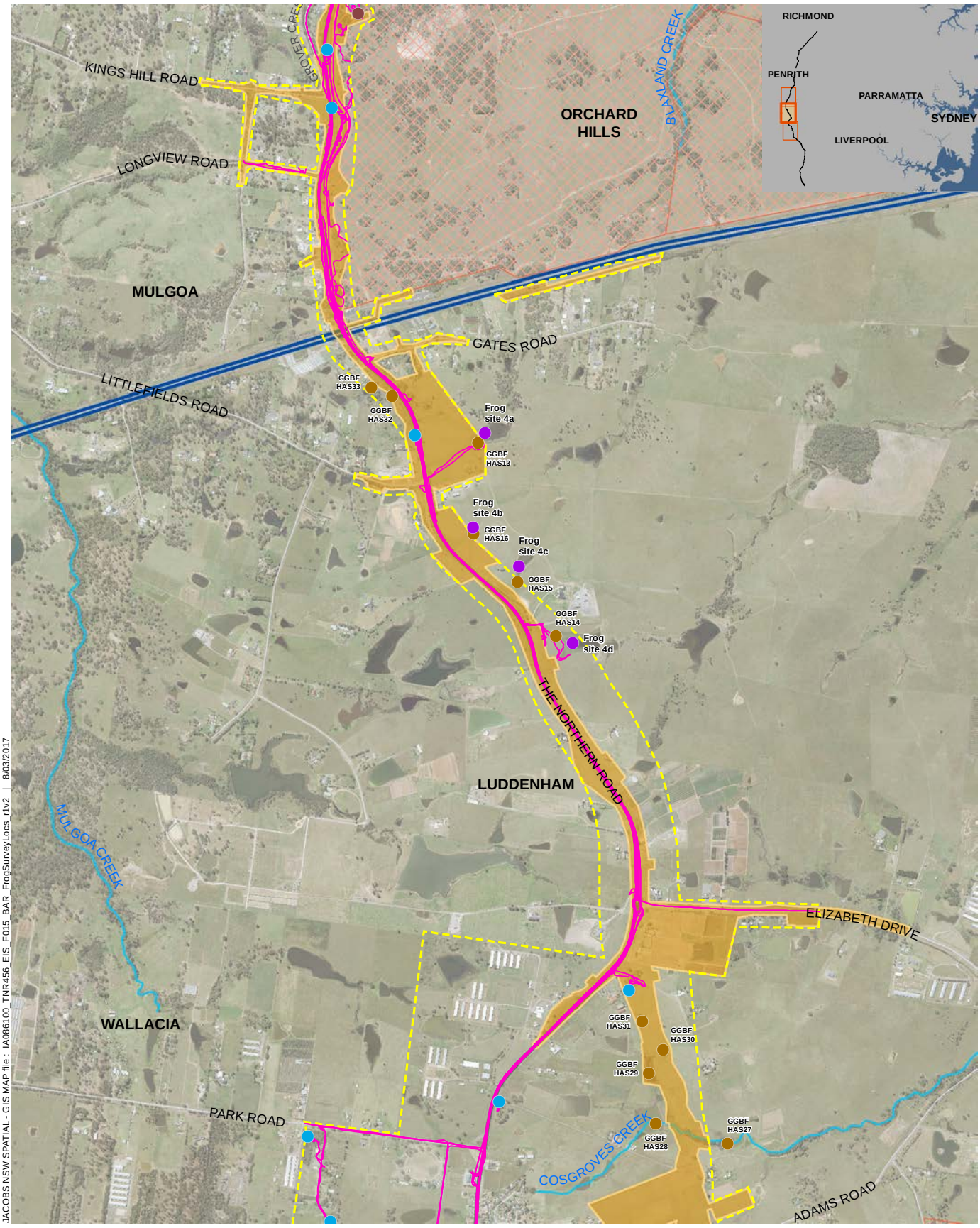
Figure 5-1 | Green and Golden Bell Frog targeted survey locations



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The Northern Road (Existing)
WaterNSW supply pipelines
Development site boundary
Ecology study area
Western Sydney Airport site (Commonwealth Land)
Defence Establishment Orchard Hills (Commonwealth Land)
Commonwealth Lands

Field surveys
Survey locations
Bat Detector
Bat Trap
Bird Survey

Cumberland Plain Snail Habitat Assessment
GGBF habitat assessment sites (HAS)
GGBF targeted survey sites

0 0.5 1 km

N

3
2
1

Figure 5-1 | Green and Golden Bell Frog targeted survey locations

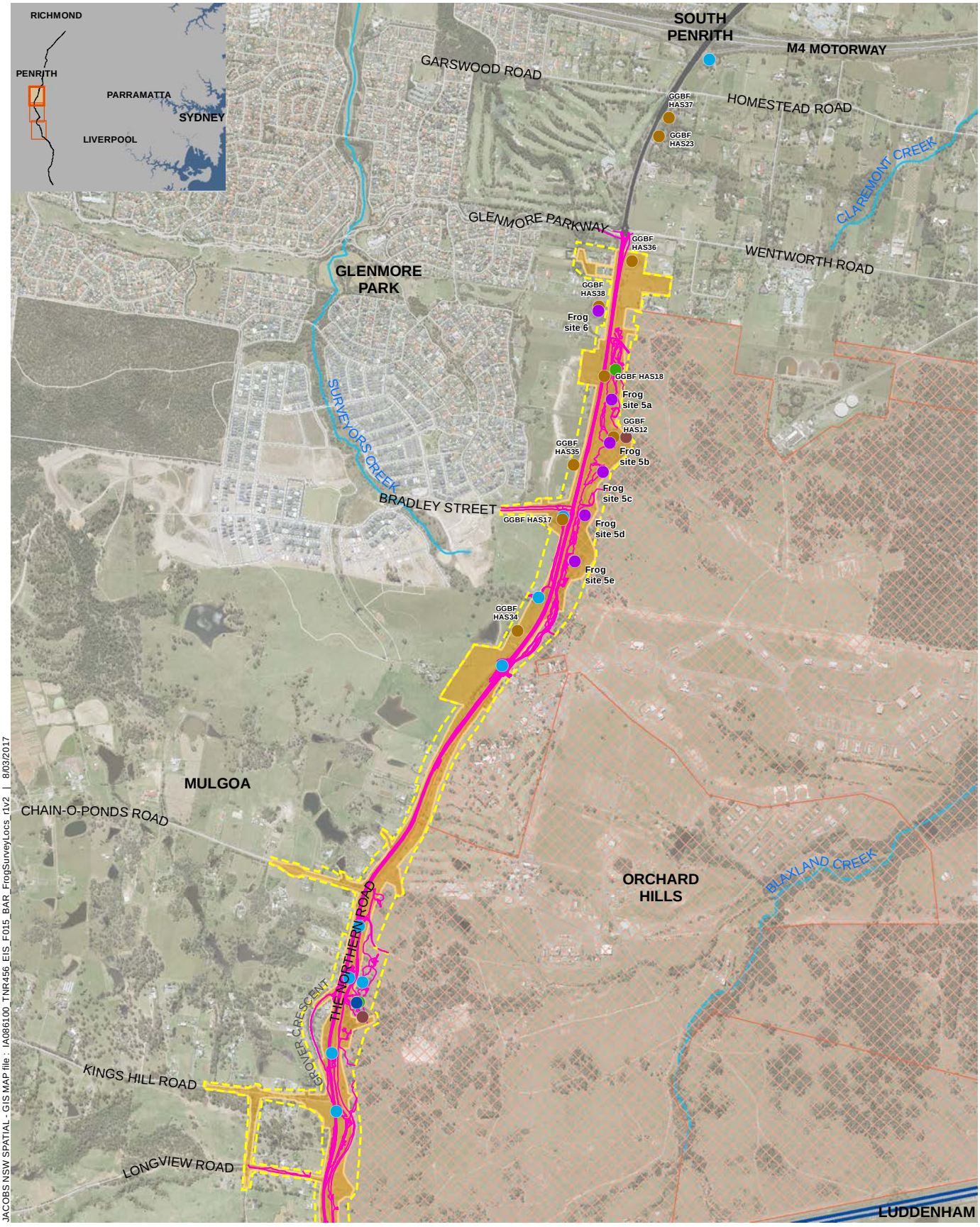


Figure 5-1 | Green and Golden Bell Frog targeted survey locations

Survey results

No Green and Golden Bell Frog individuals or populations were detected from the targeted nocturnal surveys conducted across The Northern Road stage 4 study area. Furthermore, there are no reported existing populations of the Green and Golden Bell Frog (*Litoria aurea*) in the study area. The most recent record of this species nearby is from Gow Park Mulgoa from 1999. Recent targeted surveys conducted for the Badgerys Creek airport site which adjoins the study area (GHD, 2016) did not detect a population.

A moderate diversity of frog species were recorded, reflecting the diversity and condition of the habitats, from treed woodland sites along stream, to isolated farm dams, and also the optimum conditions during the survey. Ten common species were recorded.

Table 5.5. Frog species recorded from targeted surveys

Species	Common name	Survey site													
		1A	1B	2	3	4A	4B	4C	4D	5A	5B	5C	5D	5E	6
Crinia signifera	Common Eastern Froglet	x	x	x	x	x			x	x	x	x	x	x	x
Limnodynastes peroni	Striped Marsh Frog	x	x	x	x	x	x	x	x			x	x	x	x
Limnodynastes tasmaniensis	Spotted Grass Frog	x	x	x	x	x				x	x	x	x		x
Litoria dentata	Bleating Tree Frog	x	x												
Litoria fallax	Eastern Dwarf Tree Frog	x	x				x	x	x			x	x		
Litoria latoplamata	Broad-palmed Rocket Frog	x	x		x				x			x			
Litoria peroni	Perons Tree Frog							x	x						
Litoria tyleri	Tylers Tree Frog	x	x												
Litoria verreauxii	Verreauxiis Tree Frog						x	x	x						
Uperoleia laevigata	Red-groined Toadlet	x	x	x	x				x	x	x	x	x	x	x

Australasian Bittern (*Botaurus poiciloptilus*)

There is one record of the cryptic Australasian Bittern in the study area, in 2003 to the south of Badgerys Creek, the species is considered to have a low to moderate chance of occurring Spotlighting and call playback targeting Australasian Bittern was conducted over 6 nights by two ecologists using 50W spotlights and 20W loudhailer. The survey times varied between 0.5 to 2.0 hours depending on the size of the site and concentrated on densely vegetated dams and adjoining riparian habitats and were conducted following the targeted frog surveys. In total 8 sites were sampled consistent with frog sites 1a and 1b, 2, and 4a-4e. Call playback used a single point broadcast for 5 minutes duration at the start of the survey and then quite searching and listening for individuals during the remainder of the survey. Surveys for the Australasian Bittern did not record any birds present.

Koala (*Phascolarctos cinereus*)

There is one historic record of koala from the study area in 1999 from west of Mulgoa Nature Reserve near the Warragamba River around 8km from the study area. Surveys targeting koala involved scat searches conducted over 40 plots (20 x 50 m) in woodland habitats. These surveys were conducted concurrently with the vegetation condition assessment with sites stratified by plant community type and condition.

Spotlighting and call playback targeted larger woodland habitats and was conducted at two locations, 1) in the DEOH area along the drainage area in the north-western end of the site and 2) within suitable habitat along Willowdene Avenue in the southern end of the study area.

The search involved two ecologists walking a transect of minimum 500 m using 50W spotlights. Call playback was used at the start of each transect where the call of the species was played for 5 minutes from a loudhailer. This species was not recorded in the study area.

Grey-headed Flying-fox (*Pteropus poliocephalus*)

The Grey-headed Flying-fox was recorded in one location on private property off Willowdene Avenue during spotlight surveys. This species has been recorded in the Mulgoa Nature Reserve and the Defence Establishment Orchard Hills. It is also known to use habitats along the Nepean River to the west of the study area and Kemps Creek Nature Reserve to the east. Potential foraging habitat for this species is widespread in the study area and this species is likely to forage on the flowers and fruits of various trees, including urban trees and plants in gardens, when they are flowering.

Regent Honeyeater (*Anthochaera phrygia*)

The Regent Honeyeater has been recorded in the locality to the west of the study area in areas including the lower Blue Mountains (Blue Mountains National Park) and along the Nepean River (Wallacia and Greendale). To the east of the study area, the nearest existing record of the Regent Honeyeater is from near Horsley Park and was recorded in 1930.

Rapid habitat assessments were conducted at vegetation plot sites to gather information on the type and condition of the fauna habitats present with a focus on identifying the suitability of the habitat. A time-based bird survey was repeated at four sites within four hours of sunrise in spring (3 and 30 September 2015), and summer (21-22 January and 3-4 February 2016). This involved replicated 20 minute surveys at each site. The survey was conducted by one observer using a random meander within the habitat patch and recording all birds seen and heard during the survey. All bird species heard or observed were recorded including those outside the habitat node (i.e. flying over the site). Birds were also recorded opportunistically during all other site visits and field surveys activities. Binoculars were carried in the field at all times to assist in identification.

No Regent Honeyeaters were recorded during the survey. However, the habitat in the study area is considered moderately suitable for this species and it is assumed to be present. The Regent Honeyeater may utilise the habitat in the study area on occasion but the study area is not considered to form a core habitat for this species.

Swift Parrot (*Lathamus discolor*)

The Swift Parrot is known from the locality and there have been recent records of this species made from Glenmore Park to the west of the construction footprint (from Bradley Street in 2014) and the Mulgoa Nature Reserve (from 2014). There is also an existing record of the Swift Parrot from near the Mulgoa town centre from 1997.

The field surveys for the project were undertaken in summer so surveys for the Swift Parrot were not possible. To counter the timing of the survey, rapid habitat assessments were conducted at vegetation plot sites to gather information on the type and condition of the fauna habitats present with a focus on identifying the suitability of the habitat.

The Swift Parrot is considered moderately likely to occur in the study area during winter based on the presence of suitable forgaing habitat. However, no large core areas of forgaing habitat are present and the habitat within the study area is considered supplementary and likely to be used intermittently during movements between larger patches of foraging habitat.

Large-eared Pied Bat (*Chalinolobus dwyeri*)

The Large-eared Pied Bat is considered moderately likely to occur within the study area based on the presence of suitable foraging habitat in proximity to the sandstone escarpments of the lower Blue Mountains. There are nearby records of the Large-eared Pied Bat from the Mulgoa

Nature Reserve (recorded in during surveys in 2003 and 2004). There is also a record from 2002 along Mulgoa Creek (recorded during Anabat surveys).

Recognised important populations that support high numbers of the Large-eared Pied Bat include those present in the sandstone escarpments of the Sydney Basin. Any Large-eared Pied Bats that would forage in the study area are likely to roost in the sandstone escarpments of the lower Blue Mountains.

The surveys undertaken for the Large-eared Pied Bat included harp trapping for four trap nights over two consecutive nights at four different locations (8 trap nights). The habitats in the study area did not provide optimal positions to establish harp traps so traps were placed on tracks where available and on edge of a flyway or forest edge. Remote Call detection was undertaken using four AnaBat™ II bat detectors each for two nights and each recording from 1900 hours to 0500 hours. This species was not recorded during the surveys. However, a population of the Large-eared Pied Bat is considered moderately likely to utilise the study area due to the proximity of the forgaing habitat to the lower Blue Mountains and recent records of the species from the locality.

5.5 Listed migratory species

A search of the PMST conducted on November 2015 identified 13 listed migratory species or their habitat as occurring within 10 kilometres of the proposed action. A habitat assessment was undertaken to determine the likelihood of occurrence of listed migratory species within the study area.

Surveys for birds were undertaken as part of the field surveys for the EIS. The surveys included area surveys over two hectares for 20 minutes each conducted in late spring and summer during which time most of the listed migratory species are present in eastern Australia. Specific habitats including wetlands were targeted during the survey.

No migratory species were recorded during the targeted bird surveys; however, the Latham's Snipe was recorded opportunistically in the study area on three occasions. It was recorded in the same location in an area of flooded grassland on Defence Establishment Orchard Hills. The Latham's Snipe is considered likely to utilise the extensive network of farm dams, however this habitat is not considered to comprise important habitat. The Cattle Egret was observed repeatedly in paddocks throughout the study area and broader locality. The Great Egret is also considered moderately likely to occur in the wetlands throughout the study area. The White-throated Needletail and Fork-tailed Swift are considered likely to fly over the study area during migration.

'Important habitat' for a migratory species is defined as (DoE 2013):

- Habitat utilised by a migratory species occasionally or periodically within a region that supports an ecologically significant proportion of the population of the species
- Habitat that is of critical importance to the species at particular life-cycle stages
- Habitat utilised by a migratory species which is at the limit of the species range
- Habitat within an area where the species is declining.

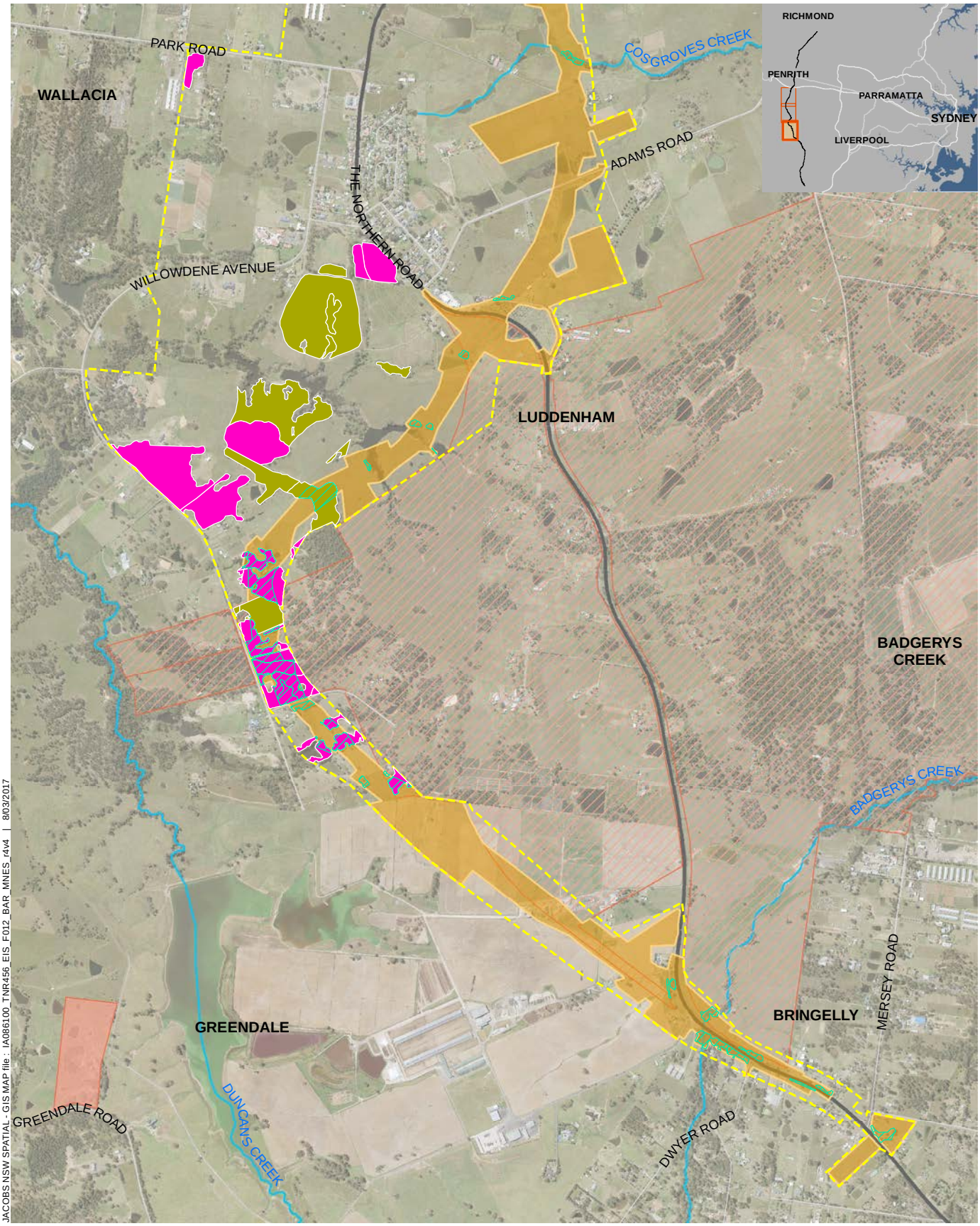
An assessment of the likely occurrence of these species and the presence of important habitat is included in Appendix B.

5.6 The environment on Commonwealth land (including the Orchard Hills Cumberland Plain Woodland)

The Orchard Hills Cumberland Plain Woodland is a Listed Place on the Commonwealth Heritage List. Chapter 8 of the EIS provides an assessment of impacts to listed places including the Orchard Hills Cumberland Plain Woodland.

The land at Orchard Hills is recognised as the least disturbed and largest remaining remnant of Cumberland Plain Woodland. The tributaries of Blaxland Creek at Orchard Hills are among the least disturbed catchments remaining on the Cumberland Plain and are regarded as possibly the most pristine creek system on Wianamatta Shale left in Western Sydney (Department of the Environment, 2016b).

The study area also contains land that has been acquired by the Commonwealth for the purposes of developing the Western Sydney Airport at Badgerys Creek which contains the biodiversity values discussed above.



The Northern Road (Existing)

Development site boundary

Ecology study area

Western Sydney Airport site (Commonwealth Land)

Defence Establishment Orchard Hills (Commonwealth Land)

Commonwealth Lands

Regent Honeyeater habitat

Threatened flora

Pultenaea parviflora

EPBC Act listed communities

Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest - Category A

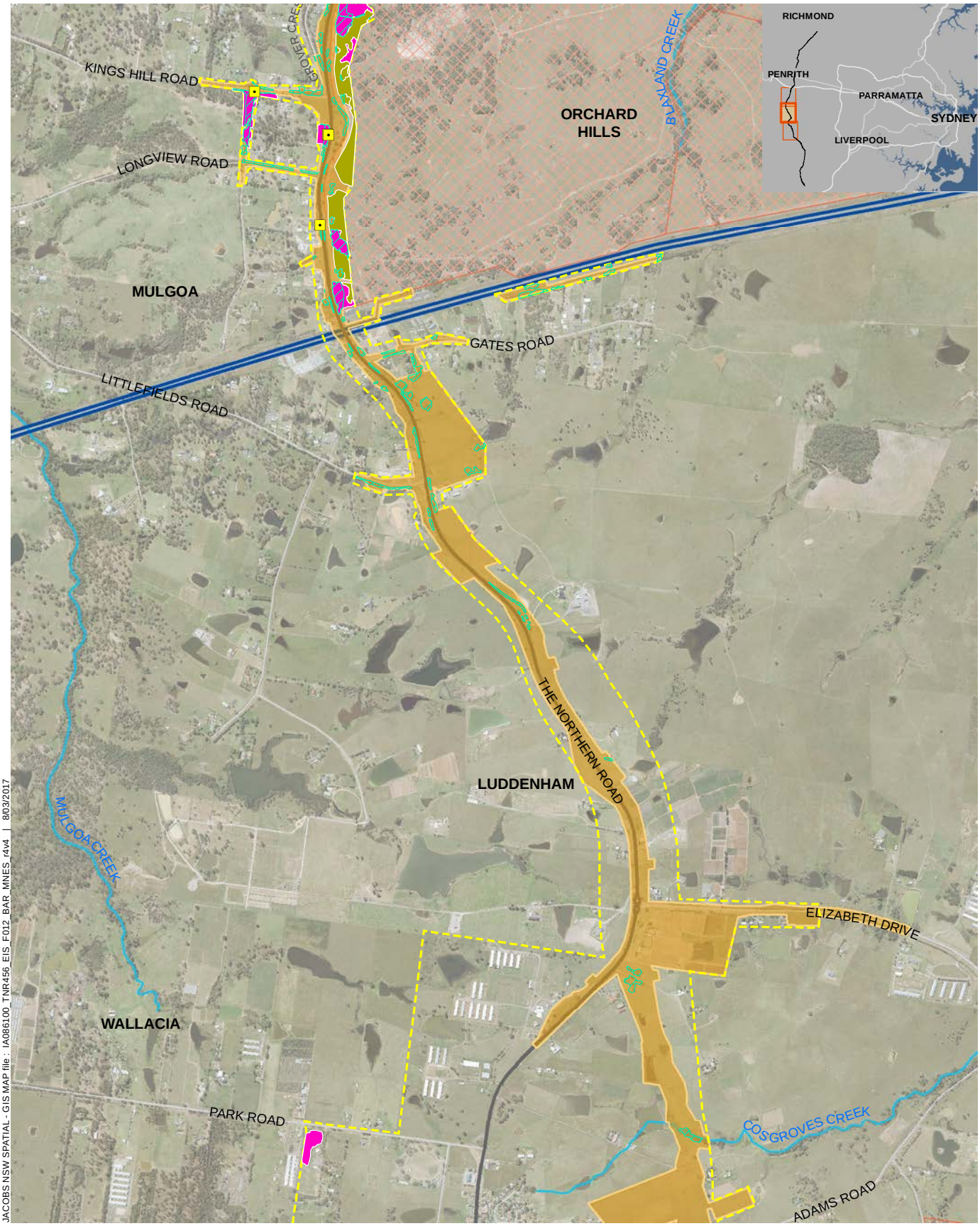
Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest - Category C

0 0.5 1 km

N

3
2
1

Figure 5-2 | Matters of National Environmental Significance



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The Northern Road (Existing)
WaterNSW supply pipelines
Development site boundary
Ecology study area
Western Sydney Airport site (Commonwealth Land)
Defence Establishment Orchard Hills (Commonwealth Land)
Commonwealth Lands

Regent Honeyeater habitat

Threatened flora

Pultenaea parviflora

EPBC Act listed communities

Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest - Category A

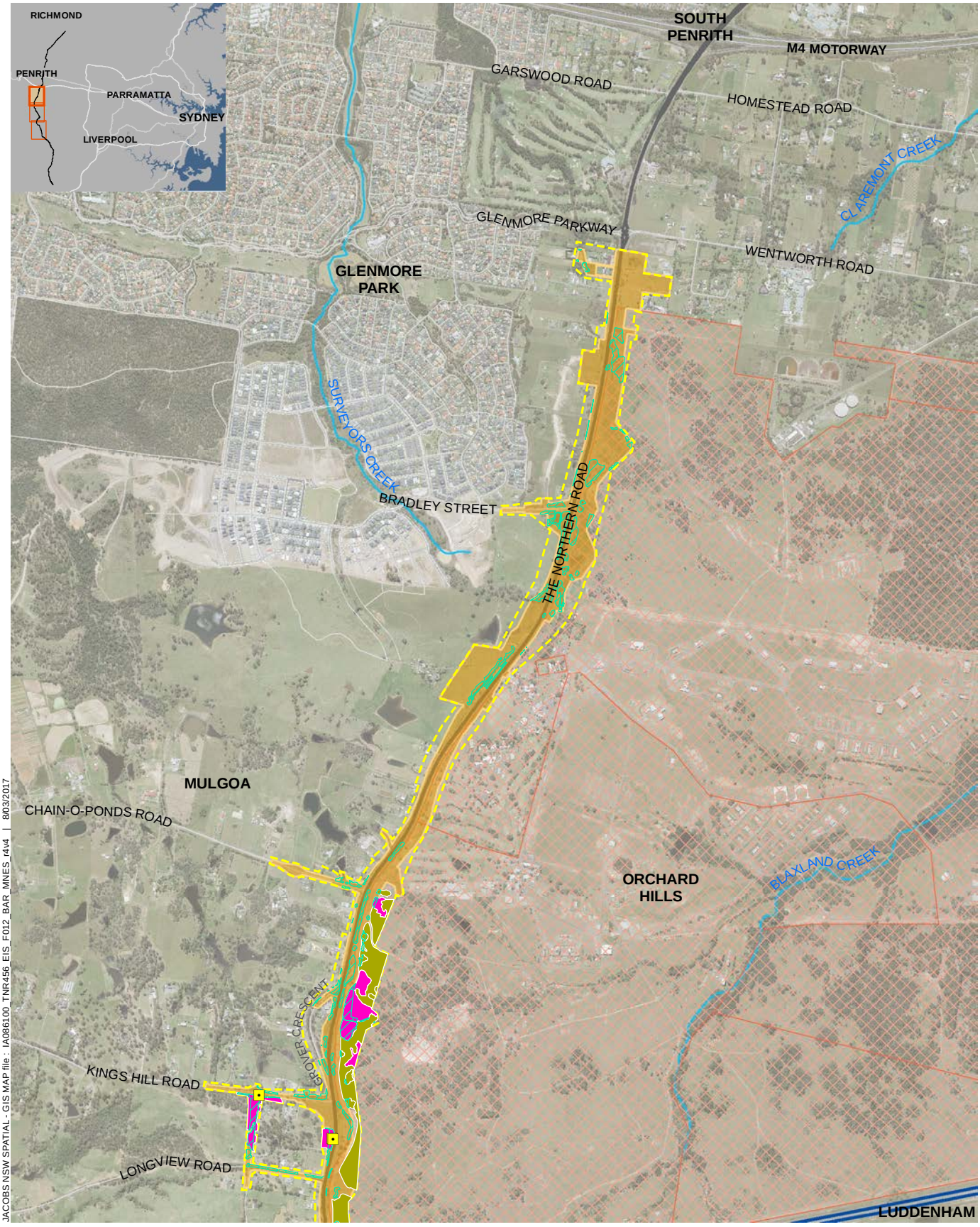
Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest - Category C

0 0.5 1 km

N

3
2
1

Figure 5-2 | Matters of National Environmental Significance



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The Northern Road (Existing)

WaterNSW supply pipelines

Development site boundary

Ecology study area

Western Sydney Airport site (Commonwealth Land)

Defence Establishment Orchard Hills (Commonwealth Land)

Commonwealth Lands

Regent Honeyeater habitat

Threatened flora

Pultenaea parviflora

EPBC Act listed communities

Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest - Category A

Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest - Category C

0 0.5 1 km

N

3

2

1

Figure 5-2 | Matters of National Environmental Significance

6 Summary of biodiversity values

6.1 Biodiversity values assessed under the FBA

This section provides a summary of biodiversity values that occur in the development footprint and require assessment under Section 9.3 of the FBA. This includes threatened species, populations and communities listed under the TSC Act and EPBC Act (see Table 6.1).

Table 6.1 Summary of biodiversity values assessed under the FBA

Biodiversity value (including species, communities,	Ecosystem or species credit species	Identification method (assumed, recorded, expert report)	Area/individuals within development footprint
Forest Red Gum - Rough-barked Apple grassy woodland on alluvial flats of the Cumberland Plain, Sydney Basin Bioregion	Ecosystem	Recorded	4.29 hectares
Grey Box - Forest Red Gum grassy woodland on flats of the Cumberland Plain, Sydney Basin Bioregion	Ecosystem	Recorded	6.67 hectares
Grey Box - Forest Red Gum grassy woodland on shale of the southern Cumberland Plain, Sydney Basin Bioregion	Ecosystem	Recorded	10.47 hectares
Phragmites australis and *Typha orientalis* coastal freshwater wetlands of the Sydney Basin Bioregion	Ecosystem	Recorded	6.17 hectares
Derived grasslands on shale hills of the Cumberland Plain (50-300m asl)	Ecosystem	Recorded	12.01 hectares
Pultenaea parviflora	Species	Recorded	4 plants
Marsdenia viridiflora subsp. *viridiflora* in the Bankstown, Blacktown, Camden, Campbelltown, Fairfield, Holroyd, Liverpool and Penrith local government areas	Species	Recorded	35 plants
Cumberland Plain Land Snail	Species	Recorded	13 hectares
Regent Honeyeater	Species	Assumed present based on presence of habitat	26.25 hectares

6.2 Biodiversity values outside the FBA

This section provides a summary of biodiversity values that occur in the study area that have not been assessed under the FBA. This includes migratory species listed under the EPBC Act (see Table 3.2).

Table 6.2 Summary of biodiversity values outside the FBA

Biodiversity value	Overview of presence within the project area and identification method (assumed, recorded, expert report)	Area/individuals within project site
Latham's Snipe	Recorded on the Defence Site Orchard Hills during field surveys	About 12.92 hectares of wetland habitat in the study area, one bird recorded in two locations on the Defence Site Orchard Hills
Cattle Egret	Recorded widely in paddocks during field surveys	Habitat widespread in grazing paddocks

7 Avoid and minimise impacts

7.1 Avoidance of impacts

Chapter 4 of the EIS describes the alternatives to the project that were considered as part of the project development process and explains how and why the project was selected as the preferred option. Chapter 4 of the EIS also outlines how particular elements of the project have been refined. A summary is provided here.

The merits of the project were considered in the context of a range of other potentially available alternatives. The alternatives considered are consistent with those considered for recent Western Sydney Infrastructure Plan (WSIP) projects and broader Sydney region motorway projects. The following alternatives to the project were considered:

- Alternative 1 – the base case / do minimum ('do minimum')
- Alternative 2 – realignment and upgrading of The Northern Road

The current alignment of The Northern Road traverses the location of the Western Sydney Airport and will not be retained within airport land following construction of the planned airport. In this case a 'do nothing' scenario would involve truncating The Northern Road north and south of the planned airport site with no provision of an alternate route between Bringelly (in the south) and Luddenham (in the north). As such, a 'do nothing' option was not considered to be a realistic alternative or representative of a base case for project decision making at this location so was not considered further.

An alternative of investing only in public transport, or a combination of public transport and road development options was not considered throughout the alternatives and options assessment process. The project would be part of WSIP, a 10 year, $3.6 billion road investment program for western Sydney that will deliver major road infrastructure upgrades to support an integrated transport solution for the region and to capitalise on the economic benefits from developing a western Sydney airport. Non road-based public transport alternatives (such as rail) would not meet key WSIP and project objectives outlined for the project. Alternative 2 considers a realistic, road-based public transport option and this was considered in the cost analysis carried out for the alternatives.

The alternatives considered have been considered and assessed based on the extent to which they could meet the project objectives and project assessment criteria and how well they performed with reference to other transport, environmental, engineering, social and economic factors. As such, non-road based public transport options have not been considered any further in this EIS.

Based on the alternatives evaluation undertaken for the project, Roads and Maritime concluded that Alternative 2 – realignment and upgrade of The Northern Road is the preferred alternative. A summary of the assessment of the preferred alternatives against the WSIP and project objectives is provided in Chapter 4 of the EIS. Alternative 2 - 'realignment and upgrade of The Northern Road ' is considered to provide the best outcome by supporting the Western Sydney Airport and catering for the growth in travel demand as a result of the planned land use changes in the region. Without the upgrades, the reduced road performance and accessibility to the area would limit the level of development that can be supported and the benefits the western Sydney airport can deliver.

7.1.1 Route options development

As outlined in Chapter 4 of the EIS, the preferred strategic alternative of realigning and upgrading The Northern Road has evolved from a series of ongoing concept developments and evaluations since 2014. The project was divided into two key segments to facilitate the development and assessment of upgrading and realignment options. These segments were:

- Segment 1: The Northern Road corridor between Littlefields Road, Luddenham and Glenmore Parkway, Glenmore Park (previously referred to as part of Stage 3). The road corridor in this section is limited by existing residential development and so route option considerations for the upgrade were limited to widening the corridor either to the west or east of the existing alignment
- Segment 2: Re-alignment of The Northern Road between Mersey Road, Bringelly and Littlefields Road, Luddenham to bypass the Western Sydney Airport (previously referred to as Stage 4). As this segment requires realigning to allow construction of a western Sydney airport at Badgerys Creek, a comprehensive route development and assessment process was undertaken.

Segment 1 - Road widening options – between Littlefields Road, Luddenham and Glenmore Parkway, Glenmore Park

The existing road reserve between Littlefield Road, Luddenham and Glenmore Parkway, Glenmore Park is generally about 40 metres wide. During early concept design it was identified that an additional 20 m of corridor may be required to provide for the proposed upgrade of The Northern Road. An Options and Scoping Value Management Workshop was held in March 2015 and attended by Roads and Maritime project team members and Penrith City Council representatives. The purpose of the workshop was to assess preliminary design options for the corridor to ensure it aligns with project objectives and stakeholder expectations.

During the Options and Scoping Value Management Workshop participants agreed that it was preferable to utilise the existing road reserve as much as possible to accommodate the road upgrade rather than investigating realignment options that would result in larger property acquisitions or property severance.

The workshop participants then gave consideration to the implication for widening to either the east or west side of the existing corridor based on potential environmental and engineering constraints. Each option was then assessed against the project objectives and project assessment criteria.

Following selection of the preferred option, the community was invited to provide feedback on the preliminary design in July and August 2015 including feedback on the access strategy.

Segment 2 - Road realignment options – Western Sydney Airport bypass

The existing alignment of The Northern Road between Mersey Road, Bringelly and Littlefields Road, Luddenham crosses a substantial portion of the Western Sydney Airport site. To enable construction of the airport, Roads and Maritime investigated preliminary route options, which comprised bypass options. In developing a long list of route options and based on preliminary desktop investigations, consideration was also given to whether or not to bypass the township of Luddenham due to the impacts road widening would have on the township.

Chapter 4 of the EIS provides a flowchart for the route options development for segment 2. A summary of the process is provided here.

A series of preliminary routes were developed by Roads and Maritime in late 2014 and early 2015 based on desktop environmental studies, engineering constraints and geometric design parameters.

A preliminary workshop was held in March 2015. The workshop was attended by Roads and Maritime project representatives and was used to review the preliminary routes against engineering and environmental constraints and to carry out a multi-criteria analysis of the preliminary routes. Constraints included land use, heritage, biodiversity, geology and the existing and planned road network. The workshop refined the preliminary route to a long list of

12 route options. The options were identified by number for ease of description and analysis. The relative cost of each long listed option was analysed.

A Short-listing Options Workshop was held in April 2015. The purpose of that workshop was to review the multi-criteria analysis applied to the 12 long listed route options and refine the long listed route options to a short-list of options to be taken forward to community engagement. The workshop included representatives from Australian, NSW and local government agencies, Roads and Maritime, and specialist engineering and environmental consultants. The participants of the workshop recommended a short-list of four options to be included in the community engagement process. As part of a broader WSIP community consultation process, the four short-listed options were presented to the community throughout July and August 2015.

During the short-listing process key areas were identified where additional field based investigations would assist in assessing the route options. Early field investigations of Aboriginal Heritage, European Heritage and Biodiversity were carried out between July and September 2015. For each of the short-listed options preliminary strategic designs and strategic cost estimates were developed.

A Preferred Option Selection Workshop was held in September 2015 to select a preferred option from the four short-listed options. The workshop included representatives from Australian, NSW and local government agencies, Roads and Maritime representatives, and specialist engineering and environmental consultants. The purpose of the workshop was to evaluate the four short-listed options against the community feedback provided and then use a multi-criteria assessment, to recommend a preferred option.

During the Preferred Option Selection Workshop Penrith City Council identified a community preference for the study area to remain a more rural community with greater connection to the Mulgoa Valley and rural villages to the west, rather than the more developed areas to the east. It was also noted that The Northern Road currently provides a boundary between the proposed employment lands associated with the WSPGA and the SWPLRA to the east and the rural lands to the west.

During the short-listing process, two of the four short-listed options clearly performed lower against the project objectives and assessment criteria. The information collected from the community consultation, field investigations and design development produced nothing that would alter the lower performance of these two options. To focus on the selection of a preferred option, a decision was endorsed by workshop participants, to only progress the two highest performing options to the multi-criteria analysis. The multi-criteria analysis assigned weightings to each criteria based on its relative importance to the overall project.

The preferred route option was then confirmed and announced to the community in November 2015.

The preferred option

The preferred option would comprise the following:

Segment1 - between Littlefields Road, Mulgoa and Glenmore Parkway, Glenmore Park

The existing The Northern Road alignment with widening generally to the east was the preferred option progressed to design development.

Segment 2 - Western Sydney Airport bypass

The preferred route option realigned the road to the west of the western Sydney airport site and to the east of Luddenham (the eastern option), before re-joining the existing road alignment at Elizabeth Drive. Subsequent to selecting the preferred option, DIRD provided in-principle agreement to use Commonwealth land on the western side of Willowdene Avenue, which meant that the southern sub option was no longer required for consideration. At this stage, Roads and Maritime continued discussions with DIRD on the availability of

Commonwealth land to the east of Willowdene Avenue for the upgrade. The preferred option that was displayed to the community included a wider corridor around the western Sydney airport site that used Commonwealth land to the west and east of Willowdene Avenue. This wider corridor would remain until DIRD provided in-principle agreement to use Commonwealth land to the east of Willowdene Avenue.

Following the selection of the preferred option, the ability to provide a higher level of access to Luddenham town centre was further considered and comprised the provision of signalised intersections. Two town access options were developed and assessed against the project objectives. The preferred access option was announced on 20 July 2016 with the release of the Strategic Design and Access Strategy for The Northern Road from Easton to Littlefields Road.

Rapid biodiversity assessment to inform final route selection for segment 2

During development of the preferred option for the Western Sydney Airport bypass portion of the project (Segment 2), a Rapid Biodiversity Assessment (RBA) was undertaken in the area of the four short listed options under consideration. The aim of the RBA was to make an initial preliminary assessment of significant ecological values potentially affected by the Segment 2 short listed options to inform decision-making for a preferred route and thus inform the concept design and Environmental Assessment. The four short-listed route options were:

- Central Option (previously Option 1)
- Campbell Street Option (previously Option 2)
- Western Option (previously Option 3B)
- Eastern Option (previously Option 9A).

Chapter 4 of the EIS provides a detailed description of each of the four short listed options.

Data collected during the field surveys undertaken for the RBA was purposefully tailored towards advancing the biodiversity survey requirements of the Environmental Assessment (EA) to be prepared for the project. In this regard, the survey method used was consistent with the sampling approach required by the FBA and the Secretary's Environmental Assessment Requirements (SEARS) for the EA. The RBA involved desktop analysis and field surveys and included plot-based vegetation condition assessment, fauna habitat assessment and targeted searches for threatened species. Identification of TECs listed under the TSC Act and EPBC Act was made through analysis of the plot data against key diagnostic characteristics described in the NSW final determinations and EPBC Act listing advice. Condition thresholds (where available) were applied to sampled vegetation patches to determine the extent and distribution of vegetation that meet the description for TECs listed under the EPBC Act.

A list of predicted species was generated from the preliminary assessment using the BioBanking Calculator (BBC) and Protected Matters Search Tool. The RBA aimed to identify the likelihood for these species to occur in the study area based on the condition of the habitat and presence of habitat features considered important for these species.

An analysis of the biodiversity data was undertaken with reference to the short listed route options proposed. The analysis was undertaken within a GIS by overlaying the short listed options onto the vegetation mapping layer that showed TECs and known or potential habitat for threatened species. Potential worst-case impacts were quantified based on a 100 metre wide corridor and considered impacts to TECs, further fragmentation of woodland, and the direct loss of vegetation / habitat.

A comparison of the impacts of the eastern and western short listed route options to threatened ecological communities is provided in Table 6.3. Impacts to TSC Act listed TECs were estimated to be greater for the eastern option. However, impacts to EPBC Act listed TECs were estimated to potentially be greater for the western option (see Table 6.3). Both

options were identified to impact on PCTs; however, the total loss of vegetation and habitat would be greatest with the eastern option.

The data collected for each option indicated that fragmentation would be comparable for each option although the western option around Duncans Creek would likely result in greater vegetation loss and fragmentation due to the traverse of the creek in two locations.

Table 6.3. Potential impacts to threatened ecological communities as identified from the rapid biodiversity assessment

Threatened ecological community	Comparative impact (ha)	
	Eastern Option	Western Option
TSC Act		
Cumberland Plain Woodland in the Sydney Basin Bioregion	22.9	21.0
River-Flat Eucalypt Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions	5.2	5.1
EPBC Act		
Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest	7.8	1.0
Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest (Potential)	6.8	10.8

7.2 Impact minimisation

Where it is not possible to avoid impacts, the project will be designed to minimise impacts as far as possible. This will include the application of measures such as road design refinements in the detailed design phase to reduce the scope of the overall impact.

An example of how ecological impacts can be minimised during the detailed design phase is via the use of retaining walls rather than embankments to reduce the overall project footprint, and incorporating design features such as bridges rather than culverts to minimise impacts.

8 Impact assessment

8.1 Areas requiring assessment under the FBA

In accordance with the FBA, areas that do not require assessment include land without native vegetation (as per the definition under the *Native Vegetation Act 2003*), unless the area of land requires assessment under the SEARs. As identified in the FBA, areas within the development footprint that do not require offsets to be calculated include:

- Impacts on PCTs that:
  - Have a site value score <17, or
  - Are not identified as critically endangered ecological communities (CEECs) or endangered ecological communities (EECs).
- Impacts on PCTs that are not associated with threatened species habitat and are not identified as CEECs/EECs
- Impacts on non-threatened species and populations that do not form part of a CEEC or EEC
- Impacts on threatened species habitat associated with a PCT within a vegetation zone with a site value score <17.

One vegetation zone within the development footprint (Vegetation zone 4, Grey Box - Forest Red Gum grassy woodland on flats of the Cumberland Plain, Sydney Basin Bioregion – Moderate/Good_Poor condition) was identified as having a site value score of less than 17 (this vegetation zone had a score of 15.94, see Section 3.4). As such, impacts to this vegetation zone do not require assessment.

The areas that require assessment are described below.

8.1.1 Removal of native vegetation

Vegetation clearance and habitat loss are likely to be the largest impacts for terrestrial biodiversity that may arise from the project. The impact may be direct in the form of vegetation and habitat removal, or indirect, as fauna may not survive due to shortages in available habitat resources. Even small-scale clearing within largely intact patches of vegetation can cause localised depletion of some species.

The potential loss of vegetation and habitat associated with the project is summarised in Table 8.1. The construction footprint would impact on up to about 39.61 hectares of remnant native vegetation (see Table 8.1). These impacts have been quantified based on the development footprint and take into consideration potential temporary disturbance during construction including compound sites and upgrading of drainage.

Mitigation measures designed to reduce the impact of vegetation removal are provided in Section 9.

Table 8.1 Impacts to native vegetation

Vegetation zone	PCT	Condition	Status (TSC Act)	Percent cleared in CMA	Area to be impacted (ha)
1	Grey Box - Forest Red Gum grassy woodland on flats of the Cumberland Plain, Sydney Basin Bioregion	Moderate/ Good	CEEC	95%	6.67
2	Forest Red Gum - Rough-barked Apple grassy woodland on alluvial flats of the Cumberland Plain, Sydney Basin Bioregion	Moderate/ Good	EEC	95%	2.53
3	Grey Box - Forest Red Gum grassy woodland on shale of the southern Cumberland Plain, Sydney Basin Bioregion	Moderate/ Good	CEEC	90%	4.92
5	Grey Box - Forest Red Gum grassy woodland on shale of the southern Cumberland Plain, Sydney Basin Bioregion	Moderate/Good_Poor	CEEC	90%	3.21
6	Forest Red Gum - Rough-barked Apple grassy woodland on alluvial flats of the Cumberland Plain, Sydney Basin Bioregion	Moderate/Good_Poor	EEC	95%	1.76
7	Grey Box - Forest Red Gum grassy woodland on shale of the southern Cumberland Plain, Sydney Basin Bioregion	Moderate/Good_High	CEEC	90%	1.25
8	Derived grasslands on shale hills of the Cumberland Plain (50-300m asl)	Moderate/Good_Derived grassland	CEEC	-	12.01
9	*Phragmites australis* and *Typha orientalis* coastal freshwater wetlands of the Sydney Basin Bioregion	Moderate/Good_Other	-	70%	6.17
10	Grey Box - Forest Red Gum grassy woodland on shale of the southern Cumberland Plain, Sydney Basin Bioregion	Moderate/Good_Medium	CEEC	90%	1.09
				Total vegetation removal to be assessed	**39.61**

8.1.2 Removal of threatened fauna species habitat and habitat features

There is about 49.58 hectares of suitable habitat (vegetation in moderate to good condition including where live snails or shells were found during the field survey) for the Cumberland Plain Land Snail in the study area. Of the known habitat for the Cumberland Plain Land Snail within the study area, the development footprint is predicted to impact on about 13 hectares.

There is about 85.43 hectares of potential habitat for the Regent Honeyeater within the study area. This species is known to utilise low condition vegetation and paddock trees so the area of potential habitat in the study area is extensive. The development footprint is predicted to impact on 26.25 hectares of potential habitat for the Regent Honeyeater. Of this predicted impact, about 15.36 hectares is moderate to high condition habitats.

The potential impacts to identified species credit fauna species is summarised in Table 8.2.

Table 8.2 Summary of threatened fauna species impacts

Threatened species	Ecosystem or species credit species	Status		Potential habitat or individuals to be impacted	Potential habitat or individuals in the study area
		TSC Act	EPBC Act		
Cumberland Plain Land Snail	Species credit species	Endangered	Not listed	13 hectares	49.58 hectares
Regent Honeyeater	Species credit species	Critically endangered	Critically endangered	26.25 hectares	85.43 hectares

8.1.3 Removal of threatened plants

There will be an impact to the following threatened plant and endangered population:

- *Pultenaea parviflora* (Endangered – TSC Act)
- *Marsdenia viridiflora* subsp. *viridiflora* population in the Bankstown, Blacktown, Camden, Campbelltown, Fairfield, Holroyd, Liverpool and Penrith local government areas (Endangered population – TSC Act).

The predicted impact to *Pultenaea parviflora* and the *Marsdenia viridiflora* subsp. *viridiflora* endangered population are outlined below in Table 8.3. The construction footprint contains (and therefore will remove) all known individuals and habitat for the *Marsdenia viridiflora* subsp. *viridiflora* endangered population in the study area. The construction footprint will also remove all known *Pultenaea parviflora* plants in the study area.

