Vegetation and Significant Biodiversity

Northern Interchange 4

Legend

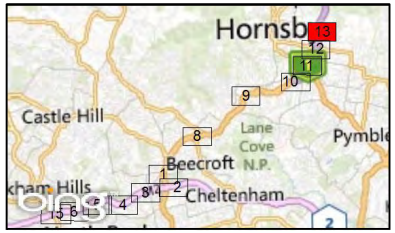
- Study Area
- Construction Footprint
- Culverts
- *Epacris purpurascens var. purpurascens*
- *Hibbertia superans*
- ELA Plots & Transects

Vegetation Type

- Blue Gum High Forest
- Blue Gum Individuals
- Coastal Enriched Sandstone Dry Forest
- Coastal Enriched Sandstone Moist Forest
- Coastal Sandstone Gallery Rainforest
- Coastal Shale-Sandstone Forest
- Cumberland Riverflat Forest
- Hinterland Sandstone Gully Forest
- Sandstone Blackbutt Woodland
- Sydney Turpentine Ironbark Forest
- Syzygium paniculatum (Lilly Pilly) (planted)
- Not surveyed
- Regeneration - Exotic
- Regeneration - Native
- Urban Native/Exotic
- Weeds and Exotics

Vegetation Condition

- Good
- Moderate
- Poor



0 50 100 200

Metres

Datum/Projection:
GDA 1994 MGA Zone 56

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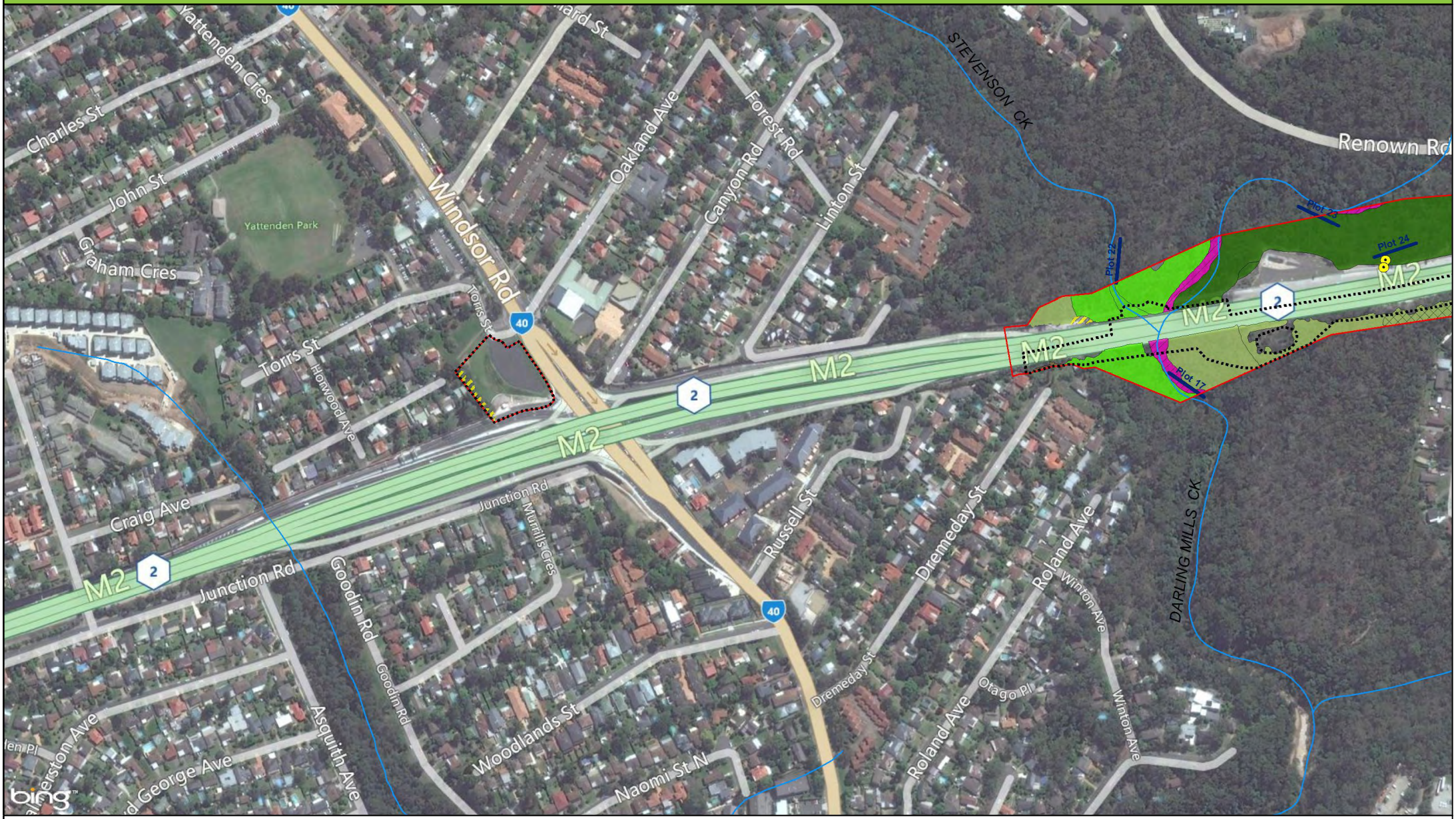
Vegetation and Significant Biodiversity

Windsor Road Compound



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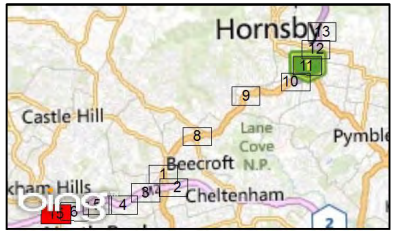

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Metres

Datum/Projection:
GDA 1994 MGA Zone 56

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Appendix E: Study area descriptions

Table E1: Southern interchange and the Hills M2 Motorway integration works area

Description	The site consists of the construction footprint associated with the southern interchange located at the current Hills M2 Motorway / Pennant Hills Road interchange and the Hills M2 Motorway integration works that runs west from the southern interchange to immediate west of the motorway bridge over Darling Mills Creek. The site contains tracts of relatively good condition native vegetation to areas that have been cleared and overtopped with spoil or fill. Around the Darling Mills Creek area to the north of the current Hills M2 Motorway and east to Blue Gum Creek, the landscape is steep with many sandstone outcrops, large hollow bearing trees and some small watercourses and several culverts, all of which provide suitable habitat for a range of fauna. The vegetation along the road corridor forms a contiguous patch of vegetation with Bidjigal Reserve, Munro Reserve and Excelsior Park. By contrast, the vegetation around the integration works area is more modified but still contains two threatened ecological communities, which persist as highly modified remnants in association with the Pennant Hills Golf Course, a patch of vegetation adjacent to Chilworth Reserve, and vegetation within a public reserve in proximity Lisle Court (to the north of the Hills M2 Motorway and approximately 400m to the west of Pennant Hills Road). Similarly, vegetation along the southern side of the existing Hills M2 Motorway is a mix of modified native vegetation and areas invaded by exotics. This site is likely to be used by a wide variety of fauna including Powerful Owl, Eastern Bent-wing Bat, other microbats, reptiles and Grey Headed Flying Fox
Condition	Poor to Good. The communities in this site ranged in condition. Where the canopy and understorey component was intact, condition was good. This was largely in the drier sclerophyll forests. By contrast areas in poor condition were generally found along riparian areas and were wetter, including areas of Blue Gum High Forest.Sections of the vegetation between the sound wall and urban development were replanted on spoil/fill, while other large areas were colonised by exotics from garden escapes or weeds.
Threatened species of plant?	Two threatened plant species were recorded at this site. They were *Epacris purpurascens* var. *purpurascens* and *Hibbertia superans*. This site also contained potential habitat for a number of other threatened plant species.
Threatened community?	This site contains two threatened communities: Blue Gum High Forest which meets the TSC Act definition but not the EPBC Act definition and Sydney Turpentine Ironbark Forest which meets the TSC Act definition but not the EPBC Act definition for areas being impacted (refer to **section 4.1**). The Blue Gum High Forest was present in two condition classes, “poor” and “moderate”. The moderate condition vegetation Blue Gum High Forest, occurred at Pennant Hills Golf Course (which will not be impacted), and at the Lisle Court Reserve (which will be impacted), For the moderate condition vegetation there native canopy cover was approximately 30 per cent, and 35 native species were present in a 0.04 hectare plot at the Lisle Court Reserve site. By contrast the poor condition Blue Gum High Forest consisted of scattered Blue Gums (*E. saligna*) with mown ground cover, consisting largely of exotic grasses with some native herbs, at the Lisle Court reserve, and areas with high exotic cover (species such as lantana), in the Hills M2 Motorway integration works area to the south of Westmore Drive. Patch sizes within the study area were:

	• 2.00 hectares at the southern interchange mapped as being in moderate condition at the Pennant Hills Golf Course to the north of Hills M2 Motorway which will be avoided, consisting of one area of 1.33 hectares along the southern boundary of Pennant Hills Golf Course, and another area of 0.67 hectares along the eastern boundary of Pennant Hills Golf Course. • 0.98 hectares of Sydney Turpentine Ironbark Forest in low condition to the east of Orchard Road, to the south of Hills M2 Motorway which will be avoided. • 0.47 hectares at the southern interchange (0.37 hecatres of moderate and 0.10 hectares of low condition), which would all be disturbed. • 1.20 hectares at the Hills M2 Motorway integration works area, which would all be disturbed.
	See map series **Appendix D**.

Southern Interchange – Blue Gum High Forest in the Pennant Hills Golf Course looking west (not impacted).

Blue Gum High Forest (moderate condition) biobanking plot and transect (impacted).

Hills M2 Motorway integration works area – Blue Gum High Forest near overpass on Oakes Road (impacted).

Coastal Shale - Sandstone Forest with native understorey (Biobanking plot transect) behind RIDBC School. Small extent of this community to be impacted.

Coastal Shale- Sandstone Forest of moderate condition with mown understorey (Biobanking plot transect) behind RIDBC School (not impacted).

Regeneration area with *Epacris purpurascens* var. *purpurascens*. Area subject to proposed impacts.

Sydney Turpentine-Ironbark Forest of poor condition located east of Orchard Rd, North Rocks (not impacted).

Coastal Enriched Sandstone Moist Forest located east of Orchard Rd, North Rocks south of the M2 (not impacted).

Planted *Syzygium paniculatum* (Lilly Pilly) located on Oakes Rd, North Rocks. Subject to proposed impacts.

Urban Native/Exotic vegetation south of the Hills M2 Motorway / east of Oakes Road, North Rocks behind residential properties. Subject to potential impacts.

Blue Gum High Forest located north of Hills M2 Motorway south is Lisle Circuit, North Rocks. Subject to potential impacts.

Coastal Sandstone Gallery Rainforest located south of the Hill M2 Motorway adjacent on the eastern side Darling Mills Creek. Location of BioBanking plot. Photo of vegetation is not subject to potential impacts. Vegetation had native canopy with mixture of native and exotic midstorey.

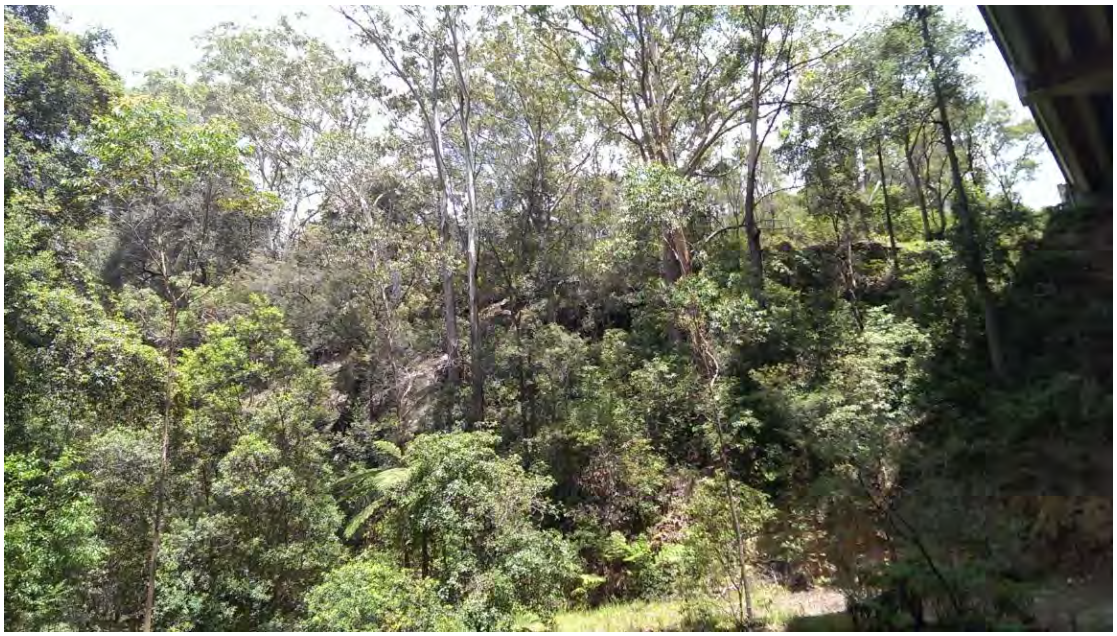

Photo facing Coastal Enriched Sandstone Moist Forest on the western side of Darling Mills Creek south of the Hills M2 Motorway. Right hand side of the vegetation closest to the Hills M2 Motorway is subject to potential impacts.

Coastal Enriched Sandstone Dry Forest located on the north of the Hills M2 Motorway east of Darling Mills Creek (not impacted).

Weeds and Exotic and Coastal Shale-Sandstone Forest mapped vegetation south of the Hills M2 Motorway facing east located north of Carlton Road, North Rocks. Vegetation is located between the Hills M2 Motorway and behind residential properties. Vegetation in photo is subject to potential impacts.

Table E2: Northern interchange

Description	This site consists of the construction footprint associated with the northern interchange, which commences near the existing intersection of Pennant Hills Road with the M1 Pacific Motorway, and extents along the M1 Pacific Motorway immediately north of the Edgeworth David Avenue overpass at North Wahroonga. This site contains linear strips of highly modified native Hinterland Sandstone Gully vegetation, urban/street planting and large linear areas of landscaping over batter/spoil up to the sound wall. In the south, at the interchange, there is a small area of modified Blue Gum High Forest. Most of the vegetation exists between the sound wall and urban development, with little connection to other tracts of remnant native vegetation. The exception is at the northern limit where vegetation is somewhat connected to Cockle Creek, which joins vegetation in Ku-ring-gai Chase National Park. At the southern limit, there is a small, narrow vegetated corridor which connects the highly modified Blue Gum High Forest with the Glade and Loggers Retreat in Wahroonga and eventually Brown Reserve at North Epping. There were few habitat features with the greatest concentration of hollow bearing trees in the Blue Gum High Forest in the south, while creeks and waterways with suitable habitat culverts existed in the northern section. The terrain was undulating with few rocky outcrops. This site is likely to be used by microbats, urban tolerant native birds, reptiles and amphibians and vagrant migratory birds. This is largely due to the narrow nature of the habitat and its relatively poor quality. The Blue Gum High Forest in the southern end of the northern interchange contains hollow bearing trees which are likely to support a range of hollow dependent fauna.
Condition	Poor to Good. The communities in this site ranged in condition. Where the canopy and understorey component was intact, condition was good. This was largely in the drier sclerophyll forests in the north. By contrast areas with poor condition were generally found along riparian areas and were wetter, including areas of Blue Gum High Forest or were areas that had been filled and planted. The greater proportion of vegetation was highly modified or planted on the batter between urban development and the sound wall. These areas also contained weeds such as *Lantana camara* and *Ligustrum* spp.
Threatened species of plant?	No threatened plant species were found at this site.
Threatened community?	This site contains one threatened community: Blue Gum High Forest, which meets the TSC Act criteria but not the EPBC Act definition (refer to **section 4.1**). Patch sizes were: • 1.67 hectares of poor condition Blue Gum High Forest, of which, 1.14 hectares would be disturbed.
	See map series **Appendix D**.

Northern interchange, west of Lucinda Avenue – Understorey of Blue Gum High Forest containing Privet.

Northern interchange, west of Lucinda Avenue – Understorey of Blue Gum High Forest containing Privet.

Northern interchange near Eastbourne Avenue – Blue Gum High Forest with managed and exotic understorey.

Vegetation along the eastern side of the M1 Pacific Motorway mapped as weeds and exotics to be impacted.

Hinterland Sandstone Gully Forest mapped between the M1 Pacific Motorway and sports field located off Coonanbarra Rd, North Wahroonga. Vegetation subject to proposed impacts.

Table E3: Ancillary facilities – Trelawney Street compound

Description	This site is a developed urban block in Pennant Hills bound by Pennant Hills Rd, Loch Maree Avenue and Trelawney Street, containing a mix of commercial and residential uses. There was no site access and the vegetation was inspected from the roadside. The larger portion of this site is urban native/exotic vegetation in gardens. There were some trees that appeared to be *Eucalyptus saligna* however this could not be confirmed due to access conditions and they are likely to fall just outside the boundary of this block. Fauna species using this area are likely to be urban tolerant species.
Condition	Likely to be Poor. The vegetation at this site is in a highly urbanised context existing primarily in private properties. Access was not available to this site, but it is presumed that the vegetation present would be managed and in poor condition.
Threatened species of plant?	No threatened plant species were found at this site.
Threatened community?	While the site may contain *Eucalyptus saligna* individuals, this could not be confirmed.
	See map series **Appendix D.** No photo available because of site access restrictions.

Table E4: Ancillary facilities – Wilson Road compound

Description	This site is an urban block (residential) in Pennant Hills bound by Pennant Hills Road, Killaloe Avenue and Wilson Road. There was no site access and the vegetation was inspected from the roadside. The larger portion of this site is urban native/exotic vegetation in gardens. There were some trees that appeared to be *Eucalyptus saligna* in the rear of private properties however this could not be confirmed due to access. Along the edge of properties on Wilson Road there were remnant *Eucalyptus saligna* and *Syncarpia glomulifera*. These species are characteristic canopy species of Sydney Turpentine Ironbark Forest under the TSC Act. Fauna species using this area are likely to be urban tolerant species.
Condition	Likely to be Poor. The vegetation at this site is in a highly urbanised context existing primarily in private properties. Access was not available to this site, but it is presumed that the vegetation present would be managed and in poor condition
Threatened species of plant?	No threatened plant species were found at this site.
Threatened community?	The site contains individuals of *Eucalyptus saligna* and *Syncarpia glomulifera* in a highly modified state. These species are characteristic canopy species of Sydney Turpentine Ironbark Forest under the TSC Act. A precautionary approach has been taken and this vegetation is therefore identified as Sydney Turpentine Ironbark Forest. This community does not meet EPBC Act definition (refer to **section 4.1**). Estimated patch size: 0.07 hectares Blue Gum individuals and 0.10 hectares of Sydney Turpentine Ironbark Forest.
	See map series **Appendix D**. No photo available due to site access restrictions.

Table E5: Ancillary facilities – Windsor Road compound

Description	This site is an open block in North Rocks, bounded by Torrs Rd, Windsor Road and the Hills M2 Motorway. There was no site access. The larger portion of this site appears to be urban native/exotic vegetation. Fauna species using this area are likely to be urban tolerant species.
Condition	Likely to be Poor. The vegetation at this site is in a highly urbanised context existing primarily in private properties. Access was not available to this site, but it is presumed that the vegetation present would be managed and in poor condition
Threatened species of plant?	No site access.
Threatened community?	None mapped – no site access
	See map series **Appendix D**. No photo available due to site access restrictions.

Table E6: Pioneer Avenue Compound

Description	This site is bound by the Hornsby railway line to the south east and industrial / commercial properties on all other boundaries. The site was previously a malt works and is not currently in use. There are a number of buildings on the site, including three large complexes and additional smaller outbuildings, sheds and a house. The site is therefore largely industrial. The vegetation communities found at this site were: • Weeds/exotics • Blue Gum High Forest. The weeds/exotics (0.44 hectares) were a mix of exotic landscaping plants and weedy colonisers such as *Ligustrum lucidum* (Large Leaved Privet), *L. sinense* (Small Leaved Privet), and a diverse range of herbaceous weeds such as *Pennisetum clandestinum* (Kikuyu), *Conyza* sp. (Fleabane), *Verbena bonariensis* (purple top), *Ehrharta erecta* (Panic Veldt Grass), *Bidens pilosa* (Cobbler's Pegs) and *Paspalum dilatatum* (Paspalum). Landscaping or planted species included *Acacia baileyana* (Cootamundra Wattle), *Strelitzia* sp. (Bird of Paradise), *Cotoneaster* sp., *Oleander neriifolia* (Oleander), *Jacaranda mimosifolia* (Jacaranda). The two patches of Blue Gum High Forest (total of 0.07 hectares) consisted of a mix of *Eucalyptus saligna* (Sydney Blue Gum) and *Angophora floribunda* (Rough Barked Apple) in the canopy, with a highly disturbed and exotic invaded understorey. The patch in the north-western corner of the Pioneer Avenue compound was dominated by exotic understorey species and no native species apart from the *E. saligna*. Understorey species in the north-western patch included *Cardiospermum* (Balloon Vine), *Ligustrum lucidum*, *Bidens pilosa*, *Pennisetum clandestinum*, and *Ehrharta erecta*. A patch of Blue Gum High Forest is adjacent to the railway line. It is noted that patch is part of a row of trees just outside the eastern cadastral boundary of the Pioneer Avenue compound, but inside of perimeter fencing for the site. For this vegetation patch the native shrub component was largely absent, with few native herbaceous species such as *Commelina cyanea*, *Bothriochloa macra* (Red-leg Grass), *Cymbopogon refractus* (Barbed Wire Grass) and *Imperata cylindrica* (Blady Grass) present. This site is likely to be used by urban tolerant fauna, with the potential habitat for microbats in the abandoned buildings. The buildings on site are disused and all the buildings observed had entry points large enough for small bats. The buildings were not surveyed for the presence of these species. The site had very few hollow bearing trees, with only three hollow bearing trees in the Pioneer Avenue compound. None of the hollows were of the size class that supports large forest owls or Glossy Black Cockatoo. However, the hollows were large enough to support microbats, diurnal birds and mammals. The site contained large concrete slabs which could potentially be used as basking substrate for reptiles. However the lack of a diverse understorey and no termite mounds would suggest that this site would not be suitable for Rosenberg's Goanna, and is more likely to be used by common and widespread reptiles.
Condition	Poor. The Pioneer Avenue compound has been used for industrial purposes and as such has been largely cleared and contains modified and fragmented small patches of native vegetation. The site is dominated by weeds and exotics, some of which have been planted.
Threatened species of plant?	None found and none likely in this site.

Threatened community?	This site contains one threatened community: Blue Gum High Forest which meets the TSC Act definition but not the EPBC Act definition (refer to **section 4.1**). The total area of this community within the study area was 0.07 hectares in two separate patches. The condition of the Blue Gum High Forest vegetation and the patch size are both too low to meet the EPBC Act definition.
	See map series **Appendix D**.

Small patch of highly modified and exotic invaded Blue Gum High Forest in the north-west corner of the Pioneer Avenue compound (not impacted).

Small patch of disturbed Blue Gum High Forest (presented here with *Angophora floribunda* canopy) adjacent to the railway line (not impacted).

Exotics and weeds typical of the site, with Privets, Kikuyu and *Conyza* sp.

Disused buildings on the site with openings suitable for entry by microbats. Yellow arrows indicate potential entry points.

Appendix F: Assessnents of Significance (State) – Heads of Consideration

ENDANGERED ECOLOGICAL COMMUNITIES

Blue Gum High Forest in the Sydney Basin Bioregion Blue Gum High Forest in the Sydney Basin Bioregion is the name given to the ecological community listed as critically endangered in Part 2 of Schedule 1A of the *Threatened Species Conservation Act 1995*. Blue Gum High Forest is described as a moist, tall open forest community dominated by either *Eucalyptus pilularis* (Blackbutt) or *E. saligna* (Sydney Blue Gum). *Angophora costata* (Smooth-barked Apple), *A. floribunda* (Rough-barked Apple), and *E. paniculata* (Grey Ironbark) also occur depending on slope and soil characteristics (OEH 2013c). The midstorey comprises mesophyllous shrubs (particularly in gullies) and small trees and the ground stratum is often dense, containing a mixture of herb, grass, and fern species (OEH 2013c). A list of flora species characteristic of the ecological community is provided by the Scientific Committee in the Final Determination for Listing (OEH 2013d).

Blue Gum High Forest is found on the north shore and northern suburbs of Sydney and has a highly restricted and fragmented geographic distribution comprised of a series of small remnant patches. Revised vegetation mapping in 2005 indicated that these small fragmented remnants are estimated to comprise 95 hectares (DotE 2013a). Further, it is confined on the Hornsby Plateau to altitudes higher than 100 metres above sea level (DotE 2013a). Highly modified relics persist as small clumps of trees without a native understorey, or which have an understorey largely replaced by woody exotic species or by increased abundance of native and exotic grasses (OEH 2013c). Relics with substantially modified understory are also likely to have reduced functionality for a range of bird and small mammal species (DotE 2013a). Small scale clearing, the influx of stormwater and dispersal of weed propagules from nearby urban areas pose significant ongoing threats to the survival of Blue Gum High Forest (OEH 2013c).

Across the study area, Blue Gum High Forest has been identified at along sections of the Hills M2 Motorway integration works area, the southern interchange, the northern interchange. A number of ancillary construction and operational sites have individual *Eucalyptus saligna* trees that also meet the definition of Blue Gum High Forest under the TSC Act. ELA is cognisant of NSW Land and Environment Court decisions in protecting very small patches of Blue Gum High Forest and individual *E. saligna* trees and as such has adopted a precautionary approach to the classification of this community under the TSC Act.

How is the proposal likely to affect the lifecycle of a threatened species and/or population?

Not applicable. Blue Gum High Forest is not a threatened species or population.

How is the proposal likely to affect the habitat of a threatened species, population or ecological community?