Table 8.3 Summary of threatened plant species impacts

Threatened species	Ecosystem or species credit species	Status		Habitat or individuals to be impacted	Habitat or individuals in the study area
		TSC Act	EPBC Act		
Pultenaea parviflora	Species credit species	Endangered	Vulnerable	4 individuals	4 individuals
Marsdenia viridiflora subsp. *viridiflora* – endangered population	Species credit species	Endangered population	Not listed	35 individuals	35 individuals

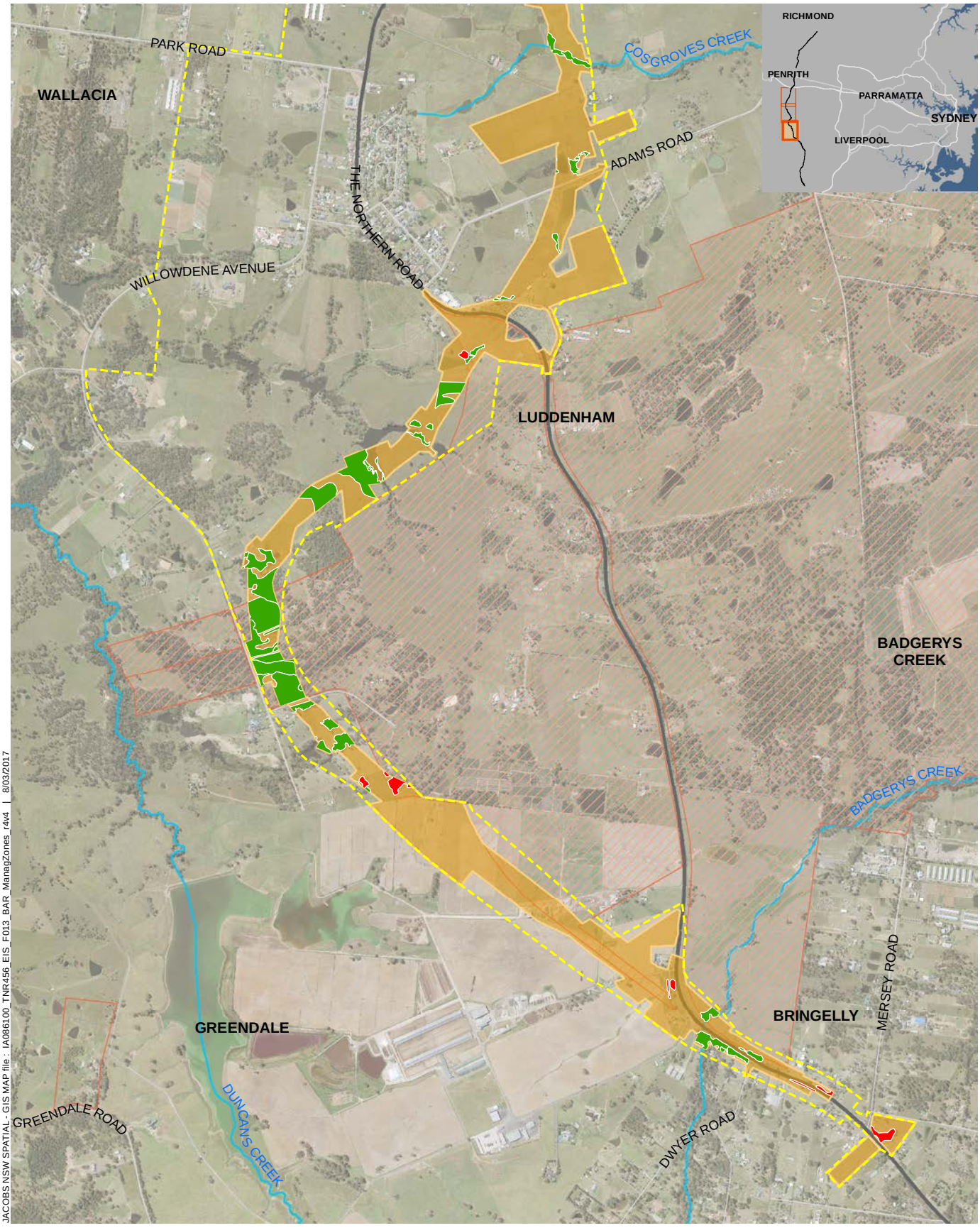

Figure 8-1 | Areas requiring assessment (management zones)

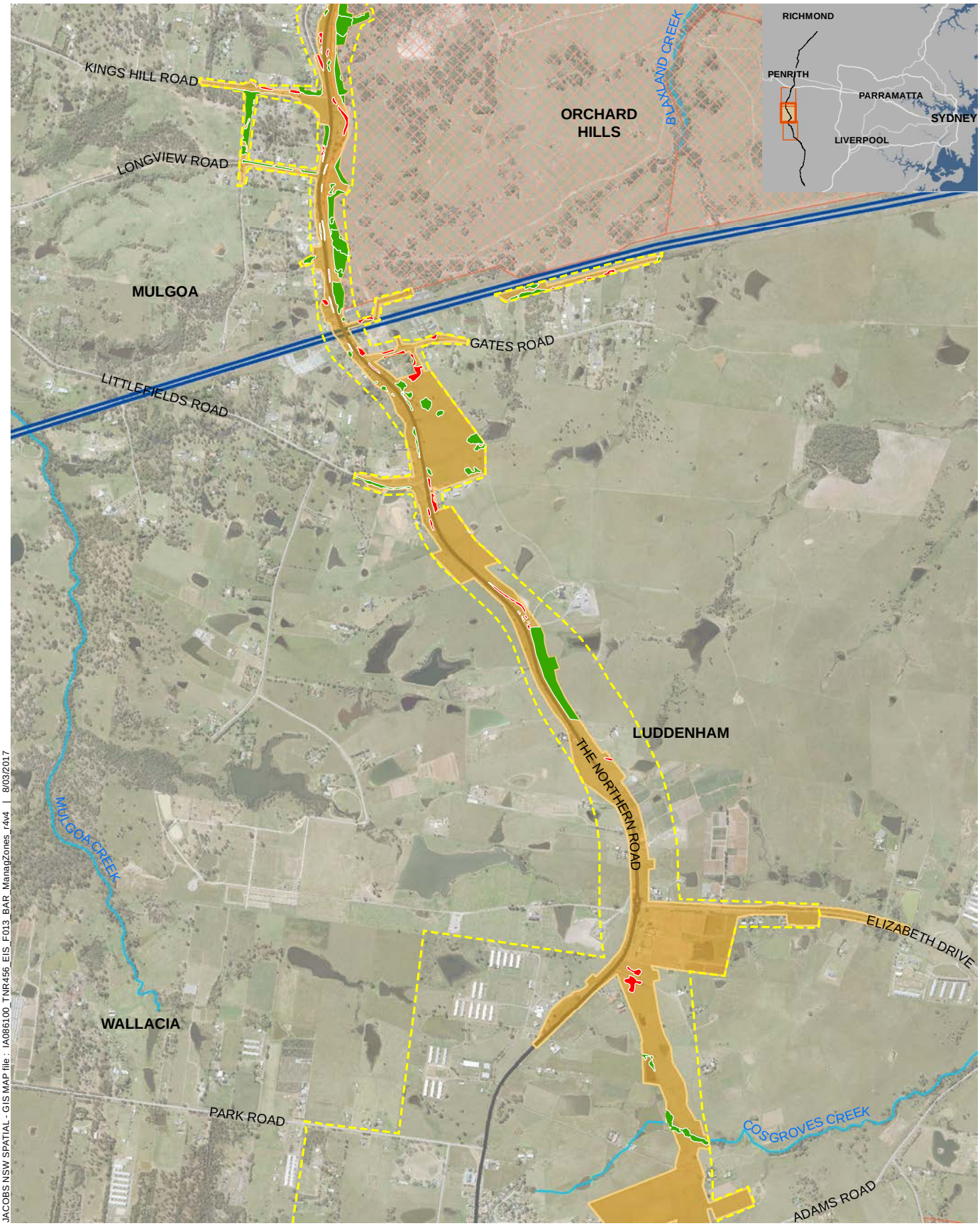

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Figure 8-1 | Areas requiring assessment (management zones)

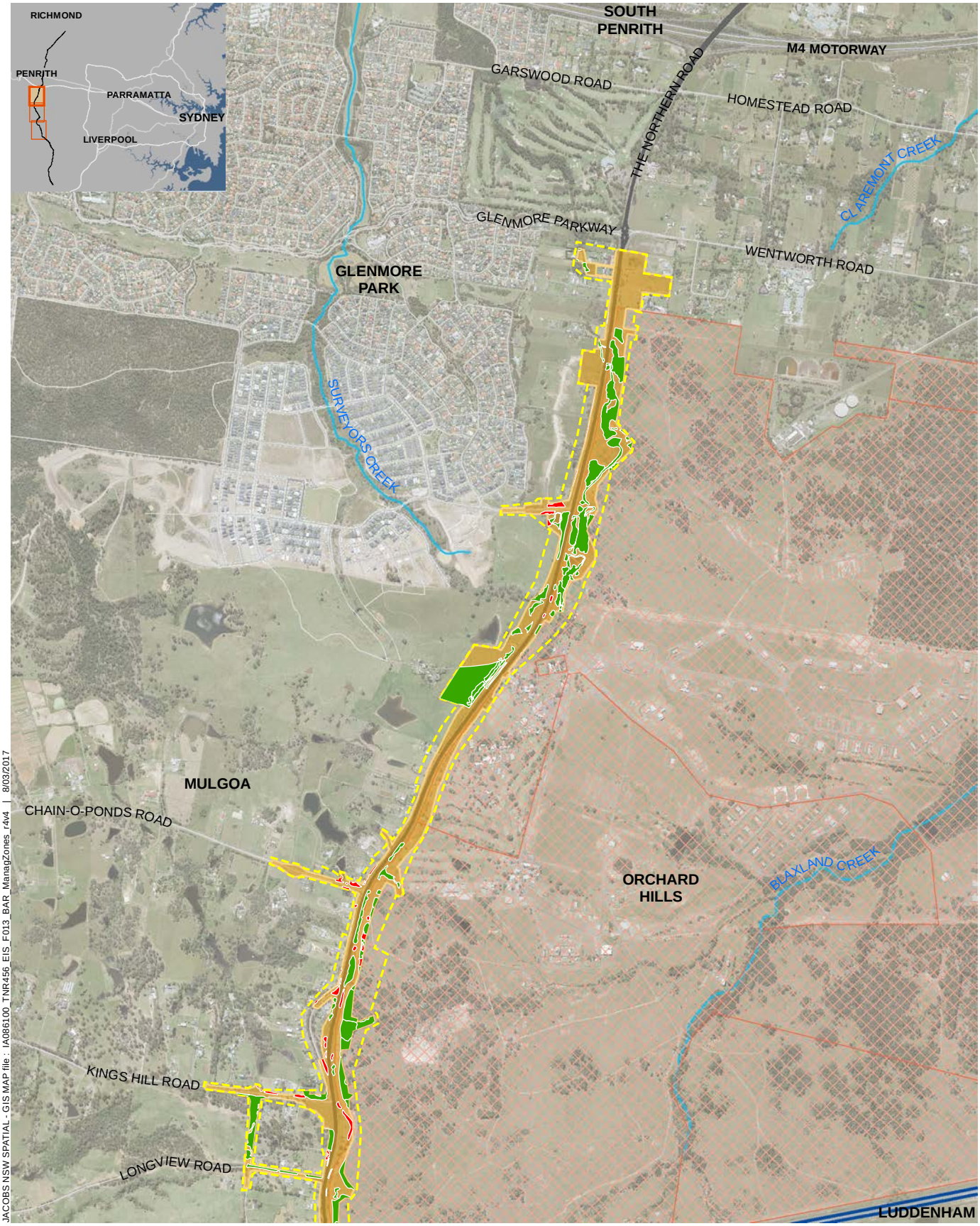

Figure 8-1 | Areas requiring assessment (management zones)

8.2 Matters for further consideration

8.2.1 Landscape features

There are no landscape features that are matters for further consideration.

8.2.2 Native vegetation

No TECs were nominated in the SEARs for further consideration.

While there will be an impact to a CEEC (Cumberland Plain Woodland), the project is considered unlikely to cause the extinction of this CEEC from the IBRA subregion. The project is however, considered likely to significantly reduce the viability of the Cumberland Plain Woodland. In accordance with the FBA, impacts on this CEEC are a matter for further consideration.

The following information is presented for further consideration of impacts to the Cumberland Plain Woodland in the Sydney Basin Bioregion CEEC:

(a) the area and condition of the CEEC or EEC to be impacted directly and indirectly by the proposed development

The area and condition of the Cumberland Plain Woodland to be impacted directly by the project is outlined below in Table 8.3. About 29.14 hectares of this CEEC will be directly impacted by the project. Of this, about 1.25 hectares is considered to be in high condition and about 11.58 in moderate/good condition (see Table 8.4). There will also be impacts to about 11.96 hectares of derived native grasslands.

Within the study area, and construction footprint, many patches of vegetation are small, irregularly shaped, and fragmented. As such, many areas of vegetation within and directly adjacent to the construction footprint are already subject to considerable edge effects. However, in the area between The Northern Road and Willowdene Avenue, the construction footprint crosses through a local vegetation corridor that contains some high quality patches of Cumberland Plain Woodland.

It is in this area that the greatest potential for edge effects resulting from the project exists. Using an edge effect buffer zone of 50 metres from the edge of the construction footprint, edge effects from the project are estimated to only indirectly impact vegetation at the edges of patches which are already subject to considerable edge effects. The core of the Cumberland Plain Woodland vegetation will be removed by the construction activities leaving the edges which are not expected to be impacted from edge effects any further.

Table 8.4 Summary of direct impacts to Cumberland Plain Woodland CEEC

PCT	Condition	Status (TSC Act)	Percent cleared in CMA	Area to be impacted (ha)
Grey Box - Forest Red Gum grassy woodland on flats of the Cumberland Plain, Sydney Basin Bioregion	Moderate/Good	CEEC	95%	6.67
Grey Box - Forest Red Gum grassy woodland on shale of the southern Cumberland Plain, Sydney Basin Bioregion	Moderate/Good	CEEC	90%	4.91

PCT	Condition	Status (TSC Act)	Percent cleared in CMA	Area to be impacted (ha)
Grey Box - Forest Red Gum grassy woodland on shale of the southern Cumberland Plain, Sydney Basin Bioregion	Moderate/Good_Poor	CEEC	90%	3.21
Grey Box - Forest Red Gum grassy woodland on shale of the southern Cumberland Plain, Sydney Basin Bioregion	Moderate/Good_High	CEEC	90%	1.25
Derived grasslands on shale hills of the Cumberland Plain (50-300m asl)	Moderate/Good_Derived grassland	CEEC	-	12.01
Grey Box - Forest Red Gum grassy woodland on shale of the southern Cumberland Plain, Sydney Basin Bioregion	Moderate/Good_Medium	CEEC	90%	1.09
Total impact to Cumberland Plain Woodland				**29.14**

(b) the extent and overall condition of the CEEC or EEC within an area of 1,000 ha and then 10,000 ha surrounding the proposed development footprint.

The extent of Cumberland Plain Woodland within an area of 1,000 hectares and 10,000 hectares surrounding the proposed development footprint has been estimated using a GIS and available regional mapping (Tozer, 2003) as follows:

- There are about 136 hectares of Cumberland Plain Woodland mapped within 1,000 hectares of the development footprint
- There are about 2,053 hectares of Cumberland Plain Woodland mapped within 10,000 hectares of the development footprint.

(c) an estimate of the extant area and overall condition of the CEEC or EEC remaining in the IBRA subregion after the impact of the proposed development has been taken into consideration

The extent of Cumberland Plain Woodland remaining within the Cumberland subregion has been estimated using a GIS and available regional mapping (Tozer, 2003). There are about 24,422 hectares of Cumberland Plain Woodland mapped within the Cumberland subregion. Of this mapped Cumberland Plain Woodland, about 10,877 hectares has a canopy cover of greater than 10 percent and considered to be in moderate/good condition. About 13,545 hectares of this mapped vegetation has a canopy cover of less than 10 percent and is considered to be in lower condition.

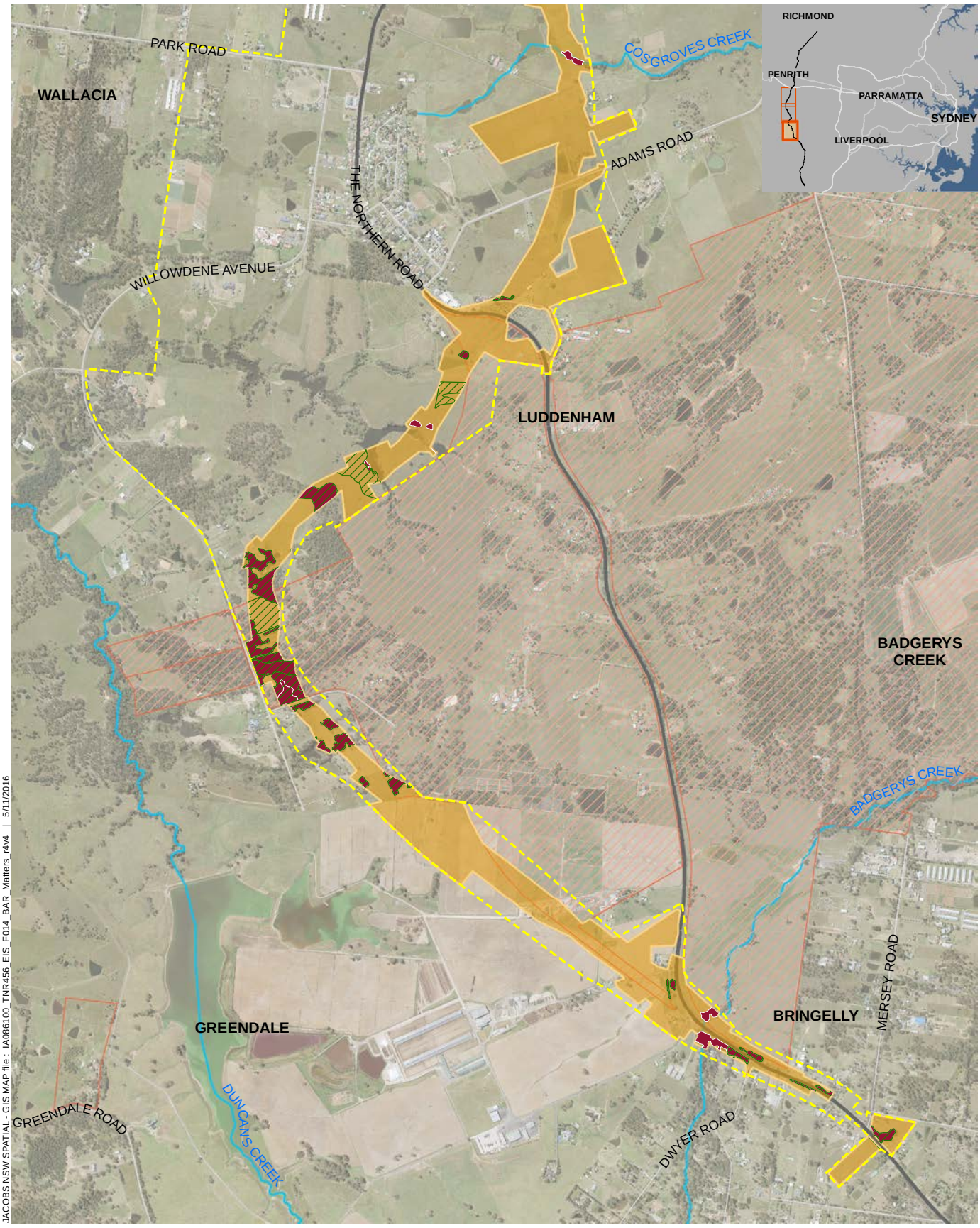

Figure 8-2 | Location of matters for further consideration

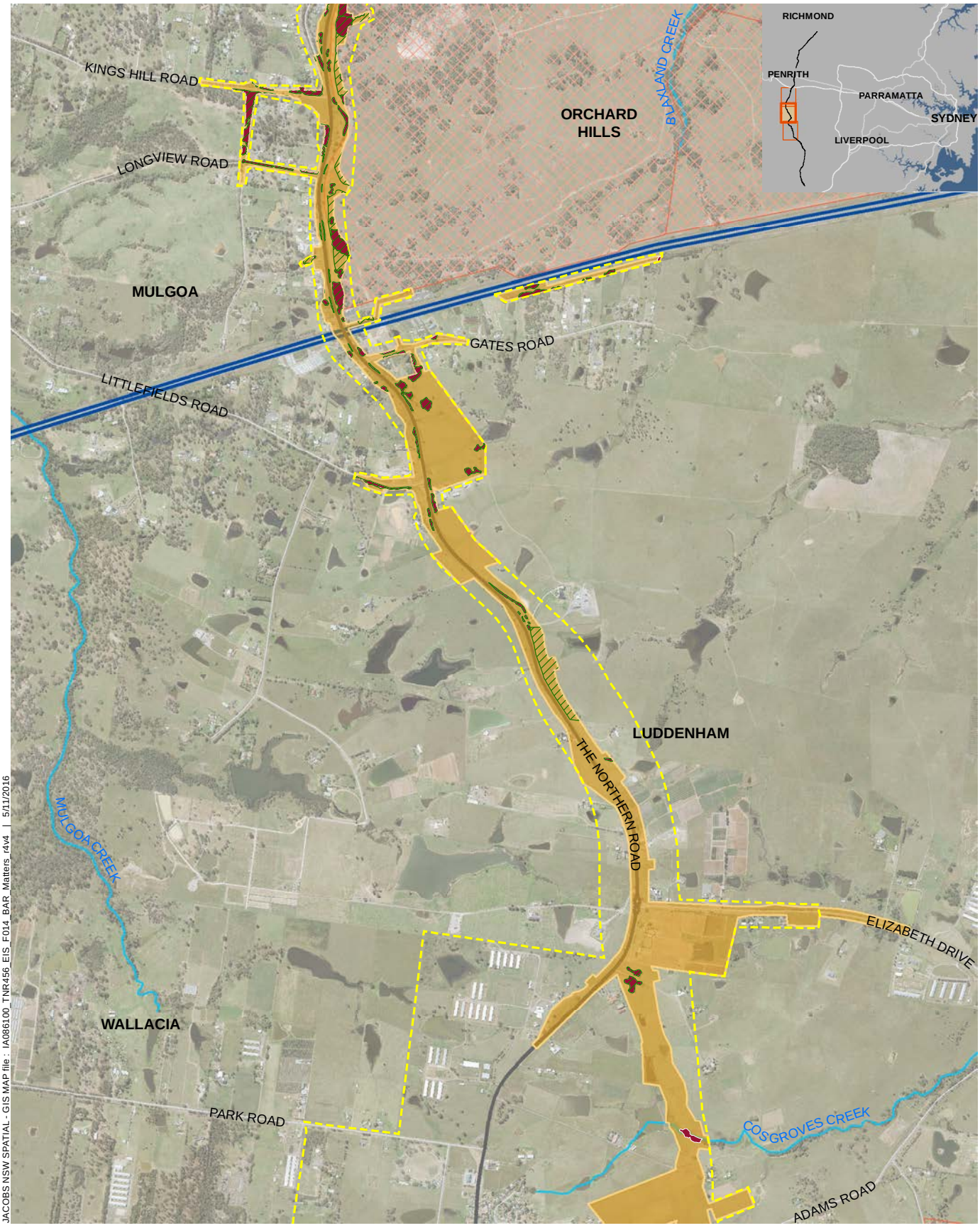

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Figure 8-2 | Location of matters for further consideration

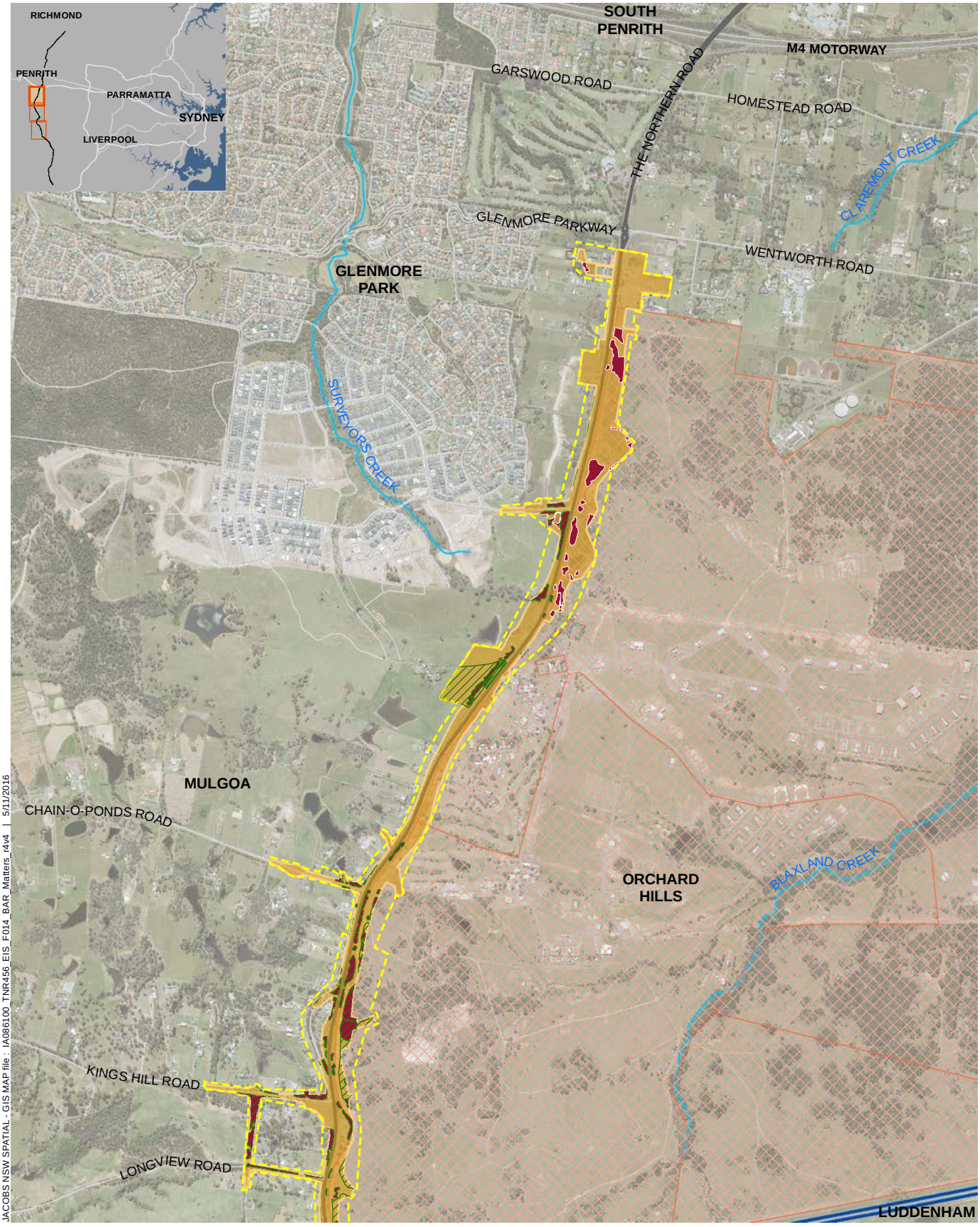

Figure 8-2 | Location of matters for further consideration

(d) the development proposal's impact on:

(i) abiotic factors critical to the long-term survival of the CEEC or EEC. For example, will the impact lead to a reduction of groundwater levels or substantial alteration of surface water patterns?

Where Cumberland Plain Woodland will be removed by the action, all abiotic factors (i.e. water, nutrients and soil) will be permanently modified and/or destroyed through vegetation removal and construction of infrastructure.

Cumberland Plain Woodland is not a GDE and no impact to groundwater levels are expected (see Section 3.4). Chapter 7 of the EIS outlines the hydrology and flooding assessment undertaken for the project. Overall, potential impacts on surface water quality during construction are considered minor and manageable with the application of standard mitigation measures (see Section 9).

(ii) characteristic and functionally important species through impacts such as, *but not limited to*, inappropriate fire/flooding regimes, removal of understorey species or harvesting of plants

The composition of Cumberland Plain Woodland is likely to be modified as a result of the action through weed invasion and removal of vegetation. The patches of Cumberland Plain Woodland are in poor to high condition and a reduction in ecological function can be expected from the action in the form of:

- altered community structure
- altered species composition
- disruption of ecological processes (e.g. altered drainage)
- invasion and establishment of exotic species
- degradation of habitat
- fragmentation of habitat.

The extent to which change in species composition of Cumberland Plain Woodland will occur cannot be predicted. However, ecological function will be altered, particularly where the action will sever connectivity of patches. Functionally important species such as pollinators may be prevented from accessing newly created fragments of Cumberland Plain Woodland. Fauna connectivity will be effectively broken by the hard barrier of the road. Weed invasion will encroach into the newly created fragments from the road edge and weed species, particularly grasses, will replace functionally important native groundcover species. This will result in altered community structure and species composition in what are currently high quality patches of Cumberland Plain Woodland and a substantial change to species composition can be expected including potential loss of functionally important species in the ground layer.

(iii) the quality and integrity of an occurrence of the CEEC or EEC through threats and indirect impacts including, *but not limited to*, assisting invasive flora and fauna species to become established or causing regular mobilisation of fertilisers, herbicides or other chemicals or pollutants which may harm or inhibit growth of species in the CEEC or EEC.

Weed introduction and spread and the infection of native plants by *Phytophthora cinnamomi* have been identified as being spread by construction machinery. Phytophthora infects the roots of plants and has the potential to cause dieback. Machinery associated with vegetation clearance and subsequent construction for the project has the potential to introduce and transmit weed propagules and Phytophthora to remaining native vegetation remnants. This is a potential indirect impact through the spread and transmission of weeds and pathogens into retained habitat near the road.

This can be mitigated through the development and implementation of suitable control measures for vehicle and plant hygiene but an impact, particularly from weeds, is likely. It is the intention to use current best practice hygiene protocols on this project as part of the CEMP to prevent the introduction or spread of weeds and pathogens. The project mitigation strategy and environmental management procedures would include guidance for preventing the introduction and/or spread of weeds and disease causing agents such as bacteria and fungi.

There may be regular mobilisation of fertilisers, herbicides or other chemicals during routine roadside vegetation maintenance. However, Roads and Maritime will implement standard management measures to ensure off site damage form herbicide application is minimised. As such, a substantial reduction in the quality or integrity of Cumberland Plain Woodland is not considered likely from herbicide spraying at the roadside edge.

(e) direct or indirect fragmentation and isolation of an important area of the CEEC or EEC.

Due to the linear nature of the project, it will result in fragmentation of a relatively large patch of Cumberland Plain Woodland on private property off Willowdene Avenue. The project will sever the current connectivity in this area by the introduction of a hard barrier in the form of an eight lane road.

Habitat connectivity will be altered during and after construction. There may be declines in population density and/or species richness within the remaining vegetation patches as a result of the project. There may also be an alteration to community composition, altered species interactions, and altered or ecosystem functioning in the locality due to the action. Habitat fragmentation is considered an important impact of the project (see Section 8.7.3).

(f) the measures proposed to contribute to the recovery of the CEEC or EEC in the IBRA subregion.

The *Cumberland Plain Recovery Plan* (Department of Environment Climate Change and Water, 2010) has been prepared with the overall objective provide for the long-term survival of the threatened biodiversity of the Cumberland Plain. Working alongside the recovery plan is the Cumberland subregion Biodiversity Investment Opportunities Map (BIO Map). This map aims to achieve better biodiversity outcomes in western Sydney by directing biodiversity investment funding to the strategic locations of greatest benefit. The areas identified for investment, termed priority investment areas, include core areas and biodiversity corridors of state and regional significance.

The project will impact on Regional Corridor 17 as identified in the BIO Map and the area of Priority Conservation Land identified in the recovery plan which is mapped on the Defence Establishment Orchard Hills. As the project will impact on an area of mapped Priority Conservation Land and Regional Corridor 17 as mapped by the BIO Map, the project can be considered likely to interfere with the measures proposed for recovery of Cumberland Plain Woodland.

8.2.3 Species and populations

There are no threatened species or endangered populations nominated for further consideration in the SEARs.

There will be no impacts on areas of land that the NSW Minister for Environment has declared as critical habitat in accordance with section 46 of the TSC Act and which is listed on the Register of Critical Habitat in NSW. However, there will be an impact to potential habitat for the critically endangered Regent Honeyeater and this is considered a matter for further consideration.

The following information is presented for further consideration of impacts to the critically endangered Regent Honeyeater:

(a) the size of the local population directly and indirectly impacted by the development

There are no resident local populations of the Regent Honeyeater that reside in the study area.

In 2011, the Regent Honeyeater's population was estimated with medium reliability at 350–400 mature birds. The majority of these birds exist in the Bundarra-Barraba area and the Capertee Valley in NSW, and north-eastern Victoria (Department of the Environment, 2016a). It is not possible to estimate the proportion of birds from the population that may use the habitat in the study area. However, the study area is not a known core habitat and it is unlikely that a significant proportion of the Regent Honeyeater population would use the habitat in the study area. The habitat within the study area is considered to be secondary habitat for the Regent Honeyeater as this species is not regularly recorded from the area and the study area is not known as critical habitat for this species.

(b) the likely impact (including direct and indirect impacts) that the development will have on the habitat of the local population, including but not limited to:

(i) an estimate of the change in habitat available to the local population as a result of the proposed development

The impacts from the project to the Regent Honeyeater are limited to seasonal forgaing habitat. The project is predicted to impact on about 26.25 hectares of potential forgaing habitat for the species. Within the study area, this potential loss of habitat represents about 31 percent of the available habitat for the species. Within the Cumberland subregion, this potential habitat removal represents less than 0.1 percent of the currently available habitat for the species.

(ii) the proposed loss, modification, destruction or isolation of the available habitat used by the local population, and

The project is predicted to impact on about 26.25 hectares of potential forgaing habitat for the Regent Honeyeater.

The project will not result in fragmentation or isolation of habitat for the Regent Honeyeater. This species is highly mobile and capable of long distance flight. However, movements between breeding populations are not frequent and most birds appear to remain in the breeding areas of Bundarra-Barraba area and the Capertee Valley in NSW, and north-eastern Victoria. The project is considered unlikely to fragment the existing Regent Honeyeater population as movement corridors between the three main populations will still remain after the road has been built.

(iii) modification of habitat required for the maintenance of processes important to the species' life cycle (such as in the case of a plant – pollination, seed set, seed dispersal, germination), genetic diversity and long-term evolutionary development.

Key habitats for the Regent Honeyeater include key breeding areas such as the Chiltern section of Chiltern-Mt Pilot National Park (NP), north-east Victoria; Capertee Valley, central east NSW; and the Bundarra-Barraba region, northern NSW. Other breeding areas include the Wangaratta-Mansfield region, Victoria; Warrumbungle NP, Pilliga forests and Mudgee-Wollar region, central north NSW; Hunter Valley and Clarence Valley, east NSW; and south-east Queensland. The study area is not situated in a key breeding area for the Regent Honeyeater. The habitat within the study area is considered to be secondary habitat for the Regent Honeyeater as this species is not regularly recorded from the area (according to records from the OEH Atlas) and the study area is not known as critical habitat.

The habitat within the study area is not considered likely to be of critical importance for the maintenance of processes important to the species life cycle, genetic diversity or long-term evolutionary development.

(c) the likely impact on the ecology of the local population. At a minimum, address the following:
(i) for fauna:
- **– breeding**
- **– foraging**
- **– roosting, and**
- **– dispersal or movement pathways**

Key breeding areas for the Regent Honeyeater include the Chiltern section of Chiltern-Mt Pilot National Park (NP), north-east Victoria; Capertee Valley, central east NSW; and the Bundarra-Barraba region, northern NSW. Other breeding areas include the Wangaratta-Mansfield region, Victoria; Warrumbungle NP, Pilliga forests and Mudgee-Wollar region, central north NSW; Hunter Valley and Clarence Valley, east NSW; and south-east Queensland. The study area is not situated in a key breeding area for the Regent Honeyeater. The habitat within the study area is considered to be secondary habitat for the Regent Honeyeater as this species is not regularly recorded from the area and it is not known as critical habitat.

8.2.4 Critical habitat

There are no areas of land within the study area that the NSW Minister for the Environment has declared 'critical habitat' in accordance with section 47 of the TSC Act and that are listed on the Register of Critical Habitat in NSW.

8.3 Matters of National Environmental Significance

8.3.1 Listed ecological communities

Calculations of the extent of direct clearing required represent a worst case scenario based on the construction footprint that has scope to be reduced at the detailed design stage. Based on the estimated construction footprint, the project would result in the direct clearing of about 16.37 hectares of the critically endangered Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest ecological community (CPSWSGTF).

This clearing includes:

- 10.69 hectares of core Category A vegetation
- 1.47 hectares of Category C vegetation
- 4.21 hectares of Category C Derived Native Grassland.

The larger and more diverse a patch of CPSWSGTF is, the greater the likely biodiversity value and its sustainability. The action will impact on patches larger than five hectares in size. The patches to be impacted are high quality (up to 96 percent native groundcover, native species richness of up to 47 species in a plot). Additionally, the action will impact on local links which connect patches of vegetation.

The local, regional, state and national occurrence of CPSWSGTF is not exactly known as this ecological community is not reliably mapped and its presence cannot be determined without on ground survey. The study area has been mapped to contain 121.7 hectares of the TSC Act listed Cumberland Plain Woodland and this can be used to develop an indication of the local impact. The local impact to CPSWSGTF (i.e. the impact to CPSWSGTF in the study area) is estimated at about 13% of the local occurrence. The extent of TSC Act listed Cumberland Plain Woodland within an area of 10,000 hectares (a regional extent) surrounding the proposed development footprint has been estimated using a GIS based on available regional mapping (Tozer, 2003) and there are about 2,053 hectares of TSC Act Cumberland Plain Woodland mapped within 10,000 hectares of the development footprint. Not all of this vegetation will be high enough quality to be part of the EPBC Act listed CPSWSGTF.

However, based off available mapping, the proportion regional impact to CPSWSGTF from the project is estimated at about 0.8 per cent.

The *Commonwealth Listing Advice on Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest* (Threatened Species Scientific Committee, 2009) indicates that as of 2009 the CPSWSGTF ecological community occupied a maximum area of about 12,300 hectares but is highly fragmented into generally small remnants, mostly under 10 hectares in size. The CPSWSGTF ecological community is limited to the Sydney Basin Bioregion with most occurrences in the Cumberland Sub-region. As such, this is a geographically limited ecological community and the state and national extent is estimated at 12,300 hectares. As such, the project is estimated to have a proportional impact on the state and national scale of about 0.13%. The CPSWSGTF ecological community is not found outside of Australia so international scale impacts cannot be considered.

An overall conclusion has been made that the action is likely to result in a significant impact to the critically endangered CPSWSGTF as it will:

- Reduce the extent of the CEEC by about 16.37 hectares
- Adversely affect habitat critical to the survival of the CEEC
- Modify or destroy abiotic (non-living) factors (such as water, nutrients, or soil) necessary for the CEECs survival
- Cause a substantial change in the species composition of an occurrence of the CEEC, including causing a decline or loss of functionally important species
- Cause a substantial reduction in the quality or integrity of an occurrence of an ecological community, particularly form potential weed invasion
- Interfere with the recovery of an ecological community.

The assessment of significance for CPSWSGTF is provided in Appendix F.

Due to the likely significant impact to the critically endangered CPSWSGTF ecological community, offsets are required to compensate for the impacts of the project. Offsets for the CEEC will be provided in accordance with the FBA (OEH 2014) on a 'like for like' basis.

Mitigation measures to manage direct and indirect impacts to CPSWSGTF are outlined in Section 9.

8.3.2 Listed threatened flora species

The proposed action would result in the direct clearing of three *Pultenaea parviflora* plants for the construction of batters. The area of surrounding habitat likely to possess a soil seedbank for this species is about 0.98 hectares. All four *Pultenaea parviflora* plants and the soil seedbank in the immediate area of the plants would be removed by the action.

The definition of an important population as provided in the *Matters of National Environmental Significance Significant Impact Guidelines 1.1* (Department of the Environment, 2013) is "… a population that is necessary for a species' long-term survival and recovery. This may include populations identified as such in recovery plans, and/or that are:

- key source populations either for breeding or dispersal
- populations that are necessary for maintaining genetic diversity, and/or
- populations that are near the limit of the species range".

The sub-population of *Pultenaea parviflora* within the study area is unlikely to be a key source population for breeding or dispersal as it is very small (four plants) and isolated from the other main population centres for this species. The sub-population within the study area is likely to

be part of the larger population on the Defence Establishment Orchard Hills. The sub-population of *Pultenaea parviflora* within the study area is, however, is at the south western edge of the species' range in the Sydney Basin Bioregion and may possess genetic diversity unlike more central populations. The removal of these three plants would contract the known range of this species to about three kilometres to the east as the closest known population is in the Defence Establishment Orchard Hills. As such, the population of *Pultenaea parviflora* within the study area can be considered as important.

Pultenaea parviflora is confined to the Cumberland Plain so impacts beyond the regional extent cannot be calculated. The regional impact will be equal to the state and national impact. The local *Pultenaea parviflora* population, to which the impacted sub-population belongs, is located about 3 kilometres to the east of the development footprint within the Defence Establishment Orchard Hills. This larger core population contains at least 1,700 plants (based on data from the OEH Atlas). As such, the proportional local impact to *Pultenaea parviflora* is estimated at 0.2%. *Pultenaea parviflora* populations in the region have been recorded as containing between 10 and 5000+ individuals (Department of the Environment, 2016c). The absolute number of *Pultenaea parviflora* individuals in the region is not known. Based on a population of 5,000 individuals the proportional regional impact is estimated at 0.08%.

A 'significant impact' is defined as an impact which is important, notable, or of consequence, having regard to its context or intensity (Department of the Environment, 2013). Whether or not an action is likely to have a significant impact depends upon the sensitivity, value, and quality of the environment which is impacted, and upon the intensity, duration, magnitude and geographic extent of the impacts (Department of the Environment, 2013).

Given the conservation status of this species (vulnerable) and the low magnitude of the impact, an overall conclusion has been made that the action is unlikely to result in a significant impact to *Pultenaea parviflora*. A significant impact to *Pultenaea parviflora* is not predicted for the following reasons:

- The larger core population, to which the impacted sub-population belongs, will still exist about three kilometres to the east within the Defence Establishment Orchard Hills. There is also potential for additional *Pultenaea parviflora* plants from the sub-population to be present on private property further to the west of the study area (e.g. Lot 23 and Lot 85 Longview Road Mulgoa, 99 Vineyard Rd Mulgoa). Overall, the removal of three plants form this apparent outlying sub-population will not lead to a long-term decrease in the size of the important population.
- The project will not result in the breaking apart of large blocks of high quality habitat for Pultenaea parviflora and will not fragment a continuous population of *Pultenaea parviflora*.
- The area of habitat to be impacted by the project is directly adjacent to the Northern Road in the road reserve. In the context of existing larger populations and areas of habitat that are clearly more critical to the survival of this species, the habitat to be affected is not considered critical.
- While the project will disrupt the breeding cycle of the *Pultenaea parviflora* sub-population, the breeding cycle of the overall core population will continue.
- The project will result in a small decrease in the availability of habitat for *Pultenaea parviflora* of about 0.98 hectares. This habitat represents about 0.7 per cent of the 126 hectares of suitable habitat for the core population on the Defence Establishment Orchard Hills. Removal of 0.98 hectares of habitat is unlikely to be so detrimental as to cause this species to decline.

The assessment of significance for *Pultenaea parviflora* undertaken according to the *EPBC Act Policy Statement 1.1 Significant Impact Guidelines* (Department of Environment, 2013) is provided in Appendix F.

Mitigation measures to manage direct and indirect impacts to listed threatened flora species are outlined in Section 9.

8.3.3 Listed threatened terrestrial fauna species

The Grey-headed Flying-fox was recorded in one location on private property off Willowdene Avenue during spotlight surveys.

Three of the 19 threatened fauna species identified in the EPBC PMST report were identified as having a moderate to high likelihood of occurring within the study area (these species were not recorded during the survey). These included:

- Regent Honeyeater
- Swift Parrot
- Large-eared Pied Bat.

The populations of the Large-eared Pied Bat and Grey-headed Flying-fox would be considered 'important' as defined under the EPBC Act. For the Large-eared Pied Bat, recognised important populations that support higher numbers of individuals include those present in the sandstone escarpments of the Sydney Basin. Any Large-eared Pied Bats that would forage in the study area are likely to roost in the sandstone escarpments of the lower Blue Mountains. As such, the population of Large-eared Pied Bat that may utilise the study area is considered to be important. The Grey-headed Flying-fox exists as a single interconnected population in Australia. As such, it is considered an important population.

A significant impact to these four species from the action is considered unlikely.

The Regent Honeyeater and Swift Parrot will suffer a reduction in extent of marginal foraging habitat from the project of about 26.25 hectares. Within the study area, this potential loss of local foraging habitat represents about 31 percent of the available habitat for these species. Within the Cumberland subregion, this potential habitat removal represents less than 0.1 percent of the currently available habitat for these species in the region. The state and national extent of habitat for these species is not known but the proportional impacts from the project to habitat at these scales will be less than 0.1%. The impacts are predicted to be minimal as these species are unlikely to use the study area consistently. The project is unlikely to reduce the population size of the Regent Honeyeater or Swift Parrot or decrease the reproductive success of these species as no breeding habitat will be affected. The action will not interfere with and key breeding sites or foraging areas and will not interfere with the recovery of these species. Appendix F contains the assessments of significance for these species undertaken according to the *EPBC Act Policy Statement 1.1 Significant Impact Guidelines* (Department of Environment, 2013).

The *National Recovery Plan for the Regent Honeyeater (Anthochaera phrygia)* (Commonwealth of Australia, 2016) contains four overarching strategies for recovery of the Regent Honeyeater as follows:

- Strategy 1: Improve the extent and quality of regent honeyeater habitat
- Strategy 2: Bolster the wild population with captive-bred birds until the wild population becomes self-sustaining.
- Strategy 3: Increase understanding of the size, structure and population trends of the wild population of regent honeyeaters
- Strategy 4: Maintain and increase community awareness, understanding and involvement in the recovery program.

Action 1c as identified in the *National Recovery Plan for the Regent Honeyeater (Anthochaera phrygia)* (Commonwealth of Australia, 2016) is to protect intact (high quality) areas of Regent Honeyeater breeding and foraging habitat. The study area is not recognised as a high quality area of Regent Honeyeater breeding or foraging habitat so the project will not interfere with this action. The remaining research and on ground actions associated with the strategies in the *National Recovery Plan for the Regent Honeyeater (Anthochaera phrygia)* (Commonwealth of Australia, 2016) are not applicable to the project. Appendix F provides a full overview of the recovery actions.

The *National Recovery Plan for the Swift Parrot* (Saunders and Tzaros, 2011) outlines recovery actions for the species (see Appendix F for a full overview of the recovery actions). The following specific recovery objectives are identified:

- Objective 1: To identify and prioritise habitats and sites used by the species across its range, on all land tenures.
- Objective 2: To implement management strategies to protect and improve habitats and sites on all land tenures
- Objective 3: To monitor and manage the incidence of collisions, competition and Beak and Feather Disease (BFD).
- Objective 4: To monitor population trends and distribution throughout the range.

These objectives, and the associated recovery actions outlined in the *National Recovery Plan for the Swift Parrot* (Saunders and Tzaros, 2011) will not be interfered with by the project (see Appendix F).

The Grey-headed Flying-fox will suffer a small reduction in extent of suitable local foraging habitat from the project of about 26.25 hectares. Within the Cumberland subregion, this potential habitat removal represents less than 0.1 percent of the currently available habitat in the region. The state and national extent of habitat for these species is not known but the proportional impacts from the project to habitat at these scales will be less than 0.1%. No breeding camps or other important habitat will be impacted. As such, the project is considered unlikely to reduce the population size of the Grey-headed Flying-fox or decrease the reproductive success of this species. The project will not interfere with the recovery of the Grey-headed Flying-fox and will not contribute to the key threats to this species. An overall conclusion has been made that the action is unlikely to result in a significant impact to the Grey-headed Flying-fox (see Appendix F).

The Large-eared Pied Bat will suffer a small reduction in extent of foraging habitat of about 26.25 hectares. Within the Cumberland subregion, this potential habitat removal represents less than 0.1 percent of the currently available habitat in the region. The state and national extent of habitat for these species is not known but the proportional impacts from the project to habitat at these scales will be less than 0.1%. No breeding habitat i.e. caves) will be impacted. As such, the project is unlikely to reduce the population size of this species or decrease its reproductive success. The project is considered unlikely to result in a significant impact to the Large-eared Pied Bat (see Appendix F).

The assessments of significance according to the *EPBC Act Policy Statement 1.1 Significant Impact Guidelines* (Department of Environment, 2013) are provided in Appendix F. Mitigation measures to manage direct and indirect impacts to listed threatened terrestrial fauna species are outlined in Section 9.

8.3.4 Listed migratory species

An assessment of significance pursuant to the *Matters of National Environmental Significance Significant Impact Guidelines 1.1* (Department of the Environment, 2013) was completed for recorded migratory species and those with a moderate or high likelihood of occurrence and is included in Appendix F.

No migratory species were recorded during the targeted bird surveys; however, the Latham's Snipe was recorded opportunistically in the study area on three occasions. It was recorded in the same location in an area of flooded grassland on Defence Establishment Orchard Hills. The Latham's Snipe is considered likely to utilise the extensive network of farm dams, however this habitat is not considered to comprise important habitat. The Cattle Egret was observed repeatedly in paddocks throughout the study area and broader locality. The Great Egret is also considered moderately likely to occur in the wetlands throughout the study area. The White-throated Needletail and Fork-tailed Swift are considered likely to fly over the study area during migration.

'Important habitat' for a migratory species is defined as (Commonwealth Department of the Environment 2013):

- Habitat utilised by a migratory species occasionally or periodically within a region that supports an ecologically significant proportion of the population of the species
- Habitat that is of critical importance to the species at particular life-cycle stages
- Habitat utilised by a migratory species which is at the limit of the species range
- Habitat within an area where the species is declining.

An assessment of the likely occurrence of these species and the presence of important habitat is included in Appendix B. The assessment concluded that although the proposed action is expected to result in the loss of occasional habitat for migratory species, but not important habitat, the proposed action is unlikely to result in a significant impact on migratory species listed under the EPBC Act.

8.3.5 Approved threat abatement plans

Threat abatement plans establish a national framework to guide and coordinate Australia's response to key threatening processes registered under the EPBC Act (Australian Government, 2017). The plans identify research, management and other actions needed to ensure the long-term survival of native species and ecological communities affected by key threatening processes (Australian Government, 2017). The list of approved threat abatement plans, and the date of approval, is as follows:

- Threat abatement plan for beak and feather disease affecting endangered psittacine species - 2005 (This plan ceased on 1 October 2015, and the Department is developing a non-statutory threat abatement advice)
- Threat abatement plan for competition and land degradation by unmanaged goats - 2008
- Threat abatement plan for competition and land degradation by rabbits - 2016
- Threat abatement plan for disease in natural ecosystems caused by *Phytophthora cinnamomi* - 2014
- Threat abatement plan for infection of amphibians with chytrid fungus resulting in chytridiomycosis - 2016
- Threat abatement plan for predation by European red fox - 2008
- Threat abatement plan for predation by feral cats - 2015
- Threat abatement plan for predation, habitat degradation, competition and disease transmission by feral pigs - 2005 (This plan ceased on 1 October 2015, and may soon be replaced by a new plan)

- Threat abatement plan for the biological effects, including lethal toxic ingestion, caused by cane toads - 2011
- Threat abatement plan for the impacts of marine debris on vertebrate marine life - 2009
- Threat abatement plan for the incidental catch (or bycatch) of seabirds during oceanic longline fishing operations - 2014
- Threat abatement plan to reduce the impacts of exotic rodents on biodiversity on Australian offshore islands of less than 100 000 hectares - 2009
- Threat abatement plan to reduce the impacts of tramp ants on biodiversity in Australia and its territories - 2006 (This plan ceased on 1 October 2016, and may soon be replaced by a new plan)
- Threat abatement plan to reduce the impacts on northern Australia's biodiversity by the five listed grasses – 2012.

Not all of the approved threat abatement plans are applicable to the project. For example, cane toads are not present in the habitat, and the project will not have direct impacts on the marine environment in the form of debris or fishing. The project will not affect an offshore island. Invasive alien tramp ants are not known to be present in the locality and are unlikely to be imported by activities associate with the project. The project is not in northern Australia so the threat abatement plan to reduce the impacts on northern Australia's biodiversity by the five listed grasses is not applicable.

The threat abatement plans that relate to the project involve invasion and spread of pests (i.e. goats, rabbits, red fox, feral cats, and pigs) and pathogens (i.e. beak and feather disease, *Phytophthora cinnamomi,* and chytrid fungus). Pest species and pathogens will be managed within the project site according to the *Biodiversity Guidelines: Protecting and managing biodiversity on RTA projects* (NSW Roads and Traffic Authority 2011). This will ensure to the greatest extent possible that invasion and spread of pests and pathogens are managed throughout the project lifecycle. The predicted impacts from pests and pathogens are discussed further in Section 8.4.5 and Section 8.4.6. The project does not include any activities that would interfere with any of the above threat abatement plans.

8.3.6 Impacts to the environment of Commonwealth land

A summary of potential impacts to the environment of Commonwealth land as a result of construction and operation of the project is provided in this section as it relates to biodiversity. This includes an assessment of ecosystems and their constituent parts and water resources as it relates to the portions of Commonwealth land associated with the project. This includes the DEOH land, and land that has been acquired by the Commonwealth for the purposes of developing the Western Sydney Airport at Badgerys Creek.

The construction footprint (including compound and laydown sites) within Commonwealth land is estimated at about 47.58 hectares. Within this footprint, the following impacts to biodiversity are expected:

- Up to 13.34 hectares of remnant native vegetation as assessed under the FBA, including about:
  - 10.51 hectares of the TSC Act listed, critically endangered Cumberland Plain Woodland in the Sydney Basin Bioregion ecological community
  - 2.84 hectares of the TSC Act listed River-Flat Eucalypt Forest on Coastal Floodplains
- About 10.07 hectares of the critically endangered Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest ecological community.

- Potential impact to aquatic ecosystems due to changes in water quality, habitat loss and instream barriers associated with works in and around waterways identified as Key Fish Habitat located within or immediately adjacent to Commonwealth land, most notably Badgerys Creek and the unnamed tributary of Surveyors Creek
- Potential impacts to aquatic and riparian habitats due to changes to flooding and hydrology during operation associated with new a drainage network, drainage structures and increased impervious surfaces
- Localised fragmentation of local wildlife corridors between The Northern Road and Willowdene Avenue where some intact habitat patches would be broken apart and the hard barrier introduced by the project would restrict fauna movement. The widening of the existing Northern Road in the north of the study area would further the barrier effects of this roadway where it bisects Regional Corridor 17 as identified in the OEH BIOMAP
- Removal of threatened fauna species habitat and habitat features, minor edging effects and the Potential high magnitude residual impact to occur as a result of edge effects to some of the more intact habitats such as those off Willowdene Avenue
- Potential injury or death of fauna on Commonwealth land, for example during vegetation clearing
- Potential for the invasion and spread of weeds, pests, pathogens and disease which would potentially impact on the environment of Commonwealth land
- General construction and operational related impacts associated with noise, vibration, dust, light and contaminants as outlined above where they impact the environment of Commonwealth land.

The predicted impacts to the critically endangered Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest ecological community on Commonwealth land is considered likely to contribute to the significant residual impacts of the Project as discussed in Section 8.3.1.

The Orchard Hills Cumberland Plain Woodland is listed on the Commonwealth Heritage List (CHL) and Register of the National Estate (RNE) for its natural heritage values. The assessment of significance, however, also includes reference to historic heritage and Indigenous heritage values. The natural heritage values specific to biodiversity are considered in this assessment. The historic heritage values of the Orchard Hills Cumberland Plain Woodland are assessed in the Non-Aboriginal heritage assessment undertaken for the project.

About 9.15 hectares of native vegetation from the western edges of the Orchard Hills Cumberland Plain Woodland Listed Place will be removed by the project. With the current design of the project, there is no way to reduce this clearing or mitigate the impact. Importantly, the core vegetation areas in the centre and east of the Orchard Hills Cumberland Plain Woodland will not be affected.

The scale of the impact to the Orchard Hills Cumberland Plain Woodland Listed Place is relatively small (with consideration of the size of the site) as the project impacts are limited to the vegetation on the western fringes and the core habitats regarded as a core biodiversity area for conservation will not be affected. At the impact site itself the impact will be intense as it involves vegetation removal and construction of a road. The impact will be permanent and irreversible. Using the severity guidelines provided in the *EPBC Act Policy Statement 1.2 Significant Impact Guidelines - Actions on, or impacting upon, Commonwealth land, and actions by Commonwealth agencies* (Department of the Environment and Heritage, 2006) the project can be considered as a Moderate severity impact.

Overall, the project is considered to be medium scale native vegetation clearance that could potentially introduce invasive weed and pest species. There may be regular mobilisation of fertilisers, herbicides or other chemicals that may stunt the growth of native vegetation. The vegetation clearance will permanently destroy some of the structural elements upon which the Orchard Hills Cumberland Plain Woodland Listed Place is based. As such, the impacts may be considered significant.

An assessment of the significance of the potential impacts to the Orchard Hills Cumberland Plain Woodland Listed Place according to the guidance provided in the *EPBC Act Policy Statement 1.2 Significant Impact Guidelines - Actions on, or impacting upon, Commonwealth land, and actions by Commonwealth agencies* (Department of the Environment and Heritage, 2006) is provided below.

Impacts on plants

Is there a real chance or possibility that the action will:

- Involve medium or large-scale native vegetation clearance

About 9.15 hectares of native vegetation from the western edges of the Orchard Hills Cumberland Plain Woodland Listed Place will be removed by the project. This is considered to be medium scale native vegetation clearance.

- Involve any clearance of any vegetation containing a listed threatened species which is likely to result in a long-term decline in a population or which threatens the viability of the species

The vegetation clearing involves the clearing of the critically endangered Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest ecological community. The potential impacts to this CEEC from the project are considered likely to be significant (see Section 8.3.1 and Appendix F).

- introduce potentially invasive species

The introduction of invasive weed and pest species is considered a risk from the project (see Section 8.4.6 and 8.4.7).

- involve the use of chemicals which substantially stunt the growth of native vegetation, or

There may be regular mobilisation of fertilisers, herbicides or other chemicals during routine roadside vegetation maintenance. However, Roads and Maritime will implement standard management measures to ensure off site damage form herbicide application is minimised.

- involve large-scale controlled burning or any controlled burning in sensitive areas, including areas which contain listed threatened species?

No burning is proposed for the project.

Impacts on animals

Is there a real chance or possibility that the action will:

- cause a long-term decrease in, or threaten the viability of, a native animal population or populations, through death, injury or other harm to individuals

About 9.15 hectares of native vegetation from the western edges of the Orchard Hills Cumberland Plain Woodland Listed Place will be removed by the project. This is considered to be medium scale native vegetation clearance which is unlikely to cause a long-term decrease in, or threaten the viability of, native animal populations due to the large amount of habitat that will remain on the site.

- displace or substantially limit the movement or dispersal of native animal populations

Fragmentation and barrier effects are discussed in detail in Section 8.4.3. The project is not expected to result in any fragmentation of the Orchard Hills Cumberland Plain Woodland Listed Place as the vegetation removal will occur on the western edge. The Listed Place will not be cut into smaller pieces from the project. The project will not influence movement or dispersal of native animal populations at the Orchard Hills Cumberland Plain Woodland Listed Place.

- Substantially reduce or fragment available habitat for native species

Fragmentation and barrier effects are discussed in detail in Section 8.4.3. The project is not expected to result in any fragmentation of the Orchard Hills Cumberland Plain Woodland Listed Place as the vegetation removal will occur on the western edge.

- Reduce or fragment available habitat for listed threatened species which is likely to displace a population, result in a long-term decline in a population, or threaten the viability of the species

As above

- Introduced exotic species which will substantially reduce habitat or resources for native species, or

The introduction of invasive weed and pest species is considered a risk from the project (see Section 8.4.6 and 8.4.7).

- Undertake large-scale controlled burning or any controlled burning in areas containing listed threatened species?

No burning is proposed for the project.

Impacts on heritage

Is there a real chance or possibility that the action will:

- Permanently destroy, remove or substantially alter the fabric (physical material including structural elements and other components, fixtures, contents, and objects) of a heritage place

About 9.15 hectares of native vegetation from the western edges of the Orchard Hills Cumberland Plain Woodland Listed Place will be removed by the project. This is considered to be medium scale native vegetation clearance which will permanently destroy some of the structural elements upon which the Orchard Hills Cumberland Plain Woodland Listed Place is based. However, the core vegetation areas in the centre and east of the Orchard Hills Cumberland Plain Woodland will not be affected.

The remaining impact criteria listed below as outlined in the *EPBC Act Policy Statement 1.2 Significant Impact Guidelines - Actions on, or impacting upon, Commonwealth land, and actions by Commonwealth agencies* (Department of the Environment and Heritage, 2006) are outside of the scope of this biodiversity assessment and include:

- Involve extension, renovation, or substantial alteration of a heritage place in a manner which is inconsistent with the heritage values of the place
- Involve the erection of buildings or other structures adjacent to, or within important sight lines of, a heritage place which are inconsistent with the heritage values of the place

- Substantially diminish the heritage value of a heritage place for a community or group for which it is significant
- Substantially alter the setting of a heritage place in a manner which is inconsistent with the heritage values of the place, or
- Substantially restrict or inhibit the existing use of a heritage place as a cultural or ceremonial site?

The Non-Aboriginal heritage assessment and corresponding section in Chapter 8 of the EIS provides an assessment of impacts to Commonwealth listed places including the Orchard Hills Cumberland Plain Woodland. This includes an assessment of impacts to the natural heritage values of the site in accordance with the the *EPBC Act Policy Statement 1.2 Significant Impact Guidelines - Actions on, or impacting upon, Commonwealth land, and actions by Commonwealth agencies* (Department of the Environment and Heritage, 2006). This assessment concluded that there would be no significant impacts to the natural heritage values of the site, as such no offset requirements specific to the natural heritage values of the site are required.

8.4 Other impacts not covered by the FBA

8.4.1 Aquatic impacts

The construction and operation of the project has the potential to impact aquatic ecosystems due to changes in water quality, hydrology, habitat loss and instream barriers.

Only five watercourses (Badgery's Creek, Cosgrove Creek, the unnamed watercourse at Site 212, the unnamed tributary of Surveyors Creek and the large dam at Site 39) were identified as Type 1 – Key Fish habitat, as they had a combination of native aquatic plants and/or woody snags. These watercourses were impacted, intermittently flowing waterways which were identified as Class 2 – Moderate key fish habitat due to the presence of limited in stream aquatic vegetation. The remaining sites were farm dams on 1st or 2nd Order Streams or gullies, and as such not considered key fish habitat. Whilst these sites are classified as key fish habitat, no protected or threatened fish species are considered likely to occur.

Several threatened species including Macquarie Perch (Macquaria australasica), Australian Grayling (*Prototroctes maraena*), Silver Perch (*Bidyanus bidyanus*), Murray Cod (*Maccullochella peelii peelii*) and Trout Cod (M*accullochella macquariensis*) have been recorded within the Hawkesbury-Nepean Catchment; however, habitat for these species is not present within the study area.

Waterways modified by the project

Construction and operation of both permanent waterway crossings (such as bridges and culverts), as well as temporary waterway crossings (such as causeways, fords) are known to have significant impacts upon passage of fish. Short term impacts include localised disturbance to riparian and instream habitats such as increased sedimentation and shading. Long term impacts include the impediment of fish movements within their natural range, habitat changes or pollution.

Construction activity around watercourses in the project area has potential to result in temporary changes to flow and loss of aquatic habitat associated with the removal of woody snags, changes to instream substrate and loss of aquatic plants (macrophytes). Inappropriate design or type of water crossing can impede or prevent fish from travelling within their natural range. Furthermore, barriers to fish passage can prevent breeding or re-population of waterways through restricting access of fish to spawning grounds (Fairfull and Witheridge, 2003). Table 4.6 summarises the crossing type at each waterway. Detailed design of these culverts would ensure that barriers to fish are not created, and that they are designed in

accordance with Fairfull & Witheridge (2003) fish friendly crossings and DPI (2004) Policy and Guidelines for fish Friendly Waterway Crossings.

There are only four freshwater watercourses in the study area that contain permanent or near permanent flows, and as such may support a variety of fish and macroinvertebrate families. Changes to water quality, aquatic habitat and natural flow regimes due to the project can favour aquatic pest species, which can then predate on native species such as Gambusia (*Gambusia holbrooki*). This fish species is a significant predator on native fish and tadpoles. Gambusia were observed at numerous watercourses throughout the study area. The species proliferate in disturbed aquatic habitats and can out-compete and predate upon native species less tolerant of disturbed environments and poor water quality.

Water Quality

The construction and operation of the project has the potential to impact on water quality. The main impact to water quality during construction comes from stockpiling of earthworks, and actual construction works such as cut and fill.

Stockpiling of earthworks causes a risk to downstream water quality during wet weather if not managed appropriately. Whilst there are numerous locations for stockpile sites (as documented in the Working Paper – Soils, Water and Contamination), they have been located such that no stock piles are within 50m of a Type 1 Fish Habitat.

Chapter 8-2 of the EIS outlines the water quality assessment undertaken for the project.

Removal of woody debris

The removal of large woody debris or snags is listed under Schedule 6 of the FM Act as a key threatening process. Woody debris plays an important role in freshwater and marine ecosystems by providing essential habitat for aquatic organisms, providing a refuge from predation and a resting place away from the main flow of the waterway and providing important refuge and breeding habitat for fish including threatened species. Woody debris also provides habitat for a number of plants, algae, microorganisms and invertebrates. Tree trunks and fallen branches are also structurally important for stabilising stream beds and banks.

Woody debris is a significant component of aquatic habitat for several waterways crossed by the project and while not quantified, was found in the majority of waterways. All woody debris and snags encountered during construction will be relocated instream to ensure impacts to the presence and availability of woody debris is prevented.

Instream barriers and changes to hydrology

Construction and operation of both permanent and temporary waterway crossings such as bridges, causeways, fords and culverts are known to have significant impacts upon passage of fish. Short term impacts include localised disturbance to riparian and instream habitats such as increased sedimentation and shading. Long term impacts include the impediment of fish movements within their natural range, habitat changes or pollution.

The project would require the traversing of minor waterways and farm dams. Water crossing structures have been designed to minimise the impacts of altering the natural flow regimes of the rivers and streams within the region. The design took into consideration all waterways within the study area. Detailed design of bridges and culverts in accordance with Fairfull & Witheridge (2003) and DPI (2004) should ensure that barriers to fish are not created and impacts to the existing hydrology are minimised.

Construction works undertaken within 50 metres of waterways has the potential to impact on bank stability and water quality through excavation, clearing or placement of construction stockpiles. Potential impacts associated with construction works include loss of suitable bank habitat, loss of in-stream shading and increased sedimentation of the watercourses through

surface runoff. Detailed design has ensured that no stock piles are placed within 50m of waterways.

There is potential for hydrology and flooding to be altered during operation which may result in increased rate, velocity and concentration of flow from the widened carriageway and new drainage system and structures. The changes to hydrology and flooding may affect biodiversity values by altering the frequency, magnitude and distribution of inundation of land adjacent to creeklines during floods and by altering the geomorphology and channel structure of waterways. Changes may include a shift in the distribution and identity of riparian species, resuspension and resettlement of instream sediments and scouring of the stream bed which may result in loss or gain of aquatic macrophytes and a shift in aquatic fauna community structure.

To mitigate impacts Roads and Maritime would consult with property owners regarding upgrades to farm dam spillways to manage areas where increased flows are predicted. Energy dissipation and scour protection measures such as rock riprap or rock gabion mattresses would be utilised along transverse drainage structures to reduce erosion. Stormwater detention ponds will control discharge to the downstream environment.

DEOH and Western Sydney Airport Commonwealth lands will be impacted by an increase in peak flows during 100 year ARI events. The increase in peak flows is not expected to impact waterways given the infrequent and short term nature of the floodwaters. There will be an increase in scour potential for a short distance from the project corridor in drainage lines flowing through DEOH site which may deepen the water way and cause some bank erosion. The potential for changes to the rate, velocity and concentration of flow due to the works associated with the project is likely to restrict impacts to direct scouring of waterways, drainage lines and shallow-rooted riparian groundcover on the DEOH and Western Sydney Airport Commonwealth lands. However changes to the distribution of overland flow and the flooding regime may impact vegetation communities on the surrounding floodplain and adjacent lands. The magnitude of impact would depend on the degree of hydrological change and the impact to soil moisture content and flood inundation.

Both sites contain the Threatened Ecological Communities; Cumberland Plain Woodland in the Sydney Basin Bioregion and River-Flat Eucalypt Forest on Coastal Floodplains of New South Wales North Coast, Sydney Basin and South East Corner Bioregions. Predicted changes to hydrology and flooding due to the proposed works would not directly impact these communities due to scouring but may result in minor changes to the distribution or relative abundance of member species. Increases to the 100 year ARI peak flows are not expected to impact vegetation communities due to the infrequent and short term nature of the impact.

Chapter 8-1 of the EIS outlines the hydrology and flooding assessment undertaken for the project.

Pond Dewatering & Creek Realignment

Many of the watercourses in the study area are artificial dams, situated in minor gullies which are either first or second order streams, and as such are not considered key fish habitat. Threatened species are unlikely to be present within these dams, however there is a possibility that native and invasive fish species have colonised these dams. Should dams or creeks be dewatered during the construction of the project, then native fish species will need to be relocated in to a similar aquatic environment to which it was found by trained aquatic ecologists under a Fisheries Permit issued by DPI.

8.4.2 Fragmentation of identified biodiversity links and habitat corridors

Habitat fragmentation

Habitat fragmentation *per se* relates to the physical dividing up of once continuous habitats into separate smaller ‘fragments’ (Fahrig, 2002). The habitat fragments created by fragmentation tend to be smaller and separated from each other by a matrix of less suitable

habitat. The new dividing habitat type between fragments is often artificial and less suitable to the species remaining within these newly created fragments (Bennett, 1990, Bennett, 1993, Lindenmayer and Fischer, 2006) or is generally only used by adaptive and aggressive generalist species (e.g. Noisy Miners) which further decreases population levels of other species remaining in the fragments.

The project is considered unlikely to result in a large increase to landscape scale fragmentation. The historic human activities including clearing for agriculture have resulted in the Cumberland Plain becoming a highly fragmented landscape. Most vegetation now occurs as small fragments in an agricultural setting of improved pasture and cropping with the only significant areas of native vegetation remaining in National Parks or Nature Reserves and Defence land.

The project is however likely to result in localised fragmentation of local wildlife corridors between the Northern Road and Willowdene Avenue (see Figure 8.3) where some intact habitat patches will be broken apart and the hard barrier introduced by the project will restrict fauna movement. The widening of the existing Northern Road in the north of the study area will further the barrier effects of this roadway (discussed in more detail below) where it bisects Regional Corridor 17 as identified in the OEH BIOMAP.

Due to the importance of connectivity, dispersal opportunities and habitat quality, for species at a local scale the project is considered likely to be detrimental to the dispersal of relatively sedentary species such as mammals, frogs, and reptiles. Reduced connectivity can lead to crowding effects and increased competition within the remaining habitat patches. Mobile species such as birds and bats may not be affected by this fragmentation as the landscape in which they currently exist is fragmented and the predicted level of fragmentation would not be enough to restrict their dispersal between habitat patches. The existing The Northern Road contributes to a considerable reduction in local connectivity. The fence along the edge of the Defence Establishment Orchard Hills increases the barrier effect provided by the existing The Northern Road in this area. In this location, dispersal of fauna is currently limited.

The predicted level of fragmentation from the project is not expected to be enough to prevent the breeding and dispersal of plant pollinators or the dispersal of plant propagules (i.e. seed or other vegetative reproductive material) between habitat patches. Functional connectivity for many species will remain in the study area. However, local division of some wildlife populations, isolation of key habitat resources, loss of genetic interchange, and loss of population viability may result from the local fragmentation caused by the project. This impact has the greatest potential to occur in the habitats between The Northern Road and Willowdene Avenue where the habitats are currently relatively intact and do not currently have a hard barrier separating habitat patches (see Figure 8.3).

Figure 8.3 Location of key area of habitat fragmentation likely to be caused by the project (black polygon is the construction footprint, Red crosshatch represent new areas of edge effects

Barrier effects

Barrier effects occur where particular species are either unable or are unwilling to move between suitable areas of habitat due to the imposition of a 'barrier' (e.g. a newly created inhospitable habitat type or physical barrier such as the project). Species most vulnerable to barrier effects include uncommon species, smaller ground-dwelling species, and relatively sessile species with smaller home ranges.

The construction and operation of the project will create barrier effects that restrict fauna movement and this impact is likely to be most obvious for fauna groups including mammals, frogs, and reptiles. An example of a potentially affected species is the Swamp Wallaby. Mobile species such as birds and bats may not be affected to the same extent.

8.4.3 Edge effects on adjacent native vegetation and habitat

The development of linear infrastructure is known to cause disturbance in terms of reducing habitat quality and patch size. This is due to the greater potential for edge effects and habitat fragmentation and barrier effects associated with these forms of development due to their impact footprint and perimeter. There is potential for a high magnitude residual impact to occur to some of the more intact habitats within the study area from edge effects (such as those off

Willowdene Avenue - see Figure 8.3) in the form of reduced habitat quality and reduced patch size which is irreversible and permanent.

Edge effects refer to the changes in environmental conditions (e.g. altered light levels, wind speed, temperature) that occur along the edges of habitats. These new environmental conditions along the habitat edges can promote the growth of different vegetation types (including weeds), promote invasion by pest animals specialising in edge habitats, or change the behaviour of resident animals (Moenting and Morris, 2006). Edge zones can be subject to higher levels of predation by introduced mammalian and native avian predators. The distance of edge effect influence can vary, with the extent of edge effects having been recorded greater than 1 km from an edge (Forman et al., 2000) and stopping as little as 50 m from an edge (Bali, 2005).

Edge effects have the potential to impact on the range of flora and fauna species identified as potentially occurring in the study area and will be felt greatest in more sensitive species with specific micro-habitat requirements and which are less tolerant to disturbance, for example some ground-dwelling reptiles and mammals, smaller birds and some plants.

Within the study area, and construction footprint, many patches of vegetation are small, irregularly shaped, and fragmented. As such, many areas of vegetation within and directly adjacent to the construction footprint are already subject to considerable edge effects. In many cases the vegetation patches are so small that no unaffected core habitat exists. Consequently, it is unlikely that the project would increase the overall extent of edge effects across the majority of the study area where the habitat is restricted to small fragments.

However, in the area between the Northern Road and Willowdene Avenue, the construction footprint crosses through a local vegetation corridor that contains some high quality patches of Cumberland Plain Woodland vegetation. It is in this area that the greatest potential for edge effects resulting from the project exists. Using an edge effect buffer zone of 50 metres from the edge of the construction footprint, edge effects from the project are estimated to indirectly impact on 1.9 hectares of vegetation (see Figure 8.3). In most cases the development footprint will impact on vegetation at the edges of patches which are already subject to considerable edge effects. This impact is limited to relatively intact patches of vegetation off Willowdene Avenue and does not consider edge effects to small patches of vegetation that are already composed of edge habitat.

8.4.4 Injury and mortality of fauna

Fauna injury or death has the greatest potential to occur during vegetation clearing and the extent of this impact will be proportionate to the extent of vegetation that is cleared. Some mobile species, such as birds, may be able to move away from the path of clearing and may not be greatly affected unless they are nesting. However, other species that are less mobile (e.g. ground dwelling reptiles), or those that are nocturnal and nest or roost in trees during the day (e.g. arboreal mammals and microchiropteran bat species), may find it difficult to move rapidly when disturbed. Common fauna species such as possums, reptiles and frogs are the most likely to be affected.

Entrapment of wildlife in any trenches that are dug is a possibility if the trenches are deep and steep sided. Wildlife may also become trapped in machinery that is stored in the study area overnight that may result in injury or death.

There is a chance of fauna mortality during the operational phase the project through vehicle collision (i.e. roadkill). Vehicle collision is a direct impact that reduces local population numbers and is a common occurrence in Australia (Coffin, 2007, Rowden et al., 2008). Mammals, reptiles, amphibians and birds are all at risk of vehicle strike, particularly those common species (e.g. macropods) that are tolerant of disturbance and/or those species that can utilise roadways for movement pathways or as foraging habitat. As there are no definitive data on current rates of roadkill or fauna population densities in the study area, the consequences of vehicle strike on local populations is unknown. With the creation of a new

road the risk of vehicle strike is introduced but the significance of such an impact cannot be predicted. The impact on threatened species however is expected to be minimal and based on evidence from other motorways in the locality most vehicle strike impacts can be expected to occur to common mammals such as possums and macropods and exotic animals including foxes.

Mitigation measures designed to reduce an injury and death of fauna are provided in Section 9.

8.4.5 Invasion and spread of weeds and pests

Weed and pest species pose some of the greatest threats to biodiversity as these species displace native species through predation and competition, and damage vegetation by grazing and trampling (Adair and Groves, 1998, Clarke et al., 2000, Thorp and Lynch, 2011). Consequently, proliferation of weed and pest species due to the project may be a key impact to biodiversity in the study area.

Proliferation of weed and pest species is an indirect impact (i.e. not a direct result of project activities) that may have cumulative effects as each project activity may act together to increase the chances of weed and pest proliferation throughout the study area. Proliferation of weed and pest species is likely to occur during construction and operation, although impacts will be greatest as a result of vegetation clearing during the construction phase. The effects of proliferation of weed and pest species may not be experienced immediately or even in the short-term, however, will likely commence a few months after the construction phase commences and gradually increase over months and seasons. This impact has potential to have the greatest impact to the quality and integrity of TECs and threatened species habitat.

Without appropriate management strategies, project activities have the potential to disperse weeds into areas of remnant vegetation where weed species are currently limited or in low density. Project activities also have the potential to import new weed species into the study area. The most likely causes of weed dispersal and importation associated with the project include earthworks, movement of soil, and attachment of seed (and other propagules) to vehicles and machinery during all phases. Weed dispersal by vehicles along roads and access tracks is a key source of weed invasion (Birdsall et al., 2012).

Large expanses of the study area have significant weed growth. Therefore, the potential for habitat modification from weed invasion resulting from the project is highest where activities take place in relatively intact areas such as the higher condition areas of Cumberland Plain Woodland along Willowdene Avenue that exhibit low weed diversity and abundance.

Mitigation measures designed to limit the spread and germination of weeds are provided in Section 9.

The study area is currently habitat for a range of pest species including rabbits. Project activities have the potential to disperse pest species out of the project footprint across the surrounding landscape and increase the ability of pest species to utilise habitats due to habitat removal, noise, and human presence during construction and operation. Construction of linear infrastructure through large patches of intact vegetation can result in the establishment of pest species (particularly predators such as foxes and cats) into areas where they are currently absent or in low numbers. However, in the context of the project this impact is predicted to be minimal as all vegetation in the study area is likely to be impacted by foxes and cats. The magnitude of this impact will be low.

The forests of southwest Sydney are currently experiencing ‘Bell miner associated dieback' (also known as BMAD). This form of tree canopy dieback is caused by over-abundant psyllids (sap-sucking insects that create a sugary excretion called lerp) in conjunction with Bell Miners that feed on the psyllids and the lerp (Bell Miners may even preferentially feed on the lerp and not the psyllid itself) (NSW Scientifc Committee, 2008). Bell miners are aggressive and exclude other bird species (that would feed on psyllids) from their territories (NSW Scientifc Committee, 2008). This can lead to psyllid populations increasing to the extent that they cause

substantial canopy damage. In western Sydney, Eucalyptus moluccana (Grey Box) trees appear to be the most effected and this is the case with the vegetation in the study area. Substantial landscape scale defoliation of Grey Box trees is occurring and as this species is a key component of the critically endangered Cumberland Plain Woodland ecological community this phenomena is of concern. As such, 'Forest eucalypt dieback associated with over-abundant psyllids and Bell Miners' is listed as a key threatening process under the TSC Act.

The BMAD strategy (Bell miner Associated Dieback Working Group, 2004) developed by the The Bell Miner Associated Dieback Working Group aims to inform people about the problem and look for solutions to this major threat to our forests. The BMAD strategy recognised that the issue is of national significance as BMAD has the potential to degrade forests across the extensive range of the Bell miner from southern Queensland to Victoria. Additionally, the OEH have identified 10 priority actions to help recover species affected by BMAD (NSW Office of Environment and Heritage).

Over-abundant psyllid populations and bell miner colonies tend to start in sites with high soil moisture and suitable tree species where the tree canopy has been reduced and a dense understorey, often of lantana, is present (NSW Scientifc Committee, 2008). These conditions are a consequence of landscape-level disturbance of forest ecosystems. As the Cumberland Plain has been heavily cleared in the past and the remaining vegetation largely exists as small heavily weed infested forest fragments in an agricultural (and increasingly urban) landscape with altered fire regimes and increased nutrient inputs, the conditions appear optimal for BMAD to flourish. The project will involve vegetation removal and some localised fragmentation of local wildlife corridors between the Northern Road and Willowdene Avenue where some intact habitat patches will be broken apart. This could increase the prevalence and severity of BMAD in the locality due to increased fragmentation and removal of trees used as habitat by psyllids and Bell Miners. However, the magnitude of this impact is unknown and the potential extent and severity of any increased effects of BMAD cannot be quantified. The influence of the project on BMAD is however likely to be insignificant when compared to the broad scale clearing that has occurred in the past for agriculture and urban development. At present, no single cause explains the cause of BMAD and expert opinion varies considerably as to which factors cause BMAD (NSW Scientifc Committee, 2008). It is not yet known if the presence of psyllids and bell miners actually causes the dieback, or are secondary consequences (NSW Scientifc Committee, 2008). Importantly, the project will not interfere with the objectives or proposed actions as identified by the BMAD working group and outlined in the BMAD strategy. The project will not interfere with any of the 10 priority actions identified to help recover species affected by BMAD (NSW Office of Environment and Heritage).

8.4.6 Invasion and spread of pathogens and disease

Several pathogens known from NSW have potential to impact on biodiversity as a result their movement and infection during construction. Of these, three are listed as a key threatening process under either the EPBC Act and/or TSC Act including:

- Dieback caused by Phytophthora (Root Rot; EPBC Act and TSC Act)
- Infection of frogs by amphibian chytrid fungus causing the disease chytridiomycosis (EPBC Act and TSC Act)
- Introduction and establishment of exotic Rust Fungi of the order Pucciniales on plants of the family Myrtaceae (TSC Act).

While these pathogens were not observed or tested for in the study area the potential for pathogens to occur should be treated as a risk during construction. The most likely causes of pathogen dispersal and importation associated with the project include earthworks, movement of soil, and attachment of plant matter to vehicles and machinery during all project phases (construction and operation). Pathogens will be managed within the project site according to the *Biodiversity Guidelines: Protecting and managing biodiversity on RTA projects* (NSW

Roads and Traffic Authority 2011). This will ensure to the greatest extent possible that invasion and spread of pests and pathogens are managed throughout the project lifecycle (see Section 9).

8.4.7 Noise, vibration, dust, light and contaminants

Noise, dust, light and contaminant pollution are direct impacts that are likely to result from project activities. These impacts are likely to have cumulative effects. Noise, dust, light and contaminant pollution are likely to occur during all phases of the project from all project activities, although will be greatest where activities take place near vegetated areas and during construction.

Using a 50 metre edge effect buffer around the construction footprint, these impacts are predicted to result in the modification of about 23.4 hectares of vegetation that will remain at the edge of the project once construction is complete.

Noise pollution

Anthropogenic noise can alter the behaviour of animals or interfere with their normal functioning (Bowles, 1997). During all phases of the project there will be increased noise and vibration levels in the study area and immediate surrounds due to vegetation clearing, ground disturbance, machinery and vehicle movements, and general human presence. The predicted noise and vibration created by the project is outlined in Chapter 7 of the EIS.

Construction of the project would be contained to the following standard working hours where practicable:

- Monday to Friday, 7am to 6pm
- Saturday, 8am to 1pm.

Some night works would be required. The noise and vibration from construction activities associated with the project will potentially disturb fauna and may disrupt foraging, reproductive, or movement behaviours. The impacts from noise emissions are likely to be localised to the construction areas and are not considered likely to have a significant, long-term, impact on wildlife populations outside the area of impact. Within the area of impact, some sensitive species (e.g. woodland birds) may avoid the noise and some more tolerant species, including small mammals, will habituate over the longer-term (Byrnes et al., 2012).

During operation, more sensitive species of fauna may avoid the road as the habitats directly adjacent to the road would be subject to a high level of traffic noise. Studies have shown that traffic noise can reduce the distance over which acoustic signals (for example fauna vocalisations) can be detected (an effect known as acoustic interference or masking) (Parris and Schneider, 2008). Studies from the northern hemisphere show that the singing behavior of birds changes in the presence of traffic noise, and traffic noise could make it more difficult for birds to establish and maintain territories, attract mates and maintain pair bonds (Parris and Schneider, 2008). This may possibly lead to reduced breeding success in noisy roadside habitats resulting in lower population densities of birds in habitats close to roads (Parris and Schneider, 2008). Calling (ie the breeding) behaviour of frogs could also be affected by traffic noise. Studies showing lowered frog species richness and abundance near roads indicate that traffic noise is detrimental to populations (Hoskin and Goosem, 2010). The consequences of traffic noise on fauna populations in the study area are unknown. With the creation of a new road the incidence of traffic noise will increase but the significance of such an impact cannot be predicted. The impact on threatened species however is expected to be minimal and most impacts can be expected to occur to common species that currently utilise the habitats.

Dust pollution

Elevated levels of dust may be deposited onto the foliage of vegetation adjacent to the project activities. This has the potential to reduce photosynthesis and transpiration and cause abrasion and radioactive heating resulting in reduced growth rates and decreases in overall health of the vegetation. Consequently, changes in the structure and composition of plant communities and consequently the grazing patterns of fauna may occur (Auerbach et al., 1997, Walker and Everett, 1987).

Dust is likely to be generated throughout the lifecycle of the project, although dust pollution is likely to be greatest during periods of substantial earthworks, vegetation clearing, vehicle movements for construction and decommissioning activities and during adverse weather conditions. However, deposition of dust on foliage is likely to be highly localised, intermittent, and temporary (particularly during the wetter seasons) and is therefore not considered likely to be a major impact of the project.

Light pollution

Ecological light pollution is the descriptive term for light pollution that includes direct glare, chronic or periodic increased illumination, and temporary unexpected fluctuations in lighting (including lights from a passing vehicles), that can have potentially adverse effects on wildlife (Longcore and Rich, 2004).

Some night works would be required during construction and lighting will be installed on the roadside. As such, the immediate area surrounding the project activities, and the roadside during operation, will be subject to artificial lighting, essentially creating permanent 'daylight' conditions. Ecological light pollution may potentially affect nocturnal fauna by interrupting their life cycle. Some species (i.e. light tolerant microchiropteran bats) may benefit from the lighting due to increased food availability (insects attracted to lights) around these areas. Due to the frequency and sustained nature of the lighting, it is unlikely that animals will habituate to the light disturbance and a long-term impact in the area of lighting is likely.

Contaminant pollution

During the construction phase localised release of contaminants (i.e. hydraulic fluids, oils, fluids, etc.) into the surrounding environment (including drainage lines) may accidentally occur. The most likely result of contaminant discharge will be the localised contamination of soil and potential direct physical trauma to flora and fauna that come into contact with contaminants. Accidental release of contaminants is likely to be localised.

8.4.8 Cumulative impacts

The potential biodiversity impacts of the project must be considered as a consequence of the construction and operation of the project within the existing environment. The project will not act alone in causing impacts to biodiversity. The incremental effects of multiple sources of impact (past, present and future) are referred to as cumulative impacts and provide an opportunity to consider the project within a strategic context.

The accumulating impacts of historic vegetation clearing for agriculture, urban development, and development and maintenance of infrastructure will likely include continued loss of biodiversity on the Cumberland Plain. The Cumberland Plain Mitchell Landscape is an over cleared landscape with 89 per cent of native vegetation having been cleared. Only 11 per cent of the original native vegetation remains. Due to the likely expansion of western Sydney and creation of housing and associated infrastructure, further impacts to biodiversity are likely to result in this region.

While data from all recent projects (or planned projects) in the locality is not freely available, some information on the likely biodiversity impacts from recent projects is available as follows:

- The predicted impacts from the Northern Road Upgrade – Glenmore Parkway, Glenmore Park to Jamison Road, Penrith are anticipated at about 2.4 hectares of remnant native vegetation and up to 3.9 hectares of planted vegetation along the M4 Motorway (6.3 hectares in total) (Jacobs, 2016a).
- The predicted impacts from the Northern Road Upgrade Narellan to Bringelly are anticipated at about 59.2 hectares of native vegetation (SKM, 2012).
- The construction footprint of the M4 Managed Motorway project is anticipated to impact on about 31.25 hectares of planted and remnant vegetation in various states of condition. This area of clearing includes 3.82 hectares of remnant vegetation (Jacobs, 2015).
- The footprint of the Western Sydney Airport is predicted to impact on 280.8 hectares of native vegetation (GHD, 2016).

When considered together, these projects combine to remove over 387 hectares of remnant native vegetation from the Cumberland Plain. This is a large cumulative impact in terms of the over cleared nature of the region. The planned industrial / employment lands in the South West Growth Centres, realignment of transmission lines, provision of water pipelines, and the planned M12 Motorway and other future orbital road links are also likely to add to the existing impacts.

It has been proposed that when a landscape reaches a vegetation retention threshold of ~30 per cent, most species will be lost from the ecosystem (McAlpine et al., 2002). With only 11 per cent of the original vegetation remaining in the Cumberland Plain Mitchell Landscape and all native vegetation classified as endangered or critically endangered, this landscape has passed a critical threshold for many species from which any further impacts are likely to result in detrimental and irreversible impacts.

Cumulative impacts to matters of national environmental significance

While data from all recent projects (or planned projects) in the locality is not freely available, some information on the likely cumulative impacts to MNES is available.

The footprint of the Western Sydney Airport is predicted to impact on 90.8 hectares of the critically endangered CPSWSGTF ecological community (GHD, 2016). This is considered likely to result in a significant impact to this CEEC as it is likely to threaten the viability and persistence of the CEEC within the locality (GHD, 2016). The Northern Road Upgrade – Glenmore Parkway, Glenmore Park to Jamison Road, Penrith (Jacobs, 2016a) will not impact on any CPSWSGTF ecological community. The M4 Managed Motorway will impact on 0.76 hectares of the CPSWSGTF Forest ecological community (Jacobs, 2015). The Northern Road Upgrade from Narellan to Bringelly would result in removal of 48.5 hectares of CPSWSGTF (SKM 2012). The cumulative impacts of these four projects, along with the Project itself, will result in a cumulative impact to this CEEC of over 156 hectares. There is also likely to be ongoing impacts to this CEEC in the future which cannot be currently quantified. These cumulative impacts to this CEEC are considered to be significant cumulative impacts.

Recent projects in the locality have had an impact on the listed plant species *Pultenaea parviflora*. The construction footprint of the M4 Managed Motorway project is anticipated to result in the removal of one plant and about 2.41 hectares of potential habitat (Jacobs, 2015). The Northern Road Upgrade – Glenmore Parkway, Glenmore Park to Jamison Road, Penrith is not predicted to impact on *Pultenaea parviflora* (Jacobs, 2016a). Likewise, the Northern Road Upgrade from Narellan to Bringelly is not expected to impact on *Pultenaea parviflora* (SKM 2012). The footprint of the Western Sydney Airport is predicted to impact on four *Pultenaea parviflora* plants and up to 221.3 hectares of potential habitat (including good and poorer quality habitats) (GHD, 2016). Combined with the predicted impacts from the Project,

the cumulative impacts to *Pultenaea parviflora* is likely to be direct removal of eight plants (including the three plants to be impacted by the Project) and up to 224.69 hectares of potential habitat (including the 0.98 hectares of habitat to be impacted by the Project). When the potential impacts of the Project on *Pultenaea parviflora* are considered in isolation, a significant impact to this species is considered unlikely (see Appendix F). However, when the potential impacts to this species are considered in the context of other projects in the locality, the potential impacts to *Pultenaea parviflora* are likely to be significant and may lead to the long-term decline of this species in the locality. This is largely due to the extensive potential impacts to habitat from the development footprint of the Western Sydney Airport.

The Grey-headed Flying-fox was recorded in one location on private property off Willowdene Avenue during spotlight surveys. Three of the 19 threatened fauna species identified in the EPBC PMST report were identified as having a moderate to high likelihood of occurring within the study area (these species were not recorded during the survey). These included:

- Regent Honeyeater
- Swift Parrot
- Large-eared Pied Bat.

A significant impact to these four species from the Project is considered unlikely when it is considered in isolation. The Project has the potential to remove about 24.41 hectares of foraging habitat for the Grey-headed Flying-fox, Large-eared Pied Bat, Regent Honeyeater and Swift Parrot. Within the Cumberland subregion, this potential habitat removal represents less than 0.1 percent of the currently available habitat for these species. These species do not breed in the study area so no impact to important breeding habitat is predicted. The Project is not considered likely to reduce the population size of these four species. When the potential impacts of the Project on habitat for these four listed fauna species are considered in the context of impacts from other projects, the impacts to potential habitat are more intense. The cumulative impacts to potential habitat for these four species from some known projects are as follows:

- The predicted impacts from the Northern Road Upgrade – Glenmore Parkway, Glenmore Park to Jamison Road, Penrith are anticipated at about 2.4 hectares of remnant native vegetation and up to 3.9 hectares of planted vegetation along the M4 Motorway (6.3 hectares in total) (Jacobs, 2016a). These four species may utilise this habitat on occasion.
- The predicted impacts from the Northern Road Upgrade Narellan to Bringelly are anticipated at about 59.2 hectares of native vegetation (SKM, 2012). These four species may utilise this habitat on occasion.
- The construction footprint of the M4 Managed Motorway project is anticipated to impact on about 31.25 hectares of planted and remnant vegetation in various states of condition. This area of clearing includes 3.82 hectares of remnant vegetation (Jacobs, 2015). These four species may utilise this habitat on occasion.
- The footprint of the Western Sydney Airport is predicted to impact on 120.6 hectares of woodland (GHD, 2016). These four species may utilise this habitat and this level of impact to potential habitat for these four species is considered extensive.

When considered together, these projects combine to impact on over 214 hectares of habitat for these four listed species from the Cumberland Plain (the Project is predicted to impact on about 24.41 hectares of habitat). This is a large cumulative impact in terms of the over cleared nature of the region. Given the area of habitat that would be lost from the cumulative impacts of these projects, and the context of the region, the potential cumulative impacts to the Grey-

headed Flying-fox, Large-eared Pied Bat, Regent Honeyeater and Swift Parrot are likely to be significant.

The planned industrial / employment lands in the South West Growth Centres, realignment of transmission lines, provision of water pipelines, and the planned M12 Motorway and other future orbital road links are also likely to add to the existing impacts to these species.

8.4.9 Impacts on ecosystem resilience

Loss of terrestrial climatic habitat caused by anthropogenic emissions of greenhouse gases is listed as a Key Threatening Process (KTP) under the EPBC Act and is relevant in the context of the project. The project will actively contribute to the functioning of this KTP. A detailed assessment of potential greenhouse gas (GHG) emissions during the construction and operation stages of the project is provided in Chapter 8.8 of the EIS and the *Northern Road Upgrade Mersey Road to Glenmore Parkway: Greenhouse Gas Assessment* (Jacobs, 2016c).

Climate change is likely to have significant impacts on Australia's biodiversity in the next century due to likely responses to the predicted increases in atmospheric carbon dioxide concentration, increased temperature, changes to rainfall patterns, and sea level rise. Human-induced climate change by the emission of greenhouse gases is known to impact on plant and animal species. The response of organisms to future climate change (however caused) is likely to differ from that in the past because climate change is compounded by a landscape in which the distribution of natural vegetation communities and habitats has been highly modified by humans. This may limit the ability of organisms to survive climate change through dispersal (Department of Environment and Heritage, 2005). Pest species and some native species may be advantaged by climate change. Fire regimes may also change and affect the species composition and the structure of ecological communities (NSW Scientific Committee, 2000).

Species at risk include those with long generation times, poor mobility (sessile species), narrow ranges, specific host relationships, and isolated and highly specialised species (Busby and Pearman, 1988). Changes in essential microhabitat conditions in areas that are fragmented from suitable habitats and/or are at the limit of a species' distribution could result in localised extinctions, affecting the recovery of threatened species.

The project involves the upgrade and realignment of an existing road to allow a greater number of vehicles to travel with greater efficiency. The potential impacts associated with this activity include GHG emissions associated with the construction of the upgrade and realignment, and the change in GHG emissions associated with its operation, in absolute and relative terms. Impacts associated with vegetation removal were not included as they do not trip the materiality threshold within CarbonGauge (clearance at 44.3Ha is less than 60% of the total pavement area (801,985 m^2 for asphalt alone)) (Jacobs, 2016c).

Land clearance has been minimised through the design process. However, due to the nature of the project, it will contribute to loss of terrestrial climatic habitat caused by anthropogenic emissions of greenhouse gases. Residual impacts from construction include impacts associated with the loss of carbon sink through removal of vegetation. Areas cleared for site compounds, and those associated with embankments are likely to be revegetated where appropriate. However, areas of removed vegetation that will be paved as part of the project will remain unvegetated. Whilst the removal of the carbon sink represents a one-off emissions event, there will also be a small ongoing loss of carbon sink as the removed vegetation will not be able to sequester carbon. This impact is relatively minor as the removed vegetation is mature forest and grassland, both of which have lower sequestration potential (than younger forest, or recently converted grassland).

Future projects including the planned industrial / employment lands in the South West Growth Centres, realignment of transmission lines, provision of water pipelines, and the planned M12 Motorway and other future orbital road links are also likely to add to the existing impacts from land clearance and cumulative impacts can be expected. The footprint of the Western Sydney Airport is predicted to impact on 280.8 hectares of native vegetation (GHD, 2016) which will

contribute the most to loss of terrestrial climatic habitat caused by anthropogenic emissions of greenhouse gases in the locality.

In the context of the study area, habitat for plant and animal species is likely to be altered by human-induced climate change and this would be compounded by the vegetation and habitat removal impacts of the project. Land suitability may change causing species to colonise new areas resulting in a shift in habitats. Impacts such as vegetation and habitat removal, fragmentation and isolation of habitats and the creation of barriers to dispersal are likely to compound the effects of climate change for threatened species.

8.5 Impact summary

A summary of biodiversity impacts is provided in Table 8.5.

Table 8.5: Summary of impacts

Impact	Biodiversity values	Nature of impact Direct, indirect, consequential, cumulative	Extent of impact Site based, Local, Regional, State, National	Duration Short term/ Long term, pre, during or post construction	Does the project constitute or exacerbate a key threatening process?
Removal of native vegetation	Native vegetation	Direct	About 39.61 hectares	Long term During construction	• Clearing of native vegetation
	Cumberland Plain Woodland CEEC (TSC Act) River-Flat Eucalypt Forest on Coastal Floodplains EEC (TSC Act) Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest CEEC (EPBC Act)	Direct	About 29.14 hectares About 4.29 hectares About 16.37 hectares	Long term During construction	• Clearing of native vegetation
Removal of threatened fauna species habitat and habitat features	Cumberland Plain Land Snail Regent Honeyeater Swift Parrot Large-eared Pied Bat Grey-headed Flying-fox	Direct	About 13 hectares About 26.25 hectares About 26.25 hectares About 26.25 hectares	Long term During construction	• Clearing of native vegetation • Loss of hollow-bearing trees • Loss or degradation (or both) of sites used for hill-topping by butterflies • Removal of dead wood and dead trees

Impact	Biodiversity values	Nature of impact Direct, indirect, consequential, cumulative	Extent of impact Site based, Local, Regional, State, National	Duration Short term/ Long term, pre, during or post construction	Does the project constitute or exacerbate a key threatening process?
			About 26.25 hectares		
Removal of threatened plants	*Pultenaea parviflora* *Marsdenia viridiflora* subsp. *viridiflora*	Direct	Four plants and 0.98 hectares of habitat 35 plants and 0.68 hectares of habitat	Long term During construction	
Aquatic impacts	Waterway modification Water Quality Removal of woody debris Instream barriers Pond Dewatering	Direct	Temporary localised disturbance and potential loss of riparian habitat Increased turbidity and nutrients Impediment of fish movements	Short term During and post construction	• Removal of large woody debris or snags (FM Act) This potential impact is prevented when all large woody snags are relocated in stream.
Changes to hydrology	Waterways	Indirect	Considered minor and manageable	Short term During and post construction	• Alteration to the natural flow regimes of rivers and streams and their floodplains and wetlands
Fragmentation of identified biodiversity links and habitat corridors	Further barrier to Regional Corridor 17 Fragmentation of local corridors between the Northern Road and Willowdene Avenue	Direct	Regional Local	Long term During and post construction	

Impact	Biodiversity values	Nature of impact Direct, indirect, consequential, cumulative	Extent of impact Site based, Local, Regional, State, National	Duration Short term/ Long term, pre, during or post construction	Does the project constitute or exacerbate a key threatening process?
Edge effects on adjacent native vegetation and habitat	Vegetation to be fragmented	Indirect	Local	Long term During and post construction	
Injury and mortality of fauna	Potentially all fauna species present	Direct	Local	Long term During and post construction	
Invasion and spread of weeds and pests	All vegetation adjacent to works	Indirect	Local in area of disturbance	Long term During and post construction	• Invasion and establishment of exotic vines and scramblers • Invasion and establishment of Scotch broom (*Cytisus scoparius*) • Invasion of native plant communities by African Olive (*Olea europaea* L. subsp. *cuspidata)* • Invasion, establishment and spread of *Lantana camara* • Invasion of native plant communities by exotic perennial grasses • Loss and degradation of native plant and animal habitat by invasion of escaped garden plants, including aquatic plants
Invasion and spread of pests	All vegetation adjacent to works	Indirect	Local in area of disturbance	Long term During and post construction	• Competition and grazing by the feral European rabbit (*Oryctolagus cuniculus*) • Predation by the European red fox (*Vulpes vulpes*) • Predation by the feral cat (*Felis catus*) • Predation by Plague Minnow or Mosquito Fish *(Gambusia holbrooki*)
Invasion and spread of pathogens and disease	All vegetation adjacent to works	Indirect	Local	Long term During and post	• Infection of native plants by *Phytophthora cinnamomi* • Introduction and Establishment of Exotic Rust Fungi

Impact	Biodiversity values	Nature of impact Direct, indirect, consequential, cumulative	Extent of impact Site based, Local, Regional, State, National	Duration Short term/ Long term, pre, during or post construction	Does the project constitute or exacerbate a key threatening process?
	Dams and waterways			construction	of the order Pucciniales pathogenic on plants of the family Myrtaceae • Infection by psittacine circoviral (beak and feather) disease affecting endangered psittacine species and populations • Infection of frogs by amphibian chytrid causing the disease chytridiomycosis
Noise, light and vibration	All local fauna species	Direct/indirect	Local	Short term and long term During and post construction	

9 Mitigation

Once all practicable steps to avoid or minimise impacts have been implemented at the design phase, mitigation measures will be implemented to further lessen the potential ecological impacts of the project.

Mitigation measures are to be undertaken during the construction and operational phases. The Roads and Maritime guidelines and procedures identify a range of mitigation techniques to be applied, including managing the vegetation clearing process, re-establishment of native vegetation at the end of a project, weed management, provision of supplementary fauna habitat (such as nest boxes for appropriate species), and installation of erosion and sediment controls as appropriate.

The following mitigation measures as outlined in the *Biodiversity Guidelines: Protecting and managing biodiversity of RTA projects* (NSW Roads and Traffic Authority, 2011) are recommended for implementation (see Table 9.1). The NSW DPI (Fisheries) document *Policy and Guidelines for fish habitat conservation and management (2013 update)* (Department of Primary Industries, 2013) has also been used.

The mitigation measures outlined below in Table 9.1 will ensure that threat abatement plans for a process that threatens an affected EPBC Act listed species or ecological community are not compromised. This is relevant to the threat abatement plants that relate to pest species, weed species and pathogens.

Table 9.1: Mitigation measures

Impact	Mitigation measures	Timing and duration	Likely efficacy of mitigation	Residual impacts anticipated
Removal of native vegetation	Native vegetation removal will be minimised through detailed design.	Detailed design	Effective	Loss of native vegetation
	Pre-clearing surveys will be undertaken in accordance with *Guide 1: Pre-clearing process* of the *Biodiversity Guidelines: Protecting and managing biodiversity on RTA projects* (NSW Roads and Traffic Authority, 2011).	Prior to construction	Effective	
	Vegetation removal will be undertaken in accordance with *Guide 4: Clearing of vegetation and removal of bushrock* of the *Biodiversity Guidelines: Protecting and managing biodiversity on RTA projects* (NSW Roads and Traffic Authority, 2011).	During construction	Effective	
	Native vegetation will be re-established in accordance with *Guide 3: Re-establishment of native vegetation* of the *Biodiversity Guidelines: Protecting and managing biodiversity on RTA projects* (NSW Roads and Traffic Authority, 2011).	Post construction	Effective	
	The unexpected species find procedure is to be followed under *Biodiversity Guidelines: Protecting and managing biodiversity on RTA projects* (NSW Roads and Traffic Authority, 2011) if threatened ecological communities, not assessed in the biodiversity assessment, are identified on the	During construction	Proven	

Impact	Mitigation measures	Timing and duration	Likely efficacy of mitigation	Residual impacts anticipated
	project. The procedure is as follows: 1. Threatened flora or fauna species unexpectedly encountered 2. Stop work 3. Notify the environment manager 4. Environmental manager would arrange for an ecologist to conduct an assessment of significance of the likely impact, develop management options and notify OEH, DPI and DoEE as appropriate 5. If a significant impact is not likely to occur, recommence work and maintain regular inspections 6. If a significant impact is likely to occur: a. Consult with OEH, DPI and DoEE as appropriate b. Obtain approvals, licenses or permits as required c. Recommence works once advice is sought and necessary approvals, licences and permits are obtained 7. include species in subsequent inductions, toolbox talks and update the CEmP.			
Removal of threatened species habitat and habitat features	Habitat removal will be minimised through detailed design.	Detailed design	Effective	Loss of threatened fauna habitat
	Habitat removal will be undertaken in accordance with *Guide 4: Clearing of vegetation and removal of bushrock* of the *Biodiversity Guidelines: Protecting and managing biodiversity on RTA projects* (NSW Roads and Traffic Authority, 2011).	During construction	Effective	
	Habitat will be replaced or re-instated in accordance with *Guide 5: Re-use of woody debris and bushrock* and *Guide 8: Nest boxes* of the *Biodiversity Guidelines: Protecting and managing biodiversity on RTA projects* (NSW Roads and Traffic Authority, 2011).	During construction	Proven	
	The unexpected species find procedure is to be followed under *Biodiversity Guidelines: Protecting and managing biodiversity on RTA projects* (NSW Roads and Traffic Authority, 2011) if threatened fauna, not assessed in the biodiversity assessment, are identified on the project.	During construction	Proven	
Removal of threatened plants	Pre-clearing surveys will be undertaken in accordance with *Guide 1: Pre-clearing process* of the *Biodiversity Guidelines: Protecting and managing biodiversity on RTA projects* (NSW Roads and Traffic Authority, 2011).	During construction	Proven	Loss of threatened plants
	The unexpected species find procedure is to be followed under *Biodiversity Guidelines: Protecting and managing biodiversity on RTA projects* (RTA 2011) if threatened flora species, not assessed in	During construction	Proven	

Impact	Mitigation measures	Timing and duration	Likely efficacy of mitigation	Residual impacts anticipated
	the biodiversity assessment, are identified on the project.			
Aquatic impacts	Aquatic habitat will be protected in accordance with *Guide 10: Aquatic habitats and riparian zones* of the *Biodiversity Guidelines: Protecting and managing biodiversity on RTA projects* (NSW Roads and Traffic Authority, 2011) and Section 3.3.2 *Standard precautions and mitigation measures* of the *Policy and guidelines for fish habitat conservation and management Update 2013* (Department of Primary Industries, 2013).	During construction	Effective	None
Removal of woody debris	All large woody debris or snags will be relocated instream.	During construction	Effective	None
Changes to hydrology	Changes to existing surface water flows will be minimised through detailed design.	Detailed design	Effective	None
Fragmentation of identified biodiversity links and habitat corridors	Connectivity measures will be implemented in accordance with the *Wildlife Connectivity Guidelines for Road Projects* (RMS in prep).	Detailed design, during construction and post construction	Effective	Loss of connectivity for fauna species
Edge effects on adjacent native vegetation and habitat	Exclusion zones will be set up at the limit of clearing in accordance with *Guide 2: Exclusion zones* of the *Biodiversity Guidelines: Protecting and managing biodiversity on RTA projects* (NSW Roads and Traffic Authority, 2011).	During construction	Effective	Loss of habitat in edge areas of about 1.94 hectares.
Injury and mortality of fauna	Fauna will be managed in accordance with *Guide 9: Fauna handling* of the *Biodiversity Guidelines: Protecting and managing biodiversity on RTA projects* (NSW Roads and Traffic Authority, 2011).	During construction	Effective	None
Invasion and spread of weeds	Weed species will be managed in accordance with *Guide 6: Weed management* of the *Biodiversity Guidelines: Protecting and managing biodiversity on RTA projects* (NSW Roads and Traffic Authority, 2011).	During construction	Effective	None
Invasion and spread of pests	Pest species will be managed within the project site according to the *Biodiversity Guidelines: Protecting and managing biodiversity on RTA projects* (NSW Roads and Traffic Authority, 2011).	During construction	Effective	None
Invasion and spread of pathogens and disease	Pathogens will be managed in accordance with *Guide 7: Pathogen management* of the *Biodiversity Guidelines: Protecting and managing biodiversity on RTA projects* (NSW Roads and Traffic Authority, 2011).	During construction	Effective	None
Noise, light and	Shading and artificial light impacts will be	Detailed	Effective	Loss of habitat

Impact	Mitigation measures	Timing and duration	Likely efficacy of mitigation	Residual impacts anticipated
vibration	minimised through detailed design.	design		in edge areas of about 1.94 hectares.