The project would remove areas of Blue Gum High Forest near the Hills M2 Motorway integration works area, the southern interchange and the northern interchange. Areas to be removed are quantified in **Table 11**. The areas to be removed are in poor condition with all patches having little to no native understorey remaining and high densities of exotic species in the understorey and groundcover. These patches do not meet the EPBC definition due to the heavy modification of the understorey components. Regardless of the condition, the proposed works are likely to have an impact on this community because of the proportion of clearing comparative to the extent of Blue Gum High Forest remaining across the Sydney Basin Bioregion.

The amount of Blue Gum High Forest to be removed constitutes around 1.5 per cent of the extant community, which is around 170 hectares (TSC Act, Tozer 2003).

Does the proposal affect any threatened species or populations that are at the limit of its known distribution?

Not applicable. Blue Gum High Forest is not a threatened species or population.

How is the proposal likely to affect current disturbance regimes?

The species composition of a Blue Gum High Forest remnant would be influenced by the size of the remnant, recent rainfall or drought conditions and by its disturbance history (including fire) (DotE 2013a). The number, and relative abundance, of species would change with time since fire, and may also change in response to changes in fire regime (including fire frequency) (DotE 2013a).

The presence of urban development surrounding the Blue Gum High Forest at the northern interchange has resulted in a fire regime of fire suppression and there was no evidence of recent fires or arson (for at least 20 years). The recommended minimum fire interval for Blue Gum High Forest is 25 to 30 years (RFS 2006) to maintain maximum biodiversity. Similarly, the presence of urban development and the existing Hills M2 Motorway at West Pennant Hills has resulted in a regime of fire suppression, with no evidence of recent fires.

The lack of fire can encourage the dominance of native mesic species like *Pittosporum undulatum*, and exotic mesic species including *Tradescantia albiflora* and *Ligustrum* spp., blackberry and *Lantana camara* in the understorey. Mitigation measures proposed to protect the poor condition Blue Gum High Forest include active weed control and bush regeneration activities targeting invasive weeds, and thinning of mesic native species where required to promote a diversity of native understorey groundcovers and shrubs.

Blue Gum High Forest is restricted to deep clay soils derived from shale, within areas of high annual rainfall (816 to 1250 millimetres) (DotE 2013a). The current drainage patterns at the Hills M2 Motorway have been impacted by surrounding urban development, including the construction of an open stormwater drain along the northern edge of the remnant backing onto a residential area on the northern side of the Hills M2 Motorway, near the Oakes Road underpass. This area is currently heavily infested with weeds including *Lantana camara*, blackberry and *Ligustrum* spp.

The bulk of the Blue Gum High Forest remnants have been mapped as degraded, with a small area at the southern interchange being mapped in a moderate condition. Weed invasion is currently high and there is the potential for the project to result in the introduction of further invasive species. A number of mitigation measures have been proposed to prevent the introduction of weeds to the construction site.

Weed monitoring, control, and progressive rehabilitation would help to reduce the potential for the remaining Blue Gum High Forest vegetation to be invaded by weeds.

Overall, the project is unlikely to alter the current disturbance regimes such that it would place the community at risk of extinction. Mitigation measures would protect the existing soil and drainage patterns and weed control would reduce the current level of weed invasion in the patches remaining at the northern interchange and southern interchange.

How is the proposal likely to affect habitat connectivity?

The project would reduce the number of remnant patches within and adjacent to the construction footprint associated with the following sites: the Hills M2 Motorway integration works area, the southern interchange and the northern interchange.

While the overall number of the patches would be reduced, habitat connectivity is unlikely to be affected because of the nature and distribution of the disparate patches in which Blue Gum High Forest currently occurs. In terms of connectivity between patches, the removal of the patches in the construction footprint would result in fewer patches and would result in greater distances between remaining patches.

In general, Blue Gum High Forest exists as small highly modified patches throughout the Sydney Metropolitan Catchment Management Authority (SMCMA). Given the existing level of fragmentation and small patch size of Blue Gum High Forest throughout its range, the areas being impacted both directly and indirectly by the project is unlikely to result in a substantial decrease in the level of connectivity of the community at the landscape level.

How is the proposal likely to affect critical habitat?

Not applicable. Critical habitat has not been declared for Blue Gum High Forest.

Conclusion

The assessment concludes that despite provision of some mitigation measures a significant impact to Blue Gum High Forest is expected because of the extent of the vegetation type to be removed relative to the extent remaining.

F.1.1. Sydney Turpentine-Ironbark Forest

Sydney Turpentine-Ironbark Forest is listed as an endangered ecological community under the *Threatened Species Conservation Act 1995*. Sydney Turpentine-Ironbark Forest is an open forest with dominant canopy trees including *Syncarpia glomulifera* (Turpentine), *Eucalyptus punctata* (Grey Gum), *Eucalyptus paniculata* (Grey Ironbark) and *E. eugenioides* (Thin-leaved Stringybark) (OEH 2013e). Other characteristic tree species in this forest community is *Eucalyptus resinifera*, *Angophora costata* and *Angophora floribunda*, and species composition varies between sites due to different geographical location and local conditions (eg topography, rainfall and exposure) (OEH 2013e). In areas of high rainfall (over 1050 millimetres per annum) *E. saligna* (Sydney Blue Gum) is more dominant. The shrub stratum is usually sparse and may contain mesic species such as *Pittosporum undulatum* (Sweet Pittosporum) and *Polyscias sambucifolia* (Elderberry Panax) (OEH 2013e).

Sydney Turpentine-Ironbark Forest occurs close to the Shale/Sandstone boundary on the more fertile shale influenced soils with higher rainfall (OEH 2013c). These areas tend to be on the higher altitude margins of the Cumberland Plain and on the shale ridge caps of sandstone plateaus. It is also a transitional community, between Cumberland Plain Woodland in drier areas and Blue Gum High Forest on adjacent higher rainfall ridges (DECC 2005).

Sydney Turpentine-Ironbark Forest is found:

- East of the southern interchange, outside the construction footprint.
- Within the Wilson Road compound, where it exists only as scattered remnant trees in relatively poor condition in an urban setting.

How is the proposal likely to affect the lifecycle of a threatened species and/or population?

Not applicable. Sydney Turpentine-Ironbark Forest is not a threatened species or population.

How is the proposal likely to affect the habitat of a threatened species, population or ecological community?

The Sydney Turpentine-Ironbark Forest present in the proposed footprint consists of small modified patches or exists as canopy species only with no understorey species. This modified and species poor Sydney Turpentine-Ironbark Forest is unlikely to be high quality habitat for any of the threatened species listed above and therefore the project is unlikely to have a significant impact on these species. The Sydney Turpentine-Ironbark Forest found to the east of the southern interchange, within the study area but not within the construction footprint. A small (0.1 hectare) patch of this community occurs at the proposed Wilson Road compound. This patch, which was only observed from the footpath due to access restrictions, appears to be in relatively poor condition and persists as scattered canopy trees and exists entirely in the construction footprint.

Apart from direct removal of the vegetation community, there would be indirect impacts to the community at the southern interchange. Indirect impacts include the creation of new edges to the vegetation and potential disturbance to soils and hydrology resulting from the works at the southern interchange.

Impacts to the Sydney Turpentine-Ironbark Forest community have been avoided where possible and the construction footprint associated with the southern interchange would avoid the Sydney Turpentine-Ironbark Forest.

Does the proposal affect any threatened species or populations that are at the limit of its known distribution?

Not applicable. Sydney Turpentine-Ironbark Forest is not a threatened species or population.

How is the proposal likely to affect current disturbance regimes?

The species composition of the Sydney Turpentine-Ironbark Forest remnants are influenced by the size of the remnant, recent rainfall or drought conditions, and by its disturbance history (including fire) (DotE 2013b). The number, and relative abundance, of species will change with time since fire, and may also change in response to changes in fire regime (including fire frequency) (DotE 2013b).

The presence of urban development surrounding the Sydney Turpentine-Ironbark Forest at each of the sites has altered the natural fire regime. Fire suppression (defined as a time period greater than 50 years since fire) can cause a loss of fire-dependent flora species. The best management practices for Sydney Turpentine-Ironbark Forest fire management recommend a fire frequency between 15 to 30 years to maintain maximum biodiversity (DECC 2008c).

An absence of fire, coupled with development in surrounding areas, has provided opportunities for weeds to become established or for the understorey to be vastly altered due to mowing and landscaping.

Sydney Turpentine-Ironbark Forest occurs on fertile soils at the Shale/Sandstone transition, within areas of high rainfall (OEH 2013e). Sydney Turpentine-Ironbark Forest community is prone to hydrological disturbances from urban development. The current condition of Sydney Turpentine-Ironbark Forest at the southern interchange study area is highly degraded.

Weed invasion within the indirectly impacted areas of Sydney Turpentine-Ironbark Forest is currently high and there is the potential for the project to result in the introduction and spread of further invasive species through road works occurring to the west of this patch. A number of mitigation measures have been proposed to prevent the introduction of weeds to the construction site at the southern interchange, and a weed control procedure will be developed as part of the flora and fauna management plan for the project, including use of clean plant and equipment. Weed monitoring, control, and progressive rehabilitation would help to reduce the potential for the remaining Sydney Turpentine-Ironbark Forest vegetation to be invaded by weeds.

Overall, the project is unlikely to alter the current disturbance regimes such that it would place the community at risk of extinction. Mitigation measures would protect the existing soil and drainage patterns and weed control would reduce the current level of weed invasion.

How is the proposal likely to affect habitat connectivity?

Further reduction in the number of Sydney Turpentine-Ironbark Forest patches may reduce the resilience of native species within this community. However, given the existing level of fragmentation and small patch size of Sydney Turpentine-Ironbark Forest throughout the landscape, the amount impacted both directly and indirectly by the project is unlikely to significantly decrease the level of habitat connectivity at the landscape level. It should also be noted that a large patch of highly disturbed Sydney Turpentine-Ironbark Forest at the southern interchange has been avoided.

How is the proposal likely to affect critical habitat?

Not applicable. Critical habitat has not been declared for Sydney Turpentine-Ironbark Forest.

Conclusion

The project is unlikely to result in a significant impact on the Sydney Turpentine Ironbark Forest due to alterations in design resulting in avoidance at the southern interchange. However, a small (0.1 hectares) of relatively poor condition Sydney Turpentine Ironbark Forest will be removed at the Wilson Road compound. Indirect impacts should be managed through the implementation of a flora and fauna management plan to manage issues such as erosion control, sedimentation and changes in hydrology.

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F.1.2. Callistemon linearifolius

Callistemon linearifolius is a vulnerable species listed under the TSC Act. It is an erect shrub three-four m tall with linear to linear-lanceolate leaves, mostly eight to 10 centimetres long and five to seven millimetres wide. It occurs within dry sclerophyll forest on the coast and adjacent ranges (Harden 1991). It has been recorded from the Georges River to Hawkesbury River in the Sydney area, and north to the Nelson Bay area of NSW, though recent records for the Sydney area are limited to the Hornsby Plateau area near the Hawkesbury River (OEH 2013f). It was more widespread across its distribution in the past, with only five-six current populations known in the Sydney area and up to 22 populations recorded in the past (OEH 2013f).

Callistemon linearifolius is threatened by a continued loss of habitat from urban expansion and by stochastic events due small population sizes. The response of this species to fire is unknown although an inter-fire interval of no less than seven years is recommended on the Threatened Species Hazard Reduction List.

Callistemon linearifolius has been recorded 128 times within ten kilometres of the study area. No *C. linearifolius* were found across the study area, however suitable habitat was found adjacent to the Hills M2 Motorway integration works between the Darling Mills Creek bridge and Blue Gum Creek on the northern side of the carriageway and on the southern side from Darling Mills Creek east for a distance of approximately 300 metres.

How is the proposal likely to affect the lifecycle of a threatened species and/or population?

There are no known occurrences of *C. linearifolius* within the construction footprint. Therefore the project would not have a significant impact on this species.

How is the proposal likely to affect the habitat of a threatened species, population or ecological community?

The project would impact potential habitat for this species along the Hills M2 Motorway integration works study area where there is dry sclerophyll forest vegetation (Coastal Shale-Sandstone Forest, Coastal Enriched Sandstone Dry Forest, Hinterland Sandstone Gully Forest). The area to be cleared is small relative to the amount of the type of vegetation that is outside of and adjacent to the construction footprint. Because potential habitat exists adjacent to the construction footprint, measures to minimise indirect impacts would need to be undertaken. Such measures may include clearance limits, management of run-off during and after construction, management of potential sediment and erosion.

Given the relatively small area of potential habitat, the absence of the species and the potential habitat adjacent to the construction footprint, the project is unlikely to result in significant impacts on

Does the proposal affect any threatened species or populations that are at the limit of its known distribution?

The potential habitat is not at the limit of this species' known distribution, therefore the project would not significantly impact population limits.

How is the proposal likely to affect current disturbance regimes?

The current disturbance regime along the Hills M2 Motorway consists of fire suppression, increased weed invasion and runoff from the motorway. The project would not result in a changed disturbance regime therefore the project would not significantly impact disturbance regimes within the construction footprint. The project may result in some disturbances (such as weed invasion and runoff) to areas of potential habitat that exist outside of the footprint through an increase in hardstand works, though it is unlikely that this would have a significant impact on the potential habitat for this species given the altered regimes that currently exist.

How is the proposal likely to affect habitat connectivity?

There are no known populations of this species along the Hills M2 Motorway integration works study area. The species has a broad coastal distribution, with this study area being approximately in the middle of its known distribution. The closest known populations are on the Hornsby Plateau near the Hawkesbury River, therefore the project would not have an impact on habitat connectivity for this species.

How is the proposal likely to affect critical habitat?

No critical habitat has been determined for *C. linearifolius*.

Conclusion

The project is unlikely to result in a significant impact on *C. linearifolius* because there were no individuals detected within the construction footprint and that impacts to potential habitat were minimal, given the extent of potential habitat existing outside the construction footprint.

F.1.3. Darwinia biflora

Darwinia biflora is listed as vulnerable under the TSC Act and is an erect to spreading shrub up to 80 centimetres high. Flowers are green, surrounded by two red bracteoles and are mostly in pairs.

It has been recorded in Ku-ring-gai, Hornsby, Baulkham Hills and Ryde local government areas. The northern, southern, eastern and western limits of the range are at Maroota, North Ryde, Cowan and Kellyville respectively. *D. biflora* occurs on the edges of weathered shale-capped ridges, where these intergrade with Hawkesbury Sandstone. The vegetation structure is usually woodland, open forest or scrub-heath.

Longevity is thought to be 15 to 20 years and flowering occurs throughout the year but is concentrated in autumn, with mature fruits being produced from May to August.

Fire is an important factor in the life cycle of this species. Fire kills all plants, but also produces a flush of germination from seed stored in the soil. The number of individuals at a site then decline with time since fire, as the surrounding vegetation develops.

No *D. biflora* was found during the field assessment, but potential habitat exists along the study areas for the Hills M2 Motorway integration works area. *D. biflora* has been recorded 904 times within ten kilometres of the study area. The surveys for the project were conducted outside of the optimal season when flowers are likely and identification is easier. However experienced observers would be able to identify these plants if they were present.

How is the proposal likely to affect the lifecycle of a threatened species and/or population?

The project would result in the removal of a small area of potential habitat for *D. biflora* at the Hills M2 Motorway integration works area. No individuals of *D. biflora* were found during the field surveys within the construction footprint therefore this project is unlikely to have a significant impact on this species' lifecycle.

How is the proposal likely to affect the habitat of a threatened species, population or ecological community?

The construction footprint contains potential habitat for this species. The project would impact potential habitat for this species along the Hills M2 Motorway integration works area where there is dry sclerophyll forest vegetation (Coastal Shale-Sandstone Forest, Coastal Enriched Sandstone Dry Forest, Hinterland Sandstone Gully Forest). However, this vegetation type exists outside the footprint and therefore the project would not have a significant impact on the habitat of this species. Given that no *D. biflora* was detected and there is suitable habitat outside the construction footprint, it is unlikely that the project would remove enough habitat for this species to be significant.

Does the proposal affect any threatened species or populations that are at the limit of its known distribution?

The construction footprint is not at the limit of the known distribution of this species, therefore the project would not significantly reduce limits of this species.

How is the proposal likely to affect current disturbance regimes?

Across all sites containing suitable habitat in the construction footprint, disturbance regimes consist of fire suppression, increased runoff due to roads or stormwater outlets and increases in weed incursions. The project would not significantly alter these current disturbance regimes, but may push out these regimes to adjoining potential habitat. However it is unlikely that this would significantly impact this species which has not been detected within the construction footprint.

How is the proposal likely to affect habitat connectivity?

The construction footprint is contained within the known distribution of this species. The project would not result in the fragmentation of known populations and would not significantly affect habitat connectivity for this species. This is because this species has a relatively large distribution and exists in a fragmented matrix.

How is the proposal likely to affect critical habitat?

No critical habitat has been declared for *D. biflora.*

Conclusion

The proposal is unlikely to result in a significant impact on *D. biflora* given that the species was not detected within the construction footprint and that potentially suitable habitat for the species within the study area occurs beyond the construction footprint.

F.1.4. Epacris purpurascens var. purpurascens

Epacris purpurascens var. *purpurascens,* listed as vulnerable under the TSC Act, is reported as being restricted to the Sydney Basin Bioregion with the known distribution from Gosford south to the vicinity of Avon Dam and from Narrabeen west to Silverdale (OEH 2013g). This species is reported as being found in a range of habitat types with these habitats frequently having a strong shale influence (OEH 2013g). The *Guide to the Berowra Regional Park* states that this species is strongly associated with Sydney Turpentine Ironbark Forest and Shale/Sandstone Transition Forest (Friends of Berowra Valley Regional Park 2004). *E. purpurascens* var. *purpurascens* has been recorded 328 times within ten kilometres of the study area.

The M2 Upgrade project found *Epacris purpurascens* var. *purpurascens* located on relocated soils including earth mounds and rock armoured batter slopes (AECOM 2010). The recent field survey found approximately 87 *E. purpurascens* var. *purpurascens*, while approximately 180 plants are known to occur in the study area along the Hills M2 Motorway (Cumberland Ecology 2012).

How is the proposal likely to affect the lifecycle of a threatened species and/or population?

Approximately 180 known plants of *Epacris purpurascens* var. *purpurascens* occur within the study area of the project, along the Hills M2 Motorway integration works area and 87 of these were found during the recent field survey. A revised construction footprint indicates that two of three known populations are likely to be directly affected by the project, with approximately 106 plants to be removed as a result of works for the Hills M2 Motorway integration works (sites 2 and 3 in Cumberland Ecology 2012). The discrepancy between the number of plants found in the recent survey and the number known may be due to plant mortality, therefore a worst case scenario has been assumed and this is that the two local populations number sites 2 and 3 (Cumberland Ecology 2012) will be completely cleared.

The project would result in the clearance of all of these individuals, affecting the majority (59 per cent) of the known population along the road corridor. Areas outside the road corridor were not surveyed, but there is habitat that could support this species. It has been assumed that 100 per cent clearance will occur, but this clearance may in fact be reduced. However, given the number of plants to be cleared, these works are likely to have a significant impact on this population.

Additional surveys should be conducted to determine the extent of the population outside of the construction footprint, in addition to the remaining 74 known plants within the existing road corridor. This survey would further identify the extent of the local population and support the clarification of actual impacts to this species.

How is the proposal likely to affect the habitat of a threatened species, population or ecological community?

The project would affect the known habitat in the road corridor of the Hills M2 Motorway through clearing habitat of *E. purpurascens* var. *purpurascens*. This impact is likely to be significant.

Does the proposal affect any threatened species or populations that are at the limit of its known distribution?

Epacris purpurascens var. *purpurascens* is restricted to the Sydney Basin Bioregion in which it has been recorded from Gosford south to the vicinity of Avon Dam and from Narrabeen west to Silverdale (NPWS 2002a). Therefore, the species is not at the limit of its known distribution within the project area.

How is the proposal likely to affect current disturbance regimes?

In general, *Epacris purpurascens* var. *purpurascens* is directly threatened by urban runoff leading to flooding, erosion, nitrification of soil substrate, altered pH, weed invasion and introduction of plant pathogens. Other threats include altered fire regimes, uncontrolled vehicular access, soil compaction, fill and rubbish dumping and trampling as a result of inappropriate pedestrian access (OEH 2013g).

The presence of urban development surrounding the study area has altered the natural fire regime, increased weed invasion, gross pollutants and trampling. Evidence of all of these disturbances exists near the current population. If there are populations nearby outside the study area, the project would result in shifting these disturbances closer to other areas of suitable habitat, particularly the spread of weeds and increases in trampling. If other suitable habitat is found adjacent to the construction area, there needs to be strict protocols to protect this habitat including induction, signage, fencing and weeds management. This is especially important in areas where the construction site is upslope from potential or actual habitat.

Because the project would remove all habitat and plants within the construction footprint, the proposed actions would result in a significant impact on the disturbance regimes for this species and may have indirect impacts on other potentially suitable habitat and known populations nearby. Adherence to the flora and fauna management plan may minimise impacts to the adjacent populations but this will not mitigate the impacts to the plants within the construction footprint.

How is the proposal likely to affect habitat connectivity?

The project would not fragment the known habitat for *Epacris purpurascens* var. *purpurascens* within the study area. This is because the areas to be cleared are adjacent to the existing road infrastructure. However this may result in greater distances between suitable habitats on either side of the Hills M2 Motorway.

How is the proposal likely to affect critical habitat?

Critical habitat has not been declared for *E. purpurascens* var*. purpurascens*.

Conclusion

Given the number of plants likely to be removed and the removal of habitat within the construction footprint and alteration to the disturbance regimes for this species, this project would result in a significant impact on *E. purpurascens* var*. purpurascens.* Mitigation measures may include relocation of known plants and seedbank. Indirect impacts from shading, trampling and erosion should be managed through an implemented flora and fauna management plan.

F.1.5. Hibbertia superans

Hibbertia superans, which is listed as endangered under the TSC Act, is a low spreading shrub which occurs in open woodland and heathland on sandstone ridgetops, often near the shale/sandstone boundary (OEH 2013i). This species may prefer open disturbed areas, including tracksides, yet is highly sensitive to both frequent and infrequent fire and other disturbance regimes (OEH 2013i).

Hibbertia superans currently occurs at 16 sites from Baulkham Hills to South Maroota in the northern outskirts of Sydney (OEH 2013i). It is also known from Mount Boss, inland from Kempsey. In the Sydney Metropolitan region this species is associated with Cumberland Dry Sclerophyll Forests, Sydney Coastal Dry Sclerophyll Forests and Sydney Hinterland Dry Sclerophyll Forests (OEH 2013i). *Hibbertia superans* is also often associated with other threatened species due to habitat requirements and restricted distribution; these include *Pimelea curviflora* var. *curviflora*, *Darwinia biflora*, *Epacris purpurascens* var. *purpurascens*, *Leucopogon fletcheri* subsp. *fletcheri*, *Acacia bynoeana*, *Eucalyptus* sp. Cattai and *Persoonia hirsuta* (OEH 2013i).

A population of *Hibbertia superans* was identified on the northern side of the Hills M2 Motorway, outside of the construction footprint associated with the integration works area. This species was found in an area of vegetation identified as Coastal Shale-Sandstone Forest, with four plants found. *Hibbertia superans* has been recorded 218 times within ten kilometres of the study area.

How is the proposal likely to affect the lifecycle of a threatened species and/or population?

The seed of *Hibbertia superans* is typically dispersed by ants and the soil seedbank is persistent (OEH 2013i). The project would avoid the removal of the species and the potential soil seed bank and seed dispersers. There is ample suitable habitat adjacent to the construction footprint which, while not surveyed, may also contain this species. Given the project will avoid these plants found and the suitable habitat adjacent to the site, the project will not result in a significant impact on the lifecycle of this species.

How is the proposal likely to affect the habitat of a threatened species, population or ecological community?

While this species is listed in association with the vegetation types Cumberland Dry Sclerophyll Forests, Sydney Coastal Dry Sclerophyll Forests and Sydney Hinterland Dry Sclerophyll Forests occurring on sandstone, it was found in Coastal Shale-Sandstone Forest. This vegetation type is a component of wet sclerophyll forests but is closely related to Sydney Hinterland Dry Sclerophyll Forests. Inside the construction footprint, habitat for this species will be removed. However, this vegetation type exists outside of the construction footprint and is likely to be suitable habitat adjacent to the existing known habitat. Therefore the project is unlikely to significantly affect the habitat of this species.

Does the proposal affect any threatened species or populations that are at the limit of its known distribution?

Hibbertia superans is mainly known from the north-west Sydney region between Baulkham Hills and Wisemans Ferry (NSW Flora Online 2013), with the study area at its southern limit of the current known distribution. Because the project will avoid these plants, there will be no loss to the range extent of this species.

How is the proposal likely to affect current disturbance regimes?

The species listing for *Hibbertia superans* stated that it is threatened by clearing for urban and rural residential development, disturbances to its habitat, weed invasion and road and rail maintenance (OEH 2013i). This species is also highly sensitive to both frequent and infrequent fire and other disturbance regimes (OEH 2013i).

The current fire regime within the construction footprint at the Hills M2 Motorway is one of suppression and there was little evidence of recent fire. The plants were found on the edge of an informal pedestrian track and adjacent to an inspection pit. There were few weeds at this site.

The project would result in clearing and the creation of new edges in potential habitat to the south of the current location. It is unlikely that the fire regime will be altered but there is a chance that there will be increased weed invasion in habitat upslope from the known population. Mitigation measures should be put into place to minimise the impact on the population and adjacent potential habitat. These would be outlined in the flora and fauna management plan and include measures to reduce effects of increased sedimentation, trampling and inadvertent clearing.

How is the proposal likely to affect habitat connectivity?

Given the species is at its southern limit, the project is unlikely to result in the fragmentation of habitat.

How is the proposal likely to affect critical habitat?