10 Residual impacts to listed threatened species and ecological communities

Residual impacts are those that remain after the implementation of avoidance and minimisation measures and after mitigation measures have been implemented for the Project. Avoidance and minimisation measures for the Project are outlined in Section 7. The proposed mitigation measures for the Project are outlined in Section 9.

Due to the design and nature of the Project (i.e. a road widening and construction of new road sections), total avoidance and mitigation of biodiversity impacts cannot be reasonably achieved. The predicted residual impacts of the Project on EPBC Act listed threatened species and ecological communities are outlined in Table 10.1. The residual impact to other biodiversity matters assessed under the FBA are outlined in Section 11 which deals with offsetting. Despite avoidance and minimisation and mitigation measures, there will still be some residual impacts to threatened biodiversity resulting from the Project.

The residual impacts from the Project will be offset and a BOS for the Project had been prepared (see Section 11 and Appendix E). The BOS is targeted to compensate for the residual impacts associated with the project and relies on direct offsets to compensate for the full duration of impacts to matters of national environmental significance.

Table 10.1: Summary of residual impacts to EPBC Act listed threatened species and ecological communities

Residual impact	Matter of NES impacted	Nature of impact Direct, indirect, consequential, cumulative	Extent of impact Site based, Local, Regional, State, National	Duration Short term/ Long term, pre, during or post construction
Removal of Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest CEEC (EPBC Act)	Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest CEEC (EPBC Act)	Direct	About 16.37 hectares	Long term – residual impact During construction
Removal of EPBC Act listed threatened fauna species habitat and habitat features	Regent Honeyeater, Swift Parrot, Large-eared Pied Bat, Grey-headed Flying-fox	Direct	About 26.25 hectares of habitat	Long term – residual impact During construction
Removal of EPBC Act listed threatened plants	*Pultenaea parviflora*	Direct	Four plants About 0.98 hectares of habitat	Long term – residual impact During construction

11 Offsetting required

The results of the BioBanking credit calculator are presented here. The required ecosystem credits are outlined in Table 11.1. Table 11.2 outlines the required species credits. The full biodiversity offset credit report is provided in Appendix C. The BOS for the project is provided in Appendix E.

The Commonwealth EIS Guidelines issued on 24 August 2016 indicate that the EIS must:

- Include details of an offset package to be implemented to compensate for residual significant impacts associated with the project as well as an analysis of how the offset meets the requirements of the Commonwealth Department of Environment and Energy's *EPBC Act Environmental Offsets Policy October 2012* (EPBC Act Offset Policy) or a state offsetting policy that has been endorsed by the Commonwealth.
- The offset package can comprise a combination of direct offsets and other compensatory measures, as long as it meets the requirements of the EPBC Act Offset Policy. Offsets should align with conservation priorities for the impacted protected matter and be tailored specifically to the attribute of the protected matter that is impacted in order to deliver a conservation gain.
- Offsets should compensate for an impact for the full duration of the impact.
- Offsets must directly contribute to the ongoing viability of the protected matter impacted by the project and deliver an overall conservation outcome that maintains or improves the viability of the protected matter, compared to what is likely to have occurred under the 'status quo' (i.e. if the action and associated offset had not taken place).
- The EIS must provide:
    - Details of the offset package to compensate for significant residual impacts on a protected matter; and
    - An analysis of how the offset package meets the requirements of the EPBC Act Offsets Policy.

The project is predicted to have residual significant impacts to the critically endangered Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest ecological community and as such an offset under the EPBC Act is required. Significant residual impacts to the Swift Parrot, Regent Honeyeater, *Pultenaea parviflora* and Grey-headed Flying-fox are not predicted (see Appendix F). However, offsets will be provided for these species as a mandatory requirement under the FBA (offset as species credits or ecosystem credits are applicable, see Appendix E).

The BOS provided in Appendix E addresses the requirements of the Commonwealth EIS Guidelines regarding offsets. This BOS is targeted to compensate for the significant residual impacts associated with the project and relies on direct offsets, and potentially other compensatory measures, to compensate for the full duration of the impact. The project offsets will aim to provide 'like for like' offsets for all biodiversity values, with this being the minimum requirement for those matters listed under the EPBC Act. Investigations for sourcing the required credits to meet the offset obligations are underway, with a range of offset options already identified (see Appendix E).

The final offset requirement for the Project will be determined during development of the offset package. During the detailed design phase the project footprint may change from that assessed here which would result in a different offset requirement for the Project than what is presented in this BAR.

Table 11.1 Ecosystem credits summary

PC type code	Plant community type (PCT)	Vegetation zone condition	Management zone area (ha)	Loss in Landscape Value	Loss in site value score	EEC Offset Multiplier	Credits req for TS	TS with highest credit req	TS offset multiplier	Ecosystem credits required
HN528	Grey Box - Forest Red Gum grassy woodland on flats of the Cumberland Plain, Sydney Basin Bioregion	Moderate/ Good	6.67	17.25	55.56	3.0	307	Barking Owl	3.0	307
HN526	Forest Red Gum - Rough-barked Apple grassy woodland on alluvial flats of the Cumberland Plain, Sydney Basin Bioregion	Moderate/ Good	2.53	17.25	53.65	3.0	113	Masked Owl	3.0	113
HN529	Grey Box - Forest Red Gum grassy woodland on shale of the southern Cumberland Plain, Sydney Basin Bioregion	Moderate/Good	4.92	17.25	57.97	3.0	235	Barking Owl	3.0	235
HN528	Grey Box - Forest Red Gum grassy woodland on flats of the Cumberland Plain, Sydney Basin Bioregion	Moderate/Good_Poor	4.68	17.25	15.94	3.0	76	Barking Owl	3.0	0
HN529	Grey Box - Forest Red Gum grassy woodland on shale of the southern Cumberland Plain, Sydney Basin Bioregion	Moderate/Good_Poor	3.21	17.25	24.64	3.0	73	Barking Owl	3.0	73

PC type code	Plant community type (PCT)	Vegetation zone condition	Management zone area (ha)	Loss in Landscape Value	Loss in site value score	EEC Offset Multiplier	Credits req for TS	TS with highest credit req	TS offset multiplier	Ecosystem credits required
HN526	Forest Red Gum - Rough-barked Apple grassy woodland on alluvial flats of the Cumberland Plain, Sydney Basin Bioregion	Moderate/Good_Poor	1.76	17.25	43.23	3.0	65	Masked Owl	3.0	65
HN529	Grey Box - Forest Red Gum grassy woodland on shale of the southern Cumberland Plain, Sydney Basin Bioregion	Moderate/Good_High	1.25	17.25	74.64	3.0	75	Barking Owl	3.0	75
HN627	Derived grasslands on shale hills of the Cumberland Plain (50-300m asl)	Moderate/Good_Derived grassland	12.01	17.25	19.05	3.0	132	Little Eagle	1.4	223
HN630	Phragmites australis and Typha orientalis coastal freshwater wetlands of the Sydney Basin Bioregion	Moderate/Good_Other	6.17	17.25	34.06	1.0	142	Eastern Freetail-bat	2.2	142
HN529	Grey Box - Forest Red Gum grassy woodland on shale of the southern Cumberland Plain, Sydney Basin Bioregion	Moderate/Good_Medium	1.09	17.25	25.85	3.0	26	Barking Owl	3.0	26

Table 11.2 Species credits summary

Scientific name	Common name	TS offset multiplier	Species credits required
Meridolum corneovirens	Cumberland Plain Land Snail	1.3	169
Marsdenia viridiflora subsp. *viridiflora* - endangered population	*Marsdenia viridiflora* subsp. *viridiflora* in the Bankstown, Blacktown, Camden, Campbelltown, Fairfield, Holroyd, Liverpool and Penrith local government areas	4.0	1,400
Pultenaea parviflora	Pultenaea parviflora	1.5	60
Anthochaera phrygia	Regent Honeyeater	7.7	2,021

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Appendix A – Species recorded

The tables in this appendix provide the results of the floristic plot surveys at the time of survey and do not provide a comprehensive inventory of all plant species that may occur in the study area.

Recorded flora in Grey Box - Forest Red Gum grassy woodland on flats of the Cumberland Plain, Sydney Basin Bioregion - Moderate/Good

Family	Scientific Name	Common name	Native?	Status		Abundance in each plot*										
				TSC Act	EPBC Act	170-2	16	Defence 2	Marsdenia 1	Defence P2	2183 TNR	2 Bradley St	P2-2	P2-3	291	27
Acanthaceae	*Brunoniella australis*	Blue Trumpet	Y						20+		20+	20+	20+		20+	20+
Adiantaceae	*Cheilanthes sieberi*	Mulga Fern	Y					2				3	1	20+		20+
Amaranthaceae	*Alternanthera denticulata*	Lesser Joyweed	Y				2									
Anthericaceae	*Arthropodium milleflorum*	Vanilla Lily	Y						1	5	20+					
	Tricoryne elatior	Yellow Autumn-lily	Y													4
Apiaceae	*Centella asiatica*	Pennywort	Y					20+					1	1		
	Cyclospermum leptophyllum	Slender Celery	N				20+			4	6		1			1
Apocynaceae	*Parsonsia straminea*	Common Silkpod	Y											1		
Asclepiadaceae	*Araujia sericifera*	Moth Vine	N				20+		20+	1	1	20+		20+		
	Gomphocarpus fruticosus	Narrow-leaved Cotton Bush	N													1
	Marsdenia viridiflora subsp. *viridiflora*	Native Pear	Y	EP					5							
Asteraceae	*Bidens pilosa*	Cobbler's Pegs	N				20+	1	1				20+	20+		
	Cirsium vulgare	Spear Thistle	N			20+	1				2	2	2	20+	3	1
	Conyza bonariensis	Flaxleaf Fleabane	N												30+	1
	Cotula australis	Common Cotula	Y			20+										
	Euchiton sphaericus		Y										1		1	
	Gamochaeta americana	American Cudweed	N							1	1					
	Hypochaeris radicata	Catsear	N						20+		2			1		
	Lactuca serriola	Prickly Lettuce	N								1					
	Senecio madagascariensis	Fireweed	N				1	4	10	8	20+	20+		11	1	1
	Sigesbeckia orientalis		Y												1	
	Sonchus oleraceus	Common Sowthistle	N				2		2		1	1				
	Taraxacum officinale	Dandelion	N			20+				2	6					

Family	Scientific Name	Common name	Native?	Status		Abundance in each plot*										
				TSC Act	EPBC Act	170-2	16	Defence 2	Marsdenia 1	Defence P2	2183 TNR	2 Bradley St	P2-2	P2-3	291	27
	Vittadinia sp.		Y						1						2	
Boraginaceae	*Cynoglossum australe*		Y												1	
Cactaceae	*Opuntia stricta*	Prickly Pear	N								2					
Campanulaceae	*Wahlenbergia communis*	Tufted Bluebell	Y				1				3	1				
	Wahlenbergia gracilis	Sprawling or Australian Bluebell	Y											1	2	1
Caryophyllaceae	*Stellaria media*	Chickweed	N			20+	20+									
Chenopodiaceae	*Einadia hastata*	Berry Saltbush	Y				1									
	Einadia nutans	Climbing Saltbush	Y				1		1		1		20+			
	Einadia trigonos		Y												3	
Clusiaceae	*Hypericum gramineum*	Small St John's Wort	Y					1						20+	20+	
Commelinaceae	*Commelina cyanea*	Native Wandering Jew	Y				20+									
Convolvulaceae	*Dichondra repens*	Kidney Weed	Y				20+	20+	20+	20+	20+	20+	20+		20+	100+
Crassulaceae	*Crassula* sp.		N						1							
Cyperaceae	*Carex inversa*	Knob Sedge	Y												1	1
	Cyperus eragrostis	Umbrella Sedge	N										1			
	Cyperus gracilis		Y			20+	1					20+	1	1	1	10
	Eleocharis gracilis		Y										20+			
Euphorbiaceae	*Breynia oblongifolia*		Y												1	
	Phyllanthus virgatus		Y									1		1	1	2
Fabaceae (Faboideae)	*Daviesia genistifolia*	Broom Bitter Pea	Y							1						
	Desmodium brachypodum	Large Tick-trefoil	Y												3	
	Desmodium varians	Slender Tick-trefoil	Y												20+	1
	Dillwynia sieberi		Y					10								
	Glycine microphylla		Y												1	
	Glycine tabacina		Y					1	20+		20+	20+	20+	20+	20+	20+
	Hardenbergia violacea	False Sarsaparilla	Y				20+	4	1		1	1				
	Medicago polymorpha	Burr Medic	N			1					20+					

Family	Scientific Name	Common name	Native?	Status		Abundance in each plot*										
				TSC Act	EPBC Act	170-2	16	Defence 2	Marsdenia 1	Defence P2	2183 TNR	2 Bradley St	P2-2	P2-3	291	27
	Trifolium repens	White Clover	N												20+	
Fabaceae (Mimosoideae)	*Acacia falcata*		Y					20+	1							
	Acacia parramattensis	Parramatta Wattle	Y						2			3				
Fumariaceae	*Fumaria muralis*		N				1									
Gentianaceae	*Centaurium erythraea*	Common Centaury	N													1
Geraniaceae	*Geranium solanderi*	Native Geranium	Y													20+
Goodeniaceae	*Goodenia hederacea*	Variable-leaved Goodenia	Y					20+								
	Scaevola albida		Y												2	
Juncaceae	*Juncus usitatus*		Y										20+			
Lamiaceae	*Mentha satureioides*	Native Pennyroyal	Y										20+			
Linaceae	*Linum trigynum*	French Flax	N							1				1		
	Plectranthus parviflorus		Y												2	
Lomandraceae	*Lomandra filiformis*	Wattle Matt-rush	Y								2					
Malvaceae	*Modiola caroliniana*	Red-flowered Mallow	N			20+	20+							1		1
	Sida rhombifolia	Paddy's Lucerne	N			20+	20+				5	20+	20+	20+	30+	20+
Myoporaceae	*Eremophila debilis*	Amulla	Y						1						20+	
Myrtaceae	*Eucalyptus crebra*	Narrow-leaved Ironbark	Y									3				
	Eucalyptus moluccana	Grey Box	Y			22	2	2	9	4	36		40	20	4	
	Eucalyptus tereticornis	Forest Red Gum	Y			3	20				2	4			2	4
Oleaceae	*Olea europaea* subsp. *cuspidata*	African Olive	N				20+			1	2		20+		11	2
Oxalidaceae	*Oxalis perennans*		Y			20+						20+		20+	10	20+
Phormiaceae	*Dianella longifolia*		Y						1		4					
Phytolaccaceae	*Phytolacca octandra*	Inkweed	N			1										
Pittosporaceae	*Bursaria spinosa*	Native Blackthorn	Y			4				1	1	20+	1	6	5	30
Plantaginaceae	*Plantago gaudichaudii*		Y												1	
	Plantago lanceolata	Lamb's Tongues	N				20+	20+	20+	2	20+	20+	1	2	20+	1

Family	Scientific Name	Common name	Native?	Status		Abundance in each plot*									
				TSC Act	EPBC Act	170-2	16	Defence 2	Marsdenia 1	Defence P2	2183 TNR	2 Bradley St	P2-2	P2-3	291	27
	Plantago major	Large Plantain	N												1	
Poaceae	*Aristida ramosa*		Y												20+	2
	Aristida vagans	Threeawn Speargrass	Y				20+		1	4	2	20+	20+	20+		
	Bothriochloa macra	Red Grass	Y									20+			5	2
	Briza subaristata		N					20+		4		20+	1	1		
	Bromus catharticus	Prairie Grass	N									1				
	Chloris gayana	Rhodes Grass	N			20+	20+	20+	20+	20=	20+					
	Chloris ventricosa	Tall Chloris	Y												20+	1
	Cynodon dactylon	Common Couch	Y							20+				20+		
	Dichelachne sp.	Plume Grass	Y										1			
	Echinopogon caespitosus	Bushy Hedgehog-grass	Y										1		3	20+
	Ehrharta erecta	Panic Veldtgrass	N			20+	20+									
	Eragrostis brownii	Brown's Lovegrass	Y													2
	Eragrostis curvula	African Lovegrass	N				20+	20+	20+	20+	20+			20+	2	
	Lachnagrostis filiformis		Y							1						
	Lolium perenne	Perennial Ryegrass	N							1		1				
	Microlaena stipoides		Y			20+							20+	20+	100+	200+
	Oplismenus aemulus	Basket Grass	Y									20+	20+		20+	1
	Panicum simile	Two-colour Panic	Y												1	1
	Paspalum dilatatum	Paspalum	N												50+	
	Pennisetum clandestinum	Kikuyu Grass	N			20+	20+			20+						
	Rytidosperma sp.	Wallaby Grass	Y													3
	Setaria parviflora	Slender Pigeon Grass	N				20+									
	Sporobolus creber	Slender Rat's Tail Grass	Y												1	20+
	Themeda triandra		Y					20+	20+		20+			20+		
Polygonaceae	*Rumex crispus*	Curled Dock	N			2	4									
Primulaceae	*Anagallis arvensis*	Scarlet/Blue Pimpernel	N								20+			1		

Family	Scientific Name	Common name	Native?	Status		Abundance in each plot*										
				TSC Act	EPBC Act	170-2	16	Defence 2	Marsdenia 1	Defence P2	2183 TNR	2 Bradley St	P2-2	P2-3	291	27
Rubiaceae	*Asperula conferta*	Common Woodruff	Y										20+			20+
	Galium sp.		Y												20+	
	Richardia stellaris		N													1
Sapindaceae	*Dodonaea viscosa*		Y							2						
Solanaceae	*Lycium ferocissimum*	African Boxthorn	N			4						3	1			
	Solanum linnaeanum	Apple of Sodom	N			20+	1									40
	Solanum prinophyllum	Forest Nightshade	Y				20+								4	20
	Solanum pseudocapsicum	Madeira Winter Cherry	N											2	1	
	Solanum seaforthianum	Climbing Nightshade	N			20+										
Stackhousiaceae	*Stackhousia viminea*	Slender Stackhousia	Y											2		
Urticaceae	*Urtica incisa*	Stinging Nettle	Y			1										
Verbenaceae	*Lantana camara*	Lantana	N			6							1			
	Verbena bonariensis	Purple top	N				1	1			1			1	1	

Note: *Abundance has been assigned according to the categories outlined in the FBA. For some species abundances are an estimate as it was impossible to count every plant in the floristic plot (e.g. it is impossible to count every individual *Microlaena stipoides* or *Cynodon dactylon* plant).

Recorded flora in Forest Red Gum - Rough-barked Apple grassy woodland on alluvial flats of the Cumberland Plain, Sydney Basin Bioregion - Moderate/Good

Family	Scientific Name	Common name	Native?	Status		Abundance in each plot*			
				TSC Act	EPBC Act	P12-1	P12-2	P12-3	P12-4
Acanthaceae	*Brunoniella australis*	Blue Trumpet	Y			1		20+	
Adiantaceae	*Adiantum aethiopicum*	Common Maidenhair	Y						
	Cheilanthes sieberi	Mulga Fern	Y					20+	20+
Apiaceae	*Centella asiatica*	Pennywort	Y			20+			
	Cyclospermum leptophyllum	Slender Celery	N			20+	20+	20+	
Asclepiadaceae	*Araujia sericifera*	Moth Vine	N			20+	20+	20+	20+
Asteraceae	*Bidens pilosa*	Cobbler's Pegs	N			20+	20+	20+	
	Chrysocephalum apiculatum	Common Everlasting	Y						20+
	Cirsium vulgare	Spear Thistle	N			2	1	1	1
	Conyza bonariensis	Flaxleaf Fleabane	N				1	1	
	Euchiton sphaericus		Y				1		
	Glossogyne tannensis	Cobbler's Tack	Y					1	
	Hypochaeris radicata	Catsear	N			20+	1	1	
	Leontodon saxatilis		N			20+			
	Senecio madagascariensis	Fireweed	N			20+	20+	20+	1
	Vittadinia sp.		Y					1	
Bignoniaceae	*Jacaranda mimosifolia*	Jacaranda	N						1
Cactaceae	*Opuntia stricta*	Prickly Pear	N				2		
Campanulaceae	*Wahlenbergia communis*	Tufted Bluebell	Y					1	
	Wahlenbergia gracilis	Sprawling or Australian Bluebell	Y					2	
Chenopodiaceae	*Einadia trigonos*	Fishweed	Y				20+		
Convolvulaceae	*Dichondra repens*	Kidney Weed	Y				20+	20+	20+
Cyperaceae	*Cyperus gracilis*		Y			20+	1		
Euphorbiaceae	*Phyllanthus virgatus*		Y					1	3
Fabaceae (Faboideae)	*Dillwynia sieberi*		Y					1	
	Glycine tabacina		Y				20+	20+	20+

Family	Scientific Name	Common name	Native?	Status		Abundance in each plot*			
				TSC Act	EPBC Act	P12-1	P12-2	P12-3	P12-4
Fabaceae (Mimosoideae)	*Acacia parramattensis*	Parramatta Wattle	Y					1	1
Gentianaceae	*Centaurium erythraea*	Common Centaury	N					1	
Goodeniaceae	*Goodenia hederacea*	Variable-leaved Goodenia	Y					1	20+
Juncaceae	*Juncus usitatus*		Y			1			
Lomandraceae	*Lomandra filiformis*	Wattle Matt-rush	Y					1	
Malvaceae	*Sida rhombifolia*	Paddy's Lucerne	N			20+	20+	20+	
Myrtaceae	*Angophora floribunda*		Y					1	4
	Eucalyptus amplifolia	Cabbage Gum	Y			7			
	Eucalyptus crebra	Narrow-leaved Ironbark	Y			42			3
	Eucalyptus moluccana	Grey Box	Y					3	2
	Eucalyptus tereticornis	Forest Red Gum	Y				49		20
Oleaceae	*Olea europaea* subsp. *cuspidata*		N					1	
Oxalidaceae	*Oxalis perennans*		Y				1	1	
Pinaceae	*Pinus* sp.	Pine Tree	N			2			
Pittosporaceae	*Bursaria spinosa*	Native Blackthorn	Y						20+
Plantaginaceae	*Plantago lanceolata*	Lamb's Tongues	N			20+	1	1	
Poaceae	*Briza subaristata*		N			20+		1	
	Cymbopogon refractus	Barbed Wire Grass	Y			1		5	1
	Cynodon dactylon	Common Couch	Y					1	
	Eragrostis curvula	African Lovegrass	N			12		20+	
	Microlaena stipoides		Y			20+	20+	20+	20+
	Themeda triandra		Y						1
Polygonaceae	*Rumex crispus*	Curled Dock	N				1		
Primulaceae	*Anagallis arvensis*	Scarlet/Blue Pimpernel	N				20+	20+	
Proteaceae	*Hakea sericea*		Y					1	
Rubiaceae	*Opercularia diphylla*	Stinkweed	Y						4
	Richardia stellaris		N					1	

Family	Scientific Name	Common name	Native?	Status		Abundance in each plot*			
				TSC Act	EPBC Act	P12-1	P12-2	P12-3	P12-4
Stackhousiaceae	*Stackhousia viminea*	Slender Stackhousia	Y						2

Note: *Abundance has been assigned according to the categories outlined in the FBA. For some species abundances are an estimate as it was impossible to count every plant in the floristic plot (e.g. it is impossible to count every individual *Microlaena stipoides* or *Cynodon dactylon* plant).

Recorded flora in Grey Box - Forest Red Gum grassy woodland on shale of the southern Cumberland Plain, Sydney Basin Bioregion - Moderate/Good

Family	Scientific Name	Common name	Native?	Status		Abundance in each plot*						
				TSC Act	EPBC Act	40	57	63	2 Bradley St 2	149	P2-1	2627 TNR
Acanthaceae	*Brunoniella australis*	Blue Trumpet	Y			1			2		20+	20+
Adiantaceae	*Cheilanthes sieberi*	Mulga Fern	Y					20+			1	
Anthericaceae	*Arthropodium milleflorum*	Vanilla Lily	Y					1			1	20+
Apiaceae	*Centella asiatica*	Pennywort	Y			20+				20+	1	
	Cyclospermum leptophyllum	Slender Celery	N						20+			
	Hydrocotyle tripartita	Pennywort	Y								1	
Asclepiadaceae	*Araujia sericifera*	Moth Vine	N							1	20+	1
	Gomphocarpus fruticosus	Narrow-leaved Cotton Bush	N			1						
Asparagaceae	*Asparagus asparagoides*		N					20+				
Asteraceae	*Bidens pilosa*	Cobbler's Pegs	N				20+	20+			1	1
	Cirsium vulgare	Spear Thistle	N			20+		1	4	1	1	1
	Conyza bonariensis	Flaxleaf Fleabane	N						20+			1
	Cotula australis	Common Cotula	Y				1		20+	20+		
	Cymbonotus lawsonianus	Bear's Ear	Y			20+						
	Hypochaeris radicata	Catsear	N			1			1	20+		
	Lactuca serriola	Prickly Lettuce	N									1
	Senecio madagascariensis	Fireweed	N			20+	20+	20+	20+	20+		20+
	Sigesbeckia orientalis		Y						20+			
	Sonchus oleraceus	Common Sowthistle	N			1		1		1		2
	Tagetes minuta	Stinking Roger	N				1					
	Taraxacum officinale	Dandelion	N			1						
	Echium sp.		N									1
Brassicaceae	*Brassica* sp.		N			1						
	Capsella bursa-pastoris		N						20+			
Campanulaceae	*Wahlenbergia communis*	Tufted Bluebell	Y					1				
	Wahlenbergia gracilis	Sprawling or Australian Bluebell	Y							20+	20+	

Family	Scientific Name	Common name	Native?	Status		Abundance in each plot*						
				TSC Act	EPBC Act	40	57	63	2 Bradley St 2	149	P2-1	2627 TNR
Caryophyllaceae	*Stellaria media*	Chickweed	N			20+	20+			20+		
Chenopodiaceae	*Einadia hastata*	Berry Saltbush	Y				20+					
	Einadia nutans	Climbing Saltbush	Y			1			20+			20+
Colchicaceae	*Wurmbea dioica*		Y					20+		3		
Commelinaceae	*Commelina cyanea*	Native Wandering Jew	Y								20+	
Convolvulaceae	*Convolvulus erubescens*		Y				1					
	Dichondra repens	Kidney Weed	Y			20+	20+	20+	20+	20+	20+	20+
Cyperaceae	*Cyperus gracilis*		Y			20+		20+		20+	1	
Euphorbiaceae	*Phyllanthus virgatus*		Y								1	
Fabaceae (Faboideae)	*Glycine clandestina*		Y				2					
	Glycine tabacina		Y			20+		20+	20+		20+	
	Indigofera australis		Y					4				
	Lotus sp.	Trefoil	N						1	20+		
	Medicago polymorpha	Burr Medic	N				20+		20+			
	Trifolium repens	White Clover	N				20+		20+			
Fabaceae (Mimosoideae)	*Acacia parramattensis*	Parramatta Wattle	Y				20+					
Geraniaceae	*Geranium solanderi*	Native Geranium	Y					1				
Lamiaceae	*Mentha satureioides*	Native Pennyroyal	Y					20+				
	Plectranthus parviflorus		Y				2					
	Scutellaria humilis	Dwarf Skullcap	Y								1	
Lomandraceae	*Lomandra filiformis*	Wattle Matt-rush	Y									20+
Luzuriagaceae	*Geitonoplesium cymosum*	Scrambling Lily	Y					4				
Malvaceae	*Malva parviflora*	Small-flowered Mallow	N						1			
	Modiola caroliniana	Red-flowered Mallow	N			1	20+					
	Sida rhombifolia	Paddy's Lucerne	N			1	20+		20+	20+	20+	1
Myoporaceae	*Eremophila debilis*	Amulla	Y			20+						
Myrtaceae	*Eucalyptus moluccana*	Grey Box	Y			18	5	10	1		1	10

Family	Scientific Name	Common name	Native?	Status		Abundance in each plot*						
				TSC Act	EPBC Act	40	57	63	2 Bradley St 2	149	P2-1	2627 TNR
	Eucalyptus tereticornis	Forest Red Gum	Y			1	9	2	6	2	6	
Oleaceae	*Olea europaea* subsp. *cuspidata*		N			1	20+	20+				1
Oxalidaceae	*Oxalis perennans*		Y			20+		1		20+	20+	
Phormiaceae	*Dianella longifolia*		Y					1				3
Pittosporaceae	*Bursaria spinosa*	Native Blackthorn	Y			20+	20+	20+	10	20+	20+	
Plantaginaceae	*Plantago gaudichaudii*		Y			1						20+
	Plantago lanceolata	Lamb's Tongues	N					1	20+	20+		
Poaceae	*Aristida vagans*	Threeawn Speargrass	Y					20+			1	
	Chloris gayana	Rhodes Grass	N					20+		20+		
	Chloris ventricosa	Tall Chloris	Y			20+						
	Cynodon dactylon	Common Couch	Y			20+						
	Dichelachne sp.	Plume Grass	Y				1					
	Ehrharta erecta	Panic Veldtgrass	N			20+						20+
	Enteropogon acicularis		Y			20+						
	Eragrostis brownii	Brown's Lovegrass	Y				1					
	Eragrostis curvula	African Lovegrass	N					20+	20+	20+		20+
	Lolium perenne	Perennial Ryegrass	N							20+		20+
	Microlaena stipoides		Y				20+			20+	20+	
	Oplismenus aemulus	Basket Grass	Y			20+	20+	20+	2			
	Pennisetum clandestinum	Kikuyu Grass	N					20+		20+		20+
	Poa annua	Winter Grass	N			20+	20+					
	Setaria parviflora	Slender Pigeon Grass	N					20+				
	Themeda triandra		Y					20+		1		20+
Polygonaceae	*Rumex crispus*	Curled Dock	N						1			
Primulaceae	*Anagallis arvensis*	Scarlet/Blue Pimpernel	N					20+		20+	1	
Ranunculaceae	*Clematis glycinoides*	Headache Vine	Y				20+					
	Ranunculus sp.		Y			1						

Family	Scientific Name	Common name	Native?	Status		Abundance in each plot*						
				TSC Act	EPBC Act	40	57	63	2 Bradley St 2	149	P2-1	2627 TNR
Rosaceae	*Rubus fruticosus* complex	Blackberry complex	N				2					
Rubiaceae	*Asperula conferta*	Common Woodruff	Y								1	20+
	Galium sp.		Y					1				
	Opercularia diphylla	Stinkweed	Y								1	
Solanaceae	*Lycium ferocissimum*	African Boxthorn	N				20+					1
	Solanum linnaeanum	Apple of Sodom	N			6	5	2				
	Solanum nigrum	Black-berry Nightshade	N			1						
	Solanum prinophyllum	Forest Nightshade	Y			1	1				20+	
Verbenaceae	*Lantana camara*	Lantana	N				20+					

Note: *Abundance has been assigned according to the categories outlined in the FBA. For some species abundances are an estimate as it was impossible to count every plant in the floristic plot (e.g. it is impossible to count every individual *Microlaena stipoides* or *Cynodon dactylon* plant).

Recorded flora in Grey Box - Forest Red Gum grassy woodland on flats of the Cumberland Plain, Sydney Basin Bioregion – Moderate/Good_Poor

Family	Scientific Name	Common name	Native?	Status		Abundance in each plot*		
				TSC Act	EPBC Act	219	209	510 Willowdene Ave
Amaranthaceae	*Gomphrena celosioides*	Gomphrena Weed	N					20+
Apiaceae	*Cyclospermum leptophyllum*	Slender Celery	N			1		
Asteraceae	*Cirsium vulgare*	Spear Thistle	N			20+		1
	Conyza bonariensis	Flaxleaf Fleabane	N			20+		1
	Cotula australis	Common Cotula	Y			20+	20+	
	Hypochaeris radicata	Cats Ear	N			20+		
	Leontodon saxatilis		N					2
	Senecio madagascariensis	Fireweed	N			20+	20+	1
	Sonchus oleraceus	Common Sowthistle	N			1	1	
	Tagetes minuta	Stinking Roger	N			1		
	Taraxacum officinale	Dandelion	N			1	1	
Brassicaceae	*Lepidium africanum*		N					10
Caryophyllaceae	*Stellaria media*	Chickweed	N			1	20+	
Chenopodiaceae	*Einadia polygonoides*		Y					20+
	Einadia trigonos	Fishweed	Y					10
Convolvulaceae	*Dichondra repens*	Kidney Weed	Y			20+		2
Cyperaceae	*Cyperus gracilis*		Y			20+	20+	10
Fabaceae (Faboideae)	*Trifolium repens*	White Clover	N			20+	20+	1
	Vicia sativa	Vetch	N			1		
Malvaceae	*Malva parviflora*	Small-flowered Mallow	N				20+	1
	Sida rhombifolia	Paddy's Lucerne	N			1		23
Myrtaceae	*Eucalyptus moluccana*	Grey Box	Y			5	2	
	Eucalyptus tereticornis	Forest Red Gum	Y			3		5
Oxalidaceae	*Oxalis perennans*		Y			20+		20+
Plantaginaceae	*Plantago lanceolata*	Lamb's Tongues	N				2	
Poaceae	*Bromus catharticus*		N			1		

Family	Scientific Name	Common name	Native?	Status		Abundance in each plot*		
				TSC Act	EPBC Act	219	209	510 Willowdene Ave
	Chloris gayana	Rhodes Grass	N			1		5
	Cynodon dactylon	Common Couch	Y					100+
	Eleusine indica	Crowsfoot Grass	N					20+
	Eragrostis brownii	Brown's Lovegrass	Y					2
	Paspalidium distans		Y					2
	Paspalum dilatatum	Paspalum	N			20+	20+	
	Pennisetum clandestinum	Kikuyu Grass	N			20+	20+	100+
	Poa annua	Winter Grass	N				20+	
	Setaria parviflora	Slender Pigeon Grass	N					1
	Sporobolus creber	Slender Rat's Tail Grass	Y					1
	Sporobolus parramattensis	Parramatta Grass	N			20+		
Polygonaceae	*Polygonum aviculare*	Wireweed	N				1	1
Solanaceae	*Lycium ferocissimum*	African Boxthorn	N			30		2
	Solanum linnaeanum	Apple of Sodom	N					47
	Solanum nigrum	Blackberry Nightshade	N			1		
Urticaceae	*Urtica incisa*	Stinging Nettle	Y				4	
Verbenaceae	*Verbena officinalis*	Common Verbena	N					1

Note: *Abundance has been assigned according to the categories outlined in the FBA. For some species abundances are an estimate as it was impossible to count every plant in the floristic plot (e.g. it is impossible to count every individual *Microlaena stipoides* or *Cynodon dactylon* plant).

Recorded flora in Grey Box - Forest Red Gum grassy woodland on shale of the southern Cumberland Plain, Sydney Basin Bioregion – Moderate/Good_Poor

Family	Scientific Name	Common name	Native?	Status		Abundance in each plot*		
				TSC Act	EPBC Act	1701	371	394
Acanthaceae	*Brunoniella australis*	Blue Trumpet	Y				1	
Amaranthaceae	*Alternanthera denticulata*	Lesser Joyweed	Y					2
	Alternanthera sp.	Joyweed	Y					1
	Gomphrena celosioides	Gomphrena Weed	N					1
Apocynaceae	*Parsonsia lanceolata*	Silkpod	Y				1	
Asclepiadaceae	*Araujia sericifera*	Moth Vine	N			20+		
Asparagaceae	*Asparagus asparagoides*		N				1	
Asteraceae	*Bidens pilosa*	Cobbler's Pegs	N				20+	
	Cirsium vulgare	Spear Thistle	N			1		5
	Conyza bonariensis	Flaxleaf Fleabane	N			3		1
	Cotula australis	Common Cotula	Y			1		
	Hypochaeris radicata	Catsear	N			1	8	1
	Senecio madagascariensis	Fireweed	N				1	20+
	Sigesbeckia orientalis		Y				1	
	Sonchus oleraceus	Common Sowthistle	N				5	
	Tagetes minuta	Stinking Roger	N					1
Brassicaceae	*Lepidium africanum*		N					20+
Campanulaceae	*Wahlenbergia gracilis*	Sprawling or Australian Bluebell	Y					1
Caryophyllaceae	*Stellaria media*	Chickweed	N			20+		
Chenopodiaceae	*Einadia hastata*	Berry Saltbush	Y			20+		
	Einadia trigonos	Fishweed	Y					100+
Clusiaceae	*Hypericum gramineum*	Small St John's Wort	Y				20+	
Commelinaceae	*Commelina cyanea*	Native Wandering Jew	Y					20+
Convolvulaceae	*Dichondra repens*	Kidney Weed	Y			20+	20+	
Cyperaceae	*Cyperus* sp.		Y					1
Fabaceae (Faboideae)	*Desmodium varians*	Slender Tick-trefoil	Y				1	

Family	Scientific Name	Common name	Native?	Status		Abundance in each plot*		
				TSC Act	EPBC Act	1701	371	394
	Glycine clandestina		Y				1	
	Glycine tabacina		Y					20+
	Indigofera australis		Y					1
	Trifolium repens	White Clover	N				1	
	Vicia sativa		N				20+	
Fabaceae (Mimosoideae)	*Acacia parramattensis*	Parramatta Wattle	Y				1	
Juncaceae	*Juncus acutus*		N			4		
Loranthaceae	*Amyema* sp.		Y				2	
Malvaceae	*Modiola caroliniana*	Red-flowered Mallow	N					20+
	Sida rhombifolia	Paddy's Lucerne	N			20+		100+
Myrtaceae	*Eucalyptus moluccana*	Grey Box	Y			14	10	7
	Eucalyptus tereticornis	Forest Red Gum	Y			17	12	
Oleaceae	*Olea europaea* subsp. *cuspidata*		N				20+	
Oxalidaceae	*Oxalis perennans*		Y			20+		20+
Phytolaccaceae	*Phytolacca octandra*	Inkweed	N			1		
Plantaginaceae	*Plantago lanceolata*	Lamb's Tongues	N			1	1	1
Poaceae	*Briza subaristata*		N					1
	Chloris gayana	Rhodes Grass	N				20+	2
	Chloris ventricosa	Tall Chloris	Y					20+
	Cynodon dactylon	Common Couch	Y			20+		
	Ehrharta erecta	Panic Veldtgrass	N			20+		
	Eragrostis curvula	African Lovegrass	N				20+	
	Paspalidium distans		Y					20+
	Paspalum dilatatum	Paspalum	N					100+
	Pennisetum clandestinum	Kikuyu Grass	N			20+		
	Rytidosperma sp.	Wallaby Grass	Y					1
	Setaria parviflora	Slender Pigeon Grass	N				20+	20+

Family	Scientific Name	Common name	Native?	Status		Abundance in each plot*		
				TSC Act	EPBC Act	1701	371	394
	Themeda triandra		Y				20+	5
Primulaceae	*Anagallis arvensis*	Scarlet/Blue Pimpernel	N					1
Rubiaceae	*Asperula conferta*	Common Woodruff	Y				1	
	Richardia stellaris		N					20+
Santalaceae	*Exocarpos cupressiformis*	Native Cherry	Y				2	
Solanaceae	*Lycium ferocissimum*	African Boxthorn	N			5		1
	Solanum nigrum	Black-berry Nightshade	N			2		1
	Solanum prinophyllum	Forest Nightshade	Y				10	
Sterculiaceae	*Brachychiton populneus*	Kurrajong	Y				1	
Verbenaceae	*Verbena bonariensis*	Purple top	N				20+	1

Note: *Abundance has been assigned according to the categories outlined in the FBA. For some species abundances are an estimate as it was impossible to count every plant in the floristic plot (e.g. it is impossible to count every individual *Microlaena stipoides* or *Cynodon dactylon* plant).

Recorded flora in Forest Red Gum - Rough-barked Apple grassy woodland on alluvial flats of the Cumberland Plain, Sydney Basin Bioregion – Moderate/Good_Poor

Family	Scientific Name	Common name	Native?	Status		Abundance in each plot*				
				TSC Act	EPBC Act	46	391	392	59	60
Acanthaceae	*Brunoniella australis*	Blue Trumpet	Y					20+	20+	
Aizoaceae	*Tetragonia tetragonoides*	Warrigal Greens	Y				20+			
Apiaceae	*Centella asiatica*	Pennywort	Y					1		
	Foeniculum vulgare	Fennel	N				1			
Asclepiadaceae	*Araujia sericifera*	Moth Vine	N			1				20+
Asteraceae	*Bidens pilosa*	Cobbler's Pegs	N				1	1		1
	Cirsium vulgare	Spear Thistle	N			20+	20+	1	20+	1
	Conyza bonariensis	Flaxleaf Fleabane	N			20+	1			
	Cotula australis	Common Cotula	Y					1	20+	
	Cymbonotus lawsonianus	Bear's Ear	Y			6				
	Hypochaeris radicata	Catsear	N				20+		20+	1
	Senecio madagascariensis	Fireweed	N			20+	20+	1	20+	20+
	Sonchus oleraceus	Common Sowthistle	N			1	20+			
	Taraxacum officinale	Dandelion	N				1	1		
Brassicaceae	*Brassica* sp.		N			1				
Caryophyllaceae	*Stellaria media*	Chickweed	N			20+	20+		20+	1
Casuarinaceae	*Casuarina glauca*	Swamp Oak	Y			1		6		
Chenopodiaceae	*Einadia hastata*	Berry Saltbush	Y			20+				
Clusiaceae	*Hypericum gramineum*	Small St John's Wort	Y							1
Convolvulaceae	*Convolvulus erubescens*		Y					1	2	20+
	Dichondra repens	Kidney Weed	Y			20+		20+	20+	20+
Cyperaceae	*Cyperus gracilis*		Y			20+	20+			
	Cyperus sp.		Y				1	1		
Fabaceae (Faboideae)	*Daviesia genistifolia*	Broom Bitter Pea	Y					1		
	Desmodium varians	Slender Tick-trefoil	Y					1		
	Dillwynia sieberi		Y					20+		

Family	Scientific Name	Common name	Native?	Status		Abundance in each plot*				
				TSC Act	EPBC Act	46	391	392	59	60
	Glycine clandestina		Y					20+	20+	1
	Glycine tabacina		Y			20+		20+	20+	1
	Indigofera australis		Y					1	2	
	Lotus sp.	Trefoil	N			20+			20+	
	Medicago polymorpha	Burr Medic	N				20+			
	Trifolium repens	White Clover	N						20+	1
	Vicia sativa		N				20+			1
Fabaceae (Mimosoideae)	*Acacia falcata*		Y					1		
	Acacia implexa	Hickory Wattle	Y				3			8
	Acacia floribunda		Y					1		
	Acacia parramattensis	Parramatta Wattle	Y							4
Geraniaceae	*Geranium solanderi*	Native Geranium	Y			1	1	20+	20+	20+
Goodeniaceae	*Scaevola albida*		Y							20+
Iridaceae	*Romulea rosea*	Onion Weed	N				20+			
Lamiaceae	*Ajuga australis*		Y					1		
	Mentha satureioides	Native Pennyroyal	Y							
	Plectranthus parviflorus		Y					1	2	
Lobeliaceae	*Pratia purpurascens*	Whiteroot	Y					20+		
Lomandraceae	*Lomandra filiformis*	Wattle Matt-rush	Y			3				1
Luzuriagaceae	*Geitonoplesium cymosum*	Scrambling Lily	Y							1
Malvaceae	*Malva parviflora*	Small-flowered Mallow	N				20+			
	Modiola caroliniana	Red-flowered Mallow	N			20+			1	
	Sida rhombifolia	Paddy's Lucerne	N			20+			2	20+
Myoporaceae	*Eremophila debilis*	Amulla	Y					1		
Myrtaceae	*Angophora floribunda*		Y						1	
	Eucalyptus moluccana	Grey Box	Y			40	2		24	
	Eucalyptus tereticornis	Forest Red Gum	Y			4	2	20+	3	3

Family	Scientific Name	Common name	Native?	Status		Abundance in each plot*				
				TSC Act	EPBC Act	46	391	392	59	60
Oleaceae	*Olea europaea* subsp. *cuspidata*		N			20+		20+	20+	20+
Oxalidaceae	*Oxalis perennans*		Y			20+			20+	20+
Pittosporaceae	*Bursaria spinosa*	Native Blackthorn	Y			20		20+	20+	20+
Plantaginaceae	*Plantago lanceolata*	Lamb's Tongues	N			20+	20+		20+	20+
Poaceae	*Aristida vagans*	Threeawn Speargrass	Y				20+	20+	20+	
	Bromus catharticus	Prairie Grass	N				20+			
	Chloris gayana	Rhodes Grass	N				20+			
	Chloris ventricosa	Tall Chloris	Y				20+			
	Ehrharta erecta	Panic Veldtgrass	N				20+	20+		
	Eragrostis curvula	African Lovegrass	N				1			
	Microlaena stipoides		Y				20+		20+	20+
	Oplismenus aemulus	Basket Grass	Y					2		20+
	Paspalum dilatatum	Paspalum	N				20+			
	Pennisetum clandestinum	Kikuyu Grass	N			20+				
	Poa annua	Winter Grass	N			20+				
	Themeda triandra		Y				20+	20+		
Polygonaceae	*Rumex crispus*	Curled Dock	N				20+		2	
Primulaceae	*Anagallis arvensis*	Scarlet/Blue Pimpernel	N			20+				
Ranunculaceae	*Clematis glycinoides*	Headache Vine	Y					20+		20+
Rosaceae	*Rubus fruticosus* complex	Blackberry complex	N						20+	1
	Rubus parvifolius		Y							1
Rubiaceae	*Asperula conferta*	Common Woodruff	Y					20+	20+	
	Galium sp.		Y							20+
	Richardia stellaris		N			20+				
Solanaceae	*Lycium ferocissimum*	African Boxthorn	N				1			
	Solanum linnaeanum	Apple of Sodom	N			1	1		1	
	Solanum nigrum	Black-berry Nightshade	N				1			

Family	Scientific Name	Common name	Native?	Status		Abundance in each plot*				
				TSC Act	EPBC Act	46	391	392	59	60
	Solanum prinophyllum	Forest Nightshade	Y			20+				
	Solanum pseudocapsicum	Madeira Winter Cherry	N				1			
Urticaceae	*Urtica incisa*	Stinging Nettle	Y			20+				
Verbenaceae	*Lantana camara*	Lantana	N					1		
	Verbena bonariensis	Purple top	N				1	20+		1

Note: *Abundance has been assigned according to the categories outlined in the FBA. For some species abundances are an estimate as it was impossible to count every plant in the floristic plot (e.g. it is impossible to count every individual *Microlaena stipoides* or *Cynodon dactylon* plant).

Recorded flora in Grey Box - Forest Red Gum grassy woodland on shale of the southern Cumberland Plain, Sydney Basin Bioregion – Moderate/Good_High

Family	Scientific Name	Common name	Native?	Status		Abundance in each plot*			
				TSC Act	EPBC Act	332	341	393	P2 CPW regen
Acanthaceae	*Brunoniella australis*	Blue Trumpet	Y			20+	20+	20+	
Adiantaceae	*Cheilanthes sieberi*	Mulga Fern	Y			1	1	20+	20+
Amaranthaceae	*Alternanthera denticulata*	Lesser Joyweed	Y			2	2		
Anthericaceae	*Caesia parviflora*	Pale Grass-lily	Y			1	1	20+	2
	Tricoryne elatior	Yellow Autumn-lily	Y			1	1		
Apiaceae	*Centella asiatica*	Pennywort	Y			1	1		
	Cyclospermum leptophyllum	Slender Celery	N			20+	20+	1	
Asteraceae	*Bidens pilosa*	Cobbler's Pegs	N			2	2	1	
	Calotis lappulacea	Yellow Burr-daisy	Y						1
	Chrysocephalum apiculatum	Common Everlasting	Y						
	Cirsium vulgare	Spear Thistle	N			4	4	20+	
	Conyza bonariensis	Flaxleaf Fleabane	N			59	59	20+	
	Cotula australis	Common Cotula	Y						1
	Cymbonotus lawsonianus	Bear's Ear	Y			2	2	1	
	Euchiton sphaericus		Y			12	12	20+	
	Gamochaeta americana	American Cudweed	N						1
	Glossogyne tannensis	Cobbler's Tack	Y						
	Hypochaeris radicata	Catsear	N						2
	Lagenifera stipitata	Blue Bottle-daisy	Y					20+	
	Ozothamnus diosmifolius	White Dogwood	Y						
	Senecio madagascariensis	Fireweed	N			20+	20+	20+	20+
	Sigesbeckia orientalis		Y			1	1	20+	
	Vernonia cinerea		Y						
Boraginaceae	*Cynoglossum australe*		Y			1	1		
Brassicaceae	*Lepidium africanum*		N			1	1		
Cactaceae	*Opuntia stricta*	Prickly Pear	N			1	1		

Family	Scientific Name	Common name	Native?	Status		Abundance in each plot*			
				TSC Act	EPBC Act	332	341	393	P2 CPW regen
Campanulaceae	*Wahlenbergia gracilis*	Sprawling or Australian Bluebell	Y					20+	20+
Chenopodiaceae	*Einadia polygonoides*		Y			20+	20+		
	Einadia trigonos	Fishweed	Y			1	1		
Clusiaceae	*Hypericum gramineum*	Small St John's Wort	Y			2	2		20+
Commelinaceae	*Commelina cyanea*	Native Wandering Jew	Y			20+	20+	20+	
Convolvulaceae	*Convolvulus erubescens*		Y			1	1		
	Dichondra repens	Kidney Weed	Y			20+	20+	20+	1
Cyperaceae	*Carex inversa*	Knob Sedge	Y						
	Cyperus gracilis		Y			20+	20+	20+	20+
	Cyperus sp.		Y			1	1		
	Eleocharis gracilis		Y						
	Fimbristylis dichotoma		Y					20+	
Dilleniaceae	*Hibbertia sp.*		Y						20+
Ericaceae	*Lissanthe strigosa*		Y						1
Euphorbiaceae	*Phyllanthus virgatus*		Y			1	1	1	1
Fabaceae (Faboideae)	*Bossiaea prostrata*		Y						
	Desmodium varians	Slender Tick-trefoil	Y						1
	Glycine clandestina		Y						20+
	Glycine tabacina		Y			20+	20+	20+	
	Zornia dyctiocarpa		Y						
Fabaceae (Mimosoideae)	*Acacia falcata*		Y						
	Acacia parramattensis	Parramatta Wattle	Y						
Geraniaceae	*Geranium solanderi*	Native Geranium	Y						
Goodeniaceae	*Goodenia hederacea*	Variable-leaved Goodenia	Y						1
Haloragaceae	*Haloragis heterophylla*		Y						1
Lamiaceae	*Mentha satureioides*	Native Pennyroyal	Y					20+	
	Plectranthus parviflorus		Y			20+	20+	20+	

Family	Scientific Name	Common name	Native?	Status		Abundance in each plot*			
				TSC Act	EPBC Act	332	341	393	P2 CPW regen
	Scutellaria humilis	Dwarf Skullcap	Y						
Lobeliaceae	*Pratia purpurascens*	Whiteroot	Y						1
Lomandraceae	*Lomandra filiformis*	Wattle Matt-rush	Y						20+
Loranthaceae	*Amyema* sp.		Y						
Malvaceae	*Modiola caroliniana*	Red-flowered Mallow	N			20+	20+		
	Sida rhombifolia	Paddy's Lucerne	N			20+	20+	20+	20+
Myrtaceae	*Eucalyptus eugenioides*	Thin-leaved Stringybark	Y						2
	Eucalyptus moluccana	Grey Box	Y			29	29	50+	
	Eucalyptus tereticornis	Forest Red Gum	Y			2	2		4
Oleaceae	*Olea europaea* subsp. *cuspidata*		N			5	5	20+	
Oxalidaceae	*Oxalis perennans*		Y			1	1	20+	20+
	Oxalis sp.		N						20+
Pittosporaceae	*Bursaria spinosa*	Native Blackthorn	Y			2	2	50+	20+
Plantaginaceae	*Plantago gaudichaudii*		Y			2	2		
	Plantago lanceolata	Lamb's Tongues	N			20+	20+		
Poaceae	*Aristida ramosa*		Y						20+
	Aristida vagans	Threeawn Speargrass	Y					1	20+
	Axonopus fissifolius	Carpet grass	N						
	Bothriochloa macra	Red Grass	Y			10	10	1	
	Briza subaristata		N						
	Chloris ventricosa	Tall Chloris	Y			20+	20+	1	20+
	Cymbopogon refractus	Barbed Wire Grass	Y						
	Cynodon dactylon	Common Couch	Y						
	Echinopogon caespitosus	Bushy Hedgehog-grass	Y			3	3	20+	
	Eragrostis brownii	Brown's Lovegrass	Y						
	Microlaena stipoides		Y			100+	100+	100+	20+
	Oplismenus aemulus	Basket Grass	Y					20+	

Family	Scientific Name	Common name	Native?	Status		Abundance in each plot*			
				TSC Act	EPBC Act	332	341	393	P2 CPW regen
	Panicum simile	Two-colour Panic	Y					20+	
	Paspalidium distans		Y			20+	20+	20+	1
	Paspalum dilatatum	Paspalum	N					1	
	Rytidosperma sp.	Wallaby Grass	Y			20+	20+		
	Setaria parviflora	Slender Pigeon Grass	N			20+	20+	1	20+
	Themeda triandra		Y						20+
Polygalaceae	*Polygala japonica*		Y						
Polygonaceae	*Rumex brownii*	Swamp Dock	Y			1	1		
Primulaceae	*Anagallis arvensis*	Scarlet/Blue Pimpernel	N			1	1	1	20+
Rubiaceae	*Asperula conferta*	Common Woodruff	Y			20+	20+		
	Galium sp.		Y			20+	20+		
	Opercularia diphylla	Stinkweed	Y						
	Richardia stellaris		N						
Scrophulariaceae	*Veronica plebeia*	Trailing Speedwell	Y						5
Solanaceae	*Lycium ferocissimum*	African Boxthorn	N			2	2		
	Solanum linnaeanum	Apple of Sodom	N			1	1		2
	Solanum prinophyllum	Forest Nightshade	Y					20+	20+
	Solanum pseudocapsicum	Madeira Winter Cherry	N						1
Stackhousiaceae	*Stackhousia viminea*	Slender Stackhousia	Y						
Verbenaceae	*Verbena bonariensis*	Purple top	N						20+

Note: *Abundance has been assigned according to the categories outlined in the FBA. For some species abundances are an estimate as it was impossible to count every plant in the floristic plot (e.g. it is impossible to count every individual *Microlaena stipoides* or *Cynodon dactylon* plant).

Recorded flora in Derived grasslands on shale hills of the Cumberland Plain (50-300m ASL) – Moderate/Good_Derived grassland

Family	Scientific Name	Common name	Native?	Status		Abundance in each plot*			
				TSC Act	EPBC Act	39 DNG	33 DNG	P2 DNG	139 DNG
Anthericaceae	*Tricoryne elatior*	Yellow Autumn-lily	Y				1		
Apiaceae	*Centella asiatica*	Pennywort	Y				20+	20+	
Asteraceae	*Conyza bonariensis*	Flaxleaf Fleabane	N				5	1	1
	Euchiton sphaericus		Y						2
	Gamochaeta americana	American Cudweed	N				20+		
	Hypochaeris radicata	Catsear	N			20+	20+	20+	20+
	Senecio madagascariensis	Fireweed	N				20+	20+	20+
Campanulaceae	*Wahlenbergia communis*	Tufted Bluebell	Y					1	
	Wahlenbergia gracilis	Sprawling or Australian Bluebell	Y						20+
Clusiaceae	*Hypericum gramineum*	Small St John's Wort	Y				5	20+	20+
Cyperaceae	*Cyperus* sp.		Y						10
	Fimbristylis dichotoma		Y				1	20+	10
Euphorbiaceae	*Phyllanthus virgatus*		Y				1	1	
Fabaceae (Faboideae)	*Glycine clandestina*		Y			1			
	Glycine tabacina		Y			20+	20+		
	Zornia dyctiocarpa		Y				1		
Gentianaceae	*Centaurium erythraea*	Common Centaury	N			1			1
Myrtaceae	*Eucalyptus tereticornis*	Forest Red Gum	Y			3			
Oxalidaceae	*Oxalis perennans*		Y			1		1	
	Plantago lanceolata	Lamb's Tongues	N			20+	1		
Poaceae	*Aristida ramosa*		Y			1			100+
	Aristida vagans	Threeawn Speargrass	Y					5	
	Axonopus fissifolius	Carpet grass	N					20+	100+
	Bothriochloa macra	Red Grass	Y				1		20+
	Briza subaristata		N			100+	20+	20+	20+
	Cymbopogon refractus	Barbed Wire Grass	Y					2	

Family	Scientific Name	Common name	Native?	Status		Abundance in each plot*			
				TSC Act	EPBC Act	39 DNG	33 DNG	P2 DNG	139 DNG
	Cynodon dactylon	Common Couch	Y				20+	20+	20+
	Eragrostis brownii	Brown's Lovegrass	Y				1	1	1
	Eragrostis curvula	African Lovegrass	N					1	
	Paspalidium distans		Y				20+		
	Paspalum dilatatum	Paspalum	N			20+	20+		20+
	Setaria parviflora	Slender Pigeon Grass	N			20+		20+	100+
	Sporobolus africanus	Parramatta Grass	N					1	1
	Sporobolus creber	Slender Rat's Tail Grass	Y						20+
	Themeda triandra		Y			200+	100+	100+	100+
Polygonaceae	*Rumex brownii*	Swamp Dock	Y			1			
Primulaceae	*Anagallis arvensis*	Scarlet/Blue Pimpernel	N			1	1		
Rosaceae	*Rosa rubiginosa*	Sweet Briar	N			1			
Rubiaceae	*Asperula conferta*	Common Woodruff	Y				20+		
Stackhousiaceae	*Stackhousia viminea*	Slender Stackhousia	Y					1	
Verbenaceae	*Verbena bonariensis*	Purple top	N			20+			

Note: *Abundance has been assigned according to the categories outlined in the FBA. For some species abundances are an estimate as it was impossible to count every plant in the floristic plot (e.g. it is impossible to count every individual *Microlaena stipoides* or *Cynodon dactylon* plant).

Recorded flora in Phragmites australis and Typha orientalis coastal freshwater wetlands of the Sydney Basin Bioregion – Moderate/Good_Other

Family	Scientific Name	Common name	Native?	Status		Abundance in each plot*		
				TSC Act	EPBC Act	P12 Wetland	P12 Wetland 2	P13 Wetland
Alismataceae	*Damasonium minus*	Starfruit	Y			20+	20+	
Amaranthaceae	*Alternanthera denticulata*	Lesser Joyweed	Y				20+	20+
Apiaceae	*Centella asiatica*	Pennywort	Y				20+	20+
	Cyclospermum leptophyllum	Slender Celery	N					20+
Asclepiadaceae	*Araujia sericifera*	Moth Vine	N					1
Asteraceae	*Aster subulatus*	Aster	N			20+		20+
	Bidens pilosa	Cobbler's Pegs	N			20+	20+	1
	Cirsium vulgare	Spear Thistle	N					20+
	Conyza bonariensis	Flaxleaf Fleabane	N			14	10	30
	Senecio madagascariensis	Fireweed	N			20+		3
	Sonchus oleraceus	Common Sowthistle	N					1
Casuarinaceae	*Casuarina glauca*	Swamp Oak	Y					1
Chenopodiaceae	*Atriplex* sp.		Y			20+		1
Cyperaceae	*Cyperus eragrostis*	Umbrella Sedge	N				2	1
	Eleocharis sphacelata		Y			10		
	Schoenoplectus validus		Y				1	
Dicksoniaceae	*Calochlaena dubia*	Rainbow Fern	Y			2		
Fabaceae (Faboideae)	*Trifolium repens*	White Clover	N			20+		1
Haloragaceae	*Haloragis heterophylla*		Y					20+
	Myriophyllum sp.	Water-milfoil	Y			20+	20+	
Juncaceae	*Juncus acutus*		N			20	3	100
	Juncus sp.		Y				10	
	Juncus usitatus		Y			20+	100+	20+
Juncaginaceae	*Triglochin* sp.		Y			20+	20+	
Lemnaceae	*Spirodela* sp.		Y			100+	20+	
Malvaceae	*Modiola caroliniana*	Red-flowered Mallow	N					2

Family	Scientific Name	Common name	Native?	Status		Abundance in each plot*		
				TSC Act	EPBC Act	P12 Wetland	P12 Wetland 2	P13 Wetland
Onagraceae	*Epilobium billardiereanum*		Y					2
	Ludwigia peploides subsp. *montevidensis*	Water Primrose	Y			20+	20+	
Oxalidaceae	*Oxalis perennans*		Y					1
Philydraceae	*Philydrum lanuginosum*	Woolly Waterlily	Y			3	20+	
Plantaginaceae	*Plantago lanceolata*	Lamb's Tongues	N			20+	20+	20+
Poaceae	*Cynodon dactylon*	Common Couch	Y			20+		100+
	Echinochloa crus-galli	Barnyard Grass	N			3		
	Lachnagrostis filiformis	Blown Grass	Y			20+		
	Paspalum dilatatum	Paspalum	N				2	
	Paspalum distichum	Water Couch	Y			20+	100+	
	Setaria parviflora	Slender Pigeon Grass	N				1	20+
Polygonaceae	*Persicaria decipiens*		Y			10	10	20+
	Persicaria hydropiper		Y			20	20+	1
	Persicaria strigosa		Y				2	
	Rumex brownii	Swamp Dock	Y			20+	20+	
	Rumex crispus	Curled Dock	N					2
Primulaceae	*Anagallis arvensis*	Scarlet/Blue Pimpernel	N					1
Pteridaceae	*Pellaea falcata*	Sickle Fern	Y					1
Ranunculaceae	*Ranunculus inundatus*		Y			20+	20+	10
Rosaceae	*Rubus fruticosus* complex	Blackberry complex	N			1		3
Salviniaceae	*Azolla pinnata*		Y			100+		
Typhaceae	*Typha orientalis*	Bull rush	Y			20+	20+	
Verbenaceae	*Verbena bonariensis*	Purple top	N					4

Note: *Abundance has been assigned according to the categories outlined in the FBA. For some species abundances are an estimate as it was impossible to count every plant in the floristic plot (e.g. it is impossible to count every individual *Microlaena stipoides* or *Cynodon dactylon* plant).

Recorded flora in Grey Box - Forest Red Gum grassy woodland on shale of the southern Cumberland Plain, Sydney Basin Bioregion – Moderate/Good_Medium

Family	Scientific Name	Common name	Native?	Status		Abundance in each plot*
				TSC Act	EPBC Act	29-2
Adiantaceae	*Adiantum aethiopicum*	Common Maidenhair	Y			5
Amaranthaceae	*Alternanthera denticulata*	Lesser Joyweed	Y			5
Asteraceae	*Bidens pilosa*	Cobbler's Pegs	N			2
	Cirsium vulgare	Spear Thistle	N			1
	Sigesbeckia orientalis		Y			1
Commelinaceae	*Commelina cyanea*	Native Wandering Jew	Y			20
Convolvulaceae	*Dichondra repens*	Kidney Weed	Y			100+
Cyperaceae	*Cyperus sp.*		Y			20
	Cyperus eragrostis	Umbrella Sedge	N			20
	Cyperus gracilis		Y			20
Euphorbiaceae	*Euphorbia peplus*	Petty Spurge	N			20
	Ricinus communis	Castor Oil Plant	N			2
Gentianaceae	*Centaurium erythraea*	Common Centaury	N			1
Geraniaceae	*Geranium solanderi*	Native Geranium	Y			3
Malvaceae	*Sida rhombifolia*	Paddy's Lucerne	N			20
Myrtaceae	*Eucalyptus moluccana*	Grey Box	Y			3
	Eucalyptus tereticornis	Forest Red Gum	Y			1
Oleaceae	*Olea europaea* subsp. *cuspidata*		N			40
Pittosporaceae	*Bursaria spinosa*	Native Blackthorn	Y			3
Poaceae	*Cynodon dactylon*	Common Couch	Y			100+
	Microlaena stipoides		Y			100+
	Oplismenus aemulus	Basket Grass	Y			50
	Paspalidium distans		Y			20
	Setaria parviflora	Slender Pigeon Grass	N			20
Primulaceae	*Anagallis arvensis*	Scarlet/Blue Pimpernel	N			1
Solanaceae	*Cestrum parqui*	Green Cestrum	N			20

Family	Scientific Name	Common name	Native?	Status		Abundance in each plot*
				TSC Act	EPBC Act	29-2
	Solanum nigrum	Black-berry Nightshade	N			20
	Solanum prinophyllum	Forest Nightshade	Y			1
Urticaceae	*Parietaria judaica*	Pellitory	N			1
Verbenaceae	*Verbena bonariensis*	Purple top	N			3

Note: *Abundance has been assigned according to the categories outlined in the FBA. For some species abundances are an estimate as it was impossible to count every plant in the floristic plot (e.g. it is impossible to count every individual *Microlaena stipoides* or *Cynodon dactylon* plant).

Vegetation condition assessment table

Transect / Plot	Native plant species*	Native over-storey cover*	Native mid-storey cover*	Native ground cover (grass)*	Native ground cover (shrubs)*	Native ground cover (other)*	Exotic plant cover*	Number of trees with hollows*	Over-storey regen*	Total length of fallen logs*	Easting	Northing	Zone*
Grey Box - Forest Red Gum grassy woodland on flats of the Cumberland Plain, Sydney Basin Bioregion - Moderate/Good													
16	12	41.00	1.00	0.00	0.00	2.00	99.00	0	1.00	1.00	288012	6244871	56
Defence 2	11	3.50	17.00	72.00	0.00	4.00	24.00	0	1.00	0.00	285626	6254457	56
Marsdenia 1	15	14.00	0.50	22.00	0.00	10.00	20.00	1	1.00	0.00	285709	6254892	56
Defence P2	9	26.50	5.00	28.00	0.00	8.00	28.00	2	1.00	0.00	285752	6255149	56
2183 NR	15	10.00	0.00	36.00	0.00	16.00	22.00	2	1.00	0.00	286404	6256329	56
2 Bradley St	14	27.50	19.50	14.00	6.00	30.00	28.00	1	1.00	1.00	286706	6257025	56
P2-2	18	32.00	0.00	6.00	0.00	36.00	65.00	1	1.00	0.00	285687	6254607	56
P2-3	16	11.50	0.00	42.00	0.00	10.00	48.00	2	1.00	1.00	285830	6255235	56
291	36	10.00	7.00	70.00	0.00	16.00	16.50	1	1.00	5.00	285921	6246596	56
27	25	8.50	0.00	64.00	2.00	22.00	6.00	0	1.00	2.00	286161	6246218	56

Transect / Plot	Native plant species*	Native over-storey cover*	Native mid-storey cover*	Native ground cover (grass)*	Native ground cover (shrubs)*	Native ground cover (other)*	Exotic plant cover*	Number of trees with hollows*	Over-storey regen*	Total length of fallen logs*	Easting	Northing	Zone*
170-2	8	21.50	1.00	86.00	0.00	0.00	14.00	1	1.00	1.20	285558	6249440	56
Forest Red Gum - Rough-barked Apple grassy woodland on alluvial flats of the Cumberland Plain, Sydney Basin Bioregion - Moderate/Good													
P12-1	8	23.50	0.00	6.00	0.00	32.00	54.00	3	1.00	47.00	286947	6257886	56
P12-2	7	21.50	0.00	60.00	0.00	0.00	40.00	2	1.00	0.00	286959	6257742	56
P12-3	17	16.00	0.00	40.00	0.00	10.00	50.00	1	1.00	0.00	286876	6257243	56
P12-4	17	24.50	5.00	18.00	0.00	72.00	8.00	1	1.00	7.00	286739	6256904	56
Grey Box - Forest Red Gum grassy woodland on shale of the southern Cumberland Plain, Sydney Basin Bioregion - Moderate/Good													
40	18	24.50	1.00	36.00	0.00	22.00	10.00	1	1.00	0.00	285570	6247392	56
63	20	15.00	3.00	60.00	0.00	8.00	24.00	0	1.00	56.00	286363	6248561	56
31	17	21.00	42.50	42.00	0.00	4.00	75.00	4	1.00	5.00	285826	6246561	56
2 Bradley St 2	10	20.00	5.00	0.00	0.00	2.00	74.00	2	1.00	1.50	286577	6256645	56

Transect / Plot	Native plant species*	Native over-storey cover*	Native mid-storey cover*	Native ground cover (grass)*	Native ground cover (shrubs)*	Native ground cover (other)*	Exotic plant cover*	Number of trees with hollows*	Over-storey regen*	Total length of fallen logs*	Easting	Northing	Zone*
149	11	13.00	14.50	4.00	0.00	6.00	90.00	0	1.00	0.00	286207	6250337	56
P2-1	21	17.50	23.00	70.00	0.00	18.00	12.00	1	1.00	1.50	285660	6253403	56
2627 NR	10	20.00	0.00	24.00	0.00	44.00	38.00	2	1.00	2.40	286035	625670	56
57	16	10.00	5.00	6.00	0.00	0.00	92.00	1	1.00	4.50	285650	6248508	56
Grey Box - Forest Red Gum grassy woodland on flats of the Cumberland Plain, Sydney Basin Bioregion - Moderate/Good_Poor													
209	4	13.50	0.00	0.00	0.00	0.00	98.00	4	0.00	1.00	287019	6250139	56
510	11	10.50	0.00	4.00	0.00	12.00	82.00	0	0.00	8.00	286308	6246044	56
219	6	32.50	0.00	0.00	0.00	6.00	82.50	8	0.00	42.20	286429	6249562	56
Grey Box - Forest Red Gum grassy woodland on shale of the southern Cumberland Plain, Sydney Basin Bioregion – Moderate/Good_Poor													
170 1	7	39.50	2.00	2.00	0.00	4.00	96.00	0	0.00	13.00	285645	6249017	56
371	10	1.40	0.00	18.00	0.00	0.00	86.00	1	0.00	2.00	286982	6248331	56

Transect / Plot	Native plant species*	Native over-storey cover*	Native mid-storey cover*	Native ground cover (grass)*	Native ground cover (shrubs)*	Native ground cover (other)*	Exotic plant cover*	Number of trees with hollows*	Over-storey regen*	Total length of fallen logs*	Easting	Northing	Zone*
394	14	4.70	0.00	12.00	0.00	16.00	72.20	0	0.00	37.00	286184	6247434	56
Forest Red Gum - Rough-barked Apple grassy woodland on alluvial flats of the Cumberland Plain, Sydney Basin Bioregion – Moderate/Good_Poor													
39 1	11	15.00	3.00	36.00	0.00	26.00	66.00	0	1.00	0.00	286326	6248084	56
39 2	27	24.00	11.50	42.00	0.00	10.00	56.00	0	1.00	2.00	285797	6247933	56
59	18	13.00	12.00	76.00	4.00	10.00	4.00	0	1.00	2.00	285480	6248145	56
60	16	17.00	33.00	76.00	0.00	26.00	12.00	0	1.00	0.00	285726	6248120	56
46	14	25.50	2.00	8.00	0.00	22.00	36.00	0	1.00	0.00	285146	6247893	56
Grey Box - Forest Red Gum grassy woodland on shale of the southern Cumberland Plain, Sydney Basin Bioregion – Moderate/Good_High													
332	34	11.50	11.00	44.00	0.00	26.00	32.00	1	1.00	12.00	285928	6246941	56
341	30	7.50	27.00	56.00	0.00	36.00	15.00	2	1.00	77.00	285891	6246984	56
393	31	24.00	0.00	80.00	0.00	10.00	2.00	2	1.00	13.70	285834	6247703	56

Transect / Plot	Native plant species*	Native over-storey cover*	Native mid-storey cover*	Native ground cover (grass)*	Native ground cover (shrubs)*	Native ground cover (other)*	Exotic plant cover*	Number of trees with hollows*	Over-storey regen*	Total length of fallen logs*	Easting	Northing	Zone*
P2 CPW regen	47	3.00	17.20	60.00	4.00	26.00	2.00	1	1.00	4.00	285779	6254812	56
Derived grasslands on shale hills of the Cumberland Plain (50-300m asl) – Moderate/Good_Derived grassland													
39 DNG	6	0.00	0.00	80.00	0.00	4.00	18.00	0	0.00	0.00	286349	6247533	56
33 DNG	14	0.00	0.00	70.00	0.00	8.00	22.00	0	0.00	0.00	285897	6246843	56
P2 DNG	12	0.00	0.00	54.00	0.00	10.00	36.00	0	0.00	0.00	285811	6254935	56
139 DNG	10	0.00	0.00	62.00	0.00	2.00	36.00	0	0.00	0.00	286625	6251787	56
***Phragmites australis* and *Typha orientalis* coastal freshwater wetlands of the Sydney Basin Bioregion – Moderate/Good_Other**													
P13 Wetland	13	0.00	0.00	30.00	0.00	0.00	70.00	0	0.00	0.00	286692	6256688	56
P12 Wetland 2	18	0.00	0.00	48.00	0.00	50.00	0.00	0	0.00	0.00	286948	6257386	56
P12 Wetland 1	19	0.00	0.00	24.00	0.00	16.00	58.00	0	0.00	0.00	286937	6257521	56
Grey Box - Forest Red Gum grassy woodland on shale of the southern Cumberland Plain, Sydney Basin Bioregion – Moderate/Good_Medium													

Transect / Plot	Native plant species*	Native over-storey cover*	Native mid-storey cover*	Native ground cover (grass)*	Native ground cover (shrubs)*	Native ground cover (other)*	Exotic plant cover*	Number of trees with hollows*	Over-storey regen*	Total length of fallen logs*	Easting	Northing	Zone*
292	16	1.00	3.00	62.00	0.00	16.00	81.00	2	0.00	13.50	285915	6246621	56

Recorded fauna

Fauna group	Common Name	Scientific name	Status		Ecosystem or species credit species?
			TSC Act	EPBC Act	
Native b**irds**					
Anatidae	Australian Wood Duck	*Chenonetta jubata*	-	-	-
	Black Swan	*Cygnus atratus*	-	-	-
	Pacific Black Duck	*Anas superciliosa*	-	-	-
	Chestnut Teal	*Anas castanea*	-	-	-
	Grey Teal	*Anas gracilis*	-	-	-
Podicipedidae	Australasian Grebe	*Tachybaptus novaehollandiae*	-	-	-
Phalacrocoracidae	Little Black Cormorant	*Phalacrocorax sulcirostris*	-	-	-
	Pied Cormorant	*Phalacrocorax varius*	-	-	-
Ardeidae	Cattle Egret	*Bubulcus ibis*	-	M	-
	White-faced Heron	*Egretta novaehollandiae*	-	-	-
Threskiornithidae	Australian White Ibis	*Threskiornis molucca*	-	-	-
	Straw-necked Ibis	*Threskiornis spinicollis*	-	-	-
Scolopacidae	Latham's Snipe	*Gallinago hardwickii*	-	M	-
Falconidae	Australian Hobby	*Falco longipennis*	-	-	-
	Nankeen Kestrel	*Falco cenchroides*	-	-	-
Rallidae	Dusky Moorhen	*Gallinula tenebrosa*	-	-	-
	Purple Swamphen	*Porphyrio porphyrio*	-	-	-
	Eurasian Coot	*Fulica atra*	-	-	-
Charadriidae	Masked Lapwing	*Vanellus miles*	-	-	-
Columbidae	Peaceful Dove	*Geopelia placida*	-	-	-
	Bar-shouldered Dove	*Geopelia humeralis*	-	-	-

Fauna group	Common Name	Scientific name	Status		Ecosystem or species credit species?
			TSC Act	EPBC Act	
	Crested Pigeon	*Ocyphaps lophotes*	-	-	-
Cacatuidae	Sulphur-crested Cockatoo	*Cacatua galerita*	-	-	-
	Little Corella	*Cacatua sanguinea*	-	-	-
	Galah	*Eolophus roseicapillus*	-	-	-
Psittacidae	Rainbow Lorikeet	*Trichoglossus haematodus*	-	-	-
	Scaly-breasted Lorikeet	*Trichoglossus chlorolepidotus*	-	-	-
	Australian King-Parrot	*Alisterus scapularis*	-	-	-
	Eastern Rosella	*Platycercus adscitus eximius*	-	-	-
	Red-rumped Parrot	*Psephotus haematonotus*	-	-	-
Cuculidae	Fan-tailed Cuckoo	*Cacomantis flabelliformis*	-	-	-
	Shining Bronze-Cuckoo	*Chalcites lucidus*	-	-	-
Centropodidae	Pheasant Coucal	*Centropus phasianinus*	-	-	-
Alcedinidae	Laughing Kookaburra	*Dacelo novaeguineae*	-	-	-
	Sacred Kingfisher	*Todiramphus sanctus*	-	-	-
Maluridae	Superb Fairy-wren	*Malurus cyaneus*	-	-	-
Pardalotidae	Spotted Pardalote	*Pardalotus punctatus*	-	-	-
	Striated Pardalote	*Pardalotus striatus*	-	-	-
Acanthizidae	Striated Thornbill	*Acanthiza lineata*	-	-	-
	Yellow Thornbill	*Acanthiza nana*	-	-	-
	Brown Thornbill	*Acanthiza pusilla*	-	-	-

Fauna group	Common Name	Scientific name	Status		Ecosystem or species credit species?
			TSC Act	EPBC Act	
	White-browed Scrubwren	*Sericornis frontalis*	-	-	-
Meliphagidae	Scarlet Honeyeater	*Myzomela sanguinolenta*	-	-	-
	Lewin's Honeyeater	*Meliphaga lewinii*	-	-	-
	Yellow-faced Honeyeater	*Lichenostomus chrysops*	-	-	-
	Noisy Miner	*Manorina melanocephala*	-	-	-
	Little Wattlebird	*Anthochaera chrysoptera*	-	-	-
	Red Wattlebird	*Anthochaera carunculata*	-	-	-
	Noisy Friarbird	*Philemon corniculatus*	-	-	-
Petroicidae	Eastern Yellow Robin	*Eopsaltria australis*	-	-	-
Pachycephalidae	Rufous Whistler	*Pachycephala rufiventris*	-	-	-
	Grey Shrike-thrush	*Colluricincla harmonica*	-	-	-
Dicruridae	Grey Fantail	*Rhipidura albiscapa*	-	-	-
	Willie Wagtail	*Rhipidura leucophrys*	-	-	-
	Satin Flycatcher	*Myiagra cyanoleuca*	-	M	-
	Magpie-lark	*Grallina cyanoleuca*	-	-	-
Campephagidae	Black-faced Cuckoo-shrike	*Coracina novaehollandiae*	-	-	-
Artamidae	Pied Currawong	*Strepera graculina*	-	-	-
	Pied Butcherbird	*Cracticus nigrogularis*	-	-	-
	Grey Butcherbird	*Cracticus torquatus*	-	-	-
	Australian Magpie	*Gymnorhina tibicen*	-	-	-

Fauna group	Common Name	Scientific name	Status		Ecosystem or species credit species?
			TSC Act	EPBC Act	
Corvidae	Australian Raven	*Corvus coronoides*	-	-	-
Corcoracidae	White-winged Chough	*Corcorax melanorhamphos*	-	-	-
Estrildidae	Double-barred Finch	*Taeniopygia bichenovii*	-	-	-
	Red-browed Finch	*Neochmia temporalis*	-	-	-
Hirundinidae	Welcome Swallow	*Hirundo neoxena*	-	-	-
	Tree Martin	*Petrochelidon nigricans*	-	-	-
Sylviidae	Australian Reed-Warbler	*Acrocephalus australis*	-	-	-
Cisticolidae	Golden-headed Cisticola	*Cisticola exilis*	-	-	-
Introduced birds					
Columbidae	Spotted Turtle-Dove	*Streptopelia chinensis*	-	-	-
Pycnonotidae	Red-whiskered Bulbul	*Pycnonotus jocosus*	-	-	-
Passeridae	House Sparrow	*Passer domesticus*	-	-	-
Sturnidae	Common Myna	*Acridotheres tristis*	-	-	-
	Common Starling	*Sturnus vulgaris*	-	-	-
Native mammals					
Acrobatidae	Common Brushtail Possum	*Trichosurus vulpecula*	-	-	-
Macropodidae	Swamp Wallaby	*Wallabia bicolor*	-	-	-
	Eastern Grey Kangaroo	*Macropus giganteus*	-	-	-
	Common Wallaroo	*Macropus robustus*	-	-	-
Miniopteridae	Eastern Bentwing-bat	*Miniopterus schreibersii oceanensis*	V	-	Ecosystem and species credit

Fauna group	Common Name	Scientific name	Status		Ecosystem or species credit species?
			TSC Act	EPBC Act	
Molossidae	Eastern Freetail-bat	Mormopterus norfolkensis	V	-	Ecosystem credit
Pteropodidae	Grey-headed Flying-fox	*Pteropus poliocephalus*	V	V	Ecosystem credit
Vespertilionidae	Eastern False Pipistrelle	Falsistrellus tasmaniensis	V	-	Ecosystem credit
Introduced mammals					
Canidae	Fox	*Vulpes vulpes*	-	-	-
Felidae	Cat	*Felis catus*	-	-	-
Leporidae	Rabbit	*Oryctolagus cuniculus*	-	-	-
Amphibians					
Myobatrachidae	Common Eastern Froglet	*Crinia signifera*	-	-	-
	Brown-striped Frog	*Limnodynastes peronii*	-	-	-
	Spotted Grass Frog	*Limnodynastes tasmaniensis*	-	-	-
	Smooth Toadlet	*Uperoleia laevigata*	-	-	-
Hylidae	Bleating Tree Frog	*Litoria dentata*	-	-	-
	Eastern Dwarf Tree Frog	*Litoria fallax*	-	-	-
	Broad-palmed Frog	*Litoria latopalmata*	-	-	-
	Peron's Tree Frog	*Litoria peronii*	-	-	-
	Tyler's Tree Frog	*Litoria tyleri*	-	-	-
	Verreaux's Frog	*Litoria verreauxii*	-	-	-
Reptiles					
Chelidae	Eastern Snake-necked Turtle	*Chelodina longicollis*	-	-	-
Agamidae	Bearded Dragon	*Pogona barbata*	-	-	-

Fauna group	Common Name	Scientific name	Status		Ecosystem or species credit species?
			TSC Act	EPBC Act	
Scincidae	Cream-striped Shinning-skink	*Cryptoblepharus virgatus*	-	-	-
	Eastern Water-skink	*Eulamprus quoyii*	-	-	-
	Dark-flecked Garden Sunskink	*Lampropholis delicata*	-	-	-
	Pale-flecked Garden Sunskink	*Lampropholis guichenoti*	-	-	-
	Eastern Blue-tongue	*Tiliqua scincoides*	-	-	-
Elapidae	Black-bellied Swamp Snake	*Hemiaspis signata*	-	-	-
	Red-bellied Black Snake	*Pseudechis porphyriacus*	-	-	-
Invertebrates					
Camaenidae	Cumberland Plain Land Snail	*Meridolum corneovirens*	E	-	Species credit

Appendix B – Habitat assessment table

Likelihood of occurrence criteria

Likelihood	Criteria
Recorded	The species was observed in the study area during the current survey
High	It is highly likely that a species inhabits the study area and is dependent on identified suitable habitat (ie for breeding or important life cycle periods such as winter flowering resources), has been recorded recently in the locality (10km) and is known or likely to maintain resident populations in the study area. Also includes species known or likely to visit the study area during regular seasonal movements or migration.
Moderate	Potential habitat is present in the study area. Species unlikely to maintain sedentary populations however may seasonally use resources within the study area opportunistically or during migration. The species is unlikely to be dependent (ie. for breeding or important life cycle periods such as winter flowering resources) on habitat within the study area, or habitat is in a modified or degraded state. Includes cryptic flowering flora species that were not seasonally targeted by surveys and that have not been recorded.
Low	It is unlikely that the species inhabits the study area and has not been recorded recently in the locality (10km). It may be an occasional visitor, but habitat similar to the study area is widely distributed in the local area, meaning that the species is not dependent (ie. for breeding or important life cycle periods such as winter flowering resources) on available habitat. Specific habitat is not present in the study area or the species are a non-cryptic perennial flora species that were specifically targeted by surveys and not recorded.
None	Suitable habitat is absent from the study area.

Habitat assessment table for threatened flora species

Common Name *(Scientific Name)*	TSC Act	EPBC Act	Habitat requirements	Number of records (source)	Likelihood of occurrence	Ecosystem or species credit species?
Austral Pillwort (*Pilularia novae-hollandiae*)	E	-	*Pilularia novae-hollandiae* is a semi-aquatic fern that grows in shallow swamps and waterways. The populations at Lake Cowal and Oolambeyan National Park are the only known extant populations in NSW. On the Cumberland Plain there is a record of *Pilularia novae-hollandiae* from a dried out drain adjacent to the rail line near the Doonside railway station from 1966 and a record from Stringer Road Kellyville that was	0 – OEH Atlas Predicted by BioBank Calculator	Low. Surveys of aquatic habitats including detailed floristic plots and traverses of dam edges were undertaken throughout the study area. No records of Pilularia novae-hollandiae were made from the study area during the survey.	Species credit

Common Name *(Scientific Name)*	TSC Act	EPBC Act	Habitat requirements	Number of records (source)	Likelihood of occurrence	Ecosystem or species credit species?
			collected in 2014.			
Bargo Geebung (*Persoonia bargoensis*)	E	V	Persoonia bargoensis is restricted to the southern edge of the Cumberland Plain region in the Picton – Razorback Hills and Upper Nepean Gorges, and Woronora Plateau landscapes. These landscapes are characterised by Triassic shale, carbonaceous claystone, and lithic sandstone geologies. Persoonia bargoensis is strongly associated with the shallow sandy soils at the shale / sandstone transitional zone at the southern edge of the Cumberland Plain. This species is associated with vegetation communities including Shale/Sandstone Transition Forest and Sydney Hinterland Transition Woodland as mapped by Tozer et al. (2013). The nearest records to the study area are from Douglas Park and the Razorback Range.	0 – OEH Atlas Predicted by BioBank Calculator	None. The study area is outside of the known distribution for this species and no suitable habitat for Persoonia bargoensis occurs in the study area. As such, this species is considered unlikely to occur.	Species credit
Brown Pomaderris (*Pomaderris brunnea*)	E	V	Within the Hawkesbury–Nepean region, Pomaderris brunnea is known from a small area around the Colo, Nepean and Hawkesbury Rivers, including the Bargo area and near Camden. It is largely restricted to the Picton – Razorback Hills and Nattai Plateau. It is also found near Camden on the Cumberland Plain, Hawkesbury – Nepean Channels and Floodplains, and Hawkesbury – Nepean Terrace Gravels. This species shows a strong preference for alluvial soils and the shale/sandstone transitional zone of the	0 – OEH Atlas Predicted by BioBank Calculator PMST modelled habitat	None. The study area is outside of the known distribution for this species (nearest records 18 km south near Camden). Pomaderris brunnea is a reasonably large non-cryptic shrub that can be readily detected via the random meander technique (as described by Cropper 1993) within suitable habitats. Despite surveys targeting PCT 835 (Forest Red Gum – Rough Barked Apple grassy woodland on alluvial flats	Species credit

Common Name *(Scientific Name)*	TSC Act	EPBC Act	Habitat requirements	Number of records (source)	Likelihood of occurrence	Ecosystem or species credit species?
			residual Lucas Heights soil landscape around Bargo. Suitable habitat is the Sydney Hinterland Transitional Woodland around Bargo as mapped by Tozer et al. (2013) and the Alluvial Woodland and Riparian Forest along the Nepean River at Camden.		of the Cumberland Plain, Sydney Basin Bioregion); this species was not recorded within the study area.	
Bynoes Wattle (*Acacia bynoeana*)	E	V	The occurrence of *Acacia bynoeana* to the north of the study area (Londonderry, Llandilo, Agnes Banks, Berkshire Park) is strongly associated with the Hawkesbury – Nepean Terrace Gravels and the presence of the Londonderry Clay geological formation (clay with sand – top layer hard, semi-indurated zone of cemented ironstone pisolites) with the Berkshire Park and Agnes Banks soil landscapes (laterite and sand). In this area *Acacia bynoeana* is found in vegetation types including Castlereagh Scribbly Gum Woodland and Cooks River Castlereagh Ironbark Forest.	0 – OEH Atlas Predicted by BioBank Calculator PMST modelled habitat	Low. The study area contains the heavy clay soils (Luddenham and Blacktown formations) of the Cumberland Plain with some small deposits of Tertiary alluvium (South Creek formation). The study area does not contain any vegetation representative of the Castlereagh Scribbly Gum Woodland or Cooks River Castlereagh Ironbark Forest. As such, there is no suitable habitat for *Acacia bynoeana* in the study area.	Species credit
Camden White Gum (*Eucalyptus benthamii*)	V	V	In western Sydney, Eucalyptus benthamii is restricted to the Hawkesbury - Nepean Channels and Floodplains and immediately adjacent areas of the Cumberland Plain, Kurrajong Fault Scarp and Silverdale Slopes. *Eucalyptus benthamii* grows on the Quaternary alluvium of the Nepean River on the Richmond soil landscape (sand and gravel). The population along the Grose River is on alluvial soils of the Freemans Reach soil landscape. Highly restricted in its	201 - OEH Atlas Predicted by BioBank Calculator PMST modelled habitat	None. No suitable habitat for *Eucalyptus benthamii* is present in the study area. The nearest population of *Eucalyptus benthamii* to the study area is along the Nepean River at Wallacia (Fowler reserve, Blaxland's Crossing Reserve) where it occurs on the alluvial soils. The record of *Eucalyptus benthamii* from Elizabeth Drive near the roundabout on	Species credit

Common Name *(Scientific Name)*	TSC Act	EPBC Act	Habitat requirements	Number of records (source)	Likelihood of occurrence	Ecosystem or species credit species?
			habitat requirements, *Eucalyptus benthamii* requires a combination of deep alluvial sands and a flooding regime that permits seedling establishment. Associated species that also occur with *Eucalyptus benthamii* on the alluvial floodplains include *Eucalyptus elata, Eucalyptus baueriana, Eucalyptus amplifolia, Eucalyptus deanei* and *Angophora subvelutina*.		the Northern Road is erroneous as the data indicates this record is from Fowler Reserve Wallacia. The record on Mulgoa Road to the south-west of the Mulgoa Nature Reserve is also erroneous as the data indicates this record is from Bents Basin.	
Dillwynia tenuifolia	V	-	In western Sydney, *Dillwynia tenuifolia* is generally found on alluvial soils or on residual soil landscapes near the alluvial boundary. In this region this species is strongly associated with the alluvial Hawkesbury – Nepean Terrace Gravels (ferruginised clay and consolidated sand of the Londonderry Clay, the conglomerate of the Rickabys Creek Gravels, laterised sand and clay of the St Mary's Formation). Dillwynia tenuifolia also occurs to a lesser extent on the residual Cumberland Plain landscape on the Bringelly Shale and Ashfield Shale where there is influence from the quaternary alluvium of the Hawkesbury – Nepean Channels and Floodplains (e.g. South Creek, Kemps Creek, Ropes Creek, and Eastern Creek) and where the gravelly Berkshire Park soil landscape is present (i.e. Kemps Creek, Scheyville). This species is strongly associated with vegetation types including Castlereagh Scribbly Gum Woodland, Cooks River Castlereagh Ironbark Forest, and Shale/Gravel Transition	188 - OEH Atlas Predicted by BioBank Calculator	Low. There are records of Dillwynia tenuifolia from the Defence Establishment Orchard Hills about 3 km east of the Northern Road in vegetation mapped as Castlereagh Ironbark Forest by Tozer et al. (2013). The record near the dam south of the golf course on the Defence Establishment Orchard Hills is erroneous and this record belongs with the others in the Castlereagh Ironbark Forest. There is also an old record (1995) of Dillwynia tenuifolia located on Park Road Wallacia about 1.3 km west of the intersection of the Northern Road and Park Road. This record was checked and no plants were found. The record of Dillwynia tenuifolia at 2161-2177 Elizabeth Drive Luddenham is also erroneous as this record belongs to the Elizabeth Drive Waste Management Site.	Species credit

Common Name *(Scientific Name)*	TSC Act	EPBC Act	Habitat requirements	Number of records (source)	Likelihood of occurrence	Ecosystem or species credit species?
			Forest. Some outlier occurrences of *Dillwynia tenuifolia* occur in patches of Shale Plains Woodland or Alluvial Woodland where these communities intergrade with the aforementioned vegetation types.		*Dillwynia tenuifolia* is a reasonably large non-cryptic shrub that can be readily detected year round by the random meander technique (as described by Cropper 1993) within suitable habitats. Detailed floristic plots and traverses by foot and vehicle throughout the study area failed to record *Dillwynia tenuifolia*. Particular survey effort was expended in the Defence Establishment Orchard Hills. Due to the absence of typical habitat (including preferred geology, soils and vegetation associations), the failure to detect this species despite targeted survey effort, combined with the fact that this species is relatively large and easily detected if present suggest that *Dillwynia tenuifolia* is unlikely to occur in the study area.	
Dillwynia tenuifolia (a shrub) population, Kemps Creek	EP	-	The endangered *Dillwynia tenuifolia* population occurs in the area bounded by Western Road, Elizabeth Drive, Devonshire Road and Cross Street, Kemps Creek in the Liverpool Local Government Area.	43 - OEH Atlas Predicted by BioBank Calculator	None. The extent of the endangered population occurs outside of the study area.	Species credit
Downy Wattle (*Acacia pubescens*)	V	V	In north-west Sydney, *Acacia pubescens* is strongly associated with the alluvial Hawkesbury – Nepean Terrace Gravels (ferruginised clay and consolidated sand of the Londonderry Clay, the conglomerate of	17 - OEH Atlas Predicted by BioBank	Low. The study area contains the heavy clay soils (Luddenham and Blacktown formations) of the Cumberland Plain	Species credit

Common Name *(Scientific Name)*	TSC Act	EPBC Act	Habitat requirements	Number of records (source)	Likelihood of occurrence	Ecosystem or species credit species?
			the Rickabys Creek Gravels). Closer to the study area, *Acacia pubescens* occurs to on the Cumberland Plain landscape on the residual Bringelly Shale and Ashfield Shale where there is influence from the quaternary alluvium of the Hawkesbury – Nepean Channels and Floodplains (e.g. Kemps Creek and Ropes Creek). The gravelly Berkshire Park soil landscape is also present at Kemps Creek where this species can be found. Acacia pubescens is associated with Shale/Gravel Transition Forest and contiguous Shale Plains Woodland that has a gravel influence. This species is also found in Castlereagh Scribbly Gum Woodland at Kemps Creek and Castlereagh.	Calculator PMST modelled habitat	with some small deposits of Tertiary alluvium (South Creek formation). *Acacia pubescens* is a reasonably large non-cryptic shrub that can be readily detected via the random meander technique within suitable habitats. This species was not found during the survey and the habitat present in the study area is not suitable.	
Dwarf Kerrawang (*Commersonia prostrata* formerly *Rulingia prostrata)*	E	E	Dwarf Kerrawang occurs on the Southern Highlands and Southern Tablelands (one plant at Penrose State Forest, one plant at Tallong, a small population near the Corang and about 2000 plants at Rowes Lagoon), a larger population in the Thirlmere Lakes area (particularly among the dying reeds at the edge of the water), and on the North Coast (less than 100 plants at the Tomago sandbeds north of Newcastle). It is also found in Victoria.	0 – OEH Atlas Predicted by BioBank Calculator	None. This species was predicted to occur by the BioBank Calculator. However, this species is not known from the region and is not considered likely to occur in the study area. No suitable habitat for this species is present.	Species credit
Hibbertia sp. Bankstown (syn. *Hibbertia puberula* subsp. *glabrescens*)	CE	CE	*Hibbertia* sp. Bankstown is currently known to occur in only one population at Bankstown Airport.	1 – OEH Atlas Predicted	None. This species is not present within the study area.	Species credit

Common Name *(Scientific Name)*	TSC Act	EPBC Act	Habitat requirements	Number of records (source)	Likelihood of occurrence	Ecosystem or species credit species?
				by BioBank Calculator		
Hypsela sessiliflora (syn. *Isotoma fluviatilis*)	E	EX	Currently known from only two adjacent sites on a single private property between Mamre Rd and Sarah Andrews Cl at Erskine Park 10 km east of the study area. Thought to be extinct until recorded in 1999 and in 2002. This species is now placed in synonymy with *Isotoma fluviatilis* subsp. *fluviatilis* (Albrecht et al., 2015).	7 - OEH Atlas Predicted by BioBank Calculator	None. This species is no longer considered to exist. The species *Isotoma fluviatilis* subsp. *fluviatilis* was recorded in one location within the study are at the edge of a farm dam at 2594-2776 The Northern Road Luddenham. This is not the threatened species.	Species credit
Illawarra Greenhood (*Pterostylis gibbosa*)	E	E	*Pterostylis gibbosa* is currently known from only five locations consisting of about 4,500 individuals. Extensive surveys conducted as part of the implementation of the recovery plan have failed to locate any populations on the Cumberland Plain in western Sydney, where it was originally discovered in 1803. It is considered that the species is probably now extinct on the Cumberland Plain.	0 – OEH Atlas PMST modelled habitat	Low. This species has not been collected from the Cumberland Plain since 1803. Between 1996 and 1998, surveys in western Sydney were conducted by the National Parks and Wildlife Service and Australian Native Orchid Society in Prospect Reservoir, defence land at Orchard Hills, Holsworthy and St Marys, Shanes Park, Kemps Creek, St Andrew's, Longneck Lagoon, and Nurragingy Reserve. No *P. gibbosa* plants were found.	Species credit
Juniper-leaved Grevillea (*Grevillea juniperina* subsp. *juniperina*)	V	-	In the locality, *Grevillea juniperina* subsp. *juniperina* is highly associated with the Quaternary alluvium of South Creek and the Londonderry Clay and areas of adjacent Bringelly Shale. The study area lies beyond the south western boundary of the known	470 - OEH Atlas Predicted by BioBank Calculator	Low. *Grevillea juniperina* subsp. *juniperina* is a reasonably large non-cryptic shrub that can be readily detected via the random meander technique (as	Species credit

Common Name *(Scientific Name)*	TSC Act	EPBC Act	Habitat requirements	Number of records (source)	Likelihood of occurrence	Ecosystem or species credit species?
			occurrence of this species (however some outliers from 1915, 1954 and 1995 occur in the locality but these records are inaccurate). There is a large population of *Grevillea juniperina* subsp. *juniperina* on and around the Defence Establishment Orchard Hills. There is a record close to the study area on Lot 14 Park Rd Wallacia.	PMST modelled habitat	described by Cropper 1993) within suitable habitats. Detailed floristic plots and traverses by foot and vehicle throughout the study area failed to record *Grevillea juniperina* subsp. *juniperina*. Particular survey effort was expended in the Defence Establishment Orchard Hills. The failure to detect this species despite targeted survey effort, combined with the fact that this species is relatively large and easily detected if present suggest that *Grevillea juniperina* subsp. *juniperina* is unlikely to occur in the study area.	
Marsdenia viridiflora subsp. *viridiflora* in the Bankstown, Blacktown, Camden, Campbelltown, Fairfield, Holroyd, Liverpool and Penrith local government areas	EP	-	Recent records are from Prospect, Bankstown, Smithfield, Cabramatta Creek and St Marys. Previously known north from Razorback Range. Grows in vine thickets and open shale woodland.	227 - OEH Atlas Predicted by BioBank Calculator	Present. The endangered *Marsdenia viridiflora* subsp. *viridiflora* population was recorded in four locations (all relatively disturbed) adjacent to the current Northern Rd alignment (two locations on the Defence Establishment Orchard Hills fence, and roadside vegetation adjacent to 2509 Northern Road, and 2627 Northern Road).	Species credit
Micromyrtus minutiflora	E	V	The occurrences of *Micromyrtus minutiflora* to the north of the study area (Londonderry, Llandilo, Agnes Banks, Berkshire Park) is strongly associated with the Hawkesbury – Nepean Terrace Gravels and the presence	8 - OEH Atlas PMST modelled	Low. There is no suitable habitat for *Micromyrtus minutiflora* in the study area.	Species credit

Common Name *(Scientific Name)*	TSC Act	EPBC Act	Habitat requirements	Number of records (source)	Likelihood of occurrence	Ecosystem or species credit species?
			of the Londonderry Clay geological formation (clay with sand – top layer hard, semi-indurated zone of cemented ironstone pisolites) with the Berkshire Park and Agnes Banks soil landscapes (laterite and sand). *Micromyrtus minutiflora* was recorded at the Fernhill Western Precinct at Mulgoa in 2014 about 6 km west of the study area (on the Kurrajong Fault Scarp landscape).	habitat		
Pimelea curviflora subsp. *curviflora*	V	V	*Pimelea curviflora* subsp. *curviflora* occurs on shaley / lateritic soils over sandstone and shale / sandstone transition soils.	0 – OEH Atlas PMST modelled habitat	None. There is no suitable habitat for *Pimelea curviflora* subsp. *curviflora* in the study area so this species is not considered to be present and will be excluded from further assessment.	Species credit
Spiked Rice-flower (*Pimelea spicata*)	E	E	Pimelea spicata is found on heavy clay soils which are prevalent in the study area. This species can grow in disturbed habitats dominated by African Olive such as what occurs at the Lizard Log in the Western Sydney Parklands. Likely to be restricted to areas with little to no grazing pressure. This species may occur in patches of PCT849 or PCT850, particularly those that aren't heavily grazed.	6 - OEH Atlas Predicted by BioBank Calculator PMST modelled habitat	Low. While some areas of suitable habitat are present in the study area this species was not detected during targeted surveys. Three reference sites were checked during the survey period to gauge flowering status. *Pimelea spicata* was flowering at all three reference sites during the survey period. Flowering conditions were optimal during the survey. As this species was targeted by the surveys during optimal flowering, and not recorded, it is considered to have a low likelihood of occurrence.	Species credit

Common Name *(Scientific Name)*	TSC Act	EPBC Act	Habitat requirements	Number of records (source)	Likelihood of occurrence	Ecosystem or species credit species?
Sydney Plains Greenhood (*Pterostylis saxicola*)	E	E	*Pterostylis saxicola* is a narrow endemic restricted to the greater Sydney region of NSW, and occurs between Picnic Point and Picton. In 1997, it was known from five locations: near Yeramba Lagoon in Georges River National Park, Ingleburn, Holsworthy Military Area, Peter Meadows Creek and St Marys Towers near Douglas Park. The only record of *Pterostylis saxicola* near to the study area is from the vicinity of Arndell Park. This record was made in 1804. This species grows in heathy forest, sclerophyll forest or woodland in shallow sandy soil over flat sheets of sandstone rock shelves above cliff lines and also in crevices between sandstone boulders; often in close proximity to streams.	1 - OEH Atlas Predicted by BioBank Calculator PMST modelled habitat	None. There is no suitable habitat for *Pterostylis saxicola* in the study area.	Species credit
Tall Knotweed (*Persicaria elatior*)	V	V	On the Cumberland Plain there is one record of *Persicaria elatior* from Picton Lakes collected in 1949.	0 - OEH Atlas Predicted by BioBank Calculator	Low. As *Persicaria elatior* has not been recorded on the greater Cumberland Plain outside of Picton Lakes. This species is considered unlikely to be present within the study area and will be excluded from further assessment	Species credit
White-flowered Wax Plant (*Cynanchum elegans*)	E	E	A nearby record of *Cynanchum elegans* exists at Bringelly recorded in 1992 in PCT 850. Habitat for *Cynanchum elegans* may be present in PCT 835, 849 and 850. However, habitat for *Cynanchum elegans* on	4 - OEH Atlas Predicted by BioBank Calculator	Low. Targeted surveys for *Cynanchum elegans* failed to detect this species within the study area. No suitable dry rainforest habitat is present in the study	Species credit

Common Name *(Scientific Name)*	TSC Act	EPBC Act	Habitat requirements	Number of records (source)	Likelihood of occurrence	Ecosystem or species credit species?
			the Cumberland Plain is thought to be restricted to small isolated remnant patches of dry rainforest.	PMST modelled habitat	area.	
Allocasuarina glareicola	E	E	*Allocasuarina glareicola* is restricted to a few small populations in and around Castlereagh Nature Reserve, north-east of Penrith, growing on tertiary alluvial gravels, with yellow clayey subsoil and lateritic soil. A record of this species also exists about 25 km to the south east of the study area from Heathcote Road (recorded in 1996) growing in open woodland of *Eucalyptus sclerophylla, Angophora bakeri* and *Eucalyptus robusta* on laterite with surficial ironstone nodules.	0 - OEH Atlas PMST modelled habitat	None. The study area contains the heavy clay soils (Luddenham and Blacktown formations) of the Cumberland Plain with some small deposits of Tertiary alluvium (South Creek formation). There is no suitable habitat for *Allocasuarina glareicola* in the study area.	Species credit
Asterolasia elegans	E	E	*Asterolasia elegans* is endemic to and has a disjunct distribution within the hills north of Sydney. It only occurs north of Maroota.	0 - OEH Atlas PMST modelled habitat	None. This species is not known from the Cumberland region. There is no suitable habitat for *Asterolasia elegans* in the study area so this species is not considered to be present and will be excluded from further assessment.	Species credit
Leafless Tongue Orchid (*Cryptostylis hunteriana*)	V	V	Cryptostylis hunteriana has been reported to occur in a wide variety of habitats including heathlands, heathy woodlands, sedgelands, Xanthorrhoea spp. plains, dry sclerophyll forests (shrub/grass sub-formation and shrubby sub-formation), forested wetlands,	0 - OEH Atlas PMST modelled habitat	None. This species has been found in the far eastern portion of the Cumberland region in the Ku-ring-gai LGA. There is no suitable habitat for *Cryptostylis*	Species credit