No critical habitat has been declared for *Hibbertia superans.*

Conclusion

The impacts to this species is unlikely to be significant given that the project has sought to avoid impacts in the first instance and would manage any potential indirect impacts through implementing a flora and fauna management plan.

F.1.6. Syzygium paniculatum

Syzygium paniculatum is listed as endangered under the TSC Act. This species occupies a narrow coastal area between Bulahdelah and Conjola State Forests in NSW. On the Central Coast, it occurs on Quaternary gravels, sands, silts and clays, in riparian gallery rainforests and remnant littoral rainforest communities (Payne 1997). In the Ourimbah Creek valley, *S. paniculatum* occurs within gallery rainforest with *Alphitonia excelsa, Acmena smithii, Cryptocarya glaucescens, Toona ciliata, Syzygium oleosum* with emergent *Eucalyptus saligna*. At Wyrrabalong NP, *S. paniculatum* occurs in littoral rainforest as a co-dominant *with Ficus fraseri, Syzygium oleosum, Acmena smithii, Cassine australe*, and *Endiandra sieberi*. Payne (1991) reports that the species appears absent from Terrigal formation shales, on which the gully rainforests occur. *S. paniculatum* is summer flowering (November-February), with the fruits maturing in May (OEH 2013 species profile).

S. paniculatum was found at four locations within the study area, three of which occur within the construction footprint. The individuals found during the field survey are planted individuals that have been used in urban landscaping. The national Recovery Plan for this species indicates that there are five metapopulations, none of which intersect with the construction footprint. *S. paniculatum* has been recorded 20 times within ten kilometres of the study area.

How is the proposal likely to affect the lifecycle of a threatened species and/or population?

The *S. paniculatum* individuals encountered in the construction footprint occurred on landscaping adjacent to roads (beside Pennant Hills Road, Carlingford and beside Oakes Road, Carlingford) or in urban gardens / landscaping (western side of northern interchange near Isis Street Wahroonga). Given that these plants have been planted for landscaping, they do not occur in any natural vegetation remnant. Although there are three patches of this species to be removed, the project is unlikely to have a significant impact on this species because the plants do not form part of a natural population, are small in extent and are unlikely to contribute genetic material to other populations of this species.

How is the proposal likely to affect the habitat of a threatened species, population or ecological community?

The project would not impact on habitat for *S. paniculatum*. No littoral or riparian gallery forests are found in and around the patches of *S. paniculatum* found during this study. A small patch (refer to **Table 11**) of Coastal Sandstone Gallery Rainforest is to be cleared as part of this project. This patch did not contain any *S. paniculatum* and the vegetation type exists outside the construction footprint around the vicinity of Darling Mills Creek. Although the project would result in clearing some potential habitat and patches of planted *S. paniculatum*, this is not a significant impact.

Does the proposal affect any threatened species or populations that are at the limit of its known distribution?

This species occupies a narrow coastal area between Bulahdelah and Conjola State Forests in NSW. The project construction footprint occurs wholly within the range and therefore the project would not have a significant effect on a threatened species at the limit of its range.

How is the proposal likely to affect current disturbance regimes?

Disturbance regimes at the sites beside Pennant Hills Road, Carlingford and Oakes Road, Carlingford and on the western side of northern interchange near Isis Street Wahroonga are of fire suppression, stormwater runoff from roadsides, management of the understorey through mowing / slashing and gross pollutants. The project would result in the clearing of three of the four patches of *S. paniculatum* but is

unlikely to affect other disturbance regimes. The project would not have a significant impact on disturbance regimes, other than clearing, that will affect this species.

How is the proposal likely to affect habitat connectivity?

The project would result in clearing three disjunct patches of *S. paniculatum* that exist in an urban matrix and are likely to have been planted. The clearing will not affect habitat connectivity for this species as a whole. At the Hills M2 Motorway integration works area adjacent to the Darling Mills Creek, there is potential habitat for this species, and a small amount of this potential habitat would be cleared. However there is other potential habitat both upstream and downstream of the area to be cleared. This would create a gap between potential habitats but this is not considered to result in a significant impact.

How is the proposal likely to affect critical habitat?

There has not been any critical habitat determinations made for this species.

Conclusion

This assessment concludes that there would be no significant impact to the planted *S. paniculatum* as a result of this project because of the small area of *S. paniculatum* to be cleared, the fact that the plants have been used for landscaping purposes, they do not occur in the natural habitat and are not within the five metapopulations of this species,

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F.1.7. Amphibians

Red-crowned Toadlet

Pseudophryne australis (Red-crowned Toadlet) is listed as vulnerable under the TSC Act. The Red-crowned Toadlet is confined to open forests of the Sydney Basin geological basin, mostly within Triassic Hawkesbury and Narrabeen Sandstones, with the associated vegetation community identified as Sydney Sandstone Ridgetop Woodland, mainly dominated by *Eucalyptus gummifera* and *E. haemastoma* (NSW NPWS 2005a). Breeding habitat in the Sydney metropolitan region has been defined as ephemeral or intermittent, low order drainage lines with a build-up of litter or other debris within heath or eucalypt forest on sandstone (OEH 2013j). The Red-crowned Toadlet will forage within 50 metres of breeding habitat, which is usually found within steep escarpment areas and plateaus, low undulating ranges and outcrops; and restricted to within 100 metres of the ridgetop (OEH 2013j). It can also be found under logs on soil, beneath thick ground litter and in horizontal rock crevices near the ground. This species also favours microhabitats that provide shelter sites, usually under flat sandstone rocks ('bush-rock') that either rest on bare rock or loamy soil.

There have been numerous sightings (314) within ten kilometres of the study area. Potential habitat was identified by during the field survey at tributaries of Cockle Creek at the northern most extent of the project but no targeted surveys were conducted. The tributaries are upstream of the construction footprint however it may be impacted indirectly by the project works near these tributaries. The habitat is surrounded by linear infrastructure and urban development and is outside the construction footprint. This species may be present and targeted surveys will be required to determine its presence.

How is the proposal likely to affect the lifecycle of a threatened species and/or population?

The Red-crowned Toadlet was not detected at the site and breeding habitat was not identified to occur within the construction footprint. A small area of potential habitat exists to the north of the M1 Pacific Motorway within the upper tributaries of Cockle Creek, which would not be impacted by the project.

While the tributaries are downstream of the construction footprint, it may be impacted indirectly through variations in runoff and movement of weed propagules. Measures to mitigate indirect impacts, such as sedimentation as a result of altering flows, should be undertaken to minimise any impacts. These steps would be outlined in a flora and fauna management plan, which includes protocols for dewatering detention basins, control of sedimentation and establishment of suitable alternate habitat.

How is the project likely to affect the habitat of a threatened species, population or ecological community?

Measures to mitigate indirect impacts such as sedimentation as a result of altering flows should be undertaken to minimise any impacts. These steps would be outlined in a flora and fauna management plan, which includes protocols for dewatering detention basins, control of sedimentation and establishment of suitable alternate habitat.

Does the proposal affect any threatened species or populations that are at the limit of its known distribution?

The Red-crowned Toadlet has a distribution from Pokolbin to Nowra and west to Mount Victoria in the Blue Mountains. The species is therefore not at the limit of its known distribution.

How is the proposal likely to affect current disturbance regimes?

The current disturbance regime along the northern interchange consists of no recent fires, weed invasion, rubbish dumping, vegetation trampling and road runoff into the detention basins and watercourses. The project would alter the detention basins. It is unlikely that the project would result in a vastly different disturbance regime than currently exists and therefore no significant impact on this species is expected.

How is the proposal likely to affect habitat connectivity?

Red-crowned Toadlet are not known from within the construction footprint and the most likely habitat is also outside the construction footprint. The project is therefore unlikely to affect habitat connectivity for this species.

How is the proposal likely to affect critical habitat?

Not applicable. Critical habitat has not been declared for this species.

Conclusions

The impact on the habitat of Red-crowned Toadlet is not likely to be significant because the habitat is outside the construction footprint and no potential breeding or foraging habitat is to be impacted.

Measures to mitigate indirect impacts to the Red-crowned Toadlet such as sedimentation and weed invasion should be incorporated into the proposal. These measures would be outlined in a flora and fauna management plan, which would be prepared prior to the commencement of construction

F.1.8. Reptiles

Rosenberg's Goanna

Varanus rosenbergi (Rosenberg's Goanna) is a vulnerable species listed under the TSC Act. It reaches a length of 1.5 metres and is dark grey above, finely spotted with yellow or white, and has paired, blackish cross-bands from the neck to the end of the tail. The pairs of narrow, regular bands around the entire length of the tail is a distinguishing feature, separating it from the more common *V. varius*, (Lace Monitor) which has very wide, light and dark bands towards the tip of the tail. Rosenberg's Goanna occurs on the Sydney Sandstone in Wollemi National Park to the north-west of Sydney, in the Goulburn and ACT regions and near Cooma in the south. It also occurs in South Australia and Western Australia (DECC 2005c). There are 45 records for this species within a ten kilometre radius of the site. The OEH threatened species website includes the following information about Rosenberg's Goanna on its species profile (DECC 2005c):

- Found in heath, open forest and woodland.
- Associated with termites, the mounds of which this species nests in; termite mounds are a critical habitat component.
- Individuals require large areas of habitat.
- Feeds on carrion, birds, eggs, reptiles and small mammals.
- Shelters in hollow logs, rock crevices and in burrows, which they may dig for themselves, or they may use other species' burrows, such as rabbit warrens.
- Runs along the ground when pursued (as opposed to the Lace Monitor, which climbs trees).
- Lays up to 14 eggs in a termite mound; the hatchlings dig themselves out of the mounds.

No Rosenberg's Goanna were found during this study, however there is suitable habitat for the species along the Hills M2 Motorway integration works study area in the vicinity of Darling Mills, Stevenson and Blue Gum Creeks. This area was relatively large in size with connection to vegetation outside the construction footprint, was open forest with large rocky outcrops and overhangs. No rabbit or other warrens were observed in this area and there were no termite mounds were found during this study. Therefore the area at the Hills M2 Motorway integration works study area represents potential habitat for this species but is lacking in the critical habitat component for breeding, namely termite mounds.

How is the proposal likely to affect the lifecycle of a threatened species and/or population?

The project would remove all vegetation and rock outcrops within the construction footprint in the Darling Mills Creek area of the Hills M2 Motorway integration works, where these rocky outcrops occur both north and south of the existing carriageway. No termite mounds, which are critical to the lifecycle of this species, were found in the area to be impacted. Because of this, it is unlikely that the lifecycle of the Rosenberg's Goanna would be impacted by the project.

How is the proposal likely to affect the habitat of a threatened species, population or ecological community?

There is suitable habitat in the Darling Mills Creek area for the Rosenberg's Goanna, although due to the absence of termite mounds, this is unlikely to be breeding habitat. The area to be impacted is steep, forested, adjacent to low flowing waterways and has considerable amounts of rocky outcrops and crevices. While these habitat features are likely to be cleared, there is suitable foraging habitat adjacent to the area to be impacted.

Given that there is no suitable breeding habitat to be impacted and ample foraging habitat nearby, the project is unlikely to have an effect on the habitat of the Rosenberg's Goanna.

Does the proposal affect any threatened species or populations that are at the limit of its known distribution?

Rosenberg's Goanna occurs on the Sydney Sandstone in Wollemi National Park to the north-west of Sydney, in the Goulburn and ACT regions and near Cooma in the south. It also occurs in South Australia and Western Australia. The Hills M2 Motorway integration works are within this range and therefore the project would not affect a species at the limit of its distribution.

How is the proposal likely to affect current disturbance regimes?

Rosenberg's Goanna is affected by habitat loss and fragmentation, removal of habitat elements, such as termite mounds and fallen timber and mortality as the result of roadkill and predation by cats and dogs.

Some foraging habitat and habitat elements such as logs and rock crevices may be removed a result of construction works associated with the Hills M2 Motorway integration works but this is unlikely to affect the species because there is other suitable foraging habitat adjacent to the construction footprint. No termite mounds were found during the study and this is a critical habitat feature for this species.

The impacted area is dissected by the existing Hills M2 Motorway, with large sound walls preventing access to the roadside. Darling Mills Creek passes underneath the Hills M2 Motorway, which is likely to the route chosen by fauna moving in a north-south direction. Given the presence of this access and the existing road corridor, the project is not expected to result in increased roadkill of this species.

The Darling Mills Creek area is abutted by urban development and is dissected by a number of formal and informal walking tracks. Presence of domestic animals such as dogs and cats is highly likely in this area and some dog scats were observed during the survey. The project is not likely to result in an increase in these potential predators.

Overall the project is unlikely to increase the impacts of the current disturbances to this species.

How is the proposal likely to affect habitat connectivity?

The area to be impacted by the project is surrounded by other suitable foraging habitat. The project would not result in fragmentation or isolation of this habitat and therefore is unlikely to affect habitat connectivity of the Rosenberg's Goanna. The project will result in the widening of the existing carriageway and will not fragment the potential habitat that exists both north and south of the Hills M2 Motorway integration works area.

How is the proposal likely to affect critical habitat?

No critical habitat has been determined for Rosenberg's Goanna.

Conclusion

Given that there is no suitable breeding habitat to be impacted and there is ample foraging habitat nearby, and that no impact on connectivity between potential habitats would occur, the project is unlikely to have a significant impact on Rosenberg's Goanna.

F.1.9. Cockatoos and parrots

Glossy Black-Cockatoo

Calyptorhynchus lathami (Glossy Black Cockatoo) is listed as vulnerable under the TSC Act. The Glossy Black-Cockatoo is uncommon although widespread from the central Queensland coast to East Gippsland in Victoria and inland to the southern tablelands and central western plains of NSW, with a small endangered population in the Riverina (OEH 2013e).

The Glossy Black-Cockatoo inhabits open forest and woodlands of the coast and the Great Dividing Range up to 1000 metres in which there are stands of she-oak species providing foraging habitat, particularly where *Allocasuarina littoralis* (Black She-oak) and *A. torulosa* (Forest She-oak) occur (OEH 2013k). The population in the Riverina is associated with hills and rocky rises supporting Drooping She-oak, but also recorded in open woodlands dominated by Belah (*Casuarina cristata*). This species feeds almost exclusively on the seeds of several *Casuarina* and *Allocasuarina* species.

The species is dependent on large hollow-bearing eucalypts for nest sites, which is commonly in a dead spout in a living tree, about 26 centimetres wide and up to 1.4 metres deep (NSW Scientific Committee 2008). In the Sydney metropolitan region important breeding habitat has been defined as tree hollows with a minimum diameter greater than 15 centimetres (OEH 2013e). A single egg is laid between March and May (OEH 2013k).

There are 109 records of the species within the ten kilometre radius Wildlife Atlas search area. There were small patches of *Allocasuarina* along the Hills M2 Motorway integration works. At this site there were hollow bearing trees, which are potential breeding habitat (see AECOM 2014 for details). No Glossy Black Cockatoo were observed during the field survey and no evidence such as crushed cones of sheoak were observed where this tree species was present.

Gang-gang Cockatoo

*Callocephalon fimbriatum (*Gang-gang Cockatoo) is listed as an endangered population in the Hornsby and Ku-ring-gai local government areas and as a vulnerable species under the TSC Act. Gang-gang Cockatoo occurs from southern Victoria through south and central-eastern NSW and up to the Hunter Valley (OEH 2013l). In summer they occur in dense, tall, wet forests of mountains and gullies, as well as alpine woodlands (NSW Scientific Committee 2008). In winter they occur at lower altitudes in drier more open forests and woodlands, particularly box-ironbark assemblages (Shields & Chrome 1992). They can often be found in urban areas in autumn/winter (Simpson & Day 2004).

The endangered population in the Hornsby and Ku-ring-gai local government areas is believed to be largely confined to an area bounded by Thornleigh and Wahroonga in the north, Epping and North Epping in the south, Beecroft and Cheltenham in the west and Turramurra/South Turramurra in the east (OEH 2013e). It is the last known breeding population in the Sydney metropolitan area. The population size is small and estimated to be between 18 to 40 pairs.

Gang-gang Cockatoos feed mostly on seeds of eucalypts and wattles and favour old growth attributes for nesting, roosting and breeding in tree hollows (OEH 2013k, NSW Scientific Committee 2008b). Important breeding habitat in the Sydney metropolitan region has been defined as a tree hollow with a minimum diameter of 10 centimetres (OEH 2013l) and typically occurs in live trees close to water (NSW Scientific Committee 2008). Breeding pairs are thought to show a high fidelity to nesting sites, selecting hollows of a particular shape, position and structure (NSW Scientific Committee 2008).

There are 47 records of the endangered population of Gang-gang and 55 of the species within the ten kilometre radius Wildlife Atlas search. No Gang-gang Cockatoo were recorded during the field survey. There is some potential foraging habitat and potential breeding habitat at the Hills M2 Motorway integration works, the northern interchange. There are hollow bearing trees at these sites. (AECOM 2014)

How is the proposal likely to affect the lifecycle of a threatened species and/or population?

Glossy Black-cockatoos are uncommon, however their range is widespread along the eastern coast and the Great Dividing Range; there is also an isolated population on Kangaroo Island, SA. They prefer rugged uncleared landscapes, inhabiting dry coastal woodlands and forests, open inland woodlands and riparian vegetation where casuarinas provide abundant food. Glossy Black-cockatoos nest in large eucalypt hollows, near other nesting pairs. No Glossy Black Cockatoo were observed during the field survey but there is potential foraging and breeding habitat at the Hills M2 Motorway integration works. The project would result in the clearance of foraging habitat and the removal of hollow bearing trees. Mitigation measures in the flora and fauna management plan outline tree clearance and nest box protocols which would minimise the impact on this species, should they be utilising these sites.

Nevertheless, given that the area to be affected is small, and that the action would occur on the edge of a significantly larger patch of potential foraging and breeding habitat, it is considered that the project would not disrupt a viable local population of Glossy Black Cockatoos such that it would be placed at risk of extinction.

The Gang-gang Cockatoo may forage across the sites because of the occurrence of eucalypts and wattles in the forest and woodland communities. The Gang-gang Cockatoo is known to be seasonally nomadic and there is the possibility that it could forage across the sites on occasion. Small areas of potential foraging habitat for this species would be removed for the project. However, more extensive areas of potential habitat are present, directly adjacent to the site and elsewhere within the locality.

No Gang-gang Cockatoo were observed during the field survey but there is potential foraging and breeding habitat at the Hills M2 Motorway integration works. The project would result in the clearance of foraging habitat and the removal of hollow bearing trees. Mitigation measures in the flora and fauna management plan outline tree clearance and nest box protocols which would minimise the impact on this species, should they be utilising these sites.

Given that Gang-gang are highly mobile and the small amount of habitat proposed for removal, it is considered unlikely that the proposal would impact on this species such that it would place a local population at risk of extinction

How is the proposal likely to affect the habitat of a threatened species, population or ecological community?

For the Glossy Black Cockatoo, it is considered that a small area of foraging habitat may be lost or modified. It is considered that these changes are not likely to be significant over the regional distribution of this species (the Sydney basin bioregion). The project would remove some potential foraging and breeding habitat but there are mitigation measures in place to minimise impacts to this potential habitat. Because there are other areas of potential breeding and foraging habitat nearby, the species is mobile and the mitigation measures in place, the project would not result in a significant impact on the habitat for this species.

An Endangered Population of this Gang-gang Cockatoo is known to occur in the Hornsby and Ku-ring-gai LGAs and therefore it is possible that individuals from this Endangered Population may on occasion

forage throughout sites in these LGAs as this species is known to be seasonally nomadic (Pizzey & Knight 1999). Extensive areas of intact bushland occur throughout the locality and would provide potential habitat for this species. The project would remove some potential foraging and breeding habitat but there are mitigation measures in place to minimise impacts to this potential habitat. Because there are other areas of potential breeding and foraging habitat nearby, the species is mobile and the mitigation measures in place, the project would not result in a significant impact on the habitat for this species. Therefore it is unlikely that the proposal would place the local population of Gang Gang Cockatoos at risk of extinction.

Does the proposal affect any threatened species or populations that are at the limit of its known distribution?

Neither species is at the limit of their known distributions within the construction footprint of this project. Therefore the project would not have a significant impact on a species or population at its range limit.

How is the proposal likely to affect current disturbance regimes?

At the sites within the project construction footprint, disturbance regimes consist of fire suppression, increased runoff due to roads or stormwater outlets, gross pollutants, trampling from walkers and bike riders, noise and light from roadways and urban development and weed incursions. The project would not significantly alter these current disturbance regimes, but may push out these regimes to adjoining potential habitat. However it is unlikely that this would significantly impact these species and population which have not been detected within the construction footprint.

Mitigation measures to limit the impacts of noise and artificial light have been outlined. These measures will include fencing sensitive areas, erection of nest boxes, limitations to clearing, weed management, control of sedimentation and erosion and use of appropriate lighting should night works occur.

Given the current and predicted future disturbances will be similar and that temporary increases in noise and light during construction will be managed, it is unlikely that the disturbances would have a significant impact on Glossy Black Cockatoo, Gang-gang Cockatoo species or endangered population.

How is the proposal likely to affect habitat connectivity?

The project would result in the clearance of potential foraging habitat and the removal of hollow bearing trees. Mitigation measures in the flora and fauna management plan outline tree clearance and nest box protocols which will minimise the impact on this species, should they be utilising these sites. There is other potential foraging habitat for the Glossy Black Cockatoo in the surrounding vegetation at the Hills M2 Motorway integration works, particularly where the construction footprint abuts the Bidjigal Reserve. The areas to be cleared of the potential habitat is small and given the existing linear infrastructure (roads) and gaps in habitat (eg urban development) and that this species is highly mobile, the project is unlikely to have a significant impact on connectivity for this species.

The area of potential habitat for the Gang-gang Cockatoo to be removed for the project is small with respect to the amount of similar habitat available within the locality. This, coupled with the nomadic patterns of the species, suggests that habitat to be would not result in a significant impact to the long-term survival of the species within the locality.

How is the proposal likely to affect critical habitat?

No critical habitat has been determined for these species or endangered population.

Conclusion

There is unlikely to be a significant impact on the species or endangered population. The area of potential habitat for the Gang-gang Cockatoo to be removed for the project is small with respect to the amount of similar habitat available within the locality. This, coupled with the nomadic patterns of the species, suggests that habitat to be removed will not result in a significant impact to this species.

While there was some foraging habitat present, there was no evidence of the Glossy Black Cockatoo utilising this habitat and that the area of potential habitat to be cleared was small relative to the potential habitat remaining in vegetation adjacent to the impact areas at Hills M2 Motorway integration works area. Therefore there is unlikely to be a significant impact on this Glossy Black Cockatoo.

F.1.10. Large Forest Owls

Barking Owl

Ninox connivens (Barking Owl) is listed as vulnerable under the TSC Act. The Barking Owl is found throughout Australia, except for the central arid regions and Tasmania. It is quite common in parts of northern Australia, but is generally considered uncommon in southern Australia. It has declined across much of its distribution in NSW and now occurs only sparsely. It is most frequently recorded on the western slopes and plains. It is rarely recorded in the far west or in coastal and escarpment forests.

The Barking Owl inhabits a variety of habitats such as savannah woodland, open eucalypt forests, wetland and riverine forest, including fragmented remnants and partly cleared farmland. This species is flexible in its habitat use and hunting can extend into closed forest and more open areas. It is sometimes able to successfully breed along timbered watercourses in heavily cleared habitats (eg. western NSW) due to the higher density of prey on these fertile soils (DECC 2005).

The habitat is typically dominated by Eucalypts (often Redgum species), however often dominated by Melaleuca species in the tropics (DECC 2005). It usually roosts in dense foliage in large trees such as River She-oak (*Allocasuarina cunninghamiana*), other Casuarina and Allocasuarina, Eucalyptus, Angophora, Acacia and rainforest species from streamside gallery forests (Debus 1997). During nesting season the male perches in a nearby tree overlooking the hollow entrance (DECC 2005). It usually nests near watercourses or wetlands, in large tree hollows with entrances averaging two to 29 metres above ground, depending on the forest or woodland structure and the canopy height (Debus 1997).

The Barking Owl requires very large permanent territories in most habitats due to sparse prey densities. Territories range from 30 to 200 hectares and birds are present all year. Monogamous pairs hunt over as much as 6000 hectares; with 2000 hectares being more typical in NSW habitats (DECC 2005).

Two or three eggs are laid in hollows of large, old trees including *Eucalyptus camaldulensis*, *E. albens*, *E. polyanthemos* and *E. blakelyi*. Living eucalypts are preferred, though dead trees are also used. Nest sites are used repeatedly over years by a pair, but they may switch sites if disturbed by predators (eg. goannas). Nesting occurs during mid-winter and spring. Young are dependent for several months (DECC 2005).

There were 19 records of this species occurring within ten kilometres of the construction footprint. It is unlikely that the species would breed within the study area, given the landscape is highly fragmented and disturbed and that the range of the species has contracted considerably in NSW, so that it is rarely found east of the Great Divide. During the field survey there was no evidence of Barking Owls, although nesting occurs in winter and spring and the survey was conducted outside this time. The hollow bearing tree survey did find a number of hollow bearing trees, most of which would be too small for this species. Three appropriately sized hollows were found in the Darling Mills Creek area.

Masked Owl

Associated with forest with sparse, open, understorey, typically dry sclerophyll forest and woodland (DECC 2007) and especially the ecotone between wet and dry forest, and non-forest habitat (Environment Australia 2000). Known to utilise forest margins and isolated stands of trees within agricultural land (Hyem 1979) and heavily disturbed forest where its prey of small and medium sized mammals can be readily obtained (Kavanagh & Peake 1993).

There were only 21 records of this species occurring within ten kilometres of the construction footprint. Potential suitable habitat occurs at the Hills M2 Motorway integration works area. This is where there was the greatest concentration of hollow bearing trees. However, most of these hollows are likely to be too small for this species, with only three hollows of appropriate size (AECOM 2014). This species is very sparse in the region and there are no known breeding records south of the Hawkesbury River (Kavanagh 2004). The number of pairs in the locality is unknown. This study has concluded on this basis that this species is unlikely to be breeding in the Darling Mills Creek area.

Powerful Owl

In NSW the Powerful Owl is widely distributed throughout the eastern forests from the coast and inland to the tablelands, within a wide range of wet and dry forest and woodland types. They require large tracts of forest or woodland but can also occur in fragmented landscapes. A key habitat requirement includes a high density of prey, such as arboreal mammals, large birds and flying foxes (Environment Australia 2000, Debus & Chafer 1994). The main prey items are medium-sized arboreal marsupials, particularly the Greater Glider, Common Ringtail Possum and Sugar Glider. Birds comprise about 10 per cent of the diet, with flying foxes important in some areas. As most prey species require hollows and a shrub layer, these are important habitat components for the owl.

By day, the Powerful Owl roosts in dense vegetation comprising species such as *Syncarpia glomulifera* (Turpentine), *Allocasuarina littoralis* (Black She-oak), *Acacia melanoxylon* (Blackwood), *Angophora floribunda* (Rough-barked Apple), *Exocarpos cupressiformis* (Cherry Ballart) and a number of eucalypt species.

Powerful Owls are monogamous and mate for life. Nesting occurs from late autumn to mid-winter, but is slightly earlier in north-eastern NSW (late summer-mid autumn). Large trees with hollows at least 0.5 m deep (Environment Australia 2000) and diameter at breast height of 80 to 240 centimetres that are at least 150 years old are required for nesting. Pairs of Powerful Owls are believed to have high fidelity to a small number of hollow-bearing nest trees and will defend a large home range of 400 to1450 hectares. During the breeding season the male Powerful Owl roosts in a ‘grove’ of up to 20 to30 trees, situated within 100 to 200 metres of the nest tree where the female shelters. Clutches consist of two dull white eggs and incubation lasts approximately 38 days.

It is understood that there are up to 40 to 50 breeding pairs in the Sydney Region and that most forested catchments will contain a pair (BirdLife Australia 2013) and that there is likely to be a breeding pair in the Darling Mills Creek area (Kavanagh 2004).

There are 326 records for Powerful Owl on the Wildlife Atlas within ten kilometres of the construction footprint. The hollow bearing tree survey found that there were only four hollows large enough to support Powerful Owls (AECOM 2014). Three of these hollows are at the Hills M2 Motorway integration works area and one at the northern interchange near Eastbourne Avenue. None of these trees are to be removed and therefore all of the suitable hollows will be retained.

How is the proposal likely to affect the lifecycle of a threatened species and/or population?

The project could impact on the lifecycle of the Masked Owl, Powerful Owl and Barking Owl by reducing the amount of potential foraging habitat. Tree hollows with a diameter greater than 300 millimetres constitute potential primary (breeding) habitat for the Masked, Powerful and Barking Owl. Removal of such habitat may impact the lifecycle of the species by reducing the availability of breeding habitat, which will impact on species fecundity in the local area. The greatest concentration of hollow bearing trees was along the Hills M2 Motorway integration works area, at the northern interchange amongst Blue Gum High Forest (AECOM 2014). No trees with suitable hollows will be removed.

If a Powerful, Masked and/or Barking Owl nesting site occur within the study area, it may be impacted through noise, vibration and artificial light during the construction and operation of the project. DECC 2005 recommend that a buffer of at least 200 metres of native vegetation should be retained around nesting trees or Powerful Owl. The species is known to be extremely sensitive to disturbance around the nest site, particularly during pre-laying, laying and downy chick stages. Nesting occurs from late autumn to mid-winter, and disturbance during these stages may affect breeding success (DECC 2005).

While the project would result in the removal of potential foraging habitat for the Masked, Powerful and Barking Owl, the project has sought in the first instance, to retain trees containing large hollows and areas of high quality foraging habitat. For areas of habitat that cannot be avoided, a Biodiversity Offset Strategy would be prepared to compensate for the loss of habitat as a result of the project.

How is the proposal likely to affect the habitat of a threatened species, population or ecological community?

The project would affect potential foraging/day-time roosting habitat both directly and indirectly. Further discussion of impacts to Masked, Powerful and Barking Owl habitat is contained in the 'lifecycle' question above.

There are a large number of hollow bearing trees that occur within the construction footprint at the Hills M2 Motorway integration works area, the southern interchange, and along the northern interchange. Only four trees are of a suitable size for these forest owls and none of these are to be cleared. No targeted survey was conducted for either species. These surveys should be conducted in winter and early spring to detect their presence and clearly establish whether they are utilising these trees or not. However given the project would retain all hollows of a suitable size, there is unlikely to be a significant impact on breeding habitat.

Does the proposal affect any threatened species or populations that are at the limit of its known distribution?

The Powerful Owl is endemic to eastern and south-eastern Australia, mainly on the coastal side of the Great Dividing Range from Mackay to south-western Victoria (DECC 2005). Therefore the site of the project is not at the limit of the species distribution.

The Barking Owl is found throughout Australia, except for the central arid regions and Tasmania. It is quite common in parts of northern Australia, but is generally considered uncommon in southern Australia. It has declined across much of its distribution in NSW and now occurs only sparsely. It is not at the limit of its distribution at the site of the project.

The greater proportion of records for Masked Owl occurs in NSW (90 per cent of all records). Extends from the coast where it is most abundant to the western plains, excluding the most arid north-western corner. It is not at the limit of its distribution within the study area.

How is the proposal likely to affect current disturbance regimes?

The current disturbance regimes operating within areas of potential habitat for the Masked, Powerful and Barking Owl include:

- Weed invasion into native vegetation communities.
- Noise, vibration and artificial light associated with typical urban areas, including vehicle traffic.
- A general fire regime of fire suppression within bushland areas due to the close proximity of urban areas.
- Highly modified natural drainage through the channelisation and piping of creeks. Where natural waterways remain, they are generally impacted by high weed growth and stormwater pollution including siltation and eutrophication.

In terms of changes to these disturbance regimes as a result of the project and the resultant impacts on the Masked, Powerful and Barking Owl, the project:

- May increase the level of weed invasion by creation of small fragments with increased edges. Construction and operation of the carriageway has the potential to import and distribute weeds species.
- Would increase the level of vegetation clearing due to the construction of tie-in areas and associated infrastructure.
- Would cause a temporary (during construction) and long-term (during operation) increase in noise, vibration and light along the length of the above ground section of the carriageway. This is only likely to impact the owls if a nesting tree is located with 200 metres of the road.
- Is unlikely to change the fire regime of the area which is currently one of fire suppression. High frequency hazard reduction burning may reduce the longevity of individuals by affecting prey availability. Reinstatement of fire regimes to protect habitat is unlikely due to the presence of private land and urban and industrial development along a lot of the project corridor.

Adherence to the flora and fauna management plan would assist in minimising temporary disturbances, while pre-clearance, clearance and nest box protocols for prey items may assist with potential longer term disturbances such as removal of hollow bearing trees.

How is the proposal likely to affect habitat connectivity?

The Powerful and Barking Owl both require large tracts of forest or woodland habitat but the Powerful Owl can occur in fragmented landscapes as well (DECC 2005). Pairs of mating owls are believed to have high fidelity to a small number of hollow-bearing nest trees and will defend a large home range of 1400 hectares to 2000 hectares (DECC 2005). Masked Owls have smaller home ranges, but nonetheless are larger given the size of the area to be cleared. Home ranges are estimated to be between 500 and 1000 hectares for pairs. Given the species are highly mobile, the large area of the landscape that they can occupy and the already highly fragmented landscape within the study area the project is unlikely to result in the loss of previously connected potential habitat for the species.

How is the proposal likely to affect critical habitat?

Not applicable. Critical habitat has not been declared for these species.

Conclusions

A significant impact to Barking Owl is unlikely. This is because there are few records of this species in the locality, with an unknown number of pairs in the northern Sydney region and no hollow bearing trees of appropriate size are to be cleared. The project has sought to avoid removing all hollows of appropriate size.

A significant impact is unlikely to Powerful Owl. All trees with suitably sized hollows would be retained in the study area and none occur within the construction footprint. Although some foraging habitat may be cleared, it is unlikely that the small amount of habitat to be cleared will have a significant impact on the foraging of this species.

There is unlikely to be a significant impact to Masked Owl. This is because of the lack of breeding records of this species south of the Hawkesbury River and the sparse records of this species in the northern Sydney region in general meaning that this species is unlikely to be breeding in the construction footprint. This project may impact on foraging habitat but is unlikely to impact on breeding habitat.

F.1.11. Woodland birds – ground and mid-storey foraging (excluding parrots)

Flame Robin

Petroica phoenicea (Flame Robin) is listed as vulnerable under the TSC Act. Flame Robins are found in a broad coastal band around the south-east corner of the Australian mainland, from southern Queensland to just west of the South Australian border (OEH 2013e). The species is also found in Tasmania.

Flame Robins prefer moist open forests and grassy woodlands for breeding, often on ridges and slopes (OEH 2013e). This species builds an open cup nest made of plant materials and spider webs which are often located near the ground and in sheltered areas ie. shallow cavities in trees, stumps or banks (OEH 2013e). For foraging, this species prefers clearings or areas with open understoreys.

The Flame Robin was not detected during this survey. Also, there were only two records of the species within the ten kilometre Wildlife Atlas search area. There is limited potential habitat available at the Hills M2 Motorway integration works.

Scarlet Robin

Petroica boodang (Scarlet Robin) is listed as vulnerable under the TSC Act. The Scarlet Robin is found from south-east Queensland to south-east South Australia and also in Tasmania and south-west Western Australia. In NSW, it occurs from the coast to the inland slopes. After breeding, some Scarlet Robins disperse to the lower valleys and plains of the tablelands and slopes. Some birds may appear as far west as the eastern edges of the inland plains in autumn and winter (DECC 2005).

The Scarlet Robin lives in dry eucalypt forests and woodlands. The understorey is usually open and grassy with a few scattered shrubs. This species lives in both mature and regrowth vegetation. It may also occur in mallee or wet forest communities, or in wetlands and tea-tree swamps. Scarlet Robin habitat usually contains abundant logs and fallen timber and are features which are considered important (DECC 2005).

The Scarlet Robin breeds on ridges, hills and foothills of the western slopes, the Great Dividing Range and eastern coastal regions; this species is occasionally found up to 1000 metres in altitude. The Scarlet Robin is primarily a resident in forests and woodlands, but some adults and young birds disperse to more open habitats after breeding. In autumn and winter many Scarlet Robins live in open grassy woodlands, and grasslands or grazed paddocks with scattered trees.

Scarlet Robin pairs defend a breeding territory and mainly breed between the months of July and January; they may raise two or three broods in each season. This species' nest is an open cup made of plant fibres and cobwebs and is built in the fork of a tree usually more than two metres above the ground; nests are often found in a dead branch in a live tree, or in a dead tree or shrub. The Scarlet Robin is a quiet and unobtrusive species which is often quite tame and easily approached (DECC 2005).

The Scarlet Robin has not been recorded within the study area. However there are 12 records of the species within the ten kilometres Wildlife Atlas search area. There is potential habitat at the Hills M2 Motorway integration works, especially in the Coastal Shale-Sandstone Forest

Varied Sittella

Daphoenositta chrysoptera (Varied Sittella) is listed as vulnerable under the TSC Act. Varied Sittella has a widespread range across mainland Australia, excluding some areas of the arid interior (Nullarbor, Pilbara and Simpson Desert). The species inhabits eucalypt forests and woodlands, especially rough-barked species and mature smooth-barked gums with dead branches, mallee and *Acacia* woodland (DECC 2005).

The Varied Sittella feeds on arthropods gleaned from crevices in rough bark, dead branches, standing dead trees and from small branches and twigs in the tree canopy. The species builds a cup-shaped nest of plant fibres and cobwebs in an upright tree fork high in the living tree canopy and individuals often re-use the same fork or tree in successive years (DECC 2005).

The Varied Sittella was not been recorded within the study area during the field survey. However there are 23 records of the species within the ten kilometres Wildlife Atlas search area. There is potential suitable habitat for this species at the Hills M2 Motorway integration works.

How is the proposal likely to affect the lifecycle of a threatened species and/or population?

None of the three woodland birds were encountered during the field surveys. There was limited habitat for these species within the project construction footprint and the project would result in the removal of only a relatively small area of vegetation (see **Table 11**) when compared with remaining vegetation adjacent to the disturbance areas (see map series in **Appendix D**). The project would not impact these species directly and therefore is unlikely to have a significant impact on the lifecycle of these three species.

How is the proposal likely to affect the habitat of a threatened species, population or ecological community?

The proposal would result in disturbance to the forests and woodlands with hollow bearing trees, shrubby understorey and trees with flaking bark which represents potential foraging and nesting habitat for these three species. The habitat that would be removed is not likely to be critical habitat for the species. This is due primarily to the relatively small areas of the proposed clearing when considering the extent of surrounding vegetation which constitutes foraging habitat.

While hollow bearing trees are to be removed, this only represents a small proportion of the total mature trees available in the area especially around the Darling Mills Creek area in the Hills M2 Motorway integration works. Mitigation measures include protocols for vegetation clearance including methods to manage tree felling and provision of artificial nest boxes. These measures along with the small vegetated areas to be removed from these sites, the project is unlikely to have a significant impact on these three species.

Does the proposal affect any threatened species or populations that are at the limit of its known distribution?

None of the species are at their range limits within the project construction footprint. Therefore the project will not affect species at the limit of their known distribution.

How is the proposal likely to affect current disturbance regimes?

At the sites within the project construction footprint, disturbance regimes consist of fire suppression, increased runoff due to roads or stormwater outlets, gross pollutants, trampling from walkers and bike riders, noise and light from roadways and urban development and weed incursions. The project would not significantly alter these current disturbance regimes, but may push out these regimes to adjoining potential habitat. However it is unlikely that this will significantly impact these species, which have not been detected within the construction footprint.

Mitigation measures to limit the impacts of noise and artificial light have been outlined. These measures will include fencing sensitive areas, erection of nest boxes, limitations to clearing, weed management, control of sedimentation and erosion and use of appropriate lighting should night works occur.

Given the current and predicted future disturbances will be similar and that temporary increases in noise and light during construction will be managed, it is unlikely that the disturbances would have a significant impact on Flame Robin, Scarlet Robin or Varied Sittella.

How is the proposal likely to affect habitat connectivity?

The project would result in the clearance of potential foraging habitat and the removal of hollow bearing trees. Mitigation measures in the flora and fauna management plan outline tree clearance and nest box protocols which would minimise the impact on this species, should they be utilising these sites. There is other potential foraging habitat for these species in the surrounding vegetation at the Hills M2 Motorway integration works, particularly where the construction footprint abuts the Bidjigal Reserve. The areas to be cleared of the potential habitat are small and given the existing linear infrastructure (roads) and gaps in habitat (eg. urban development) and that these species are mobile, the project is unlikely to have a significant impact on connectivity for these species.

How is the proposal likely to affect critical habitat?

No critical habitat has been declared for Flame Robin, Scarlet Robin or Varied Sittella.

Conclusion

While there was some foraging habitat present, there was no evidence of these species utilising this habitat and that the area of potential habitat to be cleared was small relative to the potential habitat remaining in vegetation adjacent to the impact areas at the Hills M2 Motorway integration works area. Therefore there is unlikely to be a significant impact on these woodland bird species.

F.1.12. Predominantly tree-roosting bats

Yellow-bellied Sheathtail-bat

Saccolaimus flaviventris (Yellow-bellied Sheathtail-bat) is listed as vulnerable under the TSC Act. The Yellow-bellied Sheathtail-bat is a wide-ranging species found across northern and eastern Australia. In the most southerly part of its range, most of Victoria, south-west NSW and adjacent South Australia, it is a rare visitor in late summer and autumn. There are scattered records of this species across the New England Tablelands and North West Slopes.

The Yellow-bellied Sheathtail-bat roosts singly or in groups of up to six, in tree hollows and buildings; in treeless areas they are known to utilise mammal burrows. When foraging for insects, it flies high and fast over the forest canopy, but flies lower in more open country.

This species forages in most habitats across its very wide range, with and without trees; and appears to defend an aerial territory. Breeding has been recorded from December to mid-March, when a single young is born. Seasonal movements are unknown; there is speculation about a migration to southern Australia in late summer and autumn (OEH 2013e).

A preliminary assessment undertaken by ELA in July 2013 identified potential habitat for Yellow-bellied Sheathtail-bat within Blue Gum High Forest across the study area. However, 10 records of the species occur within the study area. Also, the Yellow-bellied Sheathtail-bat was not observed in any field assessments of the study area.

Eastern False Pipistrelle

Falsistrellus tasmaniensis (Eastern False Pipistrelle) is listed as vulnerable under the TSC Act. The Eastern False Pipistrelle is distributed along the south-east coast and ranges of Australia (DECC 2005). Prefers moist habitats with trees taller than 20 metres and habitat with structurally and floristically diverse (DECC 2005). Roosts in tree hollows and bark but has also been found roosting in buildings or under loose bark (DECC 2005). Forages for flying insects near the tree canopy (DECC 2005). It is known to hibernate during winter (DECC 2005).

The Eastern False Pipistrelle was not detected during the field survey but has been recorded 21 times within ten kilometre radius Wildlife Atlas search of the study area.

Eastern Freetail-bat

Mormopterus norfolkensis (Eastern Freetail-bat) is listed as vulnerable under the TSC Act. The Eastern Freetail-bat is found along the east coast of Australia, from southern Queensland to southern NSW (OEH 2013e). However, most records of this species are from dry sclerophyll forest, woodland, swamp forests and mangrove forests east of the Great Dividing Range (OEH 2013e). Individuals have been recorded flying low over a rocky river in rainforest and wet sclerophyll forest and foraging in clearings at forest edges (Environment Australia 2000; Allison & Hoye 1998).

This species primarily roosts in hollows or behind loose bark in mature eucalypts but have been observed roosting under man-made structures (OEH 2013e).

There are 47 records of the species scattered within the ten kilometre radius Wildlife Atlas search area of the project area.

Greater Broad-nosed Bat

Scoteanax rueppellii (Greater Broad-nosed Bat) is listed as vulnerable under the TSC Act The Greater Broad-nosed Bat is associated with moist gullies in mature coastal forest, or rainforest, east of the Great Dividing Range (Churchill, 1998), tending to be more frequently located in more productive tall wet forests (Hoye and Richards 1998, OEH 2013e). Within denser vegetation type's use is made of natural and man-made openings such as roads, creeks and small rivers, where it hawks backwards and forwards for prey (Hoye and Richards 1998). In the Sydney metropolitan region important foraging habitat is defined as riparian corridors and woodland or forest edges (OEH 2013e).

The Greater Broad-nosed Bat usually roosts in tree hollows, but has also been found in buildings (OEH 2013e).

The Greater Broad-nosed Bat was not recorded during the field survey. However, there are 15 records of the species scattered within the ten kilometre radius Wildlife Atlas search area of the project area.

How is the proposal likely to affect the lifecycle of a threatened species and/or population?

The project may impact on the lifecycles of all of the tree-roosting bats through direct impact by removal of suitable breeding tree hollows or indirect impact by the removal/degradation of foraging habitat. Each of the tree-roosting species is known to occur at times or regularly within the 10 kilometre radius of the study area based on recent wildlife atlas records. It is also known that these species require small tree hollows (less than 100 millimetres) or bark or crevices for sheltering or as maternity roosts (DECC 2005) but can potentially use a wide range of hollow sizes. The study area contains suitable hollows at the northern and southern interchanges, and Hills M2 Motorway integration works for tree-roosting bats (see AECOM 2014 for details) and provides foraging habitats. Hollow-bearing trees are an important component in the lifecycle of these species. While these species are known to occasionally utilise man-made structures, tree hollows are most commonly used for breeding purposes. The loss of suitable tree-hollows may limit the ability of this species to successfully breed.

The removal and modification of habitat through fragmentation and degradation may negatively impact the species ability to forage and breed. The Yellow-bellied Sheathtail-bat, Eastern False Pipistrelle and Eastern Freetail-bat forage directly above or below the tree canopy, while the Greater Broad-nosed Bat forages between three to five metres above riparian vegetation. Additionally, the Eastern False Pipistrelle requires a structurally complex habitat with a rich floristic diversity (DECC 2005). Changes to the habitat through fragmentation of suitable foraging habitats and loss of native species diversity may reduce the availability of prey items for the Eastern False Pipistrelle and other tree-roosting bats. Indirect impacts of fragmentation or habitat degradation may reduce the size of the habitat retained and reduce the availability of foraging and breeding resources.

The production of noise during construction and on-going vehicular movements could disturb bats roosting in the vicinity of project. This could be particularly detrimental to tree-roosting bats during spring and summer months, when the Yellow-bellied Sheathtail-bat, Eastern Freetail-bat and Greater Broad-nosed Bats are breeding. The Eastern False Pipistrelle breeds during winter.

Artificial lights including temporary construction lighting and permanent street lighting may cause disturbances during breeding. Previous overseas studies have found that some bats are attracted to higher densities of prey species around artificial lights while other species avoid lights (Jones 2000). The production of noise and light may negatively impact bats with more restricted foraging habitat such as the Greater Broad-nosed Bat. However, there is a lack of research on these potential impacts to be conclusive about potential impacts.

The following mitigation measures are proposed to reduce the disturbance to bats caused by noise and artificial light:

- Artificial lighting should be directed to where it is needed and orientated downwards to avoid light spillage, with baffles or shields installed to direct light below the horizontal plane, at an angle less than 70 degrees. Face artificial light away from areas of native vegetation.
- Use of low-pressure sodium lamps instead of high-pressure sodium or mercury lights should be used. Where mercury lights are used, UV filters should be fitted.
- Reduce the brightness of lights to as low as legally possible.
- Direct amplified speakers downwards and away from areas of native vegetation to minimise disturbance from noise.
- Noise producing equipment should be fitted with noise attenuation devices (mufflers).

The loss of vegetation would result in a decrease in the amount of tree hollows for roosting/breeding and the foraging habitat for the hollow-dependent bats. There are a large number of hollow bearing trees that occur within the construction footprint at the Hills M2 Motorway integration works area, southern interchange, and along the northern interchange.

Adherence to tree clearance protocols and establishment of nest boxes as per the flora and fauna management plan should mitigate impacts to the habitat for these species.

Yellow-bellied Sheathtail-bat, Eastern False Pipistrelle, Eastern Freetail-bat and Greater Broad-nosed Bats are highly mobile species and may forage in adjacent vegetation.

How is the proposal likely to affect the habitat of a threatened species, population or ecological community?

Direct impacts would involve a loss of potential breeding habitat (tree hollows) and a loss of foraging habitat as a result of vegetation removal. Indirect impacts have been estimated to include disturbance to potential breeding sites (any tree hollows less than 100 millimetres diameter within 20 metres of the construction footprint) and potential disturbance to foraging habitat (any vegetation within 50 metres of the construction footprint).

The construction works may deter foraging by tree-roosting bats due to changes in noise, vibration and lights. However, tree-roosting bats are highly mobile and may select alternative habitats if necessary. Suitable habitats for tree-roosting bats near the construction footprint include Bidjigal Reserve.

The development and implementation of a flora and fauna management plan would assist in mitigating indirect impacts and minimising direct impacts for these species, including tree clearance protocols and next box protocols.

Does the proposal affect any threatened species or populations that are at the limit of its known distribution?

All four tree-roosting bats are broadly represented along eastern Australia. The Yellow-bellied Sheathtail-bat is widely distributed across northern and eastern Australia. In the most southerly part of its range, most of Victoria, south-western NSW and adjacent South Australia, it is a rare visitor in late summer and autumn (DECC 2005). There are scattered records of this species across the New England Tablelands and North West Slopes (OEH 2011). This species is not at the limit of it distribution within the project study area.

The Eastern False Pipistrelle is confined to moist habitats along eastern Australia, from southern Queensland to Tasmania (DECC 2005).

The Eastern Freetail-bat is the most restricted of the tree-roosting bats. It is distributed from southern Queensland to southern NSW (DECC 2005).

Finally, the Greater Broad-nosed Bat is found in riparian habitats from the Atherton tablelands in Queensland to north-eastern Victoria (DECC 2005).

Overall, the south eastern distribution for each of these species occurs within the study area. However, each of these species is widely distributed and its range is not limited to the study area.

How is the proposal likely to affect current disturbance regimes?

Current disturbances for tree-roosting bats include:

- Removal of native vegetation: loss of connectivity and suitable foraging and breeding habitat.
- Fragmentation of habitats: isolated habitats prone to other disturbances.
- Infestation of exotic weeds: reduction of prey items and habitat complexity.
- Absence of natural fire regime: resulting in low tree hollow production.

Many of the disturbances that could potentially result from the project are listed as key threats for each of the tree-roosting bats (DECC 2005). The application of pesticides/herbicides is also listed as a key threat for tree-roosting bats. Chemical use for land management practices, such as weed control, may increase with changes to land use. This can impact on bat health and availability of prey insects. It is also possible that impacts to foraging behaviour through noise and vibration disturbances could occur, although limited information is available on these impacts. Species may choose to deter from foraging in areas with high noise and vibration.

A study by Basham (2005) on the response to a range of microbats to urbanisation concluded that the Eastern False Pipistrelle is very sensitive to urbanisation and it is presumed that the Greater Broad-nosed Bat is also very sensitive to urbanisation. Basham (2005) concluded that for the Eastern Freetail-bat and Yellow-bellied Sheathtail Bat there is a paucity of data and that these species responses to urbanisation is unknown,

Despite the current disturbances present along the construction footprint and the potential increases in disturbance during the construction phase, it is unlikely that these regimes would significantly impact these forest bat species.

How is the proposal likely to affect habitat connectivity?

The existing landscape is highly fragmented and reduced to small patches of vegetation with varying condition. Further habitat fragmentation and reduction in patch size would result from the project. Tree-roosting bats are highly mobile and may forage in fragmented habitats and through more open habitats. However, noise generated from vehicular traffic may directly deter tree-roosting bats from foraging in close proximity to the road, even if suitable foraging habitat is available. Given that the project is largely within or adjacent to existing road corridors, this disturbance is unlikely to have a significant effect on the habitat connectivity of these bats.