Common Name *(Scientific Name)*	TSC Act	EPBC Act	Habitat requirements	Number of records (source)	Likelihood of occurrence	Ecosystem or species credit species?
			freshwater wetlands, grasslands, grassy woodlands, rainforests and wet sclerophyll forests (grassy sub-formation). This species has never been recorded from the Cumberland Plain.		*hunteriana* in the study area so this species is not considered to be present and will be excluded from further assessment.	
Bauer's Midge Orchid (*Genoplesium baueri*)	E	E	*Genoplesium baueri* generally occurs within coastal areas from Ulladulla on the south coast to Port Stephens on the mid-north coast, although it has been recorded from as far west as Woodford in the Blue Mountains and Penrose State Forest in the southern highlands. It usually grows in heathland to shrubby woodland on sands or sandy loams or open forest, shrubby forest and heathy forest on well-drained sandy and gravelly soils.	0 - OEH Atlas PMST modelled habitat	None. The study area contains the heavy clay soils (Luddenham and Blacktown formations) of the Cumberland Plain with some small deposits of Tertiary alluvium (South Creek formation). There is no suitable habitat for *Genoplesium baueri* in the study area.	Species credit
Small-flower Grevillea (*Grevillea parviflora* subsp. *parviflora*)	V	V	*Grevillea parviflora* subsp. *parviflora* occurs sporadically throughout the Sydney Basin. It occurs on ridge crests, upper slopes or flat plains in both low-lying areas between 30–65 m above sea level and on higher topography between 200–300 m above sea level south of Sydney. It occurs in sandy or light clay soils, usually over thin shales often with lateritic ironstone gravels which are often infertile and poorly drained. Soils are mostly derived from Tertiary sands or alluvium and from the Mittagong Formation with alternating bands of shale and fine grained sandstones. This species is known	16 - OEH Atlas PMST modelled habitat	None. There is no suitable habitat for *Grevillea parviflora* subsp. *parviflora* in the study area. The portion of the study area that possesses alluvial South Creek formation soils is not suitable for this species.	Species credit

Common Name *(Scientific Name)*	TSC Act	EPBC Act	Habitat requirements	Number of records (source)	Likelihood of occurrence	Ecosystem or species credit species?
			from Kemps Creek on the sandy lateritic soils and a recent record from Ropes Creek at Mt Druitt on the alluvial South Creek formation soils.			
Square Raspwort (*Haloragis exalata* subsp. *exalata*)	V	V	*Haloragis exalata* subsp. *exalata* is presently known from a range of vegetation types, all of which appear to have a history of recurrent disturbance. It appears to be a post-disturbance coloniser, based on observations of large numbers of plants on disturbed roadsides, cleared power-line easements, and recently burnt or flooded areas.	0 – OEH Atlas PMST modelled habitat	None. There is no suitable habitat for *Haloragis exalata* subsp. *exalata* in the study area and this species has not been recorded from the locality in the past.	Species credit
Deane's Paperbark (*Melaleuca deanei*)	V	V	*Melaleuca deanei* grows in wet heath on sandstone, sandy soils and woodlands. The nearest records of this species to the study area are from the Blue Mountains National Park. *Melaleuca deanei* was recorded in 2007 from the rail corridor at Vineyard between Quakers Hill and Riverstone train stations (this record is an anomaly in the distribution of this species).	1 - OEH Atlas PMST modelled habitat	None. There is no suitable sandstone habitat for *Melaleuca deanei* in the study area.	Species credit
Omeo Storksbill (*Pelargonium* sp. Striatellum (G.W.Carr 10345))	E	E	This species is only known from lake-beds on the basalt plains of the Monaro and one at Lake Bathurst.	0 – OEH Atlas PMST modelled habitat	None. There is no suitable habitat for *Pelargonium* sp. Striatellum (G.W.Carr 10345) in the study area so this species is not considered to be present and will be excluded from further assessment.	Species credit

Common Name *(Scientific Name)*	TSC Act	EPBC Act	Habitat requirements	Number of records (source)	Likelihood of occurrence	Ecosystem or species credit species?
Needle Geebung (*Persoonia acerosa*)	V	V	*Persoonia acerosa* is mainly found in Katoomba, Wentworth Falls and Springwood in the Blue Mountains. It grows in heath, scrubby low-woodland or dry sclerophyll forest. The species is found mostly on ridge-tops and plateau areas, growing in sandy topsoils over clayey subsoils.	0 – OEH Atlas PMST modelled habitat	None. This species is not known form the Cumberland region. There is no suitable habitat for *Persoonia acerosa* in the study area so this species is not considered to be present and will be excluded from further assessment.	Species credit
Persoonia hirsuta (Hairy Geebung)	E	E	*Persoonia hirsuta* is frequently found on ridge tops and the mid slopes of hills and rises. It grows in sandy to stony soils derived from sandstone or very rarely on shale, from near sea level to 600 m altitude. Known from Berkshire Park and Agnes Banks to the north of Penrith and Blaxland and Springwood in the Blue Mountains.	6 - OEH Atlas PMST modelled habitat	Low. There is no suitable habitat for *Persoonia hirsuta* in the study area. The study area is dominated by heavy clay soils with small areas of alluvium.	Species credit
Nodding Geebung (*Persoonia nutans*)	E	E	*Persoonia nutans* is restricted to the Cumberland Plain. It is known from an area between Richmond and Macquarie Fields, particularly near the Nepean and Georges Rivers. The range of the species is fragmented, with about 99 per cent of the known populations occurring in the north of the distribution at Agnes Banks, Londonderry, Castlereagh, Berkshire Park and Windsor Downs. This species is also known from Kemps Creek on the sandy lateritic soils. Persoonia nutans is strongly associated with the Hawkesbury – Nepean Terrace Gravels and the presence of the	25 - OEH Atlas PMST modelled habitat	Low. This species is known from Kemps Creek on the sandy lateritic soils. There is no suitable habitat for *Persoonia nutans* in the study area so this species is not considered to be present and will be excluded from further assessment.	Species credit

Common Name *(Scientific Name)*	TSC Act	EPBC Act	Habitat requirements	Number of records (source)	Likelihood of occurrence	Ecosystem or species credit species?
			Londonderry Clay geological formation (clay with sand – top layer hard, semi-indurated zone of cemented ironstone pisolites) with the Berkshire Park and Agnes Banks soil landscapes (laterite and sand).			
Smooth Bush-pea (*Pultenaea glabra*)	V	V	*Pultenaea glabra* is restricted to the higher Blue Mountains and has been recorded from the Katoomba-Hazelbrook and Mount Victoria areas.	0 – OEH Atlas PMST modelled habitat	None. There is no suitable habitat for *Pultenaea glabra* in the study area so this species is not considered to be present and will be excluded from further assessment.	Species credit
Pultenaea parviflora	E	V	*Pultenaea parviflora* is confined to the Cumberland Plain and is mainly found between Penrith and Windsor. Pultenaea parviflora is generally found in scrubby/dry heath areas within Castlereagh Ironbark Forest and Shale Gravel Transition Forest on Wianamatta shale, tertiary alluvium or laterised clays, and in transitional areas where these communities adjoin Castlereagh Scribbly Gum Woodland.	808 - OEH Atlas Predicted by BioBank Calculator PMST modelled habitat	Present. Three *Pultenaea parviflora* plants were recorded in two locations adjacent to the Northern Road during the field surveys.	Species credit
Eastern Underground Orchid (*Rhizanthella slateri*)	V	E	*Rhizanthella slateri* is currently known only from 10 locations, including near Bulahdelah, the Watagan Mountains, the Blue Mountains, Wiseman's Ferry area, Agnes Banks and near Nowra. *Rhizanthella slateri* grows in eucalypt forest but no informative assessment of the likely preferred habitat for the species is available.	0 – OEH Atlas PMST modelled habitat	Low. While the preferred habitat for this species is unknown, it has not been recorded near the study area in the past despite significant development that has disturbed the soil.	Species credit

Common Name *(Scientific Name)*	TSC Act	EPBC Act	Habitat requirements	Number of records (source)	Likelihood of occurrence	Ecosystem or species credit species?
Kangaloon Sun Orchid (*Thelymitra kangaloonica*)	CE	CE	*Thelymitra kangaloonica* is known from three locations near Robertson in the Southern Highlands. It grows in seasonally swampy sedgeland on grey silty clay loam at 600–700 m above sea level.	0 – OEH Atlas PMST modelled habitat	None. There is no suitable habitat for *Thelymitra kangaloonica* in the study area so this species is not considered to be present and will be excluded from further assessment.	Species credit
Austral Toadflax (*Thesium australe*)	V	V	*Thesium australe* is semi-parasitic on roots of a range of grass species, notably *Themeda triandra*. The most recent record of *Thesium australe* in the Cumberland region is from the Camden area from 1803.	0 – OEH Atlas PMST modelled habitat	Low. The nearest record to the study area is from Camden. This species has not been recorded in any other locations in western Sydney despite significant survey effort. It was not recorded during floristic surveys of derived native grasslands in the study area and is considered to have a low likelihood of occurrence in the study area.	Species credit

Habitat assessment table for threatened fauna species identified from the BioBanking credit calculator and PMST

Common Name *(Scientific Name)*	TSC Act	EPBC Act	Habitat requirements	Number of records (source)	Likelihood of occurrence	Ecosystem or species credit species?
Australian Painted Snipe (*Rostratula australis*)	V	E	The Australian Painted Snipe is restricted to Australia. Most records are from the south east, particularly the Murray Darling Basin, with scattered records across northern Australia and historical records from around the Perth region in Western Australia. In NSW many records are from the Murray-Darling Basin including the Paroo wetlands, Lake Cowal, Macquarie Marshes, Fivebough Swamp and more recently, swamps near Balldale and Wanganella. Other important locations with recent records include wetlands on the Hawkesbury River and the Clarence and lower Hunter Valleys. Prefers fringes of swamps, dams and nearby marshy areas where there is a cover of grasses, lignum, low scrub or open timber.	Predicted by BioBank Calculator PMST	Low. Occurs in permanent creeks, vegetated swamps particularly with dense riparian habitat, very few records in the locality, although secretive species. Targeted and not recorded.	Ecosystem
Australasian Bittern (*Botaurus poiciloptilus*)	E	E	Australasian Bitterns are widespread but uncommon over south-eastern Australia. In NSW they may be found over most of the state except for the far north-west. Favours permanent freshwater wetlands with tall, dense vegetation, particularly bullrushes (*Typha* spp.) and spikerushes (*Eleocharis* spp.).	Predicted by BioBank Calculator PMST	Low. Occurs in permanent creeks, rivers and swamps particularly with dense riparian habitat and emergent vegetation. Very few records in the locality although secretive. This species may occur in dams along drainage lines and adjacent waterways particularly where *Phragmites australis* and *Typha orientalis* occur, and is associated with PCT835. Recent records of this species exist from Oran Park from	Species

Common Name *(Scientific Name)*	TSC Act	EPBC Act	Habitat requirements	Number of records (source)	Likelihood of occurrence	Ecosystem or species credit species?
					2011.	
Australian Grayling (*Prototroctes maraena*)	E (FM Act)	V	The Australian Grayling is diadromous, spending part of its lifecycle in freshwater and at least part of the larval and/or juvenile stages in coastal seas. Adults (including pre spawning and spawning adults) inhabit cool, clear, freshwater streams with gravel substrate and areas alternating between pools and riffle zones such as the Tambo River, which is also known to have granite outcrops. The species has also been associated with clear, gravel-bottomed habitats in the Mitchell and Wonnangatta Rivers (Victoria) and in a muddy-bottomed, heavily silted habitat in the Tarwin River (Victoria). The species has been found over 100 km upstream from the sea.	PMST	Low. No suitable habitat is present.	-
Barking Owl (*Ninox connivens*)	V	-	Inhabits woodland and open forest, including fragmented remnants and partly cleared farmland. It is flexible in its habitat use, and hunting can extend in to closed forest and more open areas. Sometimes able to successfully breed along timbered watercourses in heavily cleared habitats (e.g. western NSW) due to the higher density of prey on these fertile soils.	Predicted by BioBank Calculator	Moderate. Nearest record in locality is from Mulgoa Creek opposite the Golf Course from 2002. May forage in the study area.	Ecosystem
Black Bittern (*Ixobrychus flavicollis*)	V	-	The Black Bittern has a wide distribution, from southern NSW north to Cape York and along the north coast to the Kimberley region. The species also occurs in the	Predicted by BioBank Calculator	Low. Occurs in permanent creeks, vegetated swamps particularly with dense riparian	Species

Common Name *(Scientific Name)*	TSC Act	EPBC Act	Habitat requirements	Number of records (source)	Likelihood of occurrence	Ecosystem or species credit species?
			south-west of Western Australia. In NSW, records of the species are scattered along the east coast, with individuals rarely being recorded south of Sydney or inland. Inhabits both terrestrial and estuarine wetlands, generally in areas of permanent water and dense vegetation. Where permanent water is present, the species may occur in flooded grassland, forest, woodland, rainforest and mangroves.		habitat, very few records in the locality, although secretive species. Targeted during bird surveys.	
Black-chinned Honeyeater (eastern subspecies) (*Melithreptus gularis subsp. gularis*)	V	-	In NSW it is widespread, with records from the tablelands and western slopes of the Great Dividing Range to the north-west and central-west plains and the Riverina. It is rarely recorded east of the Great Dividing Range. Occupies mostly upper levels of drier open forests or woodlands.	Predicted by BioBank Calculator	Moderate. This species was recently recorded on private property off Tyson Rd Greendale in 2013. While likely to only rarely occur in the study area there is a possibility that this species does occur based on the habitat that is present.	Ecosystem
Black-tailed Godwit (*Limosa limosa*)	V	M	The Black-tailed Godwit is a migratory wading bird. Primarily a coastal species. Usually found in sheltered bays, estuaries and lagoons with large intertidal mudflats and/or sandflats. Further inland, it can also be found on mudflats and in water less than 10 cm deep, around muddy lakes and swamps.	Predicted by BioBank Calculator	Low. The wetlands (farm dams) in the study area are not considered likely to provide suitable habitat for this species.	Ecosystem
Broad-headed Snake (*Hoplocephalus bungaroides*)	V	V	Shelters in rock crevices and under flat sandstone rocks on exposed cliff edges during autumn, winter and spring. Moves	PMST	None. This species does not occur in the study	-

Common Name *(Scientific Name)*	TSC Act	EPBC Act	Habitat requirements	Number of records (source)	Likelihood of occurrence	Ecosystem or species credit species?
			from the sandstone rocks to shelters in hollows in large trees within 200 m of escarpments in summer.		area. No habitat is present.	
Brown Treecreeper (eastern subspecies) (*Climacteris picumnus subsp. victoriae*)	V	-	The Brown Treecreeper is endemic to eastern Australia and occurs in eucalypt forests and woodlands of inland plains and slopes of the Great Dividing Range. It is less commonly found on coastal plains and ranges. Found in eucalypt woodlands (including Box-Gum Woodland) and dry open forest of the inland slopes and plains inland of the Great Dividing Range; mainly inhabits woodlands dominated by stringybarks or other rough-barked eucalypts, usually with an open grassy understorey.	Predicted by BioBank Calculator	Low. This species has not been recorded from the Cumberland Plain within the locality. The closest records are to the west at the edges of Lake Burragorang. This species is considered unlikely to occur in the study area.	Ecosystem
Brush-tailed Rock-wallaby (*Petrogale penicillata*)	E	V	Range extends from south-east Queensland to the Grampians in western Victoria, roughly following the line of the Great Dividing Range. Occupy rocky escarpments, outcrops and cliffs with a preference for complex structures with fissures, caves and ledges, often facing north. Browse on vegetation in and adjacent to rocky areas eating grasses and forbs as well as the foliage and fruits of shrubs and trees.	PMST	None. This species does not occur in the study area. No habitat is present.	-
Bush Stone-curlew (*Burhinus grallarius*)	E	-	The Bush Stone-curlew is found throughout Australia except for the central southern coast and inland, the far south-east corner, and Tasmania. Only in northern Australia is	Predicted by BioBank Calculator	Low. Two birds previously existed on the Defence Establishment Orchard Hills but	Ecosystem

Common Name *(Scientific Name)*	TSC Act	EPBC Act	Habitat requirements	Number of records (source)	Likelihood of occurrence	Ecosystem or species credit species?
			it still common however and in the south-east it is either rare or extinct throughout its former range. Inhabits open forests and woodlands with a sparse grassy ground layer and fallen timber.		have not been seen recently. Records exist from Prestons and Carne's Hill (last recorded in 1950). The species is considered unlikely to occur in the study area due to predation pressure and habitat modification.	
Comb-crested Jacana (*Irediparra gallinacea*)	V	-	The Comb-crested Jacana occurs on freshwater wetlands in northern and eastern Australia, mainly in coastal and subcoastal regions, from the north-eastern Kimberley Division of Western Australia to Cape York Peninsula then south along the east coast to the Hunter region of NSW, with stragglers recorded in south-eastern NSW (possibly in response to unfavourable conditions further north). Inhabits permanent freshwater wetlands, either still or slow-flowing, with a good surface cover of floating vegetation, especially water-lilies, or fringing and aquatic vegetation.	Predicted by BioBank Calculator	Low. This species is not known form the locality or study area. Any birds that may occur in the study area would be vagrants. The study area is not in the natural range of this species.	Species
Cumberland Plain Land Snail (*Meridolum corneovirens*)	E	-	Lives in small areas on the Cumberland Plain west of Sydney, from Richmond and Windsor south to Picton and from Liverpool west to the Hawkesbury and Nepean Rivers at the base of the Blue Mountains. Known from over 100 different locations, but not all are currently occupied, and they are usually isolated from each other as a result of land use patterns. Primarily inhabits Cumberland Plain Woodland (a critically endangered	Predicted by BioBank Calculator	Present Numerous records in the locality, occurs in natural and disturbed woodland of varying patch size. Targeted during the fauna surveys.	Species

Common Name *(Scientific Name)*	TSC Act	EPBC Act	Habitat requirements	Number of records (source)	Likelihood of occurrence	Ecosystem or species credit species?
			ecological community). This community is a grassy, open woodland with occasional dense patches of shrubs. It is also known from Shale Gravel Transition Forests, Castlereagh Swamp Woodlands and the margins of River-flat Eucalypt Forest, which are also listed communities.			
Diamond Firetail (*Stagonopleura guttata*)	V	-	Not commonly found in coastal districts, though there are records from near Sydney, the Hunter Valley and the Bega Valley. This species has a scattered distribution over the rest of NSW, though is very rare west of the Darling River. Found in grassy eucalypt woodlands, including Box-Gum Woodlands and Snow Gum Woodlands.	Predicted by BioBank Calculator	Moderate. This species was recorded from the Defence Establishment Orchard Hills in 2006. It was recorded at 'Twin Creeks' Luddenham in 2012. Also recorded near Wallacia in 1990 on the Golf Course. Considered unlikely to be common but a small population may occur in the study area.	Ecosystem
Dural Land Snail (*Pommerhelix duralensis*)	-	E	The Dural land snail is endemic to New South Wales. The species is a shale-influenced habitat specialist, which occurs in low densities along the northwest fringe of the Cumberland Plain on shale-sandstone transitional landscapes. The species has been observed resting in exposed areas, such as on exposed rock or leaf litter, however it will also shelter beneath leaves, rocks and light woody debris.	PMST	None. Study area is habitat for Cumberland Plain Land Snail.	-

Common Name *(Scientific Name)*	TSC Act	EPBC Act	Habitat requirements	Number of records (source)	Likelihood of occurrence	Ecosystem or species credit species?
Eastern Bentwing-bat (*Miniopterus schreibersii oceanensis*)	V	-	Eastern Bentwing-bats occur along the east and north-west coasts of Australia. Caves are the primary roosting habitat, but also use derelict mines, storm-water tunnels, buildings and other man-made structures.	Not predicted	Present. This species was recorded on Anabat during the field survey.	Ecosystem and Species
Eastern False Pipistrelle (*Falsistrellus tasmaniensis*)	V	-	The Eastern False Pipistrelle is found on the south-east coast and ranges of Australia, from southern Queensland to Victoria and Tasmania. Prefers moist habitats, with trees taller than 20 m	Predicted by BioBank Calculator	Present. This species was recorded on Anabat during the field survey.	Ecosystem
Eastern Freetail-bat (*Mormopterus norfolkensis*)	V	-	The Eastern Freetail-bat is found along the east coast from south Queensland to southern NSW. Occur in dry sclerophyll forest, woodland, swamp forests and mangrove forests east of the Great Dividing Range.	Predicted by BioBank Calculator	Present. This species was recorded on Anabat during the field survey.	Ecosystem
Eastern Pygmy Possum (*Cercartetus nanus*)	V	-	Found in a broad range of habitats from rainforest through to wet and dry sclerophyll forest and woodland to heath, but in most areas woodlands and heath appear to be preferred.	Predicted by BioBank Calculator	Low. May occur in a diversity of forest types depending on distribution, typically in dry sclerophyll forest in coastal areas, with heathy understorey or dry and wet heath. Found in wet forest and rainforest in northern NSW. Not expected in the dry fragmented woodland habitat in the study area.	Species
Flame Robin (*Petroica phoenicea*)	V	-	The Flame Robin is endemic to south eastern Australia, and ranges from near the	Predicted by BioBank	Moderate.	Ecosystem

Common Name *(Scientific Name)*	TSC Act	EPBC Act	Habitat requirements	Number of records (source)	Likelihood of occurrence	Ecosystem or species credit species?
			Queensland border to south east South Australia and also in Tasmania. In NSW, it breeds in upland areas and in winter, many birds move to the inland slopes and plains.	Calculator	Three records of the Flame Robin exist in Mulgoa Nature Reserve from 2001 and 2002. This species may utilise habitat in the study area on occasion in winter as birds move down onto the Cumberland Plain in winter.	
Freckled Duck (*Stictonetta naevosa*)	V	-	Prefer permanent freshwater swamps and creeks with heavy growth of Cumbungi, Lignum or Tea-tree. During drier times they move from ephemeral breeding swamps to more permanent waters such as lakes, reservoirs, farm dams and sewage ponds.	Predicted by BioBank Calculator	Low. Records of this species in the locality are from Penrith Lakes form the 1980s. The dams in the study area are not considered optimal for this species.	Ecosystem
Gang-gang Cockatoo (*Callocephalon fimbriatum*)	V	-	The Gang-gang Cockatoo is distributed from southern Victoria through south- and central-eastern New South Wales. In New South Wales, the Gang-gang Cockatoo is distributed from the south-east coast to the Hunter region, and inland to the Central Tablelands and south-west slopes. In summer, occupies tall montane forests and woodlands, particularly in heavily timbered and mature wet sclerophyll forests. Also occur in subalpine Snow Gum woodland and occasionally in temperate or regenerating forest. In winter, occurs at lower altitudes in drier, more open eucalypt forests and woodlands, particularly in box ironbark assemblages, or in dry forest in coastal areas.	Predicted by BioBank Calculator	Moderate. Inhabits the forests of the lower Blue Mountains to the west of the study area and in winter will move down into the western areas of the Cumberland Plain. Records exist at Mulgoa from December 2015.	Ecosystem

Common Name *(Scientific Name)*	TSC Act	EPBC Act	Habitat requirements	Number of records (source)	Likelihood of occurrence	Ecosystem or species credit species?
Gang-gang Cockatoo population, Hornsby and Ku-ring-gai Local Government Areas	EP	-	In summer, occupies tall montane forests and woodlands, particularly in heavily timbered and mature wet sclerophyll forests. Also occur in subalpine Snow Gum woodland and occasionally in temperate or regenerating forest. In winter, occurs at lower altitudes in drier, more open eucalypt forests and woodlands, particularly in box ironbark assemblages, or in dry forest in coastal areas. It requires tree hollows in which to breed.	Predicted by BioBank Calculator	None. The study area is not in the Ku-ring-gai or Hornsby LGA	Species
Giant Burrowing Frog (*Heleioporus australiacus*)	V	V	Found in heath, woodland and open dry sclerophyll forest on a variety of soil types except those that are clay based. Spends more than 95 per cent of its time in non-breeding habitat in areas up to 300 m from breeding sites. Whilst in non-breeding habitat it burrows below the soil surface or in the leaf litter. Individual frogs occupy a series of burrow sites, some of which are used repeatedly. The home ranges of both sexes appear to be non-overlapping suggesting exclusivity of non-breeding habitat. Home ranges are about 0.04 hectares in size. Requires ephemeral and permanent freshwater wetlands, ponds, dams with an open aspect and fringed by Typha and other aquatics, free from predatory fish.	PMST	Low. No suitable habitat is present.	-
Greater Broad-nosed	V	-	The Greater Broad-nosed Bat is found mainly in the gullies and river systems that	Predicted by BioBank	Moderate.	Ecosystem

Common Name *(Scientific Name)*	TSC Act	EPBC Act	Habitat requirements	Number of records (source)	Likelihood of occurrence	Ecosystem or species credit species?
Bat (*Scoteanax rueppellii*)			drain the Great Dividing Range, from north-eastern Victoria to the Atherton Tableland. It extends to the coast over much of its range. In NSW it is widespread on the New England Tablelands, however does not occur at altitudes above 500 m.	Calculator	Records of this species exist in Mulgoa Nature Reserve from 2004, 2013 and 2014. A record is also present at Wallacia from 1993. This species may utilise habitat in the study area.	
Green and Golden Bell Frog (*Litoria aurea*)	E	V	Since 1990 there have been about 50 recorded locations in NSW, most of which are small, coastal, or near coastal populations. These locations occur over the species' former range; however they are widely separated and isolated. Large populations in NSW are located around the metropolitan areas of Sydney, Shoalhaven and mid north coast (one an island population). There is only one known population on the NSW Southern Tablelands. Ephemeral and permanent freshwater wetlands, ponds, dams with an open aspect and fringed by *Typha* and other aquatics, free from predatory fish.	Predicted by BioBank Calculator PMST	Low. Records within 20 years within the study area, although no recent records. Occurs in a variety of ephemeral and permanent creek and pond habitats, typically with emergent vegetation. The abundance of farm dams along creek lines suggests potential habitat is present.	Species
Grey-headed Flying-fox (*Pteropus poliocephalus*)	V	V	Generally found within 200 km of the eastern coast of Australia, from Rockhampton in Queensland to Adelaide in South Australia. In times of natural resource shortages, they may be found in unusual locations. Occur in subtropical and temperate rainforests, tall sclerophyll forests and woodlands, heaths and swamps as well as urban gardens and cultivated fruit crops. Roosting camps are generally located within	PMST	Recorded. Recorded in the study area during surveys.	-

Common Name *(Scientific Name)*	TSC Act	EPBC Act	Habitat requirements	Number of records (source)	Likelihood of occurrence	Ecosystem or species credit species?
			20 km of a regular food source and are commonly found in gullies, close to water, in vegetation with a dense canopy. Individual camps may have tens of thousands of animals and are used for mating, and for giving birth and rearing young.			
Hooded Robin (south-eastern form) (*Melanodryas cucullata subsp. cucullata*)	V	-	The Hooded Robin is widespread, found across Australia, except for the driest deserts and the wetter coastal areas - northern and eastern coastal Queensland and Tasmania. However, it is common in few places, and rarely found on the coast. Prefers lightly wooded country, usually open eucalypt woodland, acacia scrub and mallee, often in or near clearings or open areas. Requires structurally diverse habitats featuring mature eucalypts, saplings, some small shrubs and a ground layer of moderately tall native grasses.	Predicted by BioBank Calculator	Low. A record of this species exists at Mulgoa from 2004. Two records also exist at Greendale from 1990. 1995 and 1996. No records of this species have been made in the locality in the last 12 years. This species is considered to have a low likelihood of occurring in the study area.	Ecosystem
Koala (*Phascolarctos cinereus*)	V	V	In NSW it mainly occurs on the central and north coasts with some populations in the west of the Great Dividing Range. Inhabit eucalypt woodlands and forests. Feed on the foliage of more than 70 eucalypt species and 30 non-eucalypt species, but in any one area will select preferred browse species.	Predicted by BioBank Calculator	Low. The Koala is considered to have a very low chance of occurring and there is only one historic record from the study area in 1999 from west of Mulgoa Nature Reserve near the Warragamba River around 8 km from the study area.	Species
Large-eared Pied Bat (*Chalinolobus dwyeri*)	V	V	Forages over a broad range of open forest and woodland habitats, this species is a	PMST	Moderate.	-

Common Name *(Scientific Name)*	TSC Act	EPBC Act	Habitat requirements	Number of records (source)	Likelihood of occurrence	Ecosystem or species credit species?
			cave roosting bat which favours sandstone escarpment habitats for roosting, in the form of shallow overhangs, crevices and caves.		May forage in the study area. Records exist nearby in Mulgoa Nature Reserve.	
Little Eagle (*Hieraaetus morphnoides*)	V	-	Occupies open eucalypt forest, woodland or open woodland. Sheoak or acacia woodlands and riparian woodlands of interior NSW are also used.	Predicted by BioBank Calculator	Moderate. This species is likely to fly over the study area and may roost in trees.	Ecosystem
Little Lorikeet (*Glossopsitta pusilla*)	V	-	Forages primarily in the canopy of open Eucalyptus forest and woodland, yet also finds food in apples (Angophora sp.), paperbarks (Melaleuca sp.) and other tree species. Riparian habitats are particularly used, due to higher soil fertility and hence greater productivity. Isolated flowering trees in open country (e.g. paddocks, roadside remnants) and urban trees also help sustain viable populations of the species.	Predicted by BioBank Calculator	Moderate. While all records of this species are from the north, the study area provides some foraging resources and may contain potential nesting sites.	Ecosystem
Littlejohn's Tree Frog *(Litoria littlejohni*)	V	V	Distribution includes the plateaus and eastern slopes of the Great Dividing Range from Watagan State Forest (90 km north of Sydney) south to Buchan in Victoria. This species breeds in the upper reaches of permanent streams and in perched swamps. Non-breeding habitat is heath based forests and woodlands where it shelters under leaf litter and low vegetation, and hunts for invertebrate prey either in shrubs or on the ground.	PMST	Low. No suitable habitat is present.	-

Common Name *(Scientific Name)*	TSC Act	EPBC Act	Habitat requirements	Number of records (source)	Likelihood of occurrence	Ecosystem or species credit species?
Macquarie Perch (*Macquaria australasica*)	E (FM Act)	E	The Macquarie Perch is a riverine, schooling species. It prefers clear water and deep, rocky holes with lots of cover. As well as aquatic vegetation, additional cover may comprise of large boulders, debris and overhanging banks. Spawning occurs just above riffles (shallow running water). Populations may survive in impoundments if able to access suitable spawning sites.	PMST	Low. No suitable habitat is present.	-
Masked Owl (*Tyto novaehollandiae*)	V	-	Dry eucalypt forests and woodland, typically prefers open forest with low shrub density. Requires old trees for roosting and nesting.	Predicted by BioBank Calculator	Moderate. Known from the Mulgoa Nature Reserve and may utilise habitat in the study area for foraging.	Ecosystem
New Holland Mouse (*Pseudomys novaehollandiae*)	-	V	Distribution is fragmented across all eastern states of Australia, where it inhabits open heath lands, open woodlands with heath understorey and vegetated sand dunes.	PMST	Low. No suitable habitat is present.	-
Painted Honeyeater (*Grantiella picta*)	V	V	The Painted Honeyeater is nomadic and occurs at low densities throughout its range. The greatest concentrations of the bird and almost all breeding occur on the inland slopes of the Great Dividing Range in NSW, Victoria and southern Queensland. During the winter it is more likely to be found in the north of its distribution. Inhabits Boree/ Weeping Myall (*Acacia pendula*), Brigalow (*A. harpophylla*) and Box-Gum Woodlands and Box-Ironbark Forests. A specialist	PMST Predicted by BioBank Calculator	Low. This species has complex movement patters and is most likely to be detected in and around the study area when mistletoes are in fruit. Lack of records in locality suggests this species is unlikely to occur.	Ecosystem

Common Name *(Scientific Name)*	TSC Act	EPBC Act	Habitat requirements	Number of records (source)	Likelihood of occurrence	Ecosystem or species credit species?
			feeder on the fruits of mistletoes growing on woodland eucalypts and acacias. Prefers mistletoes of the genus *Amyema*.			
Powerful Owl (*Ninox strenua*)	V	-	Open forests with dense wet gullies and creek areas, requires large mature trees with hollows for breeding and dense areas of vegetation for prey and roosting.	Predicted by BioBank Calculator	Moderate. Known from the Mulgoa Nature Reserve and may utilise habitat in the study area for foraging.	Ecosystem
Regent Honeyeater (*Anthochaera phrygia*)	E	CE	Temperate woodlands and open forests of the inland slopes of south-east Australia. The species inhabits dry open forest and woodland, particularly Box-Ironbark woodland, and riparian forests of River Sheoak. Regent Honeyeaters usually nest in horizontal branches or forks in tall mature eucalypts and Sheoaks.	Predicted by BioBank Calculator PMST	Moderate. Records are associated with PCT835, PCT849 and PCT850 and small fragments of higher quality shale hills woodland may be utilised by this species. This species has complex movement patters and is most likely to be detected in and around the study area in late autumn to early spring (Department of Environment Water Heritage and the Arts 2010b).	Species
Scarlet Robin (*Petroica boodang*)	V	-	The Scarlet Robin lives in dry eucalypt forests and woodlands. The understorey is usually open and grassy with few scattered shrubs. This species lives in both mature and re-growth vegetation. It occasionally occurs in mallee or wet forest communities, or in wetlands and tea-tree swamps	Predicted by BioBank Calculator	Moderate. This species may utilise habitat in the study area on occasion in winter as birds move down onto the Cumberland Plain in winter.	Ecosystem
Speckled Warbler	V	-	The Speckled Warbler lives in a wide range of Eucalyptus dominated communities that	Predicted by BioBank	Moderate.	Ecosystem

Common Name *(Scientific Name)*	TSC Act	EPBC Act	Habitat requirements	Number of records (source)	Likelihood of occurrence	Ecosystem or species credit species?
(*Chthonicola sagittatus*)			have a grassy understorey, often on rocky ridges or in gullies. Typical habitat would include scattered native tussock grasses, a sparse shrub layer, some eucalypt re-growth and an open canopy. Large, relatively undisturbed remnants are required for the species to persist in an area.	Calculator	The Speckled Warbler has been regularly recorded from the Defence Establishment Orchard Hills. May utilise habitat in the study area.	
Spotted Harrier (*Circus assimilis*)	V	-	Occurs throughout the Australian mainland and disperses into NSW as one single population. It occurs on grassy open woodland, inland riparian woodlands, grasslands and shrub steppe.	Predicted by BioBank Calculator	Moderate. This species may utilise habitat in the study area on occasion. Foraging habitat present in grasslands and open areas.	Ecosystem
Spotted-tailed Quoll (*Dasyurus maculatus*)	V	E	Wet and dry sclerophyll forests and rainforests, and adjacent open agricultural areas. Generally associated with large expansive areas of habitat to sustain territory size. Requires hollow-bearing trees, fallen logs, small caves, rock crevices, boulder fields and rocky-cliff faces as den sites.	PMST Predicted by BioBank Calculator	Low. The Spotted-tailed Quoll is considered to have a very low chance of occurring and there are few historic record from the locality.	-
Square-tailed Kite (*Lophoictinia isura*)	V	-	It is widely distributed to the coastal and sub-coastal area of Australia. Migrates to NSW in September for breeding. Occurs in dry woodlands and open forests, and timbered watercourses.	Predicted by BioBank Calculator	Moderate. This species may utilise habitat in the study area on occasion. Foraging habitat present in woodlands.	Ecosystem
Squirrel Glider (*Petaurus norfolcensis*)	V	-	The species is widely though sparsely distributed in eastern Australia, from northern Queensland to western Victoria.	Predicted by BioBank Calculator	Low The Squirrel Glider is considered to have a	Species

Common Name *(Scientific Name)*	TSC Act	EPBC Act	Habitat requirements	Number of records (source)	Likelihood of occurrence	Ecosystem or species credit species?
			Inhabits mature or old growth Box, Box-Ironbark woodlands and River Red Gum forest west of the Great Dividing Range and Blackbutt-Bloodwood forest with heath understorey in coastal areas. Prefers mixed species stands with a shrub or Acacia midstorey.		low chance of occurring. Searches of the OEH Atlas shows a lack of records in the study area and the species was absent from two comprehensive targeted fauna surveys conducted in the Defence Establishment Orchard Hills on the Northern Road (AMBS 2003; SKM 2011).	
Stuttering Frog (*Mixophyes balbus*)	V	E	Occur along the east coast of Australia from southern Queensland to north-eastern Victoria. Found in rainforest and wet, tall open forest in the foothills and escarpment on the eastern side of the Great Dividing Range. Outside the breeding season adults live in deep leaf litter and thick understorey vegetation on the forest floor.	PMST	Low. No suitable habitat is present.	-
Swift Parrot (*Lathamus discolor*)	E	CE	On the mainland they occur in areas where eucalypts are flowering profusely or where there are abundant lerp (from sap-sucking bugs) infestations. Favoured feed trees include winter flowering species such as Swamp Mahogany, Spotted Gum, Red Bloodwood, Red Ironbark, and White Box.	PMST Predicted by BioBank Calculator	Moderate. Records are associated with PCT835, PCT849 and PCT850 and small fragments of higher quality shale hills woodland may be utilised by this species. This species has complex movement patters and is most likely to be detected in and around the study area in winter.	Ecosystem
Turquoise Parrot (*Neophema pulchella*)	V	-	Lives on the edges of eucalypt woodland adjoining clearings, timbered ridges and creeks in farmland.	Predicted by BioBank Calculator	Low. Not known form the locality and considered unlikely to occur in western Sydney.	Ecosystem

Common Name *(Scientific Name)*	TSC Act	EPBC Act	Habitat requirements	Number of records (source)	Likelihood of occurrence	Ecosystem or species credit species?
Varied Sittella (*Daphoenositta chrysoptera*)	V	-	Inhabits eucalypt forests and woodlands, especially those containing rough-barked species and mature smooth-barked gums with dead branches, mallee and acacia woodland.	Predicted by BioBank Calculator	Moderate. Likely to use habitats throughout the study area	Ecosystem
White-fronted Chat (*Epthianura albifrons*)	V	-	The White-fronted Chat is found across the southern half of Australia, from southernmost Queensland to southern Tasmania, and across to Western Australia as far north as Carnarvon. Found mostly in temperate to arid climates and very rarely sub-tropical areas, it occupies foothills and lowlands up to 1000 m above sea level. In NSW, it occurs mostly in the southern half of the state, in damp open habitats along the coast, and near waterways in the western part of the state. Along the coastline, it is found predominantly in saltmarsh vegetation but also in open grasslands and sometimes in low shrubs bordering wetland areas.	Predicted by BioBank Calculator	Low. Not known from the locality and considered unlikely to occur based on absence of suitable habitat.	Ecosystem
Yellow-bellied Sheathtail-bat (*Saccolaimus flaviventris*)	V	-	Forages in most habitats across its very wide range, with and without trees; appears to defend an aerial territory. Roost in tree hollows and buildings.	Predicted by BioBank Calculator	Moderate. May utilise habitats in the study area.	Ecosystem

Habitat assessment table for EPBC Act listed migratory species identified from the PMST

Common Name *(Scientific Name)*	Habitat requirements	Number of records (source)	Likelihood of occurrence
Fork-tailed Swift (*Apus pacificus*)	Recorded in all regions of NSW. The Fork-tailed Swift is almost exclusively aerial, flying from less than 1 m to at least 300 m above ground and probably much higher.	PMST	Moderate This species is likely to fly over the study area during seasonal migration
Great Egret (*Ardea alba*)	Widespread in Australia. Reported in a wide range of wetland habitats (for example inland and coastal, freshwater and saline, permanent and ephemeral, open and vegetated, large and small, natural and artificial).	PMST	Moderate Likely to forage in wetlands throughout the study area. No breeding habitat present.
Cattle Egret (*Ardea ibis*)	Widespread and common according to migration movements and breeding localities surveys. Occurs in tropical and temperate grasslands, wooded lands and terrestrial wetlands.	PMST	Present Forages in paddocks throughout the study area. No breeding habitat present.
Oriental Cuckoo (*Cuculus optatus*)	Migrates from Eurasia as far south as Indonesia, New Guinea and North Australia. Some remain through Australia in the winter. Inhabits rainforest margins, monsoon forest, vine scrub and mangroves.	PMST	Low There is no suitable habitat in the study area.
Latham's Snipe (*Gallinago hardwickii*)	Recorded along the east coast of Australia from Cape York Peninsula through to south-eastern South Australia. Occurs in permanent and ephemeral wetlands up to 2000 m above sea-level.	PMST	Recorded Forages and lives in wetlands throughout the study area on a seasonal basis. No breeding habitat present.
White-throated Needletail	Widespread in eastern and south-eastern Australia. Almost exclusively aerial, from	PMST	Moderate

Common Name *(Scientific Name)*	Habitat requirements	Number of records (source)	Likelihood of occurrence
(*Hirundapus caudacutus*)	heights of less than 1 m up to more than 1000 m above the ground. They also commonly occur over heathland but less often over treeless areas, such as grassland or swamps.		This species is likely to fly over the study area during seasonal migration
Rainbow Bee-eater (*Merops ornatus*)	Distributed across much of mainland Australia, and occurs on several near-shore islands. Occurs mainly in open forests and woodlands, shrublands, and in various cleared or semi-cleared habitats, including farmland and areas of human habitation.	PMST	Low This species is not regularly recorded form the region
Black-faced Monarch (*Monarcha melanopsis*)	Widespread in eastern Australia. Mainly occurs in rainforest ecosystems, including semi-deciduous vine-thickets, complex notophyll vine-forest, tropical (mesophyll) rainforest, subtropical (notophyll) rainforest, mesophyll (broadleaf) thicket/shrubland, warm temperate rainforest, dry (monsoon) rainforest and (occasionally) cool temperate rainforest.	PMST	Low There is no suitable habitat in the study area.
Spectacled Monarch (*Monarcha trivirgatus*)	Occurs along the entire east coast of Australia. Breeds in dense scrub in gullies of coastal ranges.	PMST	Low There is no suitable habitat in the study area.
Yellow Wagtail (*Motacilla flava*)	Rare but regular visitor around Australian coast, especially in the NW coast Broome to Darwin. Found in open country near swamps, salt marshes, sewage ponds, grassed surrounds to airfields, bare ground; occasionally on drier inland plains.	PMST	Low There is no suitable habitat in the study area.

Common Name *(Scientific Name)*	Habitat requirements	Number of records (source)	Likelihood of occurrence
Satin Flycatcher (*Myiagra cyanoleuca*)	Widespread in eastern Australia and vagrant to New Zealand. Inhabit heavily vegetated gullies in eucalypt-dominated forests and taller woodlands, and on migration, occur in coastal forests, woodlands, mangroves and drier woodlands and open forests.	PMST	Low There is no suitable habitat in the study area.
Rufous Fantail (*Rhipidura rufifrons*)	Occurs in coastal and near coastal districts of northern and eastern Australia. In east and south-east Australia, the Rufous Fantail mainly inhabits wet sclerophyll forests, often in gullies dominated by eucalypts such as Tallow-wood (Eucalyptus microcorys), Mountain Grey Gum (E. cypellocarpa), Narrow-leaved Peppermint (E. radiata), Mountain Ash (E. regnans), Alpine Ash (E. delegatensis), Blackbutt (E. pilularis) or Red Mahogany (E. resinifera); usually with a dense shrubby understorey often including ferns.	PMST	Low There is no suitable habitat in the study area.
Osprey (*Pandion cristatus*)	Eastern Ospreys occur in littoral and coastal habitats and terrestrial wetlands of tropical and temperate Australia and offshore islands. They are mostly found in coastal areas but occasionally travel inland along major rivers. They require extensive areas of open fresh, brackish or saline water for foraging. They frequent a variety of wetland habitats including inshore waters, reefs, bays, coastal cliffs, beaches, estuaries, mangrove swamps, broad rivers, reservoirs and large lakes and waterholes.	PMST	Low There is no suitable habitat in the study area.

Appendix C – Biodiversity credit report

Biodiversity credit report

This report identifies the number and type of biodiversity credits required for a major project.

Date of report: 10/01/2017 Time: 10:28:16AM Calculator version: v4.0

Major Project details

Proposal ID:	170/2015/2161MP
Proposal name:	The Northern Road Upgrade Mersey Road, Bringelly to Glenmore Parkway, Glenmore Park
Proposal address:	Mersey Rd Glenmore Parkway Bringelly to Glenmor NSW 2748
Proponent name:	NSW Roads and Maritime Services
Proponent address:	Level 11, 27-31 Argyle Street Parramatta NSW 2150
Proponent phone:	131782
Assessor name:	Lukas Clews
Assessor address:	100 Christie St St Leonards NSW 2065
Assessor phone:	02 9928 2291
Assessor accreditation:	170

Summary of ecosystem credits required

Plant Community type	Area (ha)	Credits created
Derived grasslands on shale hills of the Cumberland Plain (50-300m asl)	12.01	223.39
Forest Red Gum - Rough-barked Apple grassy woodland on alluvial flats of the Cumberland Plain, Sydney Basin Bioregion	4.29	178.00
Grey Box - Forest Red Gum grassy woodland on flats of the Cumberland Plain, Sydney Basin Bioregion	11.35	307.00
Grey Box - Forest Red Gum grassy woodland on shale of the southern Cumberland Plain, Sydney Basin Bioregion	10.47	409.66
Phragmites australis and Typha orientalis coastal freshwater wetlands of the Sydney Basin Bioregion	6.17	142.00
Total	44.29	1,260

Credit profiles

1. Forest Red Gum - Rough-barked Apple grassy woodland on alluvial flats of the Cumberland Plain, Sydney Basin Bioregion, (HN526)

Number of ecosystem credits created	178
IBRA sub-region	Cumberland - Hawkesbury/Nepean

Offset options - Plant Community types	Offset options - IBRA sub-regions
Forest Red Gum - Rough-barked Apple grassy woodland on alluvial flats of the Cumberland Plain, Sydney Basin Bioregion, (HN526) Grey Box - Forest Red Gum grassy woodland on flats of the Cumberland Plain, Sydney Basin Bioregion, (HN528)	Cumberland - Hawkesbury/Nepean and any IBRA subregion that adjoins the IBRA subregion in which the development occurs

2. Grey Box - Forest Red Gum grassy woodland on flats of the Cumberland Plain, Sydney Basin Bioregion, (HN528)

Number of ecosystem credits created	307
IBRA sub-region	Cumberland - Hawkesbury/Nepean

Offset options - Plant Community types	Offset options - IBRA sub-regions
Grey Box - Forest Red Gum grassy woodland on flats of the Cumberland Plain, Sydney Basin Bioregion, (HN528)	Cumberland - Hawkesbury/Nepean and any IBRA subregion that adjoins the IBRA subregion in which the development occurs

3. Grey Box - Forest Red Gum grassy woodland on shale of the southern Cumberland Plain, Sydney Basin Bioregion, (HN529)

Number of ecosystem credits created	410
IBRA sub-region	Cumberland - Hawkesbury/Nepean

Offset options - Plant Community types	Offset options - IBRA sub-regions
Grey Box - Forest Red Gum grassy woodland on shale of the southern Cumberland Plain, Sydney Basin Bioregion, (HN529) Grey Box - Forest Red Gum grassy woodland on flats of the Cumberland Plain, Sydney Basin Bioregion, (HN528)	Cumberland - Hawkesbury/Nepean and any IBRA subregion that adjoins the IBRA subregion in which the development occurs

4. Derived grasslands on shale hills of the Cumberland Plain (50-300m asl), (HN627)

Number of ecosystem credits created	223
IBRA sub-region	Cumberland - Hawkesbury/Nepean

Offset options - Plant Community types	Offset options - IBRA sub-regions
Derived grasslands on shale hills of the Cumberland Plain (50-300m asl), (HN627) Forest Red Gum - Grey Box shrubby woodland on shale of the southern Cumberland Plain, Sydney Basin Bioregion, (HN524) Grey Box - Forest Red Gum grassy woodland on flats of the Cumberland Plain, Sydney Basin Bioregion, (HN528) Grey Box - Forest Red Gum grassy woodland on shale of the southern Cumberland Plain, Sydney Basin Bioregion, (HN529) Derived grasslands on shale plains of the Cumberland Plain (<100m asl), (HN628) Cabbage Gum forest in Sun Valley, Sydney Basin Bioregion, (HN634)	Cumberland - Hawkesbury/Nepean and any IBRA subregion that adjoins the IBRA subregion in which the development occurs

5. Phragmites australis and Typha orientalis coastal freshwater wetlands of the Sydney Basin Bioregion, (HN630)

Number of ecosystem credits created	142
IBRA sub-region	Cumberland - Hawkesbury/Nepean

Offset options - Plant Community types	Offset options - IBRA sub-regions
Phragmites australis and Typha orientalis coastal freshwater wetlands of the Sydney Basin Bioregion, (HN630) Coastal freshwater lagoons of the Sydney Basin Bioregion and South East Corner Bioregion, (HN520)	Cumberland - Hawkesbury/Nepean and any IBRA subregion that adjoins the IBRA subregion in which the development occurs

Summary of species credits required

Common name	Scientific name	Extent of impact Ha or individuals	Number of species credits created
Pultenaea parviflora	Pultenaea parviflora	4.00	60
Marsdenia viridiflora subsp. viridiflora in the Bankstown, Blacktown, Camden, Campbelltown, Fairfield, Holroyd, Liverpool and Penrith local government areas	Marsdenia viridiflora subsp. viridiflora - endangered population	35.00	1,400
Cumberland Plain Land Snail	Meridolum corneovirens	13.00	169
Regent Honeyeater	Anthochaera phrygia	26.25	2,021

BioBanking Credit Calculator

Ecosystem credits

Proposal ID :	170/2015/2161MP
Proposal name :	The Northern Road Upgrade Mersey Road, Bringelly to Glenmore Parkway, Glenmore Pa
Assessor name :	Lukas Clews
Assessor accreditation number :	170
Tool version :	v4.0
Report created :	10/01/2017 10:27

Assessment circle name	Landscape score	Vegetation zone name	Vegetation type name	Condition	Red flag status	Management zone name	Management zone area	Current site value	Future site value	Loss in site value	Credit required for bio diversity	Credit required for TS	TS with highest credit requirement	Average species loss	Species TG Value	Final credit requirement for management zone
TNR	17.25	HN528_Moderate/Good	Grey Box - Forest Red Gum grassy woodland on flats of the Cumberland Plain, Sydney Basin Bioregion	Moderate/Good	Yes	1	6.67	55.56	0.00	55.56	307	307	Barking Owl	50.00	3.00	307
TNR	17.25	HN526_Moderate/Good	Forest Red Gum - Rough-barked Apple grassy woodland on alluvial flats of the Cumberland Plain, Sydney Basin Bioregion	Moderate/Good	Yes	1	2.53	53.65	0.00	53.65	113	113	Masked Owl	66.67	3.00	113
TNR	17.25	HN529_Moderate/Good	Grey Box - Forest Red Gum grassy woodland on shale of the southern Cumberland Plain, Sydney Basin Bioregion	Moderate/Good	Yes	1	4.92	57.97	0.00	57.97	235	235	Barking Owl	50.00	3.00	235
TNR	17.25	HN528_Moderate/Good_Poor	Grey Box - Forest Red Gum grassy woodland on flats of the Cumberland Plain, Sydney Basin Bioregion	Moderate/Good_Poor	No	1	4.68	15.94	0.00	15.94	76	76	Barking Owl	41.67	3.00	0
TNR	17.25	HN529_Moderate/Good_Other	Grey Box - Forest Red Gum grassy woodland on shale of the southern Cumberland Plain, Sydney Basin Bioregion	Moderate/Good_Poor	No	1	3.21	24.64	0.00	24.64	73	73	Barking Owl	41.67	3.00	73
TNR	17.25	HN526_Moderate/Good_Poor	Forest Red Gum - Rough-barked Apple grassy woodland on alluvial flats of the Cumberland Plain, Sydney Basin Bioregion	Moderate/Good_Poor	Yes	1	1.76	43.23	0.00	43.23	65	65	Masked Owl	58.33	3.00	65
TNR	17.25	HN529_Moderate/Good_High	Grey Box - Forest Red Gum grassy woodland on shale of the southern Cumberland Plain, Sydney Basin Bioregion	Moderate/Good_High	Yes	1	1.25	74.64	0.00	74.64	75	75	Barking Owl	58.33	3.00	75
TNR	17.25	HN627_Moderate/Good_Derived grassland	Derived grasslands on shale hills of the Cumberland Plain (50-300m asl)	Moderate/Good_Derived grassland	No	1	12.01	19.05	0.00	19.05	223	132	Little Eagle	0.00	1.40	223