How is the proposal likely to affect critical habitat?

Not applicable. Critical habitat has not been declared for these species.

Conclusion

The significance assessments were undertaken for all four species and concluded that a significant impact is unlikely to result as part of the project if mitigation measures listed in **section 5** are implemented. These include pre-clearance surveys, tree clearing protocols, installation of nest boxes and potential retention of hollow-bearing trees. A microbat management plan should be developed and implemented to help minimise impacts to these tree dwelling bat species.

F.1.13. Predominantly cave-roosting bats

Eastern Bent-wing Bat

Miniopterus schreibersii oceanensis (Eastern Bent-wing Bat) is listed as vulnerable under the TSC Act. The Eastern Bent-wing Bat occupies a range of forested environments (including wet and dry sclerophyll forests), along the coastal portion of eastern Australia and through the Northern Territory and Kimberley area (subject to subdivision of this species).

This species has a fast, level flight exhibiting swift shallow dives. It forages from just above the tree canopy, to many times the canopy height in forested areas and will utilise open areas where it is known to forage at lower levels. Moths appear to be the main dietary component. This highly mobile species is capable of large regional movements in relation to seasonal differences in reproductive behaviour and winter hibernation. Though individuals often use numerous roosts, it congregates in large numbers at a small number of nursery caves to breed and hibernate.

Although roosting primarily occurs in caves, it has also been recorded in mines, culverts, stormwater channels, buildings and occasionally tree-hollows. This species occupies a number of roosts within specific territorial ranges usually within 300 kilometres of the maternity cave and may travel large distances between roost sites (DECC 2005).

The species has been previously recorded within the twin culverts on Devlins Creek under the Hills M2 Motorway. The Eastern Bent-wing Bat was recorded by AECOM in 2010 at the twin culverts. In addition, there are 162 records of the species scattered within ten five kilometres radius wildlife atlas search area around the project area.

Southern Myotis

Myotis macropus (Southern Myotis) is listed as vulnerable under the TSC Act. The Southern Myotis is found in the coastal band from the north-west of Australia, across the top-end and south to western Victoria. It is rarely found more than 100 kilometres inland, except along major rivers. It will occupy most habitat types such as mangroves, paperbark swamps, riverine monsoon forest, rainforest, wet and dry sclerophyll forest, open woodland and River Red Gum woodland, as long as they are close to water (Churchill 1998).

While roosting (in groups of 10 to 15) is most commonly associated with caves, this species has been observed to roost in tree hollows, amongst vegetation, in clumps of Pandanus, under bridges, in mines, tunnels and stormwater drains (Churchill 1998). However the species apparently has specific roost requirements and only a small percentage of available caves, mines, tunnels and culverts are used (Richards 1998). The species forages over streams and pools catching insects and small fish by raking their feet across the water surface. In NSW, females have one young each year usually in November or December (DECC 2005).

The Southern Myotis was not found during the field survey but has been recorded 20 times within the ten kilometre radius Wildlife Atlas search, scattered throughout the study area.

Large-eared Pied Bat

Chalinolobus dwyeri (Large-eared Pied Bat) is listed as vulnerable under the TSC Act. The Large-eared Pied Bat is found mainly in areas with extensive cliffs and caves, from Rockhampton in Queensland to Bungonia in the NSW Southern Highlands. It is generally rare with a very patchy distribution in NSW. There are scattered records from the New England Tablelands and North West Slopes.

The Large-eared Pied Bat is found in well-timbered areas containing gullies. It frequents low to mid-elevation dry open forest and woodland close to caves, crevices in cliffs, old mine workings and disused mud nests of *Hirundo ariel* (Fairy Martin). The relatively short, broad wing combined with the low weight per unit area of wing indicates manoeuvrable flight. This species probably forages for small, flying insects below the forest canopy.

The Large-eared Pied Bat roosts in caves (near their entrances), crevices in cliffs, old mine workings and in the disused, bottle-shaped mud nests of the Fairy Martin. Females have been recorded raising young in maternity roosts (c. 20-40 females) from November through to January in roof domes in sandstone caves. They remain loyal to the same cave over many years (DECC 2005).

The Large-eared Pied Bat was not recorded during the field survey within the study area. It has only been recorded three times within the ten kilometre radius Wildlife Atlas search of the study area. There are no known breeding roosts in the Sydney region (P. Knock, Ecologist, January 2014 pers comm).

Little Bent-wing bat

Miniopterus australis (Little Bent-wing Bat) is listed as vulnerable under the TSC Act. The Little Bent-wing Bat prefers well-timbered areas including rainforest, wet and dry sclerophyll forests, Melaleuca swamps and coastal forests (Churchill 1998).This species can shelter in a range of structures including culverts, drains, mines and caves. These structures are usually adjacent to large areas of dense vegetation of either wet sclerophyll forest, rainforest or dense coastal banksia scrub are usually found adjacent to caves in which this species is found (OEH 2013e).

The Little Bent-wing Bat has specifically been found to roost in caves, tunnels, tree hollows, abandoned mines, stormwater drains, culverts, bridges and sometimes buildings during the day, and at night forage for small insects beneath the canopy of densely vegetated habitats (OEH 2013e).

The Little Bent-wing Bat was not recorded during the field survey within the study area. It has only been recorded 14 times within the ten kilometre radius Wildlife Atlas search of the study area.

How is the proposal likely to affect the lifecycle of a threatened species and/or population?

The project may impact on the life cycles of Eastern Bent-wing Bats, Large-eared Pied Bats and Southern Myotis by reducing the amount of foraging, roosting and breeding habitat available to the species, or degrading their habitat. These species are predominantly cave-roosting and breeding (Churchill 2008). The project is unlikely to impact on caves. Cave-roosting bats usually require specific cave features for maternity sites. The Eastern Bent-wing Bat requires specific temperature and humidity within communal maternity caves (DECC 2005). The Southern Myotis may also utilise tree-hollows for roosting (DECC 2005), however maternity sites are usually close to water for foraging (DECC 2005). The Large-eared Pied Bat may utilise the same maternity location for consecutive years (DECC 2005). Indirect impacts on caves may adversely affect the lifecycle of the threatened species. Care should be taken to avoid all known maternity caves. Indirect impacts from noise, light and vibrations may impact on the suitability of man-made roosting structures. However, little is known about the indirect impact on these species.

The following mitigation measures are proposed to reduce the disturbance to bats caused by noise and artificial light:

- Artificial lighting should be directed to where it is needed and orientated downwards to avoid light spillage, with baffles or shields installed to direct light below the horizontal plane, at an angle less than 70 degrees. Face artificial light away from areas of native vegetation.

- Use of low-pressure sodium lamps instead of high-pressure sodium or mercury lights should be used. Where mercury lights are used, UV filters should be fitted.
- Reduce the brightness of lights to as low as legally possible.
- Direct amplified speakers downwards and away from areas of native vegetation to minimise disturbance from noise.
- Noise producing equipment should be fitted with noise attenuation devices (mufflers).

Both the Eastern Bent-wing Bat and Large-eared Pied Bat have been identified as species that are negatively impacted by land clearing (Biosis 2002) and therefore, habitat loss in the Sydney Bioregion may impact population size. Clearing of native vegetation for the project may reduce foraging habitats. The indirect impacts associated with the removal of native vegetation include increases in weed dispersal and fragmentation of habitats. These have been discussed in the 'assessment for tree-roosting bats' and are also applicable to the cave breeding bats in terms of foraging habitat.

Given the measures taken to avoid, minimise/manage and offset potential impacts on the lifecycle of Eastern Bent-wing Bat, Large-eared Pied Bat and Southern Myotis, it is unlikely that the project would detrimentally impact on the lifecycles of these species particularly given no direct impact is predicted on breeding habitat. Habitat would be degraded by increased edge effects, as well as temporary and ongoing noise and may influence the way in which bats utilise the study area and immediate surrounds. However, these species are mobile and will be able to move to adjacent patches outside the study area should they be disturbed by indirect impacts.

Adherence to a flora and fauna management plan which would include clearance protocols would help establish whether any of these bat species are present prior to and during construction.

How is the proposal likely to affect the habitat of a threatened species, population or ecological community?

The project would affect the potential foraging and/or roosting habitat of the Eastern Bent-wing Bat, the Large-eared Pied Bat and the Southern Myotis directly. A loss of tree-hollows may also directly impact the Southern Myotis if suitable cave structures are unavailable in habitats. This species also require water bodies such as streams and pools for foraging for insects and fish (DECC 2005). Under the project some clearing of riparian vegetation and creek divergence is required. This may directly impact on foraging and roosting resources for the Southern Myotis.

A colony of Eastern Bent-wing Bat is known to roost in the twin culverts across Devlins Creek under the Hills M2 Motorway. There is also suitable habitat at a culvert near Junction Road at the northern interchange and a culvert near Blue Gum Creek at the Hills M2 Motorway integration works area. Bridges culverts and other man-made structures are often used as roost sites by this species. As these sites are regularly subject to significant noise and vibration levels which do not appear to deter this species, it is unlikely that the Bent-wing Bat colony in the Hills M2 Motorway culverts would be detrimentally impact by the project. Nonetheless, it is recommended the population is monitored during the construction period and adaptive management undertaken to ensure there are no detrimental impacts and the population continues to utilise the culvert. A similar approach was adopted for this species in the northern beaches area, where monthly monitoring over the course of 12 months enabled a plan to minimise impacts of construction to the species. Some of these measures included construction periods being altered by season (summer and spring) when the bats were least likely to be present and diurnal exclusion of works.

Does the proposal affect any threatened species or populations that are at the limit of its known distribution?

The cave-roosting bats are distributed along the east coast of Australia. The study area falls well within the normal distribution for each of these species.

The Eastern Bent-wing Bat occupies a range of forested environments (including wet and dry sclerophyll forests), along the coastal portion of eastern Australia (predominantly east of the divide), and through the Northern Territory and Kimberley area (subject to subdivision of this species) (Churchill 2008; OEH 2011b).

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

The Southern Myotis has a primarily coastal distribution, rarely found more than 100 kilometres inland, although it does occur further inland along major rivers. As the species is primarily coastal, the study area occurs well within its normal distribution.

How is the proposal likely to affect current disturbance regimes?

The project would remove vegetation and fragment habitats used by the Eastern Bent-wing Bat, Large-eared Pied Bat and the Southern Myotis. Existing disturbances that apply to the cave dwelling bats are similar to those of hollow-dependent bats.

Many of the disturbances that could potentially result from the project are listed as key threats to the Eastern Bent-wing Bat, the Large-eared Pied Bat and the Southern Myotis. The application of pesticides and loss of foraging habitat, particularly close to roosting habitat, are listed as key threats to all of the bat species. Disturbances or damage to roosting caves and other roosting sites are listed as key threats to the Eastern Bent-wing Bat, the Large-eared Pied Bat and the Southern Myotis. Predation by cats and foxes are key threats to the Eastern Bent-wing Bat. The Southern Myotis is also threatened by reductions in stream water quality, affecting food resources, and clearing adjacent to food resources (DECC 2005). Adherence to a flora and fauna management plan, which would include measures to mitigate and manage impacts in riparian habitats, should assist in minimising these potential impacts.

How is the proposal likely to affect habitat connectivity?

The potential foraging habitat of the Eastern Bent-wing Bat, the Large-eared Pied Bat and the Southern Myotis would be reduced following the construction of the project. However, these species are mobile species, with the Eastern Bent-wing Bat and the Large-eared Pied Bat migrating large distances to maternity caves and the Eastern Bent-wing Bat foraging up to 65 kilometres away from roost sites in a night (DECC 2005). Thus, while the foraging habitats may be reduced as a result of the project, it would not significantly impact the foraging habitat due to the proximity to adjacent foraging habitat and the small amount of foraging habitat to be removed.

How is the proposal likely to affect critical habitat?

Not applicable. Critical habitat has not been declared for these species.

Conclusion

A significant impact is unlikely to result as part of the project if mitigation measures including the development of a Microbat Management Plan listed in **section 5** are implemented. These measures include monitoring the potential roost sites, establishing alternate habitat and exclusion of works at culverts during breeding season. Additionally the project should seek to retain the culverts that provide potential habitat and that management protocols to minimise harm to bats to be implemented prior to works commencing.

F.1.14. Grey-headed Flying Fox

Pteropus poliocephalus (Grey-headed Flying-fox) are listed as vulnerable under the TSC Act. Grey-headed Flying-fox are found within 200 kilometres of the east coast of Australia, from Bundaberg in Queensland to Melbourne in Victoria. They 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 20 kilometres of a regular food source and are commonly found in gullies, close to water, in vegetation with a dense canopy (DECC 2005).

Individual camps may have tens of thousands of animals and are used for mating, birth and the rearing of young. Annual mating commences in January and a single young is born each October or November. Site fidelity to camps is high with some camps being used for over a century. They travel up to 50 kilometres to forage (DECC 2005).

This species feeds on the nectar and pollen of native trees, in particular *Eucalyptus*, *Melaleuca* and *Banksia*, and fruits of rainforest trees and vines. They also forage in cultivated gardens and fruit crops and can inflict severe crop damage (DECC 2005).

The proposed footprint for the project would not disturb any known flying fox roosting camps. The Grey-headed Flying-fox has been recorded 1222 times within ten kilometres of the study area. Foraging habitat would be lost through the clearing of potential foraging habitat.

How is the proposal likely to affect the lifecycle of a threatened species and/or population?

The project could impact on the life cycle of Grey-headed Flying-fox by reducing the amount of foraging habitat available to the species. Grey-headed Flying-fox are not known to roost or breed within the construction footprint of the project.

The nearest Grey-headed Flying-fox roost or “camp” is located to the east at Gordon, around eight kilometres and at the Parramatta Park bat camp is located south. There are several other camps located throughout the Sydney metropolitan area that are located further from the project alignment. The proposed route includes surface infrastructure along large sections of tunnel.

Grey-headed Flying-fox forage widely on a wide variety of fruits and flowering plants. They have been known to travel up to 50 kilometres from camp during evening foraging (DECC 2005), which is likely to include habitat within the construction footprint.

Areas of habitat that would not be removed could be indirectly impacted by fragmentation and disturbance, thus degrading Grey-headed Flying-fox foraging habitat. No primary habitat (roosting/breeding habitat) would be impacted.

Given that the Grey-headed Flying-Fox is a highly mobile species, with a large foraging range, it is unlikely that this loss of foraging habitat from the project would significantly impact the species lifecycle through a reduction in availability of food sources.

Temporary noise, vibration and artificial light during construction of the project may impact on the foraging behaviour of the species by discouraging foraging close to sources of noise, vibration and light. This would be a short-term impact that should not disrupt the species lifecycle given that it would be within a relatively small area of the species’ total foraging range. During the operation of roads, there may be increased volumes of traffic resulting in more noise and light. However given this species can persist in urban environments where these disturbances exist, it is unlikely that this would affect the lifecycle of this species.

During construction of the project, the foraging habitat for the species may be impacted by artificial light and noise. However, little is known about how the Grey-headed Flying-fox would respond to noise and light and the extent to which they could avoid habitat degraded by these disturbances. Artificial night lighting potentially increases the risk of being killed by a predator, which would include the Powerful Owl, and decreases food consumption by preventing Grey-headed Flying-fox from foraging widely due to predation risks. Given the species has become somewhat habituated to artificial light sources throughout the urban environment, if light was constant and penetrated only a small distance into intact habitat, it is considered unlikely that Grey-headed Flying-fox would be impacted while foraging.

The project would result in the removal of marginal foraging habitat for Grey-headed Flying-fox across the study area. Although some habitat removal is unavoidable, the range of habitats used by foraging Grey-headed Flying-fox suggests that the species would not avoid edge habitats created along the carriageways, particularly in locations with no noise or artificial light.

Given a number of measures are proposed to avoid, mitigate and offset any potential impacts it is considered unlikely that the project would impact on the lifecycle of Grey-headed Flying-fox. Only foraging habitat for the Grey-headed Flying-fox would be impacted. Such habitat is likely to be impacted by fragmentation and increased edge effects, as well as temporary and ongoing noise and artificial light, which may discourage foraging by the Grey-headed Flying-fox. However, Grey-headed Flying-fox are highly mobile and would move to more favourable patches of foraging habitat within the locality, should they be disturbed by noise and light.

How is the proposal likely to affect the habitat of a threatened species, population or ecological community?

The project would affect secondary (foraging) habitat of Grey-headed Flying-fox through direct and indirect impacts. There will be no known disturbance to primary (roosting/breeding) habitat.

Temporary noise, vibration and artificial light during construction of the project may impact on the foraging behaviour of the species by discouraging foraging close to sources of noise, vibration and light. This would be a short-term impact that should not disrupt the species lifecycle given that it would be within a relatively small area of the species' total foraging range. During the operation of roads, there may be increased volumes of traffic resulting in more noise and light. However given this species can persist in urban environments where these disturbances exist, it is unlikely that this would affect the habitat of this species.

Does the proposal affect any threatened species or populations that are at the limit of its known distribution?

Grey-headed Flying-fox are found within 200 kilometres of the east coast of Australia, from Bundaberg in Queensland to Melbourne in Victoria (DECC 2005). The project is well within 200 kilometres of the coast; therefore species is not at the limit of its distribution.

How is the proposal likely to affect current disturbance regimes?

The project would remove vegetation representing foraging habitat for Grey-headed Flying-fox however this is unlikely to have a significant impact on this species. Loss of foraging habitat is listed as a key threat to Grey-headed Flying-fox (DECC 2005).

Existing disturbances within the project study area includes residential development, road traffic and noise, abundant artificial light sources from roads and residential areas and major weed invasion and degradation of native vegetation communities. The project has the potential to increase current

disturbance regimes, particularly the introduction of artificial light during construction. However it is unlikely that the potential increase in these disturbances will have a significant impact on this species.

How is the proposal likely to affect habitat connectivity?

The foraging habitat of Grey-headed Flying-fox is already highly fragmented throughout the Cumberland Plain and the Hornsby Plateau. However, Grey-headed Flying-fox are mobile species and can travel up to 50 kilometres from their roost sites to forage.

Habitat could be fragmented within the study area depending on how the species responded to noise, light and vibration disturbance. The species may avoid areas of habitat degraded by noise and light disturbance. However, given the current use of the area as linear transport corridors or as urban areas, the project is unlikely to have a significant effect on habitat connectivity.

How is the proposal likely to affect critical habitat?

Not applicable. Critical habitat has not been declared for these species.

Conclusion

The project would not impact on the breeding of the Grey-headed Flying-fox because no camps would be disturbed. Given that the Grey-headed Flying-Fox is a highly mobile species, with a large foraging range, it is unlikely that this loss of 5.3 hectares of foraging habitat from the project would significantly impact the species lifecycle through a reduction in availability of food sources.

Temporary noise, vibration and artificial light during construction of the project may impact on the foraging behaviour of the species by discouraging foraging close to sources of noise, vibration and light. This would be a short-term impact that should not disrupt the species lifecycle given that it would be within a relatively small area of the species' total foraging range. During the operation of roads, there may be increased volumes of traffic resulting in more noise and light. However given this species can persist in urban environments where these disturbances exist, it is unlikely that this will have a significant impact on this species.

F.1.15. Eastern Pygmy-possum

Cercartetus nanus (Eastern Pygmy Possum) is listed as vulnerable under the TSC Act. The Eastern Pygmy Possum has a broad south-eastern Australia distribution and is found from southern Queensland to eastern South Australia as well as in Tasmania (OEH 2013e). In NSW, this species occurs in a range of habitat including rainforest through sclerophyll (including Box-Ironbark) forest and woodland to heath (OEH 2013e). However, it appears to prefer woodlands and heath, with the exception in north-eastern NSW where they are most frequently encountered in rainforest.

Pygmy-Possums feed mostly on the pollen and nectar from banksias, eucalypts and understorey plants but will also eat insects, seeds and fruit (Turner & Ward 1995). Small tree hollows are favoured as day nesting sites, however breeding habitat in Sydney metropolitan areas is defined as trees with hollows >2 cm, loose bark of eucalypts or accumulations of shredded bark in tree forks for nesting (OEH 2013e).

The Eastern Pygmy Possum has not been recorded by previous ecological assessments within the study area. However, it has been recorded 72 times within the ten kilometre radius Wildlife Atlas search of the study area. There were foraging species present in the Hills M2 Motorway integration works, especially around the Darling Mills Creek area, where there were more sclerophyllous shrub species. There were hollow bearing trees at this site (AECOM 2014) as well as trees with loose bark.

How is the proposal likely to affect the lifecycle of a threatened species and/or population?

There was limited habitat for Eastern Pygmy Possum within the project construction footprint and the project will result in the removal of only a relatively small area of vegetation (see **Table 11**) when compared with remaining vegetation adjacent to the disturbance areas (see map series in **Appendix D**). The project is unlikely to impact the Eastern Pygmy Possum directly and therefore is unlikely to have a significant impact on the lifecycle of this species.

All records occurred in the Ku-ring-gai Chase National Park or Berowra Valley Regional Park.

How is the proposal likely to affect the habitat of a threatened species, population or ecological community?

The proposal would result in disturbance to the forests and woodlands with hollow bearing trees, shrubby understorey and trees with flaking bark which represents potential foraging and nesting habitat for Eastern Pygmy Possum. The habitat that would be removed is not likely to be critical habitat for the species. This is due primarily to the relatively small areas of the proposed clearing when considering the extent of surrounding vegetation which constitutes foraging habitat.

While hollow bearing trees are to be removed, this only represents a small proportion of the total mature trees available in the area especially around the Darling Mills Creek area in the Hills M2 Motorway integration works area. Mitigation measures include protocols for vegetation clearance including methods to manage tree felling and provision of artificial nest boxes. These measures, along with the small vegetated areas to be removed from these sites, the project is unlikely to have a significant impact on the Eastern Pygmy Possum.

While there is potential habitat for Eastern Pygmy Possum in the Hills M2 Motorway integration works area, there are no records from this area, with most records occurring closer to Ku-ring-gai National Park. Therefore the habitat that is present in the construction footprint is unlikely to be significant for this species.

The project is unlikely to result in a significant impact on potential habitat for the Eastern Pygmy Possum.

Does the proposal affect any threatened species or populations that are at the limit of its known distribution?

The Eastern Pygmy Possum is not at the limit of its known distribution within the construction footprint. Therefore the project will not have a significant impact by reducing a distribution or range.

How is the proposal likely to affect current disturbance regimes?

At the sites within the project construction footprint, disturbance regimes consist of fire suppression, increased runoff due to roads or stormwater outlets, gross pollutants, trampling from walkers and bike riders, noise and light from roadways and urban development and weed incursions. The project would not significantly alter these current disturbance regimes, but may push out these regimes to adjoining potential habitat. However it is unlikely that this will significantly impact the Eastern Pygmy Possum, which has not been detected within the construction footprint.

Mitigation measures to limit the impacts of noise and artificial light have been outlined. These measures would include fencing sensitive areas, erection of nest boxes, limitations to clearing, weed management, control of sedimentation and erosion and use of appropriate lighting should night works occur.

Given the current and predicted future disturbances would be similar and that temporary increases in noise and light during construction will be managed, it is unlikely that the disturbances would have a significant impact on the Eastern Pygmy Possum, as the species is unlikely to occur in the construction footprint but the footprint does support potential habitat.

How is the proposal likely to affect habitat connectivity?

The project would result in the clearance of potential foraging habitat and the removal of hollow bearing trees. Mitigation measures in the flora and fauna management plan outline tree clearance and nest box protocols which would minimise the impact on this species, should they be utilising these sites. There is other potential foraging habitat for these species in the surrounding vegetation at the Hills M2 Motorway integration works area, particularly where the construction footprint abuts the Bidjigal Reserve. However, no recent sightings or records of either species have been listed near the Hills M2 Motorway, with most records for occurring near the Ku-ring-gai Chase National Park.

The areas to be cleared of the potential habitat are small and given the existing linear infrastructure (roads) and gaps in habitat (eg. urban development) and the habitat to be cleared would not result in large gaps between potential habitats, the project is unlikely to have a significant impact on connectivity for the Eastern Pygmy Possum.

How is the proposal likely to affect critical habitat?

No critical habitat has been determined for the Eastern Pygmy Possum.

Conclusion

There is unlikely to be a significant impact on this species. This is because there is limited high quality habitat available for Eastern Pygmy Possum in the construction footprint; and of the potential habitat available in the study area, only a small amount would be cleared.

Appendix G: EPBC impact assessments

G1 EPBC IMPACT ASSESSMENT

The proposed construction footprint of the project supports areas of native vegetation and potential and known habitat for two threatened fauna species. A full list of species recorded within a ten kilometre radius of the construction footprint is found in **Appendix A**, however not all of these species or their habitats are likely to be impacted by the project. Potentially impacted species are listed below. Each species has been assessed for potential impacts that may result from the project.

Threatened Flora

- *Darwinia biflora*
- *Syzygium paniculatum* (Magenta Lilly Pilly)

Threatened Fauna

- Large-eared Pied Bat (*Chalinolobus dwyeri*)
- Grey-headed Flying-Fox (*Pteropus poliocephalus*)

G2 THREATENED FLORA

G.1.1. Darwinia biflora

Darwinia biflora is a threatened species listed as vulnerable under the EPBC Act. Background information on this species is outlined in **Appendix F**.

D. biflora was not recorded during the field survey; however this species has been recorded 904 times within ten kilometres from the Wildlife Atlas search of the study area.

An action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that the project would:

1: Lead to a long-term decrease in the size of an important population of a species

An 'important population' is a population that is necessary for a species' long-term survival and recovery. This may include populations identified as such in recovery plans, 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.

Darwinia biflora was not recorded during the field survey as such it is unlikely that this constitutes an important population.

2: Reduce the area of occupancy of an important population

D. biflora was not recorded during the field survey and therefore the proposed works is unlikely to reduce any known population.

3: Fragment an existing important population into two or more populations

The construction footprint is contained within the known distribution of this species, which is between Maroota, Cowan, North Ryde and Kellyville. The project would not result in the fragmentation of known populations and would not significantly affect habitat connectivity for this species. This is because this species has a relatively large distribution and exists in a fragmented matrix.