Assessment circle name	Landscape score	Vegetation zone name	Vegetation type name	Condition	Red flag status	Management zone name	Management zone area	Current site value	Future site value	Loss in site value	Credit required for bio diversity	Credit required for TS	TS with highest credit requirement	Average species loss	Species TG Value	Final credit requirement for management zone
TNR	17.25	HN630_Moderate/Good_Other	Phragmites australis and Typha orientalis coastal freshwater wetlands of the Sydney Basin Bioregion	Moderate/Good_Other	Yes	1	6.17	34.06	0.00	34.06	0	142	Eastern Freetail-bat	75.00	2.20	142
TNR	17.25	HN529_Moderate/Good_Medium	Grey Box - Forest Red Gum grassy woodland on shale of the southern Cumberland Plain, Sydney Basin Bioregion	Moderate/Good_Medium	No	1	1.09	25.85	0.00	25.85	26	26	Barking Owl	33.33	3.00	26

BioBanking Credit Calculator

Species credits

Proposal ID :	170/2015/2161MP
Proposal name :	The Northern Road Upgrade Mersey Road, Bringelly to Glenmore Parkway, Glenmore Pa
Assessor name :	Lukas Clews
Assessor accreditation number :	170
Tool version :	v4.0
Report created :	10/01/2017 10:27

Scientific name	Common name	Species TG value	Identified population?	Can Id. popn. be offset?	Area / number of loss	Negligible loss	Red flag status	Number of credits
Marsdenia viridiflora subsp. viridiflora - endangered population	Marsdenia viridiflora subsp. viridiflora in the Bankstown, Blacktown, Camden, Campbelltown, Fairfield, Holroyd, Liverpool and Penrith local government areas	4.00	No		35.00	0.00	Yes	1,400
Pultenaea parviflora	Pultenaea parviflora	1.50	No		4.00	0.00	Yes	60
Meridolum corneovirens	Cumberland Plain Land Snail	1.30	No		13.00	0.00	No	169
Anthochaera phrygia	Regent Honeyeater	7.70	No		26.25	0.00	No	2,021

Appendix D – Secretary's Environmental Assessment Requirements and Commonwealth EIS Guidelines

Secretary's Environmental Assessment Requirements

Section 115Y of the *Environmental Planning and Assessment Act 1979*

Application Number	SSI 7127
Proposal	The Northern Road Upgrade
Location	Land generally between Glenmore Parkway, Glenmore Park and Mersey Road, Bringelly
Proponent	Roads and Maritime Services
Date of Issue	9 March 2016
General Requirements	The Environmental Impact Statement (EIS) must meet the minimum form and content requirements in clauses 6 and 7 of Schedule 2 the *Environmental Planning and Assessment Regulation 2000*. Where relevant, the assessment of the key issues below, and any other significant issues identified in the risk assessment, must include: • adequate baseline data; • consideration of potential cumulative impacts due to other development in the vicinity; and • measures to avoid, minimise and if necessary, offset the predicted impacts, including detailed contingency plans for managing any significant risks to the environment.
Key issues	The EIS must also address the following specific matters: **Statutory and Strategic Context** — including: • a statement of the objectives of the proposal, including a description of the strategic need, justification, objectives and outcomes for the proposal, and as relevant the outcomes and objectives of relevant strategic planning and transport policies, including, but not limited to, *NSW 2021*, *NSW Government State Infrastructure Strategy*, *NSW Long Term Transport Master Plan* (December 2012), *A Plan for Growing Sydney* (December 2014) and any other relevant plans; • an analysis of feasible alternatives to the carrying out of the proposal and proposal justification, including: o an analysis of alternatives/options considered having regard to the proposal's objectives (including an assessment of the beneficial and detrimental environmental impacts of the proposal relative to alternatives and the consequences of not carrying out the proposal), and the provision of a clear discussion of the route development and selection process, the suitability of the chosen alignment and whether or not the proposal is in the public interest, and o justification for the preferred proposal taking into consideration the objects of the *Environmental Planning and Assessment Act 1979*; • a detailed description of the proposal, including: o the proposed route, o design of the alignment (vertical and horizontal), associated structures (such as bridges, arches and culverts), interchanges, and road user, pedestrian and cyclist facilities (including street furniture, lighting and intersection crossing treatments), o land use changes, including resumption of residential, commercial,

	industrial and recreational lands, and impacts to Crown land, o interactions with key utilities and services, o location and operational requirements of construction ancillary facilities and access tracks, and o relationship and/or interaction with existing public and freight transport services (including air, rail, and bus services); • an analysis of the proposal, including an identification of how relevant planning, land use and development matters (including relevant strategic and statutory matters) have been considered in the impact assessment (direct, indirect and cumulative impacts) and/or in developing management/ mitigation measures; • details of how the proposal integrates with approved and proposed infrastructure projects, including consideration of the proposed Western Sydney Airport at Badgerys Creek and future (M9) Outer Sydney Orbital; and • details of how the principles of ecologically sustainable development will be incorporated in the design, construction and ongoing operation phases of the proposal. **Traffic and Transport** — including: • details of how: o the preferred alignment, design and staging, o the proposed intersections, interchanges and connections to the surrounding road network, and o associated road infrastructure facilities, meet the traffic and transport objectives of the proposal, taking into account the following local and regional issues: o adjacent sensitive land uses, o the proposed Western Sydney Airport, o transport connectivity to and from existing communities and centres (such as South West Growth Centre), o future growth areas, o the Broader Western Sydney Employment Area, o approved and proposed infrastructure projects (including other proposed upgrades of The Northern Road, Bringelly Road Upgrade Stages 1 and 2, and the proposed M12 Motorway between M7 and The Northern Road), o traffic (vehicular, cyclist and pedestrian) needs; • an assessment and modelling of operational traffic and transport impacts on the local and regional road network, and M4 Western Motorway, including an assessment of road user safety, and discussion of the currency of baseline traffic and transport data; • a detailed assessment of public transport impacts and opportunities, including a summary of bus routes that would utilise the proposed bus lanes; • an assessment of potential impacts the proposal may have on aviation associated with the proposed Western Sydney Airport; • an assessment of impacts on cyclist and pedestrian access and safety, and description of proposed cyclist and pedestrian routes, having consideration of opportunities to integrate cycleway and pedestrian elements with surrounding networks and facilitate connectivity between existing communities and with proposed future land uses; and • construction traffic and transport impacts of the proposal (including ancillary facilities) and associated management measures, in particular: o impacts to the road network (including safety and level of service, pedestrian and cyclist access, and disruption to public transport services and access to properties),

	o access and route identification and scheduling of transport movements, o the number, frequency and size of construction related vehicles (passenger, commercial, heavy and oversized vehicles), o effects on commercial and industrial access, including staff and customer parking, o the nature of existing traffic on construction access routes (including consideration of peak traffic times), and o the need to close, divert or otherwise reconfigure elements of the road network associated with construction of the proposal, having reference to the cumulative construction impacts of other major projects preparing for or commencing construction. **Noise and Vibration** — including: • an assessment of the noise impacts of the proposal during operation, consistent with the *Road Noise Policy* (EPA 2011), NSW *Industrial Noise Policy* (EPA 2000) and relevant guidelines. The assessment must include specific consideration of impacts to receivers (such as, but not limited to, dwellings, child and aged care centres, educational establishments, hospitals, motels, nursing homes, places of worship, or recreation), including specific consideration of sleep disturbance and, as relevant, the characteristics of noise (e.g. low frequency noise), and identify reasonable and feasible mitigation measures; • an assessment of construction noise and vibration impacts, consistent with the *Interim Construction Noise Guideline* (DECCW 2009) and *Assessing Vibration: a technical guideline* (DEC 2006). The assessment must have regard to the nature of construction activities (including transport, tonal or impulsive noise-generating works and the removal of operational noise barriers, as relevant), the intensity and duration of noise and vibration impacts, cumulative effects of construction works undertaken concurrently, the nature, sensitivity and impact to potentially affected receivers, the need to balance timely conclusion of noise and vibration-generating works with periods of receiver respite, and other factors that may influence the timing and duration of construction activities (such as traffic management), and mitigation and management measures; • if blasting is required, addressing the relevant requirements of *Technical basis for guidelines to minimise annoyance due to blasting overpressure and ground vibration* (ANZECC 1990); and • if relevant, an indication of potential for works outside standard working hours, including predicted levels and exceedances, justification for the activity and discussion of available mitigation and management measures. **Hydrology, Soils and Water** — including: • impacts on watercourses, surface water flows (including stormwater drainage systems), quality, quantity, availability and users (commercial and recreational), with particular reference to any likely impacts on surrounding water bodies and their catchments, wetlands and their habitats, including how these are to be monitored; • an assessment of construction water quality impacts, taking into account impacts from both accidents and runoff (i.e. acute and chronic impacts), having consideration to impacts to surface water runoff, soil erosion and sediment transport, mass movement, and spoil and waste management. The assessment of water quality impacts is to have reference to relevant public health and environmental water quality criteria, including those specified in the *Australian and New Zealand Guidelines for Fresh*

	and Marine Water Quality (ANZECC/ARMCANZ 2000), any applicable regional, local or site-specific guidelines, water quality objectives, and any licensing requirements; • assessment of waterways to be modified as a result of the proposal, including ecological, hydrological and geomorphic impacts (as relevant), including temporary crossings, and measures to rehabilitate the waterways to preconstruction conditions or better, including fish passage requirements consistent with *Policy and Guidelines for Fish Friendly Waterway Crossings* (DPI 2004); • groundwater impacts taking into consideration impacts associated with geotechnical ground treatments, dewatering, deep cuttings and fill locations, and cumulative impacts on regional hydrology. The assessment shall consider, where relevant, the extent of drawdown, impacts to groundwater characteristics, quality, quantity, and connectivity, groundwater flow direction and levels, discharge and recharge rates, and implications for water courses, groundwater users, groundwater dependent ecosystems, riparian areas and wetlands. The assessment should be prepared having consideration to the *NSW Aquifer Interference Policy*; • measures to manage, monitor and/or mitigate impacts; • identification of potential impacts and benefits of the proposal on existing flood regimes, consistent with the *Floodplain Development Manual* (Department of Natural Resources 2005), with an assessment of the potential changes to flooding behaviour (levels, velocities and direction) and impacts on bed and bank stability, through flood modelling, and proposed management and mitigation measures; • identifying potential impacts of the development on acid sulfate soils in accordance with the relevant guidelines and a description of the mitigation measures proposed to minimise potential impacts; • an overview of spoil management processes for the proposal, including consideration of the indicative cut/fill balance and reuse options for spoil generated by the proposal; and • a contaminated lands assessment in accordance with relevant guidelines.
Other issues	**Social and Economic —** including: • impacts on directly affected properties and land uses, including impacts related to access and severance, existing and proposed land uses, property acquisition and amenity related changes; • social and economic impacts to the community and businesses in the vicinity of the proposal (including agricultural businesses), associated with traffic, access, property, public domain and amenity related changes; and • a draft Community Involvement Plan for the works, identifying relevant stakeholders, procedures for distributing information and receiving/responding to feedback and procedures for resolving community complaints during construction. Key issues that should be addressed in the draft Plan should include (but not necessarily be limited to): o traffic management (including property access and pedestrian access), and o noise and vibration mitigation and management, including work outside standard construction hours. **Urban Design and Visual Amenity** — including:

	• a consideration of the urban design and visual amenity implications of the proposal, including supporting infrastructure, during construction and operation; • a consideration of impacts on views and vistas (including impacts on extant views to the eastern escarpment of the Blue Mountains), streetscapes, existing significant vegetation, key sites and buildings; • measures to ameliorate visual impacts during construction and operation; and • measures to manage lighting impacts during construction and operation. **Heritage —** including: • impacts to *State and local historic heritage* (including conservation areas, built heritage, landscapes and archaeology) should be assessed. Where impacts to State or locally significant historic heritage are identified, the assessment shall: o be undertaken by a suitably qualified heritage consultant(s) with relevant heritage expertise (note: where archaeological excavations are proposed the relevant consultant must meet the NSW Heritage Council's Excavation Director criteria), o include a statement of heritage impact for all heritage items/conservation areas to be impacted (including significance assessment). This should include detailed mapping of all heritage items and how they are affected by the proposal, o include details of any proposed mitigation measures (architectural and landscape), o consider impacts from, including but not limited to, vibration, demolition, archaeological disturbance, altered historical arrangements and access, landscape and vistas, and architectural noise treatment (as relevant), o detail proposed mitigation and management measures (including measures to avoid significant impacts and an evaluation of the effectiveness of the mitigation measures), which are developed consistent with the guidelines in the *NSW Heritage Manual* (Heritage Office and DUAP 1996), o include provision of future mitigation strategies for all identified archaeological impacts that would arise from the proposal, and o where physical archaeological test excavations are proposed, develop an appropriate archaeological assessment methodology, including research design, in consultation with the Heritage Council of New South Wales (for items of State significance) and the Department, to guide the test excavations, and include the results of these excavations; and • impacts to *Aboriginal heritage* (including cultural and archaeological significance), in particular impacts to Aboriginal objects and potential archaeological deposits (PAD), should be assessed. The assessment shall be undertaken generally consistent with the *Guide to investigating, assessing and reporting on Aboriginal cultural heritage in NSW* (OEH 2011) and related guidelines and requirements (whilst taking into account s.115ZG of the EP&A Act). Where impacts are identified, the assessment shall: o be undertaken by a suitably qualified heritage consultant(s), o demonstrate effective consultation with Aboriginal communities in determining and assessing impacts and developing and selecting options and mitigation measures (including the final proposed measures) generally consistent with the *Aboriginal cultural heritage consultation requirements for proponents 2010* (DECCW 2010), o undertake appropriate archaeological investigations generally in accordance with the *Code of Practice for Archaeological*

	Investigation of Aboriginal Objects in NSW (DECCW 2010), to establish the full spatial extent and significance of any archaeological evidence across each site/area of PAD, and include the results of these excavations. If an alternative excavation method is proposed, it shall be developed in consultation with Office of Environment and Heritage, o assess and document the archaeological and cultural significance of cultural heritage values of affected sites, and o detail proposed mitigation and management measures (including measures to avoid significant impacts and an evaluation of the effectiveness of the mitigation measures). **Biodiversity —** including: • an assessment of impacts on biodiversity, including terrestrial and aquatic ecology, and riparian corridors, in accordance with the Framework for Biodiversity Assessment (unless otherwise agreed by OEH) and the *Policy and Guidelines for Fish Habitat Conservation And Management—Update 2013* (NSW Department of Primary Industries 2013). The assessment is to be conducted by a person accredited in accordance with s142B(1)(c) of the *Threatened Species Conservation Act 1995*. *Note: This includes a requirement for a Biodiversity Assessment Report and a Biodiversity Offset Strategy.* **Air Quality** — including: • potential for impacts on local and regional air quality, including sensitive receivers; and • details of the proposed mitigation measures to prevent the generation and emission of dust.. **Resources and Sustainability —** including: • outline of waste management for the proposal, including consideration of the waste hierarchy; and • discussion of how the principles of sustainability have been incorporated into the assessment of the proposal. **Environmental Risk Analysis** — notwithstanding the above assessment requirements, the EIS must include an environmental risk analysis to identify potential environmental impacts associated with the proposal (construction and operation), proposed mitigation measures and potentially significant residual environmental impacts after the application of proposed mitigation measures. Where additional key environmental impacts are identified through this environmental risk analysis, an appropriately detailed impact assessment of this additional key environmental impact must be included in the EIS.
Consultation	During the preparation of the EIS, you must consult with the relevant local, State and Commonwealth Government authorities, service providers, community groups and affected landowners. In particular you must consult with: • local, State and Commonwealth government authorities, including the: o Environment Protection Authority, o Office of Environment and Heritage (including Heritage Division), o Department of Primary Industries, o NSW Office of Water, o Water NSW, o Civil Aviation Safety Authority, o Airservices Australia,

	o where known, the operator of the proposed Western Sydney Airport, o Department of Defence, o Ministry of Health, including the South Western Sydney and Nepean Blue Mountains Local Health Districts, o Liverpool City Council, o Penrith City Council, and o emergency services; • specialist interest groups, including local sporting groups, Aboriginal stakeholders, and pedestrian and bicycle user groups; • utilities and service providers; and • the public, including community groups, businesses, and adjoining and affected landowners. The EIS must describe the consultation process and the issues raised, and identify where the design of the infrastructure has been amended in response to these issues. Where amendments have not been made to address an issue, a short explanation should be provided.
Further consultation after two years	If you do not lodge an EIS for the infrastructure within two years of the issue date of these SEARs, you must consult further with the Secretary in relation to the preparation of the EIS.

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Appendix E – Biodiversity offset strategy

The Northern Road Upgrade – Mersey Road to Glenmore Parkway

Prepared for Roads and Maritime Services by Jacobs Australia

Biodiversity Offset Strategy Working Paper

Final

22 February 2017

The Northern Road Upgrade - Mersey Road to Glenmore Parkway

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V7	22/02/2017	Revision 6	L Clews	C Thomson	D Williams

Contents

Executive Summary

Roads and Maritime Services (Roads and Maritime), is seeking approval to construct and operate an upgrade of a 16 km section of The Northern Road between Mersey Road, Bringelly and Glenmore Parkway, Glenmore Park.

The Northern Road is about 45 km west of the Sydney central business district and traverses the local government areas of Penrith in the north and Liverpool in the south. The Northern Road is a key north–south road between Narellan and Richmond, connecting the North West and South West Priority Growth Areas (see Figure 1-1). The corridor intersects with a number of regional motorway, arterial and collector roads such as (north to south) Richmond Road, Great Western Highway, M4 Motorway, Elizabeth Drive, Bringelly Road, and Camden Valley Way.

Approval is being sought for the project under Part 5.1 of the *Environmental Planning and Assessment Act 1979* (EP&A Act). Environmental Impacts Statements (EISs) are prepared to assess the impacts of major projects, including State Significant Infrastructure (SSI) projects, under Part 5.1 of the EP&A Act. This Biodiversity Offset Strategy (BOS) forms part of the Biodiversity Assessment Report (BAR) prepared to accompany the EIS under the Framework for Biodiversity Assessment (FBA) for the project.

On 21 July 2016, the Commonwealth Minister for the Environment determined that the project has the potential to significantly impact on matters of national environmental significance and is therefore a 'controlled action'. This means that approval of the project will be required from the Commonwealth Minister for the Environment in addition to environmental and planning approvals required under State legislation.

This BOS outlines the offsets required for unavoidable (residual) biodiversity impacts associated with the project and demonstrates that appropriate offsets are available and can be delivered for the project. The residual impacts from the project that require offsets (ecosystem and species credits) under the FBA are as follows:

- Forest Red Gum - Rough-barked Apple grassy woodland on alluvial flats of the Cumberland Plain, Sydney Basin Bioregion – 178 credits
- Grey Box - Forest Red Gum grassy woodland on flats of the Cumberland Plain, Sydney Basin Bioregion – 307 credits
- Grey Box - Forest Red Gum grassy woodland on shale of the southern Cumberland Plain, Sydney Basin Bioregion – 409.66 credits
- Derived grasslands on shale hills of the Cumberland Plain (50-300m asl) – 223.39 credits
- *Phragmites australis* and *Typha orientalis* coastal freshwater wetlands of the Sydney Basin Bioregion – 142 credits
- *Pultenaea parviflora* – 60 credits
- *Marsdenia viridiflora* subsp. *viridiflora* - endangered population – 1,400 credits
- Cumberland Plain Land Snail – 169 credits
- Regent Honeyeater – 2,021 credits.

Roads and Maritime have been assessing the likely offset requirements for projects associated with the Western Sydney Infrastructure Plan (WSIP) and a desktop assessment of available offsets was prepared in March 2016 (Eco Logical Australia, 2015). This assessment was based on a desktop appraisal of worst case potential impacts. This BOS provides a more accurate assessment of impacts and biodiversity credits required. An updated review of available credits on the BioBanking Credits Register in July 2016 indicates that appropriate offsets are generally available (in the form of ecosystem credits) and the approach for securing the offset requirement is the purchase of credits available on the BioBanking Credit Register.

A direct like-for-like offset is available for most ecosystem credits required for the project including critically endangered ecological communities listed under the NSW *Threatened Species Conservation Act 1995* (TSC

Act) and the EPBC Act. However, there is a current shortfall in credits available on the BioBanking Credit Register for:

- *Phragmites australis* and *Typha orientalis* coastal freshwater wetlands of the Sydney Basin Bioregion (HN 630)
- *Pultenaea parviflora*
- *Marsdenia viridiflora* subsp*. viridiflora* - endangered population
- Cumberland Plain Land Snail
- Regent Honeyeater.

Roads and Maritime have identified properties that may have potential to provide species credits for *Pultenaea parviflora,* Cumberland Plain Land Snail and Regent Honeyeater. A search of the BioBanking Public Register indicates that land may be available via an expression of interest to secure suitable species credits for the *Marsdenia viridiflora* subsp*. viridiflora* - endangered population. A credits wanted request was placed on the BioBanking credits wanted register on 20 July 2016.

If Roads and Maritime are unable to locate a like-for-like offset after taking reasonable steps, then they may apply the variation rules to locate an appropriate offset for non-EPBC Act listed matters. The variation rules allow vegetation to be offset with a broader suite of similar vegetation types in the locality that have similar percentage of historical clearing. They also allow species to be offset with similar species in the locality that use the same habitat and are under a similar or greater level of threat.

In the case of *Phragmites australis* and *Typha orientalis* coastal freshwater wetlands of the Sydney Basin Bioregion (HN 630), variation rules may need to be applied due to the current shortfall of credits available for this PCT on the BioBanking Public Register. However, before variation rules can be used, Roads and Maritime will:

- Continue to check the BioBanking public register and
- Liaise with an OEH office and relevant local councils to obtain a list of potential sites that meet the requirements for offsetting and

If appropriate offset sites cannot be found, Roads and Maritime may then provide funds for supplementary measures.

The final offset requirement for the Project will be determined during development of the offset package. During the detailed design phase the project footprint may change from that assessed here which would result in a different offset requirement for the Project than what is presented in this BOS.

Important note about your report

In preparing this report, Jacobs has relied upon, and presumed accurate, any information (or confirmation of the absence thereof) provided by the Client and/or from other sources. Except as otherwise stated in the report, Jacobs has not attempted to verify the accuracy or completeness of any such information. If the information is subsequently determined to be false, inaccurate or incomplete then it is possible that our observations and conclusions as expressed in this report may change.

Jacobs derived the data in this report from information sourced from the Client (if any) and/or available in the public domain at the time or times outlined in this report. The passage of time, manifestation of latent conditions or impacts of future events may require further examination of the Proposal and subsequent data analysis, and re-evaluation of the data, findings, observations and conclusions expressed in this report. Jacobs has prepared this report in accordance with the usual care and thoroughness of the consulting profession, for the sole purpose described above and by reference to applicable standards, guidelines, procedures and practices at the date of issue of this report. For the reasons outlined above, however, no other warranty or guarantee, whether expressed or implied, is made as to the data, observations and findings expressed in this report, to the extent permitted by law.

This report should be read in full and no excerpts are to be taken as representative of the findings. No responsibility is accepted by Jacobs for use of any part of this report in any other context.

This report has been prepared on behalf of, and for the exclusive use of, Jacobs's Client, and is subject to, and issued in accordance with, the provisions of the contract between Jacobs and the Client. Jacobs accepts no liability or responsibility whatsoever for, or in respect of, any use of, or reliance upon, this report by any third party.

1. Introduction

Roads and Maritime Services (Roads and Maritime), is seeking approval to construct and operate an upgrade of a 16 km section of The Northern Road between Mersey Road, Bringelly and Glenmore Parkway, Glenmore Park. The Northern Road is about 45 km west of the Sydney central business district and traverses the local government areas of Penrith in the north and Liverpool in the south. The Northern Road is a key north–south road between Narellan and Richmond, connecting the North West and South West Priority Growth Areas (see Figure 1-1). The corridor intersects with a number of regional motorway, arterial and collector roads such as (north to south) Richmond Road, Great Western Highway, M4 Motorway, Elizabeth Drive, Bringelly Road, and Camden Valley Way.

Approval is being sought for the project under Part 5.1 of the *Environmental Planning and Assessment Act 1979* (EP&A Act). Environmental Impacts Statements (EISs) are prepared to assess the impacts of major projects, including State Significant Infrastructure (SSI) projects, under Part 5.1 of the EP&A Act. This Biodiversity Offset Strategy (BOS) forms part of the Biodiversity Assessment Report (BAR) prepared to accompany the EIS under the Framework for Biodiversity Assessment (FBA) (Office of Environment and Heritage, 2014a) for the project. As such, this BOS is to be read in conjunction with the BAR for the project.

On 21 July 2016, the Commonwealth Minister for the Environment determined that the project has the potential to significantly impact on matters of national environmental significance and is therefore a 'controlled action'. The controlled action is considered likely to have a significant impact on the following EPBC Act listed threatened species and ecological communities:

- Critically endangered – Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest (Cumberland Plain Woodlands)
- Critically endangered – *Lathamus discolor* (Swift Parrot)
- Critically endangered – *Anthochaera phrygia* (Regent Honeyeater)
- Vulnerable – *Pultenaea parviflora*
- Vulnerable – *Pteropus poliocephalus* (Grey-headed Flying-fox).

This means that approval of the project will be required from the Commonwealth Minister for the Environment in addition to environmental and planning approvals required under State legislation.

1.1 Requirements under the Framework for Biodiversity Assessment

The *NSW Biodiversity Offsets Policy for Major Projects* (Office of Environment and Heritage, 2014b) clarifies and standardises biodiversity impact assessment and offsetting for major project approvals in NSW. The FBA underpins and operationalises the *NSW Biodiversity Offsets Policy for Major Projects*. The FBA contains the assessment methodology that is adopted by the *NSW Biodiversity Offsets Policy for Major Projects* to quantify and describe the impact assessment requirements and offset guidance that apply to Major Projects.

The Secretary's Environmental Assessment Requirements (SEARs) issued for the project on 28 July 2015 and amended SEARs issued on 9 March 2016 require the FBA to be applied to the project to assess impacts on biodiversity. The SEARs included a requirement for a BAR and a BOS to accompany the EIS.

Under the *NSW Biodiversity Offsets Policy for Major Projects*, offsets must be targeted to the biodiversity values being lost or to higher conservation priorities. This generally means that a like-for-like offset is required. However, the *NSW Biodiversity Offsets Policy for Major Projects* provides greater flexibility for proponents to meet their offset requirements by providing various offset options while ensuring that the best and most credible offsets are provided (Office of Environment and Heritage, 2014b). This flexibility includes variations to the like-for-like requirement, mine site rehabilitation and supplementary measures (funds for other measures that benefit biodiversity). This BOS is centred on providing like-for-like offsets in the first instance in accordance with the *NSW Biodiversity Offsets Policy for Major Projects*. This is necessary where offsets are for critically endangered

ecological communities listed under the NSW *Threatened Species Conservation Act 1995* (TSC Act) and/or EPBC Act listed matters. If a like-for-like offset cannot be found, the variation rules, and potentially supplementary measures, will be examined and implemented where applicable.

All effort will be made to offset all Matters of National Environmental Significance (MNES) on a strict like-for-like basis.

1.2 Requirements of the Commonwealth EIS Guidelines

The Commonwealth EIS Guidelines issued on 5 August 2016 indicate that the EIS must:

Commonwealth EIS Guidelines	Where addressed in BOS
The EIS must include details of an offset package to be implemented to compensate for residual significant impacts associated with the project as well as an analysis of how the offset meets the requirements of the Department's *Environmental Protection and Biodiversity Conservation Act 1999* Environmental Offsets Policy October 2012 (EPBC Act Offset Policy) or a state offsetting policy that has been endorsed by the Commonwealth.	Section 4
The offset package can comprise a combination of direct offsets and other compensatory measures, as long as it meets the requirements of the EPBC Act Offset Policy. Offsets should align with conservation priorities for the impacted protected matter and be tailored specifically to the attribute of the protected matter that is impacted in order to deliver a conservation gain.	Section 2, 3 and 4
Offsets should compensate for an impact for the full duration of the impact.	Section 4
Offsets must directly contribute to the ongoing viability of the protected matter impacted by the project and deliver an overall conservation outcome that maintains or improves the viability of the protected matter, compared to what is likely to have occurred under the 'status quo' (i.e. if the action and associated offset had not taken place).	Section 4
Note: Offsets do not make an unacceptable impact acceptable and do not reduce the likely impacts of a proposed action. Instead, offsets compensate for any residual significant impact.	Section 4
The EIS must provide: a. Details of the offset package to compensate for significant residual impacts on a protected matter b. An analysis of how the offset package meets the requirements of the EPBC Act Offsets Policy.	Section 3 Section 4

Commonwealth EIS Guidelines	Where addressed in BOS
Details in relation to the proposed offsets package, including: a. The location and size, in hectares, of any offset site(s) b. Maps for each offset site that clearly show: i. The relevant ecological features ii. The landscape context iii. The cadastre boundary c. The current tenure arrangements (including zoning and ownership) of any proposed offset sites d. Confirmed records of presence (or otherwise) of relevant protected matter(s) on the offset site(s) e. Details of studies and surveys used to confirm the presence of individuals and or likely habitat within offset site(s), including the scope, timing/effort (survey season/s) and methodologies employed f. Detailed information regarding the extent (in hectares) and quality of habitat for relevant protected matter(s) on the offset site. The quality of habitat should be assessed in a manner consistent with the approach outlined in the document titled How to use the offset assessment guide available at http://www.environment.gov.au/epbc/publications/environmental-offsets-policy.html	This offset strategy
Provide information and justification regarding how the offsets package will deliver a conservation outcome that will maintain or improve the viability of the protected matter(s) consistent with the EPBC Act environmental offsets policy (October 2012) including: a. Management actions that will be undertaken to improve or maintain the quality of the proposed offset site(s) for the relevant protected matter(s). Management actions must be clearly described, planned and resourced as to justify any proposed improvements in quality for the protected matter(s) over time b. The time over which management actions will deliver any proposed improvement or maintenance of habitat quality for the relevant protected matter(s) c. The risk of damage, degradation or destruction to any proposed offset site(s) in the absence of any formal protection and/or management over a foreseeable time period (20 years). Such risk assessments may be based on: i. Presence of pending development applications, mining leases or other activities on or near the proposed offset site(s) that indicate development intent ii. Average risk of loss for similar sites iii. Presence and strength of formal protection mechanisms currently in place d. The legal mechanism(s) that are proposed to protect offset site(s) into the future and avert any risk of damage, degradation or destruction.	This offset strategy
Provide information regarding how the proposed offsets package is additional to that already required, as determined by law or planning regulations, agreed to under other schemes or programs or required under an existing duty-of-care.	Section 4

Commonwealth EIS Guidelines	Where addressed in BOS
The overall cost of the proposed offsets package; including costs associated with, but not necessarily limited to: a. Acquisition and transfer of lands/property b. Implementation of all related management actions c. Monitoring, reporting and auditing of offset performance.	This offset strategy

This BOS addresses the requirements of the Commonwealth EIS Guidelines regarding offsets. The Commonwealth EIS Guidelines that contain the information requirements for EPBC Act offset proposals is provided in Appendix D of the BAR. The approach taken to offsets for the project is a direct offset that aims to provide 'like for like' offset for all biodiversity values, with this being the minimum requirement for those matters listed under the EPBC Act. The offset package itself will be finalised after the offset investigations have been completed (see Section 2). As such, this BOS cannot outline specific details of a proposed offset package (i.e. location and size of any offset sites, maps for an offset site, ownership and tenure, etc.).

1.3 Impacts to be offset

The residual impacts to biodiversity that are to be offset, as identified in the BAR, are outlined in Table 1.1 and Table 1.2 below. These impacts to be offset include the impacts to the EPBC Act listed Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest, Swift Parrot, Regent Honeyeater, *Pultenaea parviflora* and Grey-headed Flying-fox. Under the FBA, offsets for impacts to this ecological community and these species are mandatory whether a significant impact is likely or not. An important note is that the Swift Parrot and Grey-headed Flying-fox are classed as 'ecosystem credit species' so the offset for these species is calculated depending on the Plant Community Type which provides habitat for these species. No specific 'species credits' are available for the Swift Parrot and Grey-headed Flying-fox under the FBA or BioBanking framework.

Table 1.1 : Summary of ecosystem credits required

Plant community type	Status		Area (ha)	Credits required
	TSC Act	EPBC Act		
Derived grasslands on shale hills of the Cumberland Plain (50-300m asl) (HN627)	Critically endangered Cumberland Plain Woodland in the Sydney Basin Bioregion	Critically endangered Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest (in part)	12.01	223.39
Forest Red Gum - Rough-barked Apple grassy woodland on alluvial flats of the Cumberland Plain, Sydney Basin Bioregion (HN 526)	Endangered River-Flat Eucalypt Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions	Not listed	4.29	178
Grey Box - Forest Red Gum grassy woodland on flats of the Cumberland Plain, Sydney Basin Bioregion (HN 528)	Critically endangered Cumberland Plain Woodland in the Sydney Basin Bioregion	Critically endangered Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest	11.35	307
Grey Box - Forest Red Gum grassy woodland on shale of the southern Cumberland Plain, Sydney Basin Bioregion (HN 529)	Critically endangered Cumberland Plain Woodland in the Sydney Basin Bioregion	Critically endangered Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest	10.47	409.66
Phragmites australis and *Typha orientalis* coastal freshwater wetlands	Not listed	Not listed	6.17	142

Plant community type	Status		Area (ha)	Credits required
	TSC Act	EPBC Act		
of the Sydney Basin Bioregion (HN 630)				
		Total	**44.29**	**1,260**

Table 1.2 : Summary of species credits required

Common name	Scientific name	Status		Extent of impact (ha or individuals)	Number of species credits required
		TSC Act	EPBC Act		
Pultenaea parviflora	*Pultenaea parviflora*	Endangered	Vulnerable	4 plants	60
Marsdenia viridiflora subsp. *viridiflora* in the Bankstown, Blacktown, Camden, Campbelltown, Fairfield, Holroyd, Liverpool and Penrith local government areas	*Marsdenia viridiflora* subsp. *viridiflora* - endangered population	Endangered population	Not listed	35 plants	1,400
Cumberland Plain Land Snail	*Meridolum corneovirens*	Endangered	Not listed	13 ha	169
Regent Honeyeater	*Anthochaera phrygia*	Critically endangered	Critically endangered	26.25 ha	2,021

2. Offset investigations

The FBA outlines two options to fulfil the offset requirement for the project:

- Retiring biodiversity credits – like-for-like offsets are secured and credits retired (or variation rules are applied)
- Contributing to supplementary measures.

A combination of the above two measures can also be used. The project offsets will aim to provide 'like for like' offsets for all biodiversity values, with this being the minimum requirement for those matters listed under the EPBC Act.

Roads and Maritime have been assessing the likely offset requirements for projects associated with the Western Sydney Infrastructure Plan (WSIP) which includes The Northern Road upgrades and a desktop assessment of available offsets was prepared in March 2016. Potential sources of credits (ecosystem and species) were identified through:

- A search of the BioBanking Public Registers on the Office of Environment and Heritage (OEH) BioBanking webpage
- Communication with credit owners, accredited BioBanking assessors and other sources closely involved with the biodiversity credit market
- Communication with local Councils who are currently pursuing options to establish Biobank sites on their own Council land, or who were known to be interested
- Investigation of provide properties.

To update this initial assessment, an updated investigation of credits available on the BioBanking Public Registers was undertaken in July 2016. A credits wanted request was placed on the BioBanking credits wanted register on 21 July 2016.

2.1 Reasonable steps to locate offsets

Reasonable steps must be undertaken to locate appropriate like-for-like offset sites before supplementary measures can be considered. Reasonable steps to locate like-for-like offsets include, in addition to consideration of any feasible sites known to the proponent:

- checking the BioBanking public register and having an expression of interest for credits on it for at least six months
- liaising with an OEH office (or Fisheries NSW office for aquatic biodiversity) and relevant local councils to obtain a list of potential sites that meet the requirements for offsetting
- providing evidence of why offset sites are not feasible – suitable evidence may include:
  - the unwillingness of a landowner to sell or establish a biobank site
  - the cost of an offset site itself should not be a factor unless it can be demonstrated the landowner is charging significantly above market rates.

Roads and Maritime will undertake reasonable steps to secure like-for-like offset sites before considering the variation criteria and/or supplementary measures. A key part of the reasonable steps taken so far has been the initial assessment of the likely offset requirements for projects associated with the Western Sydney Infrastructure Plan (WSIP) (Eco Logical Australia, 2015). The BioBanking public register has been checked for available credits and a credits wanted request was placed on the BioBanking credits wanted register on 21 July 2016.

3. Offset options for the project

3.1 Derived grasslands on shale hills of the Cumberland Plain (50-300m asl) (HN 627)

The credit requirement for this PCT is 223.39 credits. Roads and Maritime have not yet identified any potential properties / sources that provide credits directly for this PCT (Eco Logical Australia, 2015). Additionally, a search of the BioBanking Public Register indicates that no credits for this vegetation type are available for purchase.

However, there are other offset options for this PCT as outlined in the credit report for the project as follows:

- Forest Red Gum - Grey Box shrubby woodland on shale of the southern Cumberland Plain, Sydney Basin Bioregion, (HN524)
- Grey Box - Forest Red Gum grassy woodland on flats of the Cumberland Plain, Sydney Basin Bioregion, (HN528)
- Grey Box - Forest Red Gum grassy woodland on shale of the southern Cumberland Plain, Sydney Basin Bioregion, (HN529)
- Derived grasslands on shale plains of the Cumberland Plain (<100m asl), (HN628) (no credits available)
- Cabbage Gum forest in Sun Valley, Sydney Basin Bioregion, (HN634) (no credits available).

This PCT may be offset in the Cumberland - Hawkesbury/Nepean sub-region and any IBRA subregion that adjoins the Cumberland - Hawkesbury/Nepean sub-region.

There are 2,199 credits (from three of the PCTs listed above) available on the BioBanking Public Register for purchase which could be used to offset the residual impacts to this PCT. A summary of the credits on the public register available to offset the residual impacts to Derived grasslands on shale hills of the Cumberland Plain (50-300m asl) is provided in Table 3.1.

Roads and Maritime have also identified potential properties / sources that provide credits for some of the other offset options for this PCT (Eco Logical Australia, 2015). Eleven sites have been identified with existing agreements, agreements in progress or on private land should the above options not be available.

Table 3.1 : Summary of available offsets for Derived grasslands on shale hills of the Cumberland Plain (50-300m asl)

ID/name	IBRA sub-region	Credits available
Forest Red Gum - Grey Box shrubby woodland on shale of the southern Cumberland Plain, Sydney Basin Bioregion, (HN524)		
Biobank site 1	Cumberland - Hawkesbury/Nepean	69
Biobank site 2	Wollemi - Hawkesbury/Nepean	46
Biobank site 2	Cumberland - Hawkesbury/Nepean	45
Biobank site 1	Cumberland - Hawkesbury/Nepean	38
Grey Box - Forest Red Gum grassy woodland on flats of the Cumberland Plain, Sydney Basin Bioregion, (HN528)		
Biobank site 3	Cumberland - Hawkesbury/Nepean	222
Biobank site 4	Cumberland - Hawkesbury/Nepean	204
Biobank site 3	Cumberland - Hawkesbury/Nepean	102
Biobank site 4	Cumberland - Hawkesbury/Nepean	93
Biobank site 5	Cumberland - Hawkesbury/Nepean	84
Biobank site 4	Cumberland - Hawkesbury/Nepean	75
Biobank site 6	Cumberland - Hawkesbury/Nepean	60

ID/name	IBRA sub-region	Credits available
Biobank site 5	Cumberland - Hawkesbury/Nepean	49
Biobank site 5	Cumberland - Hawkesbury/Nepean	24
Biobank site 4	Cumberland - Hawkesbury/Nepean	18
Biobank site 4	Cumberland - Hawkesbury/Nepean	16
Biobank site 5	Cumberland - Hawkesbury/Nepean	11
Biobank site 4	Cumberland - Hawkesbury/Nepean	10
Biobank site 1	Cumberland - Hawkesbury/Nepean	325
Biobank site 1	Cumberland - Hawkesbury/Nepean	234
Biobank site 1	Cumberland - Hawkesbury/Nepean	206
Biobank site 1	Cumberland - Hawkesbury/Nepean	109
Biobank site 2	Cumberland - Hawkesbury/Nepean	54
Biobank site 1	Cumberland - Hawkesbury/Nepean	54
Biobank site 7	Cumberland - Hawkesbury/Nepean	20
Biobank site 6	Cumberland - Hawkesbury/Nepean	10
Biobank site 8	Cumberland - Hawkesbury/Nepean	7
Biobank site 4	Cumberland - Hawkesbury/Nepean	4
Biobank site 4	Cumberland - Hawkesbury/Nepean	4
Biobank site 4	Cumberland - Hawkesbury/Nepean	3
Biobank site 9	Cumberland - Hawkesbury/Nepean	2
Biobank site 4	Cumberland - Hawkesbury/Nepean	1

3.2 Forest Red Gum - Rough-barked Apple grassy woodland on alluvial flats of the Cumberland Plain, Sydney Basin Bioregion (HN 526)

The credit requirement for this PCT is 178 credits. Roads and Maritime have identified 10 potential properties / sources that provide credits for this PCT (Eco Logical Australia, 2015). An updated search of the BioBanking Public Register indicates that there are credits available for this vegetation type (see Table 2.2 for a list of credits available on the public register). There is also an offset option for this PCT as outlined in the credit report for the project. This PCT may be offset with the Grey Box - Forest Red Gum grassy woodland on flats of the Cumberland Plain, Sydney Basin Bioregion, (HN528) (availability of offsets for HN 528 is outlined in Table 2.1).

This PCT may be offset in the Cumberland - Hawkesbury/Nepean sub-region and any IBRA subregion that adjoins the Cumberland - Hawkesbury/Nepean sub-region.

There are 874 credits available on the BioBanking Public Register for purchase which could be used to offset the residual impacts to this PCT. A summary of the available credits to offset the residual impacts to Forest Red Gum - Rough-barked Apple grassy woodland on alluvial flats of the Cumberland Plain, Sydney Basin Bioregion (HN 526) is provided in Table 3.2.

Roads and Maritime have also identified potential properties / sources that provide, or may provide, credits for Forest Red Gum - Rough-barked Apple grassy woodland on alluvial flats of the Cumberland Plain, Sydney Basin Bioregion (HN 526) (Eco Logical Australia, 2015). Six sites have been identified with existing agreements, agreements in progress or on private land should the above options not be available

Table 3.2 : Summary of available offsets for Forest Red Gum - Rough-barked Apple grassy woodland on alluvial flats of the Cumberland Plain, Sydney Basin Bioregion (HN 526)

ID/name	IBRA sub-region	Credits available
Forest Red Gum - Rough-barked Apple grassy woodland on alluvial flats of the Cumberland Plain, Sydney Basin Bioregion (HN 526)		
Biobank site 2	Cumberland - Hawkesbury/Nepean	160
Biobank site 1	Cumberland - Hawkesbury/Nepean	144
Biobank site 4	Cumberland - Hawkesbury/Nepean	142
Biobank site 1	Cumberland - Hawkesbury/Nepean	83
Biobank site 5	Cumberland - Hawkesbury/Nepean	57
Biobank site 1	Cumberland - Hawkesbury/Nepean	53
Biobank site 4	Cumberland - Hawkesbury/Nepean	47
Biobank site 4	Cumberland - Hawkesbury/Nepean	46
Biobank site 4	Cumberland - Hawkesbury/Nepean	29
Biobank site 4	Cumberland - Hawkesbury/Nepean	29
Biobank site 4	Cumberland - Hawkesbury/Nepean	21
Biobank site 10	Cumberland - Hawkesbury/Nepean	12
Biobank site 5	Cumberland - Hawkesbury/Nepean	10
Biobank site 11	Cumberland - Hawkesbury/Nepean	8
Biobank site 4	Cumberland - Hawkesbury/Nepean	8
Biobank site 4	Cumberland - Hawkesbury/Nepean	7
Biobank site 4	Cumberland - Hawkesbury/Nepean	5
Biobank site 1	Cumberland - Hawkesbury/Nepean	4
Biobank site 4	Cumberland - Hawkesbury/Nepean	4
Biobank site 4	Cumberland - Hawkesbury/Nepean	2
Biobank site 12	Cumberland - Hawkesbury/Nepean	1
Biobank site 12	Cumberland - Hawkesbury/Nepean	1
Biobank site 4	Cumberland - Hawkesbury/Nepean	1

3.3 Grey Box - Forest Red Gum grassy woodland on flats of the Cumberland Plain, Sydney Basin Bioregion (HN 528)

The credit requirement for this PCT is 307 credits. Roads and Maritime have identified 11 potential properties / sources that provide credits for this PCT (Eco Logical Australia, 2015). An updated search of the BioBanking Public Register indicates that there are credits available for this vegetation type (see Table 3.3 for a list of credits available on the public register). There are no offset options for this PCT and a direct like-for-like offset is required. Variation of the FBA offset rules is not possible for HN529 because a variation cannot be granted for BVTs that are listed as critically endangered under the NSW TSC Act and/or as an ecological community listed under the EPBC Act.

This PCT may be offset in the Cumberland - Hawkesbury/Nepean sub-region and any IBRA subregion that adjoins the Cumberland - Hawkesbury/Nepean sub-region.

There are 968 credits available on the BioBanking Public Register for purchase which could be used to offset the residual impacts to this PCT. A summary of the available credits to offset the residual impacts to Grey Box -

Forest Red Gum grassy woodland on flats of the Cumberland Plain, Sydney Basin Bioregion (HN 528) is provided in Table 3.3.

Roads and Maritime have also identified potential properties / sources that provide, or may provide, credits for Grey Box - Forest Red Gum grassy woodland on flats of the Cumberland Plain, Sydney Basin Bioregion (HN 528) (Eco Logical Australia, 2015). Eight sites have been identified with existing agreements, agreements in progress or on private land should the above options not be available

Table 3.3 : Summary of available offsets for Grey Box - Forest Red Gum grassy woodland on flats of the Cumberland Plain, Sydney Basin Bioregion (HN 528)

ID/name	IBRA sub-region	Credits available
Grey Box - Forest Red Gum grassy woodland on flats of the Cumberland Plain, Sydney Basin Bioregion (HN 528)		
Biobank site 3	Cumberland - Hawkesbury/Nepean	222
Biobank site 4	Cumberland - Hawkesbury/Nepean	204
Biobank site 3	Cumberland - Hawkesbury/Nepean	102
Biobank site 4	Cumberland - Hawkesbury/Nepean	93
Biobank site 5	Cumberland - Hawkesbury/Nepean	84
Biobank site 4	Cumberland - Hawkesbury/Nepean	75
Biobank site 6	Cumberland - Hawkesbury/Nepean	60
Biobank site 5	Cumberland - Hawkesbury/Nepean	49
Biobank site 5	Cumberland - Hawkesbury/Nepean	24
Biobank site 4	Cumberland - Hawkesbury/Nepean	18
Biobank site 4	Cumberland - Hawkesbury/Nepean	16
Biobank site 5	Cumberland - Hawkesbury/Nepean	11
Biobank site 4	Cumberland - Hawkesbury/Nepean	10

3.4 Grey Box - Forest Red Gum grassy woodland on shale of the southern Cumberland Plain, Sydney Basin Bioregion (HN 529)

The credit requirement for this PCT is 409.66 credits. Roads and Maritime have identified 11 potential properties / sources that provide credits for this PCT (Eco Logical Australia, 2015). An updated search of the BioBanking Public Register indicates that there are credits available for this vegetation type (see Table 3.4 for a list of credits available on the public register). There are no current offset options for this PCT and a direct like-for-like offset is required. Variation of the FBA offset rules is not possible for HN529 because a variation cannot be granted for BVTs that are listed as critically endangered under the NSW TSC Act and/or as an ecological community listed under the EPBC Act.

This PCT may be offset in the Cumberland - Hawkesbury/Nepean sub-region and any IBRA subregion that adjoins the Cumberland - Hawkesbury/Nepean sub-region.

There are 1,033 credits available on the BioBanking Public Register for purchase which could be used to offset the residual impacts to this PCT. A summary of the available credits to offset the residual impacts to Grey Box - Forest Red Gum grassy woodland on shale of the southern Cumberland Plain, Sydney Basin Bioregion (HN 529) is provided in Table 3.4.

Roads and Maritime have also identified potential properties / sources that provide, or may provide, credits for Grey Box - Forest Red Gum grassy woodland on shale of the southern Cumberland Plain, Sydney Basin Bioregion (HN 529) (Eco Logical Australia, 2015). Six sites have been identified with existing agreements, agreements in progress or on private land should the above options not be available.

Table 3.4 : Summary of available offsets for 2.5 Grey Box - Forest Red Gum grassy woodland on shale of the southern Cumberland Plain, Sydney Basin Bioregion (HN 529)

ID/name	IBRA sub-region	Credits available
Grey Box - Forest Red Gum grassy woodland on shale of the southern Cumberland Plain, Sydney Basin Bioregion (HN 529)		
Biobank site 1	Cumberland - Hawkesbury/Nepean	325
Biobank site 1	Cumberland - Hawkesbury/Nepean	234
Biobank site 1	Cumberland - Hawkesbury/Nepean	206
Biobank site 1	Cumberland - Hawkesbury/Nepean	109
Biobank site 2	Cumberland - Hawkesbury/Nepean	54
Biobank site 1	Cumberland - Hawkesbury/Nepean	54
Biobank site 7	Cumberland - Hawkesbury/Nepean	20
Biobank site 6	Cumberland - Hawkesbury/Nepean	10
Biobank site 8	Cumberland - Hawkesbury/Nepean	7
Biobank site 4	Cumberland - Hawkesbury/Nepean	4
Biobank site 4	Cumberland - Hawkesbury/Nepean	4
Biobank site 4	Cumberland - Hawkesbury/Nepean	3
Biobank site 9	Cumberland - Hawkesbury/Nepean	2
Biobank site 4	Cumberland - Hawkesbury/Nepean	1

3.5 Phragmites australis and Typha orientalis coastal freshwater wetlands of the Sydney Basin Bioregion (HN 630)

The credit requirement for this PCT is 142 credits. Roads and Maritime have not yet identified any potential properties / sources that provide credits for this PCT (Eco Logical Australia, 2015). A search of the BioBanking Public Register indicates that there are credits available for this vegetation type (see Table 3.5 for a list of credits available on the public register).

There is also an offset option for this PCT as outlined in the credit report for the project. This PCT may be offset with the Coastal freshwater lagoons of the Sydney Basin Bioregion and South East Corner Bioregion, (HN520) (although no credits are currently available on the public register).

There are 22 credits available on the BioBanking Public Register for purchase which could be used to offset the residual impacts to this PCT (see Table 3.5). There is a shortage of available credits for this PCT.

This PCT may be offset in the Cumberland - Hawkesbury/Nepean sub-region and any IBRA subregion that adjoins the Cumberland - Hawkesbury/Nepean sub-region.

Table 3.5 : Summary of available offsets for 2.6 *Phragmites australis* and *Typha orientalis* coastal freshwater wetlands of the Sydney Basin Bioregion (HN 630)

ID/name	Agreement ID	IBRA sub-region	Credits available
Phragmites australis and *Typha orientalis* coastal freshwater wetlands of the Sydney Basin Bioregion (HN 630)			
Biobank site 13	117	Wollemi - Hawkesbury/Nepean	22

3.6 Pultenaea parviflora

The credit requirement for *Pultenaea parviflora* is 60 species credits.

No credits for *Pultenaea parviflora* are currently available for purchase on the BioBanking Public Register. There is no solid data on the availability of species credits for *Pultenaea parviflora* (see Eco Logical Australia, 2015). There have been no credit transactions for this species to date.

Roads and Maritime have identified two properties that may have potential to provide species credits for *Pultenaea parviflora* from the initial desktop assessment (Eco Logical Australia, 2015).

3.7 Marsdenia viridiflora subsp. viridiflora - endangered population

The credit requirement for the *Marsdenia viridiflora* subsp*. viridiflora* - endangered population is 1,400 species credits.

No credits for the *Marsdenia viridiflora* subsp*. viridiflora* - endangered population are currently available for purchase on the BioBanking Public Register. There is no solid data on the availability of species credits for the *Marsdenia viridiflora* subsp*. viridiflora* - endangered population (see Eco Logical Australia, 2015).

The initial desktop assessment of likely offset requirement (Eco Logical Australia, 2015) did not consider the potential for credits for the *Marsdenia viridiflora* subsp*. viridiflora* - endangered population as the initial assessment determined that the likelihood of occurrence of habitat for this species was very low.

A search of the BioBanking Public Register indicates that land may be available via an expression of interest to secure suitable species credits for the *Marsdenia viridiflora* subsp*. viridiflora* - endangered population. However, the presence of the *Marsdenia viridiflora* subsp*. viridiflora* - endangered population is assumed by the landowner and the presence of this population has not been verified by a threatened species survey.