4: Adversely affect habitat critical to the survival of a species

D. biflora was not recorded during the field survey and therefore the habitat is not considered to be habitat critical to the survival of this species.

5: Disrupt the breeding cycle of an important population

D. biflora was not recorded during the field survey and as the proposed works will be localised, it is not likely that the breeding cycle of an important population of this species will be disrupted.

6: Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline

Across all sites containing suitable habitat in the construction footprint, disturbance regimes consist of fire suppression, increased runoff due to roads or stormwater outlets and increases in weed incursions. The project would not significantly alter these current disturbance regimes, but may push out these regimes to adjoining potential habitat. However it is unlikely that this would significantly impact this species which has not been detected within the construction footprint.

7: Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat

The proposed project will not result in invasive species that are harmful to *D. biflora* becoming established in their habitat.

8: Introduce disease that may cause the species to decline,

The proposed project is unlikely to result in introducing diseases that may cause *D. biflora* to decline.

9: Interfere substantially with the recovery of the species.

As the project does not involve the removal of individuals of this species and the project would result in the removal of a small area of potential habitat for *D. biflora* and is not limited to the range of this species known habitat the project are unlikely to interfere with the recovery of this species.

Is a significant impact likely to result?

No, based on the above assessment it is concluded that the project is unlikely to have a significant impact on *D. biflora*. As such, no referral to the DotE for assessment and approval by the Environment Minister for the species is necessary.

G.1.2. Syzygium paniculatum

Syzygium paniculatum (Brush Cherry, Magenta Lilly Pilly) is a threatened species listed as vulnerable under the EPBC Act. Background information on this species is outlined in **Appendix F**.

Syzygium paniculatum has been recorded 20 times within ten kilometres from the Wildlife Atlas search of the study area.

An action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that the project would:

1: Lead to a long-term decrease in the size of an important population of a species

An 'important population' is a population that is necessary for a species' long-term survival and recovery. This may include populations identified as such in recovery plans, 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.

Only three *S. paniculatum* patches occur in the construction footprint and they have been planted. As such it is unlikely that this constitutes an important population. None of the patches occur within the five metapopulations identified within the recovery plan.

2: Reduce the area of occupancy of an important population

The planted *S. paniculatum* in the construction footprint do not constitute an important population

3: Fragment an existing important population into two or more populations

The planted *S. paniculatum* in the construction footprint do not constitute an important population

4: Adversely affect habitat critical to the survival of a species

The areas within the construction footprint do not represent the natural habitat for this species and the occurrence of this species on the site is the result of it being planted at this location. The natural habitat for this species is within littoral rainforest and rainforest habitats along creeks. Therefore, the site is not considered to be habitat critical to the survival of this species.

5: Disrupt the breeding cycle of an important population

The planted *S. paniculatum* in the construction footprint do not constitute an important population

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 areas within the construction footprint do not represent the natural habitat for this species and the occurrence of this species on the site is the result of it being planted at this location. The natural habitat for this species is within littoral rainforest and rainforest habitats along creeks. Therefore, the site is not considered to be habitat critical to the survival of this species.

The removal of the *S. paniculatum* is not considered to impact 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

Invasive species such as *Lantana camara* (Lantana) species have been identified as harmful to *S. paniculatum*. Lantana is present within the construction footprint and strategies to minimise introduction of weeds are to be included within a flora and fauna management plan. Given the presence of Lantana already at the site and the intention to minimise new weeds, it is unlikely that there will be a significant impact to *S. paniculatum*.

8: Introduce disease that may cause the species to decline,

Myrtle rust is recognised as a risk to *S. paniculatum*. However, the project would not involve any natural habitat for this species and as such are highly unlikely to introduce disease that will cause the species to decline.

9: Interfere substantially with the recovery of the species.

As the project does not involve any naturally occurring individuals of this species or any natural habitat, the project are unlikely to interfere with the recovery of this species.

Is a significant impact likely to result?

No, based on the above assessment it is concluded that the project is unlikely to have a significant impact on *S. paniculatum*. As such, no referral to the DotE for assessment and approval by the Environment Minister for the species is necessary.

G3 THREATENED FAUNA

G.1.1. Large-eared Pied Bat

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

Large-eared Pied Bat is found in well-timbered areas containing gullies. It frequents low to mid-elevation dry open forest and woodland close to caves, crevices in cliffs, old mine workings and disused mud nests of *Hirundo ariel* (Fairy Martin). The relatively short, broad wing combined with the low weight per unit area of wing indicates manoeuvrable flight. This species probably forages for small, flying insects below the forest canopy.

Large-eared Pied Bat roosts in caves (near their entrances), crevices in cliffs, old mine workings and in the disused, bottle-shaped mud nests of the Fairy Martin. Females have been recorded raising young in maternity roosts (c. 20-40 females) from November through to January in roof domes in sandstone caves. They remain loyal to the same cave over many years (DECC 2005).

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

The Large-eared Pied Bat has not been recorded by previous ecological assessments within the study area, but has been recorded three times within the ten kilometre Wildlife Atlas search, scattered through the study area. One record was from 1992 in Turramurra.

Due to the absence of cliffs, sandstone rock or cave-like crevices that contain the moisture required for roost sites for this species, it is considered unlikely that the study area supports any suitable roosting (primary) habitat. Areas of potential foraging habitat include both woodlands and forests, thus impacts to potential secondary habitat is all native vegetation within the construction footprint. There may also be some indirect impacts, primarily from noise and light. It is proposed to mitigate these potential indirect impacts by directing artificial lighting downwards to where it is needed away from areas of native vegetation, using low-pressure sodium lamps and reducing the brightness to as low as legally possible, directing speakers away from native vegetation, and fitting noise producing equipment with attenuation devices (mufflers).

An action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that the project would:

1. Lead to a long-term decrease in the size of an important population of the species

No. The study area does not contain any known breeding areas and the paucity of records (three) from the wildlife atlas database suggests that the species would rarely pass through the area while foraging/migrating. Therefore, an important population of this species is unlikely to occur.

2. Reduce the area of occupancy of an important population

No. An important population of Large-eared Pied Bat does not occur within the study area.

3. Fragment an existing important population into two or more populations

No. The species is highly mobile and an important population of Large-eared Pied Bat does not occur within the study area.

4. Adversely affect habitat critical to the survival of a species

No. The potential foraging habitat for the species within the study area is not considered to be critical to the species survival.

5. Disrupt the breeding cycle of an important population

No. No breeding habitat will be impacted by the project.

6. Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline

No. The loss of potential foraging habitat from the site is unlikely to cause a decline in the species.

7. Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat

No.

8. Introduce disease that may cause the species to decline, or

No.

9. Interfere substantially with the recovery of the species.

No.

Is a significant impact on the species likely to result?

No.

G.1.2. Grey-headed Flying Fox

Pteropus poliocephalus (Grey-headed Flying-fox) are listed as vulnerable under the EPBC Act. Grey-headed Flying-foxes are found within 200 kilometres of the eastern coast of Australia, from Bundaberg in Queensland to Melbourne in Victoria. They 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 20 kilometres of a regular food source and are commonly found in gullies, close to water, in vegetation with a dense canopy (DECC 2005).

Individual camps may have tens of thousands of animals and are used for mating, birth and the rearing of young. Annual mating commences in January and a single young is born each October or November. Site fidelity to camps is high with some camps being used for over a century. They travel up to 50 kilometres to forage (DECC 2005).

This species feeds on the nectar and pollen of native trees, in particular *Eucalyptus*, *Melaleuca* and *Banksia*, and fruits of rainforest trees and vines. They also forage in cultivated gardens and fruit crops and can inflict severe crop damage (DECC 2005).

The construction footprint for the project would not disturb any known flying fox roosting camps. The nearest Grey-headed Flying-fox roost or “camp” is located to the east at Gordon, around eight kilometres and at the Parramatta Park bat camp is located south. There are several other camps located throughout the Sydney metropolitan area that are located further from the project. The project includes surface infrastructure along large sections of tunnel.

Foraging habitat would be lost through the clearing of potential marginal foraging habitat across the construction footprint. Areas of potential foraging habitat to be cleared have been calculated based on the clearing of native vegetation within the construction footprint. While the species would also forage on cultivated gardens and fruit crops, this has not been included in the analysis; as such foraging habitat is widespread within the Sydney urban area and including such data within the calculation of available regional Grey-headed Flying-fox habitat extent would be problematic. It is anticipated that direct impacts to Grey-headed Flying-foxes would be the loss of up to 12.6 hectares of potential secondary habitat within the construction footprint (note that this figure excludes urban / native and exotics).

An action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that the project would:

1. Lead to a long-term decrease in the size of an important population of the species

No. The project study area does not support a breeding population (camp) of Grey-headed Flying-fox. While there would be some loss of foraging habitat, the species forages widely on a variety of vegetation. Therefore, the study area is unlikely to support an important population of this species and no decline is expected to result in foraging Grey-headed Flying-fox populations.

2. Reduce the area of occupancy of an important population

No. An important population of Grey-headed Flying-fox does not occur within the study area.

3. Fragment an existing important population into two or more populations

No. The species is highly mobile and an important population of Grey-headed Flying-fox does not occur within the study area.

4. Adversely affect habitat critical to the survival of a species

No breeding habitat (camps) would be impacted by the project. There will be some loss of foraging habitat (5.3 hectares) with the camp in closest proximity to the study area located to the east at Gordon, around eight kilometres away. Under the DECC (2009c) Draft National Recovery Plan foraging habitat within a 50 kilometre radius of a roost site with greater than 30,000 individuals is foraging habitat critical to survival. The Gordon camp site can vary in the number of individuals present from zero to 80,000 (Ku-ring-gai Council 2013) and the data for this camp suggests that the camp will vary during the breeding season (summer) between 20,000 and 40,000. Therefore there is foraging habitat present which meets the definition of habitat critical to the survival of the species. However, the amount of loss of habitat is not considered to be significant in terms of the regional context, as from analysis of the Native Vegetation mapping GIS dataset for the Sydney Metropolitan Area (Office of Environment and Heritage 2013m), more than 77,000 hectares of native vegetation were identified as occurring within 50km of the Gordon camp site, noting that this dataset is limited in its extent to the Sydney metropolitan Catchment management Authority area, and thus includes approximately 50% of the native vegetation within 50km of the camp site.

5. Disrupt the breeding cycle of an important population

No. No breeding habitat (camps) would be impacted by the project.

6. Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline

No. The species forages widely across the landscape on a variety of vegetation. The loss of 5.3 hectares of foraging habitat within the project study area is unlikely to cause a decline in the species.

7. Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat

No.

8. Introduce disease that may cause the species to decline, or

No.

9. Interfere substantially with the recovery of the species.

No.

Is a significant impact on the species likely to result?

No.

Appendix H: BioBanking Assessment Technical Information

H.1 Avoiding and minimising impacts to red flag areas

The study area contains the following 'red flags' that will be affected by the proposal:

- 2.81 hectares of Sydney Blue Gum – Blackbutt – Smooth-barked Apple moist shrubby open forest on shale ridges of the Hornsby Plateau, Sydney Basin, which equates to the threatened ecological community (TEC), Blue Gum High Forest in the Sydney Basin Bioregion, listed under the NSW *Threatened Species Conservation Act 1995* (TSC Act) as a critically endangered ecological community.
- 0.10 hectares of Sydney Turpentine Ironbark Forest at the Wilson Road compound in the construction footprint where it exists only as scattered remnant trees. This may equate to the TSC Act listed endangered ecological community.
- *Epacris purpurascens* var. *purpurascens*, as the number considered to be a 'negligible loss' is five individuals, and based on survey performed by Cumberland Ecology (2012), 106 plants would be removed (grand total of both adult and juvenile plants).
- 3.37 hectares of potential habitat for the Gang-gang Cockatoo population in the Hornsby and Ku-ring-gai local government areas, as the number considered to be a 'negligible loss' is zero.

H.2 Catchment Management Authority region, Catchment Management Authority region sub-region and Mitchell Landscape

The entire construction footprint extends across both the **Hawkesbury/Nepean** and **Sydney Metro** Catchment Management Authority (CMA) regions, occurring in the **Cumberland** CMA sub-region for both CMAs and also in the **Pittwater** CMA sub-region in the Hawkesbury Nepean CMA (**Figure 17**).

In the Hawkesbury/Nepean CMA, the Mitchell Landscape that covers the majority of the construction footprint is the **Pennant Hills Ridges**. In the Sydney Metro CMA, it is the **Port Jackson Basin** Mitchell Landscape. The Mitchell Landscapes Version 3 data layer was used for this assessment (Mitchell 2002) (**Figure 18**).

The BioBanking Assessment Methodology (BBAM) (DECC 2009a) states that two separate assessments are required when the construction footprint occurs in more than one CMA region. As a result, separate assessments are required for the Hawkesbury/Nepean and Sydney Metro CMA regions and the vegetation impacted has been entered based on the CMA region in which it is present.

H.3 Assessment circles

Assessment circles with a radius of 1,784 metres (1,000 hectares) and 564 metres (100 hectares) are used to assess the impact of proposals on the surrounding vegetation cover at a landscape and local scale (respectively).

Due to the spread of the proposed development, several 1,000 hectare circles (and therefore one additional 100 hectare circle for each additional 1,000 hectare circle) are required to assess the local and regional impact of the development (**Figure 19**). The BBAM also describes the requirement of at

least one assessment circle for each CMA sub-region that the construction footprint occurs. To reduce the amount of data entry, and consistent with assessments for large infrastructure projects, one circle was entered in the BioBanking Credit Calculator (DECC 2009b) for each CMA sub-region, using the average native vegetation cover for the circles in **Figure 19** for each.

The amount of vegetation within the 100 hectare and 1,000 hectare assessment circles before the development was calculated using ArcGIS using the Native Vegetation of the SMCMA GIS layer (DECCW 2009) (excluding the non-native categories). Where this layer did not cover the whole circle, the gaps were filled in manually. To determine the native vegetation cover after development in the 1,000 hectare circle, the total amount of clearing was subtracted from the average. The development footprint was then used to calculate the amount of vegetation loss for 100 hectare each circle. **Table 23** outlines the vegetation in each circle, before and after development, and the average and associated Native Vegetation Cover Class (per cent) to be entered into the Credit Calculator.

Table 23: Area of vegetation in each assessment circle

Circle	Native Vegetation Cover (Before Development)					Native Vegetation Cover (After Development)				
	1	2	3	4	Average	1	2	3	4	Average
1 000 ha circle	377 ha	237 ha	362 ha	175 ha	288 ha (21-30%)	Total clearing is 5 ha				283 ha (21-30%)
100 ha circle	57 ha	5 ha	9 ha	22 ha	23 ha (21-30%)	56 ha	4 ha	9 ha	15 ha	21 ha (21-30%)

H.4 Connectivity assessment

A connectivity assessment was conducted for the proposal using the technique outlined in the Operational Manual (DECC 2009a). The following aspects were considered:

- The width of the current and future connecting link (**Table 24**)
- The condition of the current and future connecting link (overstorey and mid-storey/ground cover) (**Table 25**)

The proposed development is split across several locations with the majority occurring as a widening of existing roads along the M1 Pacific Motorway and Hills M2 Motorway, or is an expansion of existing disturbed areas. As the 1,000 hectare circles are all adjoining, only one connectivity assessment is required. The same connectivity results for width and condition was applied for each assessment circle, as in section A3. The connection most impacted by the development (and thus the 'primary link') has been identified as running north-south to the east of the M1 Pacific Motorway at the northern end study area.

Connectivity width assessment

The current most limiting width within the corridor is approximately 40 metres, thus falling into the less than 30-100 metre linkage width class (**Figure 20**). As the area of minimum width does not occur within the proposed development it does not reduce the minimum width of this link. Therefore, the proposed development will not result in a change in the linkage width class, remaining unchanged at less than 30-100 metres after development (**Table 24**).

Table 24: Linkage width classes before and after development

	Linkage Width Class (Before Development)	Linkage Width Class (After Development)
Connectivity Value (Width)	>30-100m	>30-100m

Connectivity condition assessment

The connectivity condition assessment was undertaken on woody vegetation as woody vegetation types dominate the construction footprint. Two measures were used to assess the condition of the connection:

- The condition of over-storey vegetation before and after development.
- The condition of ground cover vegetation before and after development.

The vegetation within the link is connected to Ku-ring-gai Chase National Park and so the condition of the overstorey is high. Over-storey vegetation before development has therefore been assessed as Projected Foliage Cover (PFC) at Benchmark. The impact of the proposed development on the average overstorey condition across the entire connection is minimal. It is therefore expected that the average overstorey condition after development will remain the same at PFC at Benchmark.

While it is difficult to estimate the condition of the mid-storey and ground cover through the entire connection, from the field visit and analysis of aerial photos, it is likely that exotic vegetation would be present due to the connection within an urban area. The average condition of the mid-storey/ground cover vegetation before development has been assessed to also be greater than 25 per cent of the lower benchmark (PFC greater than 25 per cent of the Lower Benchmark). As previously described, the impact of the proposed development would be minimal on the condition of the connectivity, and the ground cover after development will remain at PFC greater than 25 per cent of the Lower Benchmark (**Table 25**).

Table 25: Condition of vegetation within the assessment circle before and after development

	Width Class (Before Development)	Width Class (After Development)
Connectivity Value (Overstorey Condition)	PFC at Benchmark	PFC at Benchmark
Connectivity Value (Mid-storey/Ground Cover Condition)	PFC >25% of the Lower Benchmark	PFC >25% of the Lower Benchmark