3.8 Cumberland Plain Land Snail

The credit requirement for Cumberland Plain Land Snail is 169 species credits.

No credits for the Cumberland Plain Land Snail are currently available for purchase on the BioBanking Public Register.

Roads and Maritime have identified properties that may have potential to provide species credits for Cumberland Plain Land Snail from the initial desktop assessment (Eco Logical Australia, 2015). Nine sites have been identified with existing agreements, agreements in progress or on private land should the above options not be available.

3.9 Regent Honeyeater

The credit requirement for the Regent Honeyeater is 2,021 species credits.

No credits for the Regent Honeyeater are currently available for purchase on the BioBanking Public Register.

A search of the BioBanking Public Register indicates that land may be available via an expression of interest to secure suitable species credits for the Regent Honeyeater (four sites with expressions of interest are available – two in Penrith LGA and two outside of the bioregion). However, the presence of the Regent Honeyeater at these four sites is assumed by the landowners and the presence of this species has not been verified by a threatened species survey.

Roads and Maritime have identified two properties that may have potential to provide species credits for Regent Honeyeater from the initial desktop assessment (Eco Logical Australia, 2015).

4. Adequacy of the offset

The offset proposed for the project in this BOS has been developed in accordance with the FBA. The FBA has been endorsed by the Commonwealth so the BOS prepared according to the FBA is adequate to offset the impacts to EPBC Act listed biodiversity from the project. This section of the BOS applies to the critically endangered Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest ecological community which is considered likely to be significantly impacted by the Project.

The EPBC Act Environmental Offsets Policy (Department of Sustainability Environment Water Population and Communities, 2012) recognises an offset package is a suite of actions that a proponent undertakes in order to compensate for the residual significant impact of a project. An offset package can include a combination of direct offsets and other compensatory measures, but offsets should align with conservation priorities for the impacted protected matter and be tailored specifically to the attribute of the protected matter that is impacted in order to deliver a conservation gain.

The EPBC Act Environmental Offsets Policy (Department of Sustainability Environment Water Population and Communities, 2012) outlines eight requirements for a suitable offset and the BOS is compared to each of these below:

1) *Suitable offsets must deliver an overall conservation outcome that improves or maintains the viability of the protected matter:*

Through the purchase of biodiversity credits, this BOS will directly contribute to the ongoing viability of the critically endangered Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest ecological community. The BOS will deliver an overall conservation outcome that improves or maintains the viability of the Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest ecological community compared to what is likely to have occurred under the status quo. The proposed offset is tailored specifically to the Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest ecological community and are a direct 'like for like' offset.

2) *Suitable offsets must be built around direct offsets but may include other compensatory measures:*

This BOS provides for a direct offset for the Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest ecological community (in the form of ecosystem credits) in order to compensate for the residual significant impact of the project. The offset posed for Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest ecological community is a 100 percent direct offset. No other compensatory measures will be used and supplementary measures are not permitted.

3) *Suitable offsets must be in proportion to the level of statutory protection that applies to the protected matter:*

The offsets required for those protected matters with higher conservation status must be greater than those with a lower status (Department of Sustainability Environment Water Population and Communities, 2012). As the Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest ecological community is listed as Critically Endangered, it has a very high probability of extinction. The proposed offset is a 100 percent direct 'like for like' offset in the form of ecosystem credits.

4) *Suitable offsets must be of a size and scale proportionate to the residual impacts on the protected matter:*

Offsets must be proportionate to the size and scale of the residual impacts arising from the action so as to deliver a conservation gain that adequately compensates for the impacted matter (Department of Sustainability, Environment, Water, Population and Communities 2012). Through calculation of offsets through the BioBanking credit calculator, the type and number of credits required to offset the residual impacts to the Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest ecological community has been calculated. The BioBanking credit calculator outputs a credit requirement that is considered to be of a size and scale appropriate to the impact.

5) *Suitable offsets must effectively account for and manage the risks of the offset not succeeding:*

The level of risk considered here relates to whether individual offsets are likely to be successful in compensating for the residual impacts of a particular action over a period of time (Department of sustainability, Environment, Water, Population and Communities 2012). This risk has a bearing on the scale of offset required. As a direct offset in the form of ecosystem credits is proposed, this approach presents a lower risk than other compensatory measures and is considered likely to result in a conservation gain. The direct offset means that the offset strategy is deemed suitable and successfully manages the risks of the offset not succeeding. Importantly, no perverse outcomes relating to social or economic factors are considered likely to occur.

6) *Suitable offsets must be additional to what is already required, determined by law or planning regulations, or agreed to under other schemes or programs:*

Offsets must deliver a conservation gain for the impacted protected matter, and that conservation gain must be new, or additional to what is already required by a duty of care or to any environmental planning laws at any level of government (Department of Sustainability Environment Water Population and Communities, 2012). It is important to note however that this does not preclude the recognition of state or territory offsets that may be suitable as offsets under the EPBC Act for the same action (Department of Sustainability Environment Water Population and Communities, 2012). All the required state assessment and approval processes have been followed (i.e. the FBA). As such, the proposed offset is considered appropriate.

7) *Suitable offsets must be efficient, effective, timely, transparent, scientifically robust and reasonable:*

Efficient and effective offsets are those that maintain or improve the viability of a protected matter through the sound allocation of resources (Department of Sustainability Environment Water Population and Communities, 2012). The proposed offset delivers a streamlined combined offset for state and commonwealth matters in the form of ecosystem credits. This is considered a sound allocation of resources and therefore an efficient and effective offset.

Offsets should be implemented either before, or at the same point in time as, the impact arising from the action (Department of Sustainability Environment Water Population and Communities, 2012). The proposed offset strategy is a vital component of the EIS and under the FBA the offsets bust be in place before works begin.

Offsets must be based on both scientifically robust and transparent information that sufficiently analyses and documents the benefit to a protected matter's ecological function or values (Department of Sustainability Environment Water Population and Communities, 2012). The use of ecosystem credits under the FBA is considered a scientifically robust and transparent approach.

8) *Suitable offsets must have transparent governance arrangements including being able to be readily measured, monitored, audited and enforced:*

Offsets must be delivered within appropriate and transparent governance arrangements and proponents must report on the success of the offsets so that conditions of approval can be varied if the offsets are not delivering the desired outcome (Department of Sustainability Environment Water Population and Communities, 2012). The offsets for the project will be registered with the OEH under the BioBanking framework and the establishment costs of the offsets will be borne by Roads and Maritime.

5. Conclusion

This BOS outlines the offsets required for unavoidable (residual) biodiversity impacts associated with the project and demonstrates that appropriate offsets are generally available (in the form of credits) and can be delivered for the project. The preferred approach for this BOS is the purchase of credits available on the BioBanking Credit Register which would result in a direct 'like for like' offset.

A direct like-for-like offset is available for most ecosystem credits required for the project. However, there is a current shortfall in credits available on the BioBanking Credit Register for:

- *Phragmites australis* and *Typha orientalis* coastal freshwater wetlands of the Sydney Basin Bioregion (HN 630)
- *Pultenaea parviflora*
- *Marsdenia viridiflora* subsp*. viridiflora* - endangered population
- Cumberland Plain Land Snail
- Regent Honeyeater.

Roads and Maritime have been assessing the likely offset requirements for projects associated with the WSIP (Eco Logical Australia, 2015) and properties that may have potential to provide species credits for *Pultenaea parviflora,* Cumberland Plain Land Snail and Regent Honeyeater have been identified. A search of the BioBanking Public Register indicates that land may be available via an expression of interest to suitable species credits for the *Marsdenia viridiflora* subsp*. viridiflora* - endangered population. However, the presence of the *Marsdenia viridiflora* subsp*. viridiflora* - endangered population is assumed by the landowner and the presence of this population has not been verified by a threatened species survey.

The FBA has been endorsed by the Commonwealth so this BOS as required under the FBA so will be sufficient to compensate for residual significant impact the EPBC Act listed Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest ecological community. The impacts to the EPBC Act listed Swift Parrot, Regent Honeyeater, Grey-headed Flying-fox and *Pultenaea parviflora* are not considered likely to be significant. However, the offsets required by the FBA will also account for residual impacts to these species.

If Roads and Maritime are unable to locate a like-for-like offset after taking reasonable steps, then they may apply the variation rules to locate an appropriate offset for non-EPBC Act listed matters. The variation rules allow vegetation to be offset with a broader suite of similar vegetation types in the locality that have undergone a similar or greater amount of past clearing. They also allow species to be offset with similar species in the locality that use the same habitat and are under a similar or greater level of threat. In the case of *Phragmites australis* and *Typha orientalis* coastal freshwater wetlands of the Sydney Basin Bioregion (HN 630), variation rules may need to be applied due to the current shortfall of credits available for this PCT on the BioBanking Public Register and no current sites with credits for this community on the EOI register. However, before variation rules can be used, Roads and Maritime will:

- Continue to check the BioBanking public register and
- Liaise with an OEH office and relevant local councils to obtain a list of potential sites that meet the requirements for offsetting

If appropriate offset sites cannot be found, Roads and Maritime can then provide funds for supplementary measures.

The final offset requirement for the Project will be determined during development of the offset package. During the detailed design phase the project footprint may change from that assessed here which would result in a different offset requirement for the Project than what is presented in this BOS.

6. References

DEPARTMENT OF SUSTAINABILITY ENVIRONMENT WATER POPULATION AND COMMUNITIES 2012. Environment Protection and Biodiversity Conservation Act 1999 Environmental Offsets Policy. Canberra: Australian Government.

ECO LOGICAL AUSTRALIA 2015. WSIP – Biodiversity Offset Requirements Stage 2/3 Report, Prepared for Roads and Maritime Services.

OFFICE OF ENVIRONMENT AND HERITAGE 2014a. Framework for Biodiversity Assessment: NSW Biodiversity Offsets Policy for Major Projects. Sydney: Office of Environment and Heritage.

OFFICE OF ENVIRONMENT AND HERITAGE 2014b. NSW Biodiversity Offsets Policy for Major Projects. Sydney: Office of Environment and Heritage.

Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest

An action is likely to have a significant impact on a Critically Endangered or Endangered ecological community if there is a real chance or possibility that it will:

1. **reduce the extent of an ecological community**

Based on the estimated construction footprint, the project would result in the direct clearing of about 16.37 hectares of the critically endangered CPSWSGTF ecological community.

This clearing includes:

- 10.69 hectares of core Category A vegetation
- 1.47 hectares of Category C vegetation
- 4.21 hectares of Category C Derived Native Grassland

2. **fragment or increase fragmentation of an ecological community, for example by clearing vegetation for roads or transmission lines**

Due to the linear nature of the action, it will result in fragmentation of a relatively large patch of the TEC on private property off Willowdene Avenue. The action will sever the current connectivity in this area by the introduction of a hard barrier in the form of an eight lane motorway.
Habitat connectivity will be altered after construction of the action. There may be declines in population density and/or species richness within the remaining vegetation patches as a result of the action. There may also be an alteration to community composition, altered species interactions, and altered or ecosystem functioning in the locality due to the action. Habitat fragmentation is considered an important impact of the action with regard to its context and intensity.

3. **adversely affect habitat critical to the survival of an ecological community**

Existing habitat, where this community occurs, will be cleared for construction and operation of the action. This will result in the direct removal of about 16.37 hectares of habitat.

The patches to be impacted by the action are relatively large (>5 hectares) and although modified by human activity, are good quality (as determined by floristic plots). The patches are therefore some of the largest and highest quality patches of the TEC in the locality.

Due to the conservation significance of the TEC, all remaining patches and associated habitat within NSW are likely to be important for its survival. The patches of this TEC to be impacted are high quality which makes the habitat more important to the survival of this TEC in the locality its wider occurrence.

4. **modify or destroy abiotic (non-living) factors (such as water, nutrients, or soil) necessary for an ecological community's survival, including reduction of groundwater levels, or substantial alteration of surface water drainage patterns**

Where the TEC will be removed by the action, all abiotic factors (i.e. water, nutrients and soil) will be permanently modified and/or destroyed through vegetation removal and construction of infrastructure.

This TEC is not a GDE and no impact to groundwater levels are expected (see Section 3.4). Chapter 7 of the EIS outlines the hydrology and flooding assessment undertaken for the project.

Overall, potential impacts on surface water quality during construction are considered minor and manageable with the application of standard mitigation measures (see Section 9).

5. cause a substantial change in the species composition of an occurrence of an ecological community, including causing a decline or loss of functionally important species, for example through regular burning or flora or fauna harvesting

The composition of the TEC is likely to be modified as a result of the action through weed invasion and removal of vegetation. The patches of TEC are in good condition and a reduction in ecological function can be expected from the action in the form of:

- altered community structure
- altered species composition
- disruption of ecological processes (e.g. altered drainage)
- invasion and establishment of exotic species
- degradation of habitat
- fragmentation of habitat.

The extent to which change in species composition of the TEC will occur cannot be predicted. However, ecological function will be altered, particularly where the action will sever connectivity of patches. Functionally important species such as pollinators may be prevented from accessing newly created fragments of the TEC. Fauna connectivity will be effectively broken by the hard barrier of the road. Weed invasion will encroach into the newly created fragments from the road edge and weed species, particularly grasses, will replace functionally important native groundcover species. This will result in altered community structure and species composition in what are currently high quality patches of the TEC and a substantial change to species composition can be expected.

6. cause a substantial reduction in the quality or integrity of an occurrence of an ecological community, including, but not limited to:

a) assisting invasive species, that are harmful to the listed ecological community, to become established

b) causing regular mobilisation of fertilisers, herbicides or other chemicals or pollutants into the ecological community which kill or inhibit the growth of species in the ecological community

Weed introduction and spread and the infection of native plants by *Phytophthora cinnamomi* have been identified as being spread by construction machinery. *Phytophthora* infects the roots of plants and has the potential to cause dieback. Machinery associated with vegetation clearance and subsequent construction for the project has the potential to introduce and transmit weed propagules and *Phytophthora* to remaining native vegetation remnants. This is a potential indirect impact through the spread and transmission of weeds and pathogens into retained habitat near the road.

This can be mitigated through the development and implementation of suitable control measures for vehicle and plant hygiene but an impact, particularly from weeds, is likely. It is the intention to use current best practice hygiene protocols as detailed in RTA (2011) on this project as part of the CEMP to prevent the introduction or spread of weeds and pathogens. The project mitigation strategy and environmental management procedures would include guidance for preventing the introduction and/or spread of weeds and disease causing agents such as bacteria and fungi.

There may be regular mobilisation of fertilisers, herbicides or other chemicals during routine roadside vegetation maintenance. However, Roads and Maritime will implement standard management measures to ensure off site damage form herbicide application is minimised. As

such, a substantial reduction in the quality or integrity of the TEC is not considered likely from herbicide spraying at the roadside edge.

7. interfere with the recovery of an ecological community.

A national recovery plan for the TEC has not been prepared. However, the OEH *Cumberland Plain Recovery Plan* (Department of Environment Climate Change and Water, 2010) has been prepared with the overall objective provide for the long-term survival of the threatened biodiversity of the Cumberland Plain. As this TEC is restricted to NSW, this recovery plan should be considered.

The Cumberland subregion Biodiversity Investment Opportunities Map (BIO Map) (Office of Environment and Heritage, 2015a) aims to achieve better biodiversity outcomes in western Sydney by directing biodiversity investment funding to the strategic locations of greatest benefit. The areas identified for investment, termed priority investment areas, include core areas and biodiversity corridors of state and regional significance. The action will impact on Regional Corridor 17 as identified in the BIO Map and the area of Priority Conservation Land as mapped on the Defence Establishment Orchard Hills and identified in the *Cumberland Plain Recovery Plan*.

As the action will impact on an area of mapped Priority Conservation Land and Regional Corridor 17 as mapped by the BIO Map, the action can be considered likely to interfere with the recovery of the TEC.

Conclusion

After consideration of the factors above, an overall conclusion has been made that the action is likely to result in a significant impact to the critically endangered Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest ecological community as it will:

- reduce the extent of the TEC by about 16.37 hectares
- adversely affect habitat critical to the survival of the TEC
- modify or destroy abiotic (non-living) factors (such as water, nutrients, or soil) necessary for the TECs survival
- cause a substantial change in the species composition of an occurrence of the TEC, including causing a decline or loss of functionally important species
- cause a substantial reduction in the quality or integrity of an occurrence of an ecological community, particularly form potential weed invasion
- interfere with the recovery of an ecological community.

Pultenaea parviflora

Pultenaea parviflora is listed as vulnerable under the EPBC Act. This species was recorded in two locations within the study area; both on the western side of the Northern Road within the existing road reserve (see Section 3.1).

Pultenaea parviflora is known to have a juvenile period of 3 - 4 years (Benson and McDougall, 1996). Flowering occurs from August to November, with peak flowering occurring in September. The flowers of *Pultenaea parviflora* are typical zygomorphic (bilaterally symmetrical) pea flowers with hidden floral rewards and reproductive structures. These flowers offer nectar as a reward and require special manipulation for insect access and bees (European Honeybee, and native bees form the Halictidae and Colletidae) are predicted to be the principle pollinators based on their ability to operate the wing and keel petals to access the reproductive structures as has been shown in other species of *Pultenaea* (see Ogilvie et al., 2009). Fruiting occurs from October to November, maturing in December (De Kok and West, 2002). Current estimates are that reproductive maturity is not reached for 3–4 years (Benson and McDougall, 1996), and peak reproduction until 5–6 years (NSW National Parks and Wildlife Service, 2004). The fruit/seed is contained within a swollen pod, is 5 mm long, hard coated and has an aril (Benson & McDougall 1996). Seed dispersal has not been studied but is likely to be short distance via ants considering the presence of an aril (as in other species of *Pultenaea*) (see Westoby et al., 1990). *Pultenaea parviflora* is an obligate seeder which is killed by fire and has a hard coated seed (Benson & McDougall 1996). As such, seedling recruitment probably occurs mainly after fire from the soil-stored seedbank but possibly also from other soil disturbances (Benson & McDougall 1996). *Pultenaea parviflora* is not known to spread vegetatively (Benson & McDougall 1996) and as such is considered dependent on insects for pollination and seed dispersal.

In insect-pollinated plants, pollen movement, rather than movement of seeds, is generally the main component of gene flow (Ennos, 1994, Fenster, 1991). The foraging range of honeybees has been found to range from 45 m to 5,983 m (Hagler et al., 2011). Native solitary bees travel much smaller distances of up to a few hundred metres (Goulson, 2003). The *Pultenaea parviflora* plants subject to this assessment are located about three kilometres to the west of the known occurrences on the Defence Establishment Orchard Hills and may exchange pollen via dispersal from honeybees. As such, the *Pultenaea parviflora* plants within the study area are considered to be a small sub-population belonging to the larger population on the Defence Establishment Orchard Hills.

The definition of an important population as provided in the *Matters of National Environmental Significance Significant Impact Guidelines 1.1* (Department of the Environment, 2013) is a "… a population that is necessary for a species' long-term survival and recovery. This may include populations identified as such in recovery plans, and/or that are:

- key source populations either for breeding or dispersal
- populations that are necessary for maintaining genetic diversity, and/or
- populations that are near the limit of the species range".

The sub-population of *Pultenaea parviflora* within the study area is unlikely to be a key source population for breeding or dispersal as it is very small (three plants). The sub-population of *Pultenaea parviflora* within the study area is however at the south western edge of the species' range in the Sydney Basin Bioregion and may possess genetic diversity unlike the southern populations at Badgerys Creek and Kemps Creek or the more northern populations at Shanes Park, Cranebrook, Berkshire Park, Londonderry, Vineyard, Oakville and Pitt Town. As such, the population of *Pultenaea parviflora* within the study area can be considered as important and the significant impact criteria for vulnerable species has been addressed below taking into account that the local population of *Pultenaea parviflora* is important.

The proposed action would result in the direct clearing of three *Pultenaea parviflora* plants for the construction of batters. This will result in the removal of the entire sub-population that is known to be in the study area. The area of surrounding habitat likely to possess a soil seedbank for this species is about 0.6 hectares. All three *Pultenaea parviflora* plants and the soil seedbank in the immediate area of the plants would be removed by the action. The removal of these three plants would contract the known range of this species to about three kilometres to the east. However, as the private properties to the west of the study area have not been surveyed the western extent of this population is not known.

An action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that it will:

1. lead to a long-term decrease in the size of an important population of a species

The risk of extinction of the local *Pultenaea parviflora* population will increase if anything reduces its population size or reproductive success. The lifecycle of the local *Pultenaea parviflora* sub-population within the study area is dependent on the habitat that is present within the study area. Genetic exchange with the larger core population on the Defence Establishment Orchard Hills will no longer occur as the plants in the study area will be removed.

As all three known plants in this small outlier sub-population will be removed by the action, the local sub-population may become extinct. However, the larger core population, to which the impacted sub-population belongs, will still exist about 3 kilometres to the east within the Defence Establishment Orchard Hills. The larger core population contains at least 1,700 plants (based on data from the OEH Atlas). There is also potential for additional *Pultenaea parviflora* plants from the sub-population to be present on private property further to the west of the study area (e.g. Lot 23 and Lot 85 Longview Road Mulgoa, 99 Vineyard Rd Mulgoa). Overall, the removal of three plants form this apparent outlying sub-population will not lead to a long-term decrease in the size of the important population

1. reduce the area of occupancy of an important population

The three *Pultenaea parviflora* plants which would be removed are at the south western edge of the species range. The removal of these three plants and associated habitat would contract the current known range of this species to about three kilometres to the east as the closest known plants from the same population are located in the Defence Establishment Orchard Hills. However, additional *Pultenaea parviflora* plants may occur further to the west of the study area where vegetation is present (e.g. Lot 23 and Lot 85 Longview Road Mulgoa, 99 Vineyard Rd Mulgoa).

2. fragment an existing important population into two or more populations

Importantly, the action will not result in the breaking apart of large blocks of high quality habitat for *Pultenaea parviflora* and will not fragment a continuous population of *Pultenaea parviflora*. Fragmentation of the *Pultenaea parviflora* population has already occurred via construction of the existing Northern Road.

While the action will result in fragmentation of Cumberland Plain Woodland in the south of the study area, *Pultenaea parviflora* was not recorded in these habitats during the survey and is considered unlikely to occur in the vegetation to be fragmented.

3. adversely affect habitat critical to the survival of a species

Habitat critical to the survival of a species refers to areas that are necessary for activities such as:

- Foraging, breeding, roosting, or dispersal

- For the long-term maintenance of the species including the maintenance of other species essential to the survival of the species, such as pollinators
- To maintain genetic diversity and long-term evolutionary development
- For the reintroduction of populations or recovery of the species.

Critical habitats for the *Pultenaea parviflora* include Scheyville National Park, Windsor Downs Nature Reserve, Castlereagh Nature Reserve, and the ADI Regional Park. These are all public land reserved for conservation. Populations on private property are also likely to be important for the survival of this species but no specific areas of critical habitat have been identified.

The area of habitat to be impacted by the action is directly adjacent to the Northern Road in the road reserve. The sub-population is small (three plants) and the habitat is unsuitable for any management actions to preserve *Pultenaea parviflora* to be employed. In the context of existing larger populations and areas of habitat that are clearly more critical to the survival of this species, the habitat to be affected is not considered critical.

4. disrupt the breeding cycle of an important population

The action will disrupt the breeding cycle of the *Pultenaea parviflora* sub-population as all three plants and soil seedbank from the sub-population within the study area will be removed for the creation of batters. The breeding cycle of the overall core population will continue.

5. modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline

The action will result in a very small decrease in the availability of habitat for *Pultenaea parviflora* of about 0.98 hectares. This habitat represents about 0.7 per cent of the 126 hectares of suitable habitat for the core population on the Defence Establishment Orchard Hills. Removal of the 0.98 hectares of habitat within the study area is unlikely to be so detrimental as to cause this species to decline.

6. result in invasive species that are harmful to a vulnerable species becoming established in the Vulnerable species' habitat

The potential for weed invasion was considered possible with a project of this nature and appropriate controls are required during construction and operation of the road to reduce this threat. The management of invasive species would be managed under the construction environmental management plan and during operation of the highway using best practice methods as outlined in RTA (2011).

7. introduce disease that may cause the species to decline, or

There are no diseases that are known to affect *Pultenaea parviflora*. Furthermore, the project mitigation strategy and environmental management procedures would include guidance for preventing the introduction and/or spread of disease causing agents such as bacteria and fungi.

8. interfere substantially with the recovery of the species.

There is no recovery plan for *Pultenaea parviflora*. However, the OEH have identified six priority actions to help recover this species as follows:

- Fire intervals of 10–15 years (where there is no need for asset protection zones).
- Protect areas of known and potential habitat from clearing and further fragmentation.
- A community awareness program.
- Research into pollinating species for Pultenaea parviflora.

- Identify and survey potential habitat for the species.
- Monitor known populations.

The action will remove an area of known habitat and is inconsistent with the priority actions identified for this species. However, the recovery of *Pultenaea parviflora* as a species is not dependent on the three individuals to be removed by the action.

Conclusion

Three *Pultenaea parviflora* plants from an isolated sub-population (part of the larger core population on the Defence Establishment Orchard Hills) situated in disturbed roadside vegetation will be removed by the action. This is a very small sub-population and only a small reduction in extent of suitable habitat will occur from the action. The local occurrence of this species will persist after the action is built as the larger population on the Defence Establishment Orchard Hills will not be disturbed.

Given the conservation status of this species (vulnerable) and the low magnitude of the impact, an overall conclusion has been made that the action is unlikely to result in a significant impact to Pultenaea parviflora. A significant impact to *Pultenaea parviflora* is not predicted for the following reasons:

- The larger core population, to which the impacted sub-population belongs, will still exist about 3 kilometres to the east within the Defence Establishment Orchard Hills. There is also potential for additional Pultenaea parviflora plants from the sub-population to be present on private property further to the west of the study area (e.g. Lot 23 and Lot 85 Longview Road Mulgoa, 99 Vineyard Rd Mulgoa). Overall, the removal of three plants form this apparent outlying sub-population will not lead to a long-term decrease in the size of the important population.
- The project will not result in the breaking apart of large blocks of high quality habitat for Pultenaea parviflora and will not fragment a continuous population of Pultenaea parviflora.
- The area of habitat to be impacted by the project is directly adjacent to the Northern Road in the road reserve. In the context of existing larger populations and areas of habitat that are clearly more critical to the survival of this species, the habitat to be affected is not considered critical.
- While the project will disrupt the breeding cycle of the Pultenaea parviflora population, the breeding cycle of the overall core population will continue.
- The project will result in a very small decrease in the availability of habitat for Pultenaea parviflora of about 0.98 hectares. This habitat represents about 0.7 per cent of the 126 hectares of suitable habitat for the core population on the Defence Establishment Orchard Hills. Removal of 0.98 hectares of habitat is unlikely to be so detrimental as to cause this species to decline.

Given the context and intensity of the potential impact and the impact magnitude, a significant impact to *Pultenaea parviflora* is considered unlikely.

Grey-headed Flying-fox (*Pteropus poliocephalus*)

The Grey-headed Flying-fox (*Pteropus poliocephalus*) was recorded in one location on private property off Willowdene Avenue during spotlight surveys. This species is considered likely to occur throughout the study area based on the presence of suitable foraging habitat. The Grey-headed Flying-fox exists as a single interconnected population in Australia. As such, it is considered an important population.

An action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that it will:

1. lead to a long-term decrease in the size of an important population of a species

There are no roost camps in the study area and the action will not impact on any known permanent roosting, breeding / maternity site. Therefore it is likely that the impacts of construction and operation of the action would be confined to loss of feeding habitat caused by direct clearing or damage to native vegetation during the construction phase. There is also a low risk of vehicle strike during operation.

The project would directly remove about 26.25 hectares of potential foraging habitat. Within the study area, this potential loss of habitat represents about 25.2 percent of the available habitat for these species. Within the Cumberland subregion, this potential habitat removal represents less than 0.1 percent of the currently available habitat for this species. Given the relative widespread nature of similar native vegetation and planted vegetation in the locality and abundance of higher quality foraging habitat within the feeding range of regional populations, the project is not expected to lead to a long-term decrease in the size of an important population.

2. reduce the area of occupancy of an important population

The area of occupancy of the Grey-headed Flying-fox is not known but the species exists as one interconnected population along the eastern Australian coastal belt from Rockhampton in central Queensland to Melbourne in Victoria. The area occupied by this species will remain the same after the action. No impact to area of occupancy is expected.

3. fragment an existing important population into two or more populations

Highly mobile species such as bats are expected to be less impacted by fragmentation and the Grey-headed Flying-fox is particularly well adapted to accessing widely spaced habitat resources given its mobility and preference for seasonal fruits and blossom in differing parts of the landscape. The project would not fragment an important population of the Grey-headed Flying-fox. Individuals will still be able to disperse between roosts along the east Australian coast.

4. adversely affect habitat critical to the survival of a species

This species typically exhibits very large home range and Grey-headed Flying-fox is known to travel distances of at least 50 kilometres from roost sites to access seasonal foraging resources. There are no known roost camps within the study area and the site does not provide critical roosting habitat. However there are a number of known roost camps with a 50km radius of the project, including Parramatta, Emu Plains, Cabramatta, Clyde and Brownlow Hill. The draft recovery plan for the Grey-headed Flying-fox identifies critical foraging habitat for this species as:

- Productive during winter and spring, when food bottlenecks have been identified
- Known to support populations of >30,000 individuals, within an area of 50 kilometre radius of a camp site

- Productive during the final weeks of gestation, and during the weeks of birth, lactation and conception (Sept-May)
- Productive during the final stages of fruit development and ripening in commercial crops affected by Grey-headed Flying-foxes
- Known to be continuously occupied as a camp site.

Native vegetation within the study area would constitute critical foraging habitat. The affected area of critical foraging habitat would represent a small percentage of the total extent of important foraging vegetation types present within a 50 kilometre radius of the camp sites described. Given the relative widespread nature of similar vegetation in the locality and abundance of higher quality foraging habitat within the feeding range of regional populations, the project is not expected to adversely affect foraging habitat critical to the survival of this species in this region.

5. disrupt the breeding cycle of an important population

As stated above there would be a minor impact on foraging habitat identified as important during the breeding cycle of the species. The upgrade would not directly impact on a known roost camp / breeding or maternity site.

6. modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline

No evidence of a roost camp has been identified from the study area. Further, there would be a relatively minor impact on critical foraging habitat. This impact is not expected to lead to a decline in the species in this region.

7. result in invasive species that are harmful to a vulnerable species becoming established in the Vulnerable species' habitat

The action is unlikely to result in an invasive species harmful to the Grey-headed Flying-fox becoming established in the habitat. The potential for weed invasion was considered possible with a project of this nature and appropriate controls are required during construction and operation of the road to reduce this threat. The management of invasive species would be managed under the construction environmental management plan and during operation of the highway using best practice methods.

8. introduce disease that may cause the species to decline, or

There are no known disease issues affecting this species in relation to the action. The action would be unlikely to increase the potential for significant disease vectors to affect local populations.

9. interfere substantially with the recovery of the species.

The *Draft National Recovery Plan for the Grey-headed Flying-fox* (*Pteropus poliocephalus*) (Department of Environment Climate Change and Water, 2009) outlines the following actions:

- Identify and protect foraging habitat critical to the survival of Grey-headed Flying-foxes across their range
- Enhance winter and spring foraging habitat for Grey-headed Flying-foxes
- Identify, protect and enhance roosting habitat critical to the survival of Grey-headed Flying-foxes
- Significantly reduce levels of deliberate Grey-headed Flying-fox destruction associated with commercial horticulture
- Provide information and advice to managers, community groups and members of the public that are involved with controversial flying-fox camps

- Produce and circulate educational resources to improve public attitudes toward Grey-headed Flying-foxes, promote the recovery program to the wider community and encourage participation in recovery actions
- Monitor population trends for the Grey-headed Flying-fox
- Assess the impacts on Grey-headed Flying-foxes of electrocution on powerlines and entanglement in netting and barbed wire, and implement strategies to reduce these impacts
- Oversee a program of research to improve knowledge of the demographics and population structure of the Grey-headed Flying-fox
- Maintain a National Recovery Team to oversee the implementation of the Grey-headed Flying-fox National Recovery Plan

The recovery actions listed above are largely not applicable to the action and the action is not expected to interfere substantially with the recovery of the species.

Conclusion

The Grey-headed Flying-fox will suffer a small reduction in extent of suitable foraging habitat from the action. No breeding camps or other important habitat will be impacted. The action is unlikely to reduce the population size of the Grey-headed Flying-fox or decrease the reproductive success of this species. The action will not interfere with the recovery of the Grey-headed Flying-fox and will not contribute to the key threats to this species. After consideration of the factors above, an overall conclusion has been made that the action is unlikely to result in a significant impact to the Grey-headed Flying-fox.

Regent Honeyeater (*Anthochaera phrygia*)

The Regent Honeyeater (*Anthochaera phrygia*) is considered likely to occur based on the presence of suitable winter foraging habitat.

An action is likely to have a significant impact on a Critically Endangered or Endangered species if there is a real chance or possibility that it will:

1. lead to a long-term decrease in the size of a population

In 2011, the Regent Honeyeater's population was estimated with medium reliability at 350–400 mature birds. The majority of these birds exist in the Bundarra-Barraba area and the Capertee Valley in NSW, and north-eastern Victoria. The impacts to some potential foraging habitat in the study area are considered unlikely to lead to a long-term decrease in the size of the Regent Honeyeater population as the work will not impact on the critical remaining strongholds of the species.

2. reduce the area of occupancy of the species

The Regent Honeyeater is endemic to south-east Australia, where it is widespread but with an extremely patchy distribution. The Regent Honeyeater's area of occupancy is estimated at 300 km^2 but in NSW, the Regent Honeyeater has an area of occupancy of less than 200 km^2. This species is noted as being largely absent around Sydney.

The action will not reduce the current area of occupancy for the Regent Honeyeater.

3. fragment an existing population into two or more populations

Importantly, the action will not result in fragmentation of habitat for the Regent Honeyeater. This species is highly mobile and capable of long distance flight. However, movements between breeding populations are not frequent and most birds appear to remain in the breeding areas of Bundarra-Barraba area and the Capertee Valley in NSW, and north-eastern Victoria.

The action is considered unlikely to fragment the existing population as movement corridors between the three main populations will still remain after the road has been built.

4. adversely affect habitat critical to the survival of a species

The *National Recovery Plan for the Regent Honeyeater (Anthochaera phrygia)* (Commonwealth of Australia, 2016) identifies habitat critical for the survival of the Regent Honeyeater which includes:

- Any breeding or foraging areas where the species is likely to occur.
- Any newly discovered breeding or foraging locations.

Key areas include the Bundarra-Barraba, Pilliga Woodlands, Mudgee-Wollar and the Capertee Valley and Hunter Valley areas in New South Wales, and the Chiltern and Lurg-Benalla regions of north-east Victoria (Commonwealth of Australia, 2016).

The study area is not situated in a key breeding area for the Regent Honeyeater. The habitat within the study area is considered to be secondary habitat for the Regent Honeyeater as this species is not regularly recorded from the area and it is not known as critical habitat.

5. disrupt the breeding cycle of a population

The key breeding areas for the Regent Honeyeater are the Chiltern section of Chiltern-Mt Pilot National Park (NP), north-east Victoria; Capertee Valley, central east NSW; and the Bundarra-Barraba region, northern NSW. Other breeding areas include the Wangaratta-Mansfield region, Victoria; Warrumbungle NP, Pilliga forests and Mudgee-Wollar region, central north NSW; Hunter Valley and Clarence Valley, east NSW; and south-east Queensland.

The action will not influence breeding habitat for this species. Additionally, important winter foraging grounds will not be impacted.

6. modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline

Potential foraging habitat for this species will be reduced by about 26.25 hectares. Within the study area, this potential loss of habitat represents about 31 percent of the available habitat for these species. Within the Cumberland subregion, this potential habitat removal represents less than 0.1 percent of the currently available habitat for this species. This species is an occasional visitor to the region and may utilise trees in the study area for foraging intermittently when no other suitable resources are available. The action is unlikely to modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline.

7. result in invasive species that are harmful to a Critically Endangered or Endangered species becoming established in the Endangered or Critically Endangered species' habitat

The main invasive species harmful to habitat for the Regent Honeyeater are weeds. Noisy Miners and Bell Miners are abundant in the habitat which may make the habitat less suitable for the Regent Honeyeater due to competitive exclusion. The action may result in weed invasion and the removal of habitat may concentrate local miner populations increasing competition. The management of invasive species would be managed under the construction environmental management plan and during operation.

8. introduce disease that may cause the species to decline, or

Infection of native plants by *Phytophthora cinnamomi* has been identified as being spread by construction machinery. This water-borne mould infects the roots of plants and has the potential to cause dieback. Machinery associated with vegetation clearance and subsequent construction has the potential to transmit the fungus to remaining native vegetation remnants of the species. This is a potential indirect impact to the species through the transmission of pathogens into retained habitat near the road. This can be mitigated through the development and implementation of suitable control measures for vehicle and plant hygiene and is unlikely to have a significant impact. It is the intention to use current best practice hygiene protocols as part of the CEMP to prevent the introduction or spread of pathogens.

The project mitigation strategy and environmental management procedures would include guidance for preventing the introduction and/or spread of disease causing agents such as bacteria and fungi.

9. interfere with the recovery of the species.

The *National Recovery Plan for the Regent Honeyeater (Anthochaera phrygia)* (Commonwealth of Australia, 2016) identifies habitat critical for the survival of the Regent Honeyeater, recovery strategies and criteria for success and failure. The identified recovery actions focus on a landscape approach to habitat protection and regeneration, coupled with ongoing releases of captive birds to bolster the wild population until such time as the wild population became self-sustaining.

The *National Recovery Plan for the Regent Honeyeater (Anthochaera phrygia)* (Commonwealth of Australia, 2016) contains four overarching strategies for recovery of the Regent Honeyeater as follows:

- Strategy 1: Improve the extent and quality of regent honeyeater habitat
- Strategy 2: Bolster the wild population with captive-bred birds until the wild population becomes self-sustaining.
- Strategy 3: Increase understanding of the size, structure and population trends of the wild population of regent honeyeaters
- Strategy 4: Maintain and increase community awareness, understanding and involvement in the recovery program.

Each strategy has a series of actions that include research actions and on-ground actions. Many of the identified actions are not applicable to the project. However, there are some actions that apply to developments and these are discussed below.

Strategy 1: Improve the extent and quality of regent honeyeater habitat

Action 1c is to protect intact (high quality) areas of Regent Honeyeater breeding and foraging habitat (as described in '3.4.6 Habitat critical to survival'). The study area is not recognised as a high quality area of Regent Honeyeater breeding or foraging habitat so the project will not interfere with this action. The remaining research and on ground actions for Strategy 1 are not applicable to the project.

Strategy 2: Bolster the wild population with captive-bred birds until the wild population becomes self-sustaining

The research and on ground actions associated with this strategy involve developing population models and maintaining a captive population of Regent Honeyeaters. The actions associated with this strategy are not applicable to the project.

Strategy 3: Increase understanding of the size, structure and population trends of the wild population of regent honeyeaters

The research and on ground actions associated with this strategy involve developing a monitoring program and analysing data to improve knowledge of the Regent Honeyeater population. The actions are not applicable to the project.

Strategy 4: Maintain and increase community awareness, understanding and involvement in the recovery program

The research and on ground actions associated with this strategy are based on raising community awareness and support of Regent Honeyeater conservation, supporting agencies to maintain Regent Honeyeater operations groups, and community training workshops. The actions are not applicable to the project.

Overall, the project will not interfere with the strategies identified for recovery of the Regent Honeyeater.

Conclusion

The Regent Honeyeater will suffer a small reduction in extent of foraging habitat from the action. However, impacts are predicted to be minimal as this species is unlikely to use the study area consistently. The action is unlikely to reduce the population size of the Regent Honeyeater or decrease the reproductive success of this species. The action will not interfere with key breeding sites or foraging areas and will not interfere with the recovery of the Regent Honeyeater. After

consideration of the factors above, an overall conclusion has been made that the action is unlikely to result in a significant impact to the Regent Honeyeater.

Swift Parrot (*Lathamus discolor*)

The Swift Parrot (*Lathamus discolor*) is considered likely to occur based on the presence of suitable winter foraging habitat.

An action is likely to have a significant impact on a Critically Endangered or Endangered species if there is a real chance or possibility that it will:

1. lead to a long-term decrease in the size of a population

The study area contains some potential foraging habitat for the Swift Parrot. While the habitat in the study area is not optimal, the loss of potential feed trees would directly affect the species opportunity to feed in the area. However, the study area is not considered a critical area for the Swift Parrot. The Swift Parrot may utilise trees in the study area for foraging intermittently when no other suitable inland (i.e. box ironbark woodlands) or coastal resources (i.e. Spotted Gum and Swamp Mahogany forests) are available. The action would remove Potential foraging habitat for this species will be reduced by about 26.25 hectares. Within the study area, this potential loss of habitat represents about 31 percent of the available habitat for these species. Within the Cumberland subregion, this potential habitat removal represents less than 0.1 percent of the currently available habitat for this species.

The Swift Parrot does not breed in the study area and the extent of habitat remaining in the study area would provide sufficient resources to sustain future visitation, such that the action is unlikely to lead to a long-term decrease in the size of the Australian population.

2. reduce the area of occupancy of the species

As a specialist nectarivore dependent on flowering eucalypts, Swift Parrots are vulnerable to the loss of quantity and quality of key forage tree species. As a large-scale migrant, it has the ability to cover vast areas of its winter range, seeking suitable flowering eucalypt habitat. The species is an occasional visitor to the region and may utilise trees in the study area for foraging intermittently when no other suitable resources are available.

The project would contribute to the loss of potential foraging habitat which would reduce the area of habitat available. However, the action will not reduce the area of occupancy of this species which is estimated at 4,000 km².

3. fragment an existing population into two or more populations

Importantly, the action will not result in fragmentation of habitat for the Swift Parrot. This species is highly mobile and as a regular behaviour flies long distances over open areas to move between suitable foraging habitats. The action will not affect the movement of the Swift Parrot between habitat patches or fragment the population.

4. adversely affect habitat critical to the survival of a species

Key habitats for this species on the coast and coastal plains of New South Wales include large stands of Spotted Gum (*Corymbia maculata*), Swamp Mahogany (*E. robusta*), Red Bloodwood (*Eucalyptus gummifera*) and Forest Red Gum (*E. tereticornis*) forests. The study area supports stands of Forest Red Gum, hence why suitable habitat for this species is considered to be present. The habitat within the study area is considered to be secondary habitat for the Swift Parrot as this species is not regularly recorded from the area and it is not known as critical habitat.

5. disrupt the breeding cycle of a population

The Swift Parrot is endemic to south-eastern Australia and breeds only in Tasmania, and migrates to mainland Australia in autumn. As such, the action will not impact on breeding habitat for this species. Important winter foraging grounds will not be impacted.

6. modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline

Foraging habitat for this species will be reduced by about 33 hectares. As a large-scale migrant, it has the ability to cover vast areas of its winter range, seeking suitable flowering eucalypt habitat. The species is an occasional visitor to the region and may utilise trees in the study area for foraging intermittently when no other suitable resources are available. The action is unlikely to modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline.

7. result in invasive species that are harmful to a Critically Endangered or Endangered species becoming established in the Endangered or Critically Endangered species' habitat

The main invasive species harmful to the habitat for the swift parrot are weeds. Noisy Miners and Bell Miners are abundant in the habitat which may make the habitat less suitable for the Swift Parrot due to competitive exclusion. The action may result in weed invasion and the removal of habitat may concentrate local miner populations increasing competition. The management of invasive species would be managed under the construction environmental management plan and during operation.

8. introduce disease that may cause the species to decline, or

Infection of native plants by *Phytophthora cinnamomi* has been identified as being spread by construction machinery. This water-borne mould infects the roots of plants and has the potential to cause dieback. Machinery associated with vegetation clearance and subsequent construction has the potential to transmit the fungus to remaining native vegetation remnants of the species. This is a potential indirect impact to the species through the transmission of pathogens into retained habitat near the road. This can be mitigated through the development and implementation of suitable control measures for vehicle and plant hygiene and is unlikely to have a significant impact. It is the intention to use current best practice hygiene protocols as part of the CEMP to prevent the introduction or spread of pathogens.

The project mitigation strategy and environmental management procedures would include guidance for preventing the introduction and/or spread of disease causing agents such as bacteria and fungi.

9. interfere with the recovery of the species.

The *National Recovery Plan for the Swift Parrot* (Saunders and Tzaros, 2011) aims to prevent further population decline of the Swift Parrot and to achieve a demonstrable sustained improvement in the quality and quantity of Swift Parrot habitat to increase carrying capacity. These objectives will be achieved by implementing recovery actions for each of the following specific recovery objectives:

- Objective 1: To identify and prioritise habitats and sites used by the species across its range, on all land tenures.
- Objective 2: To implement management strategies to protect and improve habitats and sites on all land tenures

- Objective 3: To monitor and manage the incidence of collisions, competition and Beak and Feather Disease (BFD).
- Objective 4: To monitor population trends and distribution throughout the range.

These objectives, and the associated recovery actions outlined in the National Recovery Plan for the Swift Parrot (Saunders and Tzaros, 2011) are not applicable to the study area or project. The identified recovery actions mostly relate to identifying the extent and quality of habitat, monitoring, raising community awareness, and coordinating and reviewing the recovery process. There is an action relating to manage and protect Swift Parrot habitat at the landscape scale. However, this action applies to fencing off habitat on private land to encourage regeneration of habitat, revising forestry practices, developing a strategic management plan for Swift Parrot breeding habitat in Tasmania, and providing Swift Parrot conservation information for consideration during the New South Wales Local Government Local Environmental Planning review process. The recovery actions identified in the National Recovery Plan for the Swift Parrot (Saunders and Tzaros, 2011) will not be interfered with by the project.

Conclusion

The Swift Parrot will suffer a small reduction in extent of foraging habitat from the action. The action is unlikely to reduce the population size of the Swift Parrot or decrease the reproductive success of this species. The action will not interfere with the recovery of the Swift Parrot. For the Swift Parrot, impacts are most likely to be significant where a proposal or activity may result in loss of habitat in, or adjacent to priority foraging, nesting and roosting sites (Saunders and Tzaros, 2011). The project will not impact on any priority foraging habitat. As such, after consideration of the factors above, an overall conclusion has been made that the action is unlikely to result in a significant impact to the Swift Parrot.

Large-eared Pied Bat (*Chalinolobus dwyeri*)

The Large-eared Pied Bat (*Chalinolobus dwyeri*) is considered moderately likely to occur within the study area based on the presence of suitable foraging habitat in proximity to sandstone escarpments of the lower Blue Mountains and nearby records from the Mulgoa Nature Reserve.

Recognised important populations that support higher numbers of individuals include those present in the sandstone escarpments of the Sydney Basin. Any Large-eared Pied Bats that would forage in the study area are likely to roost in the sandstone escarpments of the lower Blue Mountains. As such, the population of Large-eared Pied Bat that may utilise the study area is considered to be important. An action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that it will:

1. lead to a long-term decrease in the size of an important population of a species

Potential foraging habitat for this species will be reduced by about 26.25 hectares. Within the study area, this potential loss of habitat represents about 31 percent of the available habitat for these species. Within the Cumberland subregion, this potential habitat removal represents less than 0.1 percent of the currently available habitat for this species

No breeding or roosting habitat will be affected (there are no sandstone caves in the study area). The size of local population is not known, although expected to not to be considerably large considering the highly urbanised and modified habitats in the locality and absence of caves. Potential foraging habitat in the study area is generally widespread. Impacts to these habitats would impact on the potential breeding habitat for prey species (invertebrates), however any potential overall reductions to the abundance of prey species is likely to be minimal, considering the widespread nature of these habitats in the locality.

As no breeding habitat will be impacted, and considering the abundance of suitable foraging habitat in the locality, the action is considered unlikely to lead to a long-term decrease in the size of an important population of this species.

2. reduce the area of occupancy of an important population

Potential foraging habitat for this species will be reduced by about 26.25 hectares. Within the study area, this potential loss of habitat represents about 31 percent of the available habitat for these species. Within the Cumberland subregion, this potential habitat removal represents less than 0.1 percent of the currently available habitat for this species

No breeding habitat will be impacted. As such, the Large-eared Pied Bat can be expected to remain in the locality after completion of the action. The action is therefore considered unlikely to reduce the area of occupancy of an important population of this species. The area of occupancy for this species will remain at about 9,120 km².

3. fragment an existing important population into two or more populations

There is currently a high degree of habitat fragmentation across the study area. As a highly mobile species, the fragmentation caused by the action is considered unlikely to detrimentally impact the Large-eared Pied Bat. The action is not expected to fragment an important population of this species.

4. adversely affect habitat critical to the survival of a species

Habitat critical to the survival of a species refers to areas that are necessary for activities such as:

- Foraging, breeding, roosting, or dispersal
- For the long-term maintenance of the species including the maintenance of other species essential to the survival of the species, such as pollinators
- To maintain genetic diversity and long-term evolutionary development
- For the reintroduction of populations or recovery of the species.

The project would impact to up to 26.25 hectares of foraging habitat. The proposed area of disturbance represents a very small fraction of the potential foraging habitat for the Large-eared Pied-bat. Impacts to areas of roosting habitat are not anticipated. As such, the project is unlikely to impact habitat critical to the survival of the species.

5. disrupt the breeding cycle of an important population

The action would not directly impact on a known roost or maternity site and such as unlikely to disrupt the breeding cycle of this species.

6. modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline

The action would have an impact of up to 26.25 hectares of foraging habitat for the Large-eared Pied Bat. The proposed area of disturbance represents a small proportion of the potential foraging habitat available in the locality for this species. This species is expected to continue using the remaining habitats in the study area and the action is unlikely to modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline.

7. result in invasive species that are harmful to a vulnerable species becoming established in the Vulnerable species' habitat

The potential for weed invasion was considered possible with an action of this nature and appropriate controls are required during construction and operation of the road to reduce this threat. The management of invasive species would be managed under the construction environmental management plan and during operation of the road using best practice methods.

8. introduce disease that may cause the species to decline

There are no known disease issues affecting this species in relation to the action.

Infection of native plants by *Phytophthora cinnamomi* has been identified as being spread by construction machinery. This water-borne mould infects the roots of plants and has the potential to cause dieback. Machinery associated with vegetation clearance and subsequent construction for the project has the potential to transmit the fungus to remaining native vegetation remnants of the species. This is a potential indirect impact to the species through the transmission of pathogens into retained habitat near the road. This can be mitigated through the development and implementation of suitable control measures for vehicle and plant hygiene and is unlikely to have a significant impact. It is the intention to use current best practice hygiene protocols as part of the CEMP to prevent the introduction or spread of pathogens.

9. interfere substantially with the recovery of the species

The *National Recovery Plan for the Large-eared Pied Bat* (Department of Environment and Resource Management, 2011) identifies the following objectives for recovery of this species:

- Identify priority roost and maternity sites for protection.
- Implement conservation and management strategies for priority sites.

- Educate the community and industry to understand and participate in the conservation of the large-eared pied bat.
- Research the large-eared pied bat to augment biological and ecological data to enable conservation management.
- Determine the meta-population dynamics throughout the distribution of the large-eared pied bat.

The action will not interfere with any of the objectives identified in the *National Recovery Plan for the Large-eared Pied Bat.*

Conclusion

The Large-eared Pied Bat will suffer a small reduction in extent of foraging habitat. No breeding habitat will be impacted. The action is unlikely to reduce the population size of this species or decrease its reproductive success. The action is unlikely to result in a significant impact to the Large-eared Pied Bat.

Migratory species

An action is likely to have a significant impact on a migratory species if there is a real chance or possibility that it will:

1. substantially modify (including by fragmenting, altering fire regimes, altering nutrient cycles or altering hydrological cycles), destroy or isolate an area of important habitat for a Migratory species

2. result in an invasive species that is harmful to the Migratory species becoming established in an area of important habitat for the Migratory species, or

3. seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a Migratory species.

An area of 'important habitat' for a migratory species is defined as:

- habitat used by a migratory species occasionally or periodically within a region that supports an ecologically significant proportion of the population of the species, and/or
- habitat that is of critical importance to the species at particular life-cycle stages, and/or
- habitat used by a migratory species which is at the limit of the species range, and/or
- habitat within an area where the species is declining.

While migratory species of bird do use the study area and locality, the study area would not be classed as an 'important habitat' as defined under the EPBC Act Policy Statement 1.1 Significant Impact Guidelines (DoE 2013), in that the study area does not contain:

- a region that supports an ecologically significant proportion of a population of migratory species
- habitat utilised by a migratory species which is at the limit of the species range
- habitat within an area where the species is declining.

As such, it is unlikely that the action would significantly affect migratory species.

There is no evidence to suggest that an ecologically significant proportion of the population of any identified migratory species exists within the study area (see Section 3.1 of the referral).

The potential for weed invasion has been considered highly likely with an action of this nature and appropriate controls will be provided during the construction and operation of the road to reduce this threat in accordance with standards Roads and Maritime procedures. The management of invasive species would be managed under the construction environmental management plan