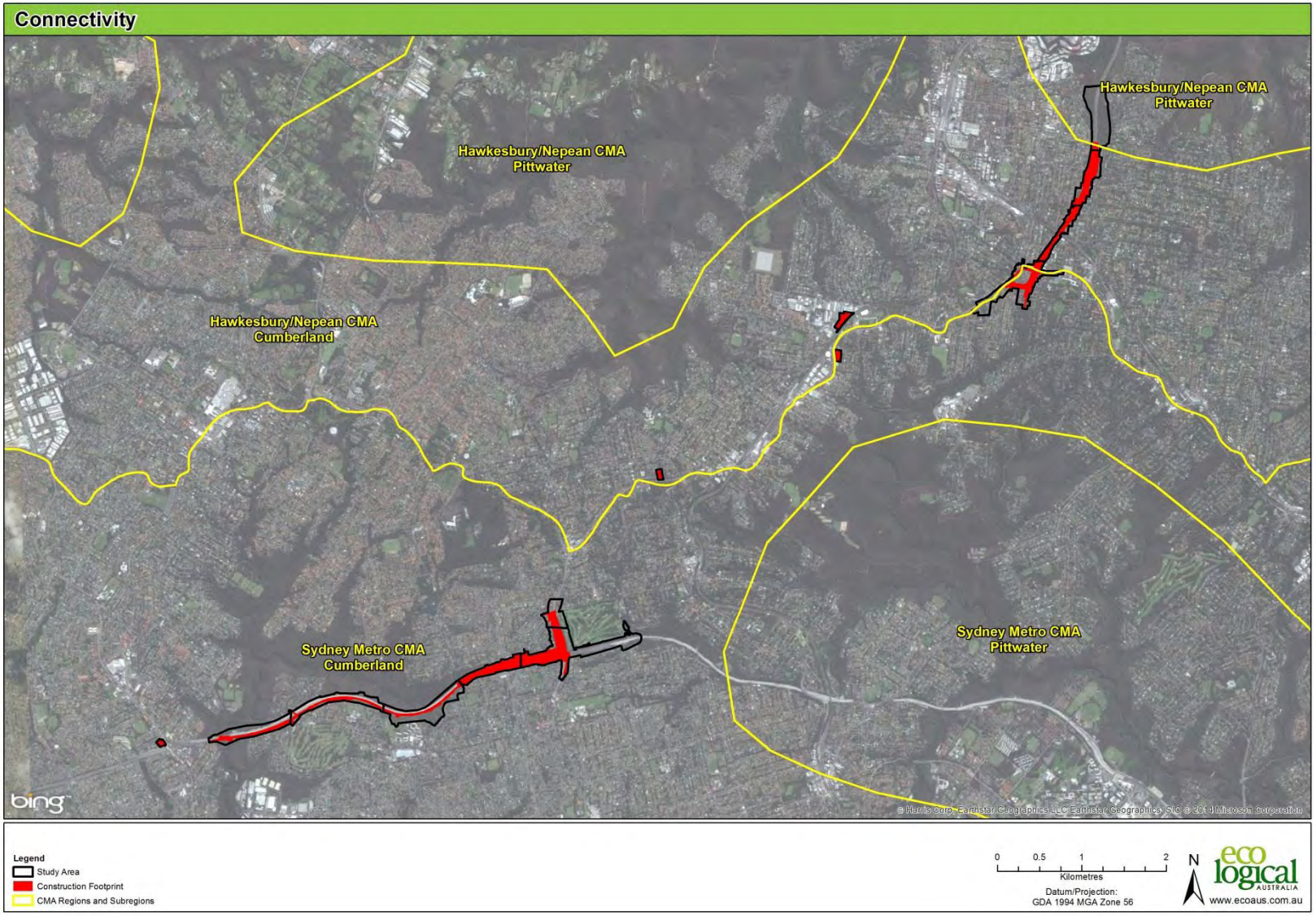

Figure 17: CMA regions and subregions

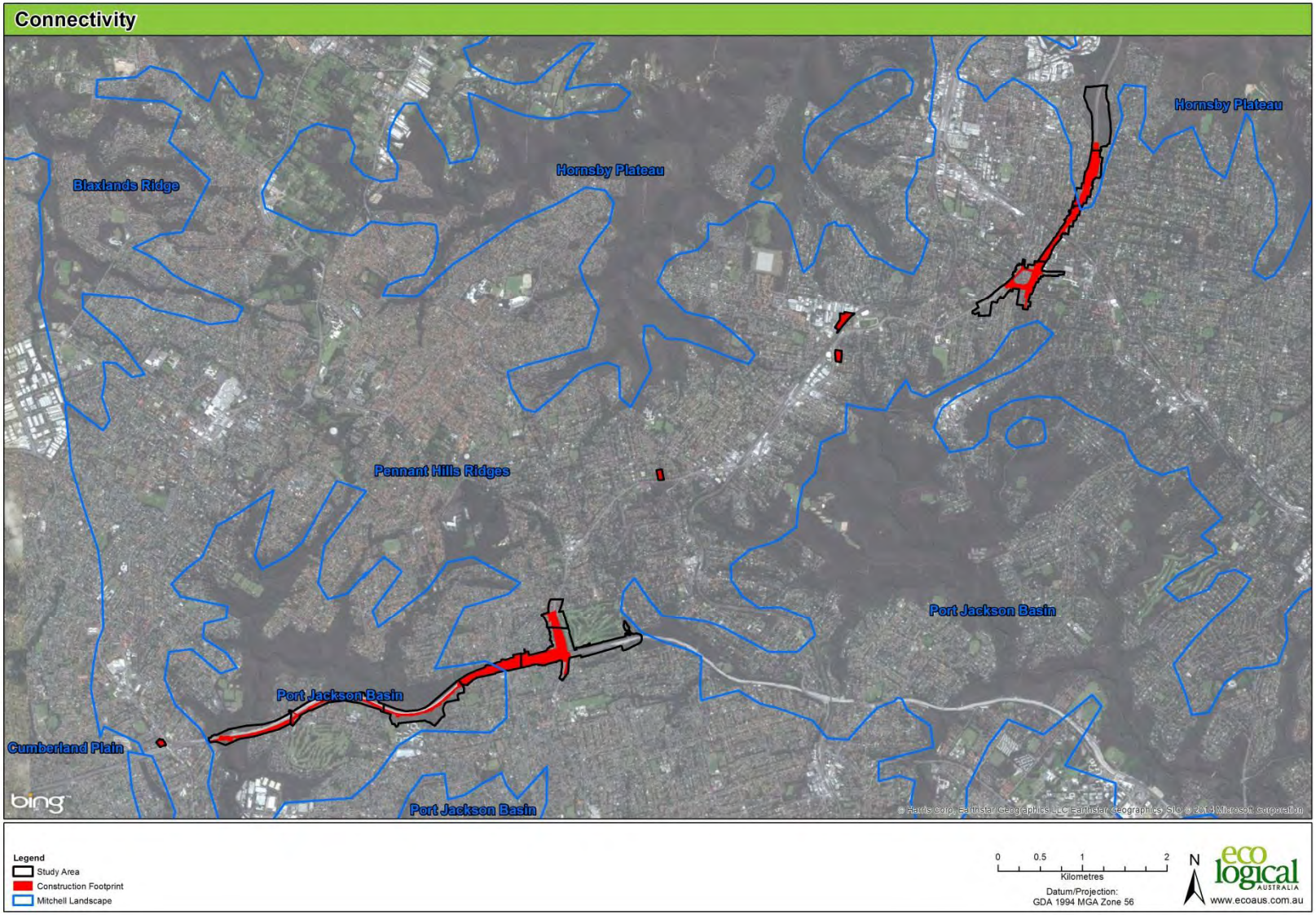

Figure 18: Mitchell Landscapes

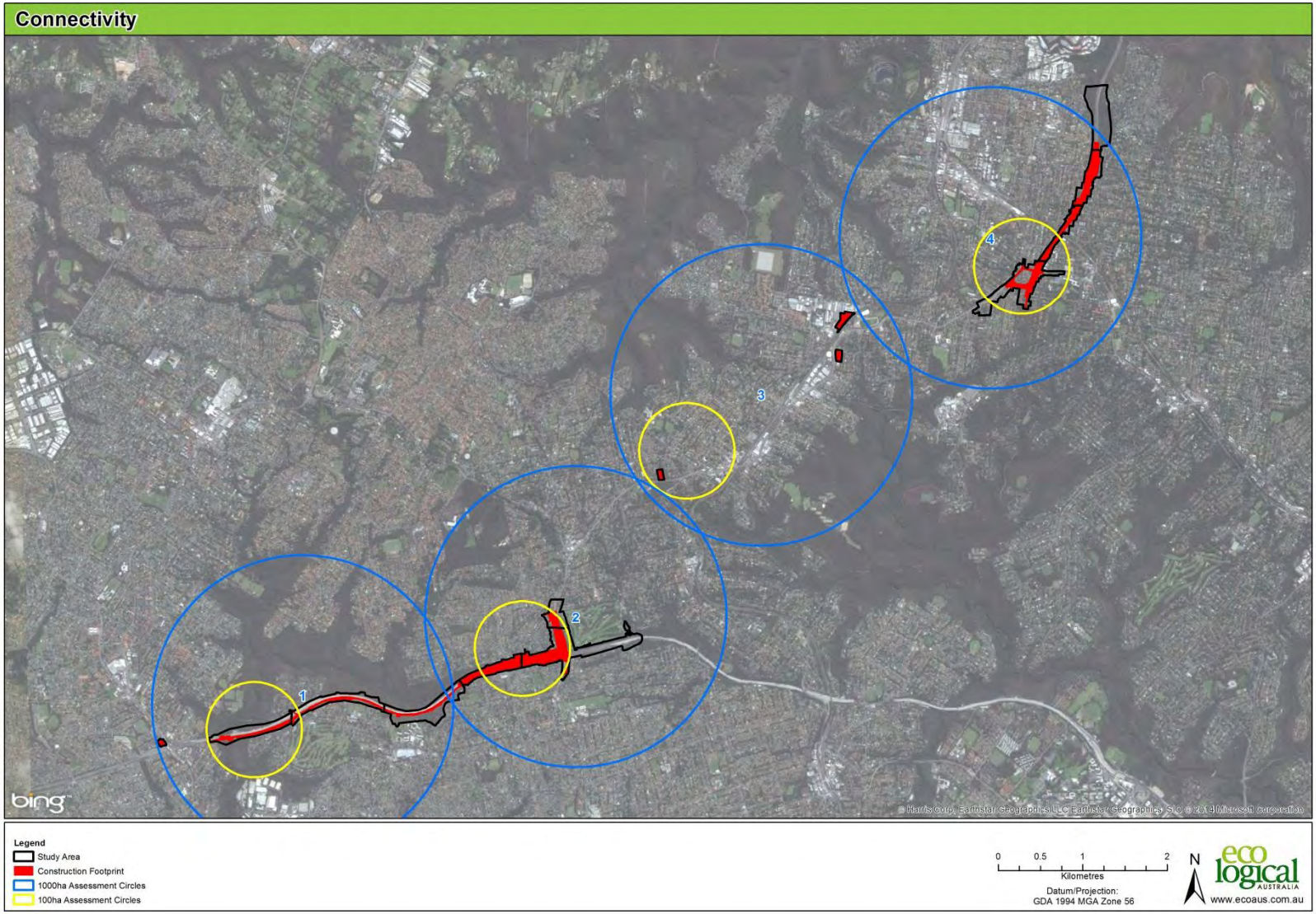

Figure 19: Assessment circles

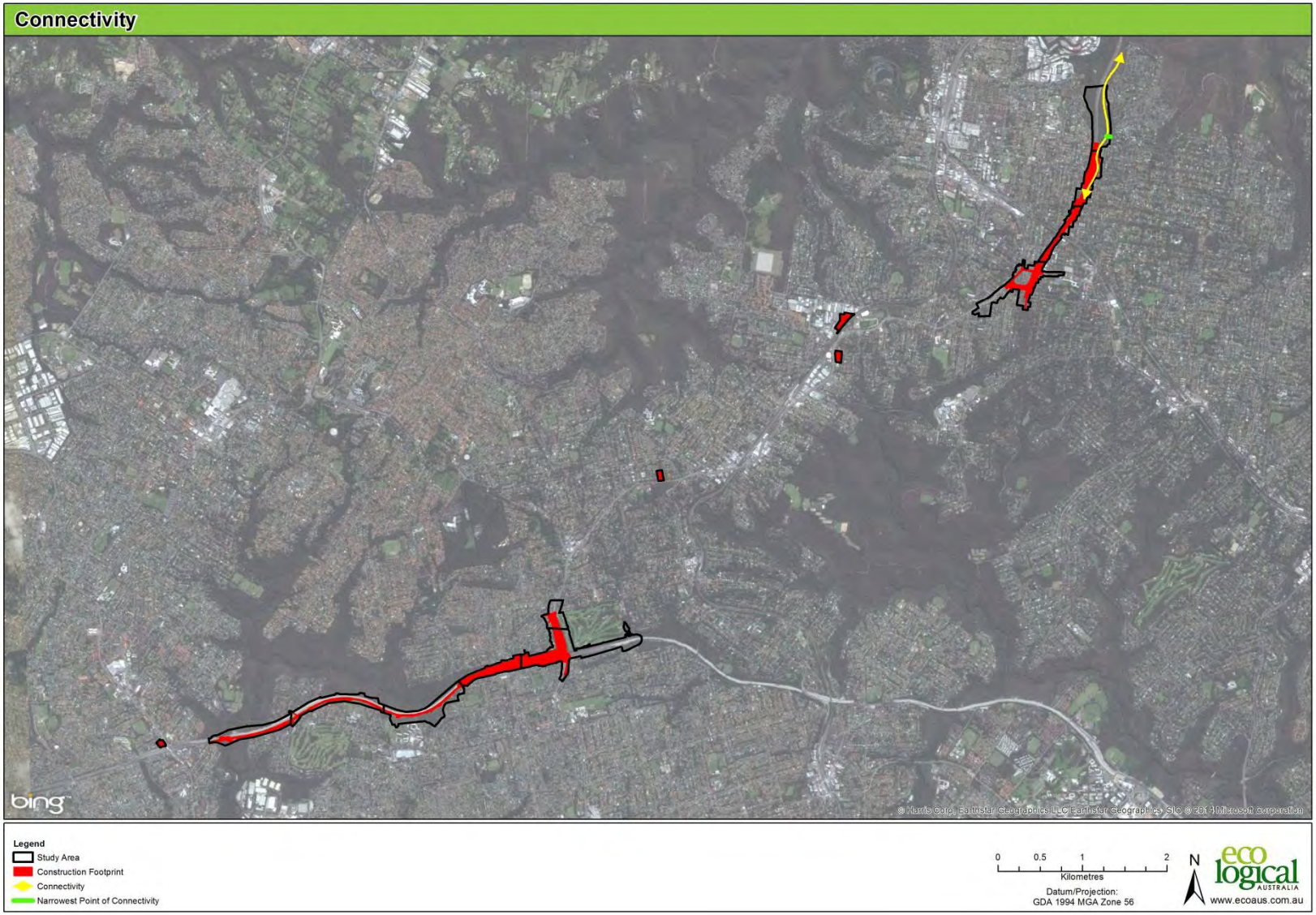

Figure 20: Connectivity assessment

H.5 Geographic and habitat features

The following questions were asked in Step 2 of the calculator (**Table 26**). The answers were obtained from the site visit, and where the assessor was not confident, the default answer of 'Yes' was used.

Table 26: Geographic and habitat questions and answers

Question: Does any part of the development impact on…	Answer
Heath or eucalypt forest on sandstone with a build-up of litter or other debris and containing, or within 40 metres of, ephemeral or intermittent drainage lines	Yes
Land within 40 metres of heath, woodland or forest	Yes
Land situated in damp, disturbed sites	Yes
Lateritic to shaley ridgetops	Yes
Land within 100 metres of emergent aquatic or riparian vegetation	Yes
Land within 250 metres of termite mounds or rock outcrops	Yes
Land within 50 m of sandstone escarpments with hollow-bearing trees, rock crevices or flat sandstone rocks on exposed cliff edges	Yes
Restricted to Lane Cove Bushland Park	No
Land within Blue Mountains National Park in Wollemi CMA subregion	No
Land within Blue Mountains National Park, Mt Wilson and Hazelbrook in Wollemi CMA subregion	No
Confined to Lane Cove Bushland Park	No
Land within Blue Mountains National Park, Hazelbrook in Wollemi CMA subregion	No

H.6 Vegetation zones and Biometric plots

Field validation of the vegetation communities impacted classified the vegetation as communities mapped in the SMCMA (DECCW 2009). These vegetation units were aligned with the 'best fit' Biometric Vegetation Type (BVT) classification system for the Hawkesbury-Nepean and Sydney Metro CMAs (DECC 2008a), which is the vegetation classification system recognised by the Biobanking credit calculator.

Vegetation zones are defined as areas of the same vegetation type and condition within the development area, and have been mapped for the study area. The area of each vegetation zone was determined by intersecting the vegetation types mapped with the proposed construction footprint. Several vegetation zones were less than the required 0.25 hectares as defined in the BBAM, and were merged with other vegetation zones (though see notes for vegetation zone 4). **Table 27** lists the original vegetation communities derived from field validation and the corresponding vegetation zone to which it was assigned and the areas that were excluded from the assessment. The result of the Biometric conversion and analysis of vegetation zone sizes is four BVTs and six 'vegetation zones' were identified within the study area.

Biometric plots were collected as part of the field validation of vegetation communities. As several vegetation zones were required to be combined together as described previously, the plots used in the credit calculations were also modified. **Table 28** lists the number of plots required and used for each vegetation zone. Eighteen biometric plots were entered for vegetation being impacted by the proposal to satisfy the requirements for all vegetation zones according to that required by the Operational Manual. Appendix I provides a summary of plot data by vegetation zone.

Table 27: Mapped vegetation communities and the assigned vegetation zones

Vegetation types (as per Table 11)			BioBanking Vegetation Zones for analysis purposes				
Vegetation community	**Ancillary**	**Total area impacted (ha)**	**Veg Zone No.**	**Biometric Vegetation Type (BVT)**	**Ancillary**	**Total Area (ha)**	**Justification**
Blue Gum High Forest	Moderate	0.37	1	Sydney Blue Gum - Blackbutt - Smooth-barked Apple moist shrubby open forest on shale ridges of the Hornsby Plateau, Sydney Basin	Moderate	0.37	No change
	Poor	2.44	2		Poor	2.44	No change
Coastal Enriched Sandstone Dry Forest	Good	0.01	3	Sydney Peppermint - Smooth-barked Apple - Red Bloodwood shrubby open forest on slopes of moist sandstone gullies, eastern Sydney Basin	Good	0.20*	Area of all these vegetation zones too small for analysis on their own. It is noted that the total size of the vegetation zone (0.20 ha due to rounding of numbers) is less than the minimum vegetation zone size of 0.25 ha. However, professional judgement was used for merging these areas together into one vegetation zone because; (a) the zone is close to the minimum size requirement, (b) these vegetation types are similar in nature, (c) the areas of vegetation were located in close spatial proximity to each other.
Coastal Enriched Sandstone Moist Forest	Good	0.15					
Coastal Sandstone Gallery Rainforest	Moderate	0.03					
Coastal Shale-Sandstone Forest	Good	0.55	4	Red Bloodwood - Smooth-barked Apple shrubby forest on shale or ironstone of coastal plateaux, Sydney Basin	Good	0.55	No change
	Moderate	0.30	5		Moderate	1.35*	No plots completed in ‘poor’ condition Coastal Shale-Sandstone Forest zone and so merged with 'moderate' condition Coastal Shale-Sandstone Forest zone.
	Poor	0.85					
Regeneration - Native	Moderate	0.19					For ‘Regeneration – Native’ zone this was assessed as it was classified as regenerating natives. Due to small size and lack of plot data it was merged with most likely vegetation, which is the Coastal Shale-Sandstone Forest in ‘moderate’ condition

Vegetation types (as per Table 11)			BioBanking Vegetation Zones for analysis purposes				
Vegetation community	**Ancillary**	**Total area impacted (ha)**	**Veg Zone No.**	**Biometric Vegetation Type (BVT)**	**Ancillary**	**Total Area (ha)**	**Justification**
Hinterland Sandstone Gully Forest	Poor	0.72	6	Smooth-barked Apple - Red Bloodwood - Sydney Peppermint heathy open forest in sandstone gullies of western Sydney, Sydney Basin	Poor	0.72	No change
Blue Gum Individuals		0.08	Excluded from assessment			n/a	Identification to be confirmed Limited access available
Sydney Turpentine Ironbark Forest		0.10					No access to vegetation zone possible. Not confirmed as Sydney Turpentine Ironbark Forest.
Syzygium paniculatum (Lilly Pilly)		0.07					Planted vegetation
Regeneration - Exotic		0.56					Non-native vegetation and other cleared areas
Urban Native/Exotic		6.37					
Weeds and Exotics		7.79					
Cleared		34.46					
Not surveyed		4.04					No access possible – vegetation zone could not be assigned
Total		59.09				5.63	

* Some small differences in areas for BioBanking vegetation zones from original vegetation areas due to rounding associated with merger of zones.

Table 28: Vegetation zones and plot requirements

Vegetation zone	Biometric Vegetation Type	Ancillary	Area impacted (ha)	Plots required	Plots collected	Description of plots used
1	Sydney Blue Gum - Blackbutt - Smooth-barked Apple moist shrubby open forest on shale ridges of the Hornsby Plateau, Sydney Basin	Moderate	0.37	1	1	Plot collected in the Blue Gum High Forest 'moderate' zone
2	Sydney Blue Gum - Blackbutt - Smooth-barked Apple moist shrubby open forest on shale ridges of the Hornsby Plateau, Sydney Basin	Poor	2.44	2	3	All plots collected in the Blue Gum High Forest 'poor' zone
3*	Sydney Peppermint - Smooth-barked Apple - Red Bloodwood shrubby open forest on slopes of moist sandstone gullies, eastern Sydney Basin	Good	0.20	1	3	All plots collected in the Coastal Enriched Sandstone Moist Forest 'good' zone. A plot in the Gallery Rainforest was excluded because it was rated as poor condition and only comprised 0.03 ha of the total 0.20 ha zone
4	Red Bloodwood - Smooth-barked Apple shrubby forest on shale or ironstone of coastal plateaux, Sydney Basin	Good	0.55	1	6	All plots collected in the Coastal Shale-Sandstone Forest 'good' zone
5	Red Bloodwood - Smooth-barked Apple shrubby forest on shale or ironstone of coastal plateaux, Sydney Basin	Moderate	1.35	1	1	Plot collected in the Coastal Shale-Sandstone Forest 'moderate' zone (no plots were collected in the 'poor' zone or ‘regeneration native’ zone)
6**	Smooth-barked Apple - Red Bloodwood - Sydney Peppermint heathy open forest in sandstone gullies of western Sydney, Sydney Basin	Poor	0.72	1	4	Plots collected in the Hinterland Sandstone Gully Forest 'good' zone were used. No plots had been collected from the 'poor' zone as these were smaller linear fragments.
			5.63	7	18	

* The transect/plots used for this zone were those from ‘good’ condition vegetation of the same biometric vegetation type, as no transect/plots from ‘poor’ were available.

** This transect/plot was located in a small patch of ‘good’ condition vegetation between areas mapped as ‘poor’ condition, and likely best reflects the actual condition of the ‘poor’ zone

H.7 Threatened species sub-zones

Threatened species sub-zones, which form the base units of vegetation zones, were mapped for the impact area. The threatened species sub-zones allow the entry of data such as adjacent remnant area and patch size for individual vegetation zones.

The majority of the vegetation impacted is adjacent (via the BioBanking 'stepping stone' approach to measuring patch size) to large patches of vegetation with an area of greater than 501 hectares. Using a conservative approach, the adjacent remnant area and patch size for all threatened species sub-zones was entered as the maximum 501 hectares.

H.8 Management zones and site scores

Management zones combine the mapping of vegetation zones with the final development outcome on site. They enable the assessor to increase, or decrease, the number of credits required depending on the final condition of the vegetation after development (DECC 2008b).

It has been assumed that all vegetation within the construction footprint would be completely cleared. The current and future site value scores used in this calculation can be seen in **Table 29**. It has been assumed that all vegetation within the construction footprint would be completely cleared and therefore only one management zone is required for each vegetation zone.

It is also noted that the assessment was conducted across two CMA areas, which required two separate assessments. In this regard vegetation zones 1 – 5 all occur within the Sydney Metro CMA (Cumberland subregion), and vegetation zone 6 occurs within the Hawkesbury Nepean CMA (subregion Cumberland).

Table 29: Management zone site value scores

Management zone	Final management outcome	Vegetation zone	Area impacted (ha)	Current site value	Future site value	Loss in site value
MZ1	Development	1	0.37	52.60	0	52.60
MZ2	Development	2	2.44	42.19	0	42.19
MZ3	Development	3	0.20	45.14	0	45.14
MZ4	Development	4	0.55	71.88	0	71.88
MZ5	Development	5	1.35	22.40	0	22.40
MZ6	Development	6	0.72	34.30	0	34.30

H.9 Ecosystem credit calculations

Table 30 provides a summary of the number of credits required for each vegetation zone.

Table 30: Number of credits required per hectare for each vegetation zone

Vegetation zone	Biometric vegetation type	Ancillary	Area impacted (ha)	Number of credits required
1	Sydney Blue Gum - Blackbutt - Smooth-barked Apple moist shrubby open forest on shale ridges of the Hornsby Plateau, Sydney Basin	Moderate	0.37	25
2	Sydney Blue Gum - Blackbutt - Smooth-barked Apple moist shrubby open forest on shale ridges of the Hornsby Plateau, Sydney Basin	Poor	2.44	138
3	Sydney Peppermint - Smooth-barked Apple - Red Bloodwood shrubby open forest on slopes of moist sandstone gullies, eastern Sydney Basin	Good	0.20	8
4	Red Bloodwood - Smooth-barked Apple shrubby forest on shale or ironstone of coastal plateaux, Sydney Basin	Good	0.55	38
5	Red Bloodwood - Smooth-barked Apple shrubby forest on shale or ironstone of coastal plateaux, Sydney Basin	Moderate	1.35	52
6	Smooth-barked Apple - Red Bloodwood - Sydney Peppermint heathy open forest in sandstone gullies of western Sydney, Sydney Basin	Poor	0.72	19
Total			5.63	280

H.10 Threatened species habitat

A number of threatened species have been recorded or may occur within the study area. Many of the fauna species are included as ecosystem credit species are:

- Glossy Black-Cockatoo.
- Gang-gang Cockatoo (Endangered Population has a separate species credit listing).
- Barking Owl.
- Masked Owl.
- Powerful Owl.
- Flame Robin.
- Scarlet Robin.
- Varied Sittella.
- Yellow-bellied Sheathtail-bat.
- Eastern False Pipistrelle.
- Eastern Freetail-bat.
- Greater Broad-nosed Bat.

A number of threatened species are species credit species. A brief discussion is provided for each of these below using Hawkesbury Nepean CMA BioBanking data from Bionet, in particular using the 'Tg' or 'threatened gain' value from the database which is a key component of calculations:

- *Epacris purpurascens* var*. purpurascens* (Tg 0.6). Loss of 106 individuals (based on a worst case scenario from Cumberland Ecology 2012 counts). As this species has a Tg value of 0.6, a total of 1,767 *Epacris purpurascens* var*. purpurascens* credits would be required. However it is noted that these plants appear to have originated from translocation and seed soil bank propagation from previous Hills M2 Motorway works (which has proven successful), and a similar approach is proposed for this project.
- Red-crowned Toadlet (Tg 0.75). This species is not directly impacted and mitigation measures are proposed to manage potential indirect impacts.
- Rosenbergs Goanna (Tg 0.3). Potential habitat was identified along the Hills M2 Motorway integration works in the vicinity of Darling Mills, Stevenson and Blue Gum Creeks. However, given that there is no critical breeding habitat features such as termite mounds present, and therefore no suitable breeding habitat to be impacted, and ample foraging habitat nearby, no offset calculations have been performed.
- Gang-gang Cockatoo population in the Hornsby and Ku-ring-gai local government areas (Tg 0.5). There is some potential foraging habitat and potential breeding habitat at the Hills M2 Motorway integration works (excluding the Coastal Sandstone Gallery Rainforest) and the northern interchange. All habitat within the Hills M2 Motorway integration works construction footprint, however, is outside of the Hornsby and Ku-ring-gai local government areas, and thus outside the occurrence for the Endangered Population. Within the remainder of the footprint the total area of habitat affected is 3.37 hectares. As this species has a Tg value of 0.5, a total of 67 Gang-gang Cockatoo population in the Hornsby and Ku-ring-gai local government areas credits would be required.

- Eastern Pygmy possum (Tg 0.5). Suitable habitat for this species within the construction footprint is highly limited and fragmented, and therefore no offset calculations have been performed.
- Eastern Bent-wing Bat (Tg breeding = 0.125, Tg foraging = 0.75). With the implementation of the Microbat Management Plan the impacts would be mitigated and therefore offsets are not required.
- Southern Myotis (Tg breeding = 0.125, Tg foraging = 0.45). With the implementation of the microbat management plan the impacts would be mitigated and therefore offsets are not required.
- Large-eared Pied Bat (Tg 0.75). With the implementation of the microbat management plan the impacts will be mitigated and therefore offsets are not required.
- Little Bent-wing Bat (Tg breeding = 0, Tg foraging = 0.75). With the implementation of the microbat management plan the impacts would be mitigated and therefore offsets are not required.

H.11 Indirect impacts

The credit calculator is used to assess only direct impacts to biodiversity (ie. vegetation clearance). Section 2.4 of the Operational Manual (DECC 2009a) requires the Biobank Assessor to 'estimate the number of credits required to offset the impacts resulting from indirect impacts off-site following the implementation of all cost effective on-site measures to minimise these impacts'.

Some indirect impacts from increased run-off, weed encroachment, light and noise may have the potential to affect surrounding vegetated areas, but are anticipated to be minor in nature. The credit calculations therefore have not made any provisions for the retirement of additional credits for indirect impacts.

Appendix I: Biometric Plot Data

Vegetation plot/transect data summarised by the BioBanking vegetation zones (refer to **Appendix H** for details of vegetation zones). It is noted that some plot/transect data collected is not presented as it from site(s) originally considered in the project scoping, but ultimately not incorporated into the final design and study area. Plots labelled from “Plot 1” – “Plot 16” were gathered during the July / August 2103 survey period, “Plot 17” – “Plot 28” during the December 2013 survey period, and “Plot 29” in the April 2014 survey period.

I.1 Vegetation Zone 1

Vegetation Type: Sydney Blue Gum - Blackbutt - Smooth-barked Apple moist shrubby open forest on shale ridges of the Hornsby Plateau, Sydney Basin

Condition: Moderate/Good (Moderate)

Plot Name	NPS	NOS	NMS	NGC (G)	NGC (S)	NGC (O)	EPC	NTH	OR	FL	Easting	Northing	Zone
Plot 29	35	31	23.4	0	0	32	64.4	1	0	19	318791	6262877	56

I.2 Vegetation Zone 2

Vegetation Type: Sydney Blue Gum - Blackbutt - Smooth-barked Apple moist shrubby open forest on shale ridges of the Hornsby Plateau, Sydney Basin

Condition: Moderate/Good (Poor)

Plot Name	NPS	NOS	NMS	NGC (G)	NGC (S)	NGC (O)	EPC	NTH	OR	FL	Easting	Northing	Zone
Plot 10	10	33.2	0	20	0	6	60	1	1	8	324774	6267030	56
Plot 11	1	8.5	0	2	0	0	97.2	0	1	51	324752	6267169	56
Plot 12	6	35	0	0	0	0	83.3	0	1	32	324752	6267120	56

I.3 Vegetation Zone 3

Vegetation Type: Sydney Peppermint - Smooth-barked Apple - Red Bloodwood shrubby open forest on slopes of moist sandstone gullies, eastern Sydney Basin

Condition: Moderate/Good (Good)

Plot Name	NPS	NOS	NMS	NGC (G)	NGC (S)	NGC (O)	EPC	NTH	OR	FL	Easting	Northing	Zone
Plot 9	16	51.5	0	0	0	20	99	0	0.43	10	320142	6263105	56
Plot 19*	42	72.6	3	2	2	42	0	2	0.43	24	317970	6262515	56
Plot 21	32	16.5	62.5	4	0	26	0	0	0.43	0	315213	6261954	56

I.4 Vegetation Zone 4

Vegetation Type: Red Bloodwood - Smooth-barked Apple shrubby forest on shale or ironstone of coastal plateaux, Sydney Basin

Condition: Moderate/Good (Good)

Plot Name	NPS	NOS	NMS	NGC (G)	NGC (S)	NGC (O)	EPC	NTH	OR	FL	Easting	Northing	Zone
Plot 3	47	25	8.5	80	6	16	0	0	0.57	62	317624	6262116	56
Plot 4	39	25.5	44.5	10	2	72	10	1	0.57	16	317678	6262164	56
Plot 5	40	18.5	11.5	56	14	38	2	1	0.57	1	317825	6262210	56
Plot 6	39	18.5	14.5	30	4	18	1.5	0	0.57	12	317946	6262389	56
Plot 7	45	54	11	24	10	36	0	0	0.57	17	317427	6262141	56
Plot 18	56	27.5	17	36	10	12	14.5	0	0.57	8	316479	6262395	56

I.5 Vegetation Zone 5

Vegetation Type: Red Bloodwood - Smooth-barked Apple shrubby forest on shale or ironstone of coastal plateaux, Sydney Basin

Condition: Moderate/Good (Moderate)

Plot Name	NPS	NOS	NMS	NGC (G)	NGC (S)	NGC (O)	EPC	NTH	OR	FL	Easting	Northing	Zone
Plot 8	26	57.5	0	8	0	12	40	0	0	0	317478	6262118	56

I.6 Vegetation Zone 6

Vegetation Type: Smooth-barked Apple - Red Bloodwood - Sydney Peppermint heathy open forest in sandstone gullies of western Sydney, Sydney Basin

Condition: Moderate/Good (Poor)

Plot Name*	NPS	NOS	NMS	NGC (G)	NGC (S)	NGC (O)	EPC	NTH	OR	FL	Easting	Northing	Zone
Plot 13	30	49.5	37	0	2	40	8	1	0	47	325483	6269592	56
Plot 14	37	41.5	0.5	24	0	14	0	0	0	28	325551	6269586	56
Plot 15**	37	26.5	8.5	22	0	28	64.4	0	0	39	325695	6268961	56
Plot 16	30	27	10.6	8	0	70	0	0	0	4	625654	6269333	56

* The transect/plots used for this zone were those from 'good' condition vegetation of the same biometric vegetation type, as no transect/plots from 'poor' were available.

** This transect/plot was located in a small patch of 'good' condition vegetation between areas mapped as 'poor' condition, and likely best reflects the actual condition of the 'poor' zone.

I.7 Plots not associated with BioBanking Calculations

Vegetation Type: Coastal Sandstone Gallery Rainforest (plots data not used in calculations as only 0.03 ha of this vegetation type impacted)

Condition: Moderate/Good (Moderate)

Plot Name	NPS	NOS	NMS	NGC (G)	NGC (S)	NGC (O)	EPC	NTH	OR	FL	Easting	Northing	Zone
Plot 17	25	24.5	57	0	2	6	68.5	3	0.2	23	315312	6261826	56

Vegetation Type: Coastal Enriched Sandstone Dry Forest (plots data not used in calculations as only 0.01 ha of this vegetation type impacted)

Condition: Moderate/Good (Good)

Plot Name	NPS	NOS	NMS	NGC (G)	NGC (S)	NGC (O)	EPC	NTH	OR	FL	Easting	Northing	Zone
Plot 23	49	35	27.5	10	2	38	0	2	0.6	7	315418	6262040	56
Plot 24	45	39	23.5	32	14	22	0	0	0.6	42	315503	6261982	56

CODES: NPS = native plant species; NOS = native over-storey cover; NMS = native mid-storey cover; NGCS = native ground cover (grasses); NGCS = native ground cover (shrubs); NGCO = native ground cover (other); EPC = exotic plant cover; NTH = number of trees with hollows; OR = overstorey regeneration; FL = total length of fallen logs.

Appendix: J Aquatic Rapid Assessment Data and Photographs

Table 31: Rapid assessment of aquatic and riparian habitat

Stream Name	Reach	Hydrology	Physical Form	Water Quality & Aquatic Habitat	Streamside Vegetation	Overall Condition
Arianna Ave Creek	AAC	Creek. 1st order stream (Strahler). Partially modified channel. No barriers to fish passage. Mostly cleared catchment.	Bank slope = >70 degrees. Sheet erosion = <1%. Gully erosion = <1%. Slump erosion = 1-5%. Undercut erosion = 1-5%.	Average wetted channel width = 0-1 m. Minimum depth of water = <10 cm. Maximum depth of water = 20-30 cm. Average depth of water = <10 cm. Velocity = Slow (<0.1 m/s). Turbidity = Moderate. Riffle = 80%. Run = 15%. Pool = 5%. Dominant substrate = Bedrock. Subdominant substrate = Boulder. Instream woody debris = Abundant. Aquatic vegetation richness = 0 species. Native aquatic vegetation abundance = Absent. Fish habitat = Class 4 - Unlikely fish habitat. Not a key fish habitat. Riparian bird habitat = Moderate. Frog habitat = Moderate.	Only small patches of well-separated native vegetation remain. One or more strata dominated by exotic species, high impact species present. One stratum missing or extra, cover within remaining strata 50% lower or higher than reference. Reduced cover (75-50%) of dominant strata, and/or only two age classes present. Some evidence of unnatural loss of debris.	Largely modified

Stream Name	Reach	Hydrology	Physical Form	Water Quality & Aquatic Habitat	Streamside Vegetation	Overall Condition
Blue Gum Creek	BGA	Creek. 1st order stream (Strahler). Partially modified channel. Minor barrier/s with fish passage during all flows. Mostly cleared catchment.	Bank slope = 30-70 degrees. Sheet erosion = <1%. Gully erosion = <1%. Slump erosion = 1-5%. Undercut erosion = 5-25%.	Average wetted channel width = 1-3 m. Minimum depth of water = <10 cm. Maximum depth of water = 20-30 cm. Average depth of water = 10-20 cm. Velocity = Slow (<0.1 m/s). Turbidity = Moderate. Riffle = 5%. Run = 5%. Pool = 90%. Dominant substrate = Cobble. Subdominant substrate = Gravel. Instream woody debris = Occasional. Aquatic vegetation richness = 1 species. Native aquatic vegetation abundance = Rare. Fish habitat = Class 3 - Minimal fish habitat. Not a key fish habitat. Riparian bird habitat = Moderate. Frog habitat = Moderate.	No or little evidence of broad-scale loss of native vegetation. One or more strata dominated by exotic species, high impact species present. Cover within one stratum up to 50% lower or higher than reference. Reduced cover (75-50%) of dominant strata, and only one age class present. Quantities and cover of debris similar to reference.	Moderately modified
Blue Gum Creek	BGB	Creek. 1st order stream (Strahler). Partially modified channel. Minor barrier/s with fish passage during all flows. Mostly cleared catchment.	Bank slope = 30-70 degrees. Sheet erosion = <1%. Gully erosion = <1%. Slump erosion = 5-25%. Undercut erosion = <1%.	Average wetted channel width = 1-3 m. Minimum depth of water = <10 cm. Maximum depth of water = 10-20 cm. Average depth of water = 10-20 cm. Velocity = Slow (<0.1 m/s). Turbidity = Moderate. Riffle = 10%. Run = 10%. Pool = 80%. Dominant substrate = Boulder. Subdominant substrate = Pebble. Instream woody debris = Occasional. Aquatic vegetation richness = 2 species. Native aquatic vegetation abundance = Rare. Fish habitat = Class 3 - Minimal fish habitat. Not a key fish habitat. Riparian bird habitat = Moderate. Frog habitat = Moderate.	About 50% of the native vegetation remains, either in strips or patches. One or more strata dominated by exotic species, high impact species present. One stratum missing or extra, cover within remaining strata 50% lower or higher than reference. Reduced cover (75-50%) of dominant strata, and only one age class present. Some evidence of unnatural loss of debris.	Largely modified

Stream Name	Reach	Hydrology	Physical Form	Water Quality & Aquatic Habitat	Streamside Vegetation	Overall Condition
Butterfield St Creek	BSA	Creek. 1st order stream (Strahler). Partially modified channel. No barriers to fish passage. Mostly cleared catchment.	Bank slope = 30-70 degrees. Sheet erosion = <1%. Gully erosion = <1%. Slump erosion = 1-5%. Undercut erosion = <1%.	Average wetted channel width = 1-3 m. Minimum depth of water = <10 cm. Maximum depth of water = 10-20 cm. Average depth of water = <10 cm. Velocity = Slow (<0.1 m/s). Turbidity = Clear. Riffle = 80%. Run = 10%. Pool = 10%. Dominant substrate = Boulder. Subdominant substrate = Cobble. Instream woody debris = Abundant. Aquatic vegetation richness = 3 species. Native aquatic vegetation abundance = Rare. Fish habitat = Class 4 - Unlikely fish habitat. Not a key fish habitat. Riparian bird habitat = Moderate. Frog habitat = Moderate.	Only small patches of well-separated native vegetation remain. One or more strata dominated by exotic species, high impact species present. One stratum missing or extra, cover within remaining strata 50% lower or higher than reference. Reduced cover (<50%) of dominant strata, and only one age class present. Some evidence of unnatural loss of debris.	Largely modified
Butterfield St Creek	BSB	Creek. 2nd order stream (Strahler). Partially modified channel. Minor barrier/s with fish passage during all flows. Partially cleared catchment.	Bank slope = >70 degrees. Sheet erosion = <1%. Gully erosion = <1%. Slump erosion = 1-5%. Undercut erosion = <1%.	Average wetted channel width = 0-1 m. Minimum depth of water = Dry. Maximum depth of water = 20-30 cm. Average depth of water = <10 cm. Velocity = Slow (<0.1 m/s). Turbidity = Clear. Riffle = 90%. Run = 5%. Pool = 5%. Dominant substrate = Boulder. Subdominant substrate = Cobble. Instream woody debris = Abundant. Aquatic vegetation richness = 0 species. Native aquatic vegetation abundance = Absent. Fish habitat = Class 4 - Unlikely fish habitat. Not a key fish habitat. Riparian bird habitat = Good. Frog habitat = Poor.	Width reduced by up to 1/3 and/or some breaks in continuity. Exotic species present but not dominating any strata, high impact species rare. Cover within one stratum up to 50% lower or higher than reference. Reduced cover (75-50%) of dominant strata, and/or only two age classes present. Some evidence of unnatural loss of debris.	Moderately modified

Stream Name	Reach	Hydrology	Physical Form	Water Quality & Aquatic Habitat	Streamside Vegetation	Overall Condition
Cockle Creek	CCA	Creek. 1st order stream (Strahler). Mostly modified channel. No barriers to fish passage. Mostly cleared catchment.	Bank slope = >70 degrees. Sheet erosion = <1%. Gully erosion = <1%. Slump erosion = <1%. Undercut erosion = <1%.	Average wetted channel width = 1-3 m. Minimum depth of water = <10 cm. Maximum depth of water = 20-30 cm. Average depth of water = 10-20 cm. Velocity = Slow (<0.1 m/s). Turbidity = Clear. Riffle = 20%. Run = 50%. Pool = 30%. Dominant substrate = Bedrock. Subdominant substrate = Cobble. Instream woody debris = Occasional. Aquatic vegetation richness = 0 species. Native aquatic vegetation abundance = Rare. Fish habitat = Class 3 - Minimal fish habitat. Mapped as key fish habitat in the Sydney area. Riparian bird habitat = Moderate. Frog habitat = Moderate.	About 50% of the native vegetation remains, either in strips or patches. Most strata dominated by exotic species, high impact species abundant. More than one stratum completely altered from reference (lost or <10% remaining). Reduced cover (<50%) of dominant strata, and only one age class present. Some evidence of unnatural loss of debris.	Substantially modified
Cockle Creek	CCB	Creek. 1st order stream (Strahler). Unmodified channel. Minor barrier/s with fish passage during all flows. Mostly cleared catchment.	Bank slope = >70 degrees. Sheet erosion = <1%. Gully erosion = <1%. Slump erosion = <1%. Undercut erosion = <1%.	Average wetted channel width = 3-5 m. Minimum depth of water = <10 cm. Maximum depth of water = 30-100 cm. Average depth of water = 20-30 cm. Velocity = Medium (0.1-0.3 m/s). Turbidity = Clear. Riffle = 40%. Run = 30%. Pool = 30%. Dominant substrate = Bedrock. Subdominant substrate = Boulder. Instream woody debris = Abundant. Aquatic vegetation richness = 0 species. Native aquatic vegetation abundance = Absent. Fish habitat = Class 3 - Minimal fish habitat. Mapped as key fish habitat in the Sydney area. Riparian bird habitat = Good. Frog habitat = Moderate.	No or little evidence of broad-scale loss of native vegetation. Exotic species present but not dominating any strata, high impact species rare. Cover within one stratum up to 50% lower or higher than reference. Reduced cover (75-50%) of dominant strata, and/or only two age classes present. Quantities and cover of debris similar to reference.	Moderately modified

Stream Name	Reach	Hydrology	Physical Form	Water Quality & Aquatic Habitat	Streamside Vegetation	Overall Condition
Cockle Creek	CCC	Creek. 1st order stream (Strahler). Unmodified channel. No barriers to fish passage. Mostly cleared catchment.	Bank slope = 30-70 degrees. Sheet erosion = <1%. Gully erosion = <1%. Slump erosion = <1%. Undercut erosion = <1%.	Average wetted channel width = 1-3 m. Minimum depth of water = <10 cm. Maximum depth of water = 30-100 cm. Average depth of water = 20-30 cm. Velocity = Medium (0.1-0.3 m/s). Turbidity = Clear. Riffle = 40%. Run = 30%. Pool = 30%. Dominant substrate = Boulder. Subdominant substrate = Cobble. Instream woody debris = Abundant. Aquatic vegetation richness = 0 species. Native aquatic vegetation abundance = Absent. Fish habitat = Class 2 - Moderate fish habitat. Mapped as key fish habitat in the Sydney area. Riparian bird habitat = Excellent. Frog habitat = Good.	No or little evidence of broad-scale loss of native vegetation. Vegetation predominantly native, few weeds and no high impact species. Number of strata and cover within each similar to reference. Dominant strata with reference level of cover and at least three age classes present (juveniles, sub-adults and adults). Quantities and cover of debris similar to reference.	Slightly modified
Cockle Creek	CCD	Creek. 2nd order stream (Strahler). Unmodified channel. Minor barrier/s with fish passage during all flows. Mostly cleared catchment.	Bank slope = 30-70 degrees. Sheet erosion = <1%. Gully erosion = <1%. Slump erosion = <1%. Undercut erosion = <1%.	Average wetted channel width = 3-5 m. Minimum depth of water = <10 cm. Maximum depth of water = >100 cm. Average depth of water = 20-30 cm. Velocity = Medium (0.1-0.3 m/s). Turbidity = Clear. Riffle = 40%. Run = 20%. Pool = 40%. Dominant substrate = Cobble. Subdominant substrate = Cobble. Instream woody debris = Abundant. Aquatic vegetation richness = 0 species. Native aquatic vegetation abundance = Absent. Fish habitat = Class 2 - Moderate fish habitat. Mapped as key fish habitat in the Sydney area. Riparian bird habitat = Excellent. Frog habitat = Good.	No or little evidence of broad-scale loss of native vegetation. Exotic species present but not dominating any strata, high impact species rare. Cover within one stratum up to 50% lower or higher than reference. Reduced cover (75-50%) of dominant strata, and/or only two age classes present. Quantities and cover of debris similar to reference.	Slightly modified

Stream Name	Reach	Hydrology	Physical Form	Water Quality & Aquatic Habitat	Streamside Vegetation	Overall Condition
Coups Creek	COA	Creek. 2nd order stream (Strahler). Some modification channel. Numerous low-flow barriers without fish passage. Mostly cleared catchment.	Bank slope = 30-70 degrees. Sheet erosion = <1%. Gully erosion = <1%. Slump erosion = 1-5%. Undercut erosion = 1-5%.	Average wetted channel width = 1-3 m. Minimum depth of water = Dry. Maximum depth of water = 30-100 cm. Average depth of water = <10 cm. Velocity = Slow (<0.1 m/s). Turbidity = Clear. Riffle = 60%. Run = 20%. Pool = 20%. Dominant substrate = Bedrock. Subdominant substrate = Cobble. Instream woody debris = Abundant. Aquatic vegetation richness = 0 species. Native aquatic vegetation abundance = Absent. Fish habitat = Class 3 - Minimal fish habitat. Not a key fish habitat. Riparian bird habitat = Excellent. Frog habitat = Good.	No or little evidence of broad-scale loss of native vegetation. Exotic species present but not dominating any strata, high impact species rare. Cover within one stratum up to 50% lower or higher than reference. Reduced cover (75-50%) of dominant strata, and/or only two age classes present. Quantities and cover of debris similar to reference.	Moderately modified
Darling Mills Creek	DMA	Creek. 4th order stream (Strahler). Some modification channel. No barriers to fish passage. Mostly cleared catchment.	Bank slope = 30-70 degrees. Sheet erosion = <1%. Gully erosion = <1%. Slump erosion = <1%. Undercut erosion = <1%.	Average wetted channel width = 3-5 m. Minimum depth of water = <10 cm. Maximum depth of water = 30-100 cm. Average depth of water = 20-30 cm. Velocity = Slow (<0.1 m/s). Turbidity = Clear. Riffle = 10%. Run = 10%. Pool = 80%. Dominant substrate = Sand. Subdominant substrate = Gravel. Instream woody debris = Occasional. Aquatic vegetation richness = 2 species. Native aquatic vegetation abundance = Rare. Fish habitat = Class 2 - Moderate fish habitat. Type 1 key fish habitat. Riparian bird habitat = Excellent. Frog habitat = Good.	No or little evidence of broad-scale loss of native vegetation. One or more strata dominated by exotic species, high impact species present. Cover within one stratum up to 50% lower or higher than reference. Dominant strata with reference level of cover and at least three age classes present (juveniles, sub-adults and adults). Quantities and cover of debris similar to reference.	Moderately modified

Stream Name	Reach	Hydrology	Physical Form	Water Quality & Aquatic Habitat	Streamside Vegetation	Overall Condition
Darling Mills Creek	DMB	Creek. 4th order stream (Strahler). Unmodified channel. No barriers to fish passage. Mostly cleared catchment.	Bank slope = 30-70 degrees. Sheet erosion = <1%. Gully erosion = <1%. Slump erosion = <1%. Undercut erosion = <1%.	Average wetted channel width = 5-8 m. Minimum depth of water = <10 cm. Maximum depth of water = 30-100 cm. Average depth of water = 30-100 cm. Velocity = Slow (<0.1 m/s). Turbidity = Clear. Riffle = 5%. Run = 5%. Pool = 90%. Dominant substrate = Cobble. Subdominant substrate = Gravel. Instream woody debris = Occasional. Aquatic vegetation richness = 2 species. Native aquatic vegetation abundance = Rare. Fish habitat = Class 2 - Moderate fish habitat. Type 1 key fish habitat. Riparian bird habitat = Good. Frog habitat = Good.	No or little evidence of broad-scale loss of native vegetation. One or more strata dominated by exotic species, high impact species present. Cover within one stratum up to 50% lower or higher than reference. Reduced cover (75-50%) of dominant strata, and/or only two age classes present. Quantities and cover of debris similar to reference.	Moderately modified
Darling Mills Creek	DMC	Creek. 3rd order stream (Strahler). Unmodified channel. No barriers to fish passage. Mostly cleared catchment.	Bank slope = 30-70 degrees. Sheet erosion = <1%. Gully erosion = <1%. Slump erosion = 1-5%. Undercut erosion = 5-25%.	Average wetted channel width = 1-3 m. Minimum depth of water = <10 cm. Maximum depth of water = 30-100 cm. Average depth of water = 10-20 cm. Velocity = Slow (<0.1 m/s). Turbidity = Moderate. Riffle = 30%. Run = 30%. Pool = 40%. Dominant substrate = Cobble. Subdominant substrate = Gravel. Instream woody debris = Occasional. Aquatic vegetation richness = 0 species. Native aquatic vegetation abundance = Absent. Fish habitat = Class 3 - Minimal fish habitat. Type 1 key fish habitat. Riparian bird habitat = Good. Frog habitat = Good.	No or little evidence of broad-scale loss of native vegetation. Exotic species present but not dominating any strata, high impact species rare. Cover within one stratum up to 50% lower or higher than reference. Dominant strata with reference level of cover and at least three age classes present (juveniles, sub-adults and adults).	Moderately modified

Stream Name	Reach	Hydrology	Physical Form	Water Quality & Aquatic Habitat	Streamside Vegetation	Overall Condition
Darling Mills Creek	DMD	Creek. 2nd order stream (Strahler). Unmodified channel. Minor barrier/s with fish passage during all flows. Mostly cleared catchment.	Bank slope = >70 degrees. Sheet erosion = <1%. Gully erosion = <1%. Slump erosion = 1-5%. Undercut erosion = 5-25%.	Average wetted channel width = 3-5 m. Minimum depth of water = <10 cm. Maximum depth of water = 30-100 cm. Average depth of water = 10-20 cm. Velocity = Slow (<0.1 m/s). Turbidity = Moderate. Riffle = 5%. Run = 5%. Pool = 90%. Dominant substrate = Cobble. Subdominant substrate = Gravel. Instream woody debris = Occasional. Aquatic vegetation richness = 0 species. Native aquatic vegetation abundance = Absent. Fish habitat = Class 3 - Minimal fish habitat. Type 1 key fish habitat. Riparian bird habitat = Good. Frog habitat = Good.	No or little evidence of broad-scale loss of native vegetation. One or more strata dominated by exotic species, high impact species present. Cover within one stratum up to 50% lower or higher than reference. Reduced cover (75-50%) of dominant strata, and/or only two age classes present. Quantities and cover of debris similar to reference.	Moderately modified
Exeter St Creek	ERA	Creek. 1st order stream (Strahler). Mostly modified channel. Minor barrier/s with fish passage during all flows. Mostly cleared catchment.	Bank slope = 30-70 degrees. Sheet erosion = <1%. Gully erosion = <1%. Slump erosion = <1%. Undercut erosion = <1%.	Average wetted channel width = 0-1 m. Minimum depth of water = <10 cm. Maximum depth of water = 10-20 cm. Average depth of water = <10 cm. Velocity = Slow (<0.1 m/s). Turbidity = Moderate. Riffle = 70%. Run = 20%. Pool = 10%. Dominant substrate = Bedrock. Subdominant substrate = Boulder. Instream woody debris = Common. Aquatic vegetation richness = 0 species. Native aquatic vegetation abundance = Absent. Fish habitat = Class 4 - Unlikely fish habitat. Not a key fish habitat. Riparian bird habitat = Moderate. Frog habitat = Moderate.	About 50% of the native vegetation remains, either in strips or patches. One or more strata dominated by exotic species, high impact species present. One stratum missing or extra, cover within remaining strata 50% lower or higher than reference. Reduced cover (75-50%) of dominant strata, and only one age class present. Some evidence of unnatural loss of debris.	Largely modified

Stream Name	Reach	Hydrology	Physical Form	Water Quality & Aquatic Habitat	Streamside Vegetation	Overall Condition
Lane Cove River	LCA	Creek. 3rd order stream (Strahler). Unmodified channel. No barriers to fish passage. Mostly cleared catchment.	Bank slope = 30-70 degrees. Sheet erosion = <1%. Gully erosion = <1%. Slump erosion = 1-5%. Undercut erosion = <1%.	Average wetted channel width = 3-5 m. Minimum depth of water = Dry. Maximum depth of water = 20-30 cm. Average depth of water = 10-20 cm. Velocity = Slow (<0.1 m/s). Turbidity = Clear. Riffle = 80%. Run = 10%. Pool = 10%. Dominant substrate = Boulder. Subdominant substrate = Cobble. Instream woody debris = Abundant. Aquatic vegetation richness = 0 species. Native aquatic vegetation abundance = Absent. Fish habitat = Class 2 - Moderate fish habitat. Type 1 key fish habitat. Riparian bird habitat = Excellent. Frog habitat = Good.	No or little evidence of broad-scale loss of native vegetation. Vegetation predominantly native, few weeds and no high impact species. Number of strata and cover within each similar to reference. Dominant strata with reference level of cover and at least three age classes present (juveniles, sub-adults and adults). Quantities and cover of debris similar to reference.	Slightly modified
Lane Cove River	LCB	River. 3rd order stream (Strahler). Unmodified channel. No barriers to fish passage. Partially cleared catchment.	Bank slope = 30-70 degrees. Sheet erosion = <1%. Gully erosion = <1%. Slump erosion = <1%. Undercut erosion = <1%.	Average wetted channel width = 5-8 m. Minimum depth of water = Dry. Maximum depth of water = 10-20 cm. Average depth of water = Dry. Velocity = Dry. Turbidity = Clear. Riffle = 85%. Run = 5%. Pool = 10%. Dominant substrate = Boulder. Subdominant substrate = Bedrock. Instream woody debris = Abundant. Aquatic vegetation richness = 3 species. Native aquatic vegetation abundance = Rare. Fish habitat = Class 3 - Minimal fish habitat. Type 1 key fish habitat. Riparian bird habitat = Excellent. Frog habitat = Moderate.	No or little evidence of broad-scale loss of native vegetation. Vegetation predominantly native, few weeds and no high impact species. Number of strata and cover within each similar to reference. Dominant strata with reference level of cover and at least three age classes present (juveniles, sub-adults and adults). Quantities and cover of debris similar to reference.	Slightly modified

Stream Name	Reach	Hydrology	Physical Form	Water Quality & Aquatic Habitat	Streamside Vegetation	Overall Condition
Tedbury Creek	TCA	Creek. 1st order stream (Strahler). Mostly modified channel. Minor barrier/s with fish passage during all flows. Mostly cleared catchment.	Bank slope = >70 degrees. Sheet erosion = <1%. Gully erosion = <1%. Slump erosion = <1%. Undercut erosion = 25-50%.	Average wetted channel width = 0-1 m. Minimum depth of water = <10 cm. Maximum depth of water = 10-20 cm. Average depth of water = <10 cm. Velocity = Slow (<0.1 m/s). Turbidity = Moderate. Riffle = 10%. Run = 70%. Pool = 20%. Dominant substrate = Cobble. Subdominant substrate = Silt. Instream woody debris = Rare. Aquatic vegetation richness = 4 species. Native aquatic vegetation abundance = Rare. Fish habitat = Class 4 - Unlikely fish habitat. Not a key fish habitat. Riparian bird habitat = Moderate. Frog habitat = Moderate.	Only small patches of well-separated native vegetation remain. One or more strata dominated by exotic species, high impact species present. More than one stratum completely altered from reference (lost or <10% remaining). Reduced cover (75-50%) of dominant strata, and only one age class present. Some evidence of unnatural loss of debris.	Substantially modified
Tedbury Creek	TCB	Creek. 1st order stream (Strahler). Unmodified channel. No barriers to fish passage. Mostly cleared catchment.	Bank slope = 30-70 degrees. Sheet erosion = 1-5%. Gully erosion = 1-5%. Slump erosion = <1%. Undercut erosion = 5-25%.	Average wetted channel width = 1-3 m. Minimum depth of water = Dry. Maximum depth of water = 10-20 cm. Average depth of water = <10 cm. Velocity = Stagnant. Turbidity = Moderate. Riffle = 5%. Run = 80%. Pool = 15%. Dominant substrate = Silt. Subdominant substrate = Cobble. Instream woody debris = Abundant. Aquatic vegetation richness = 0 species. Native aquatic vegetation abundance = Absent. Fish habitat = Class 4 - Unlikely fish habitat. Not a key fish habitat. Riparian bird habitat = Moderate. Frog habitat = Moderate.	No or little evidence of broad-scale loss of native vegetation. One or more strata dominated by exotic species, high impact species present. Cover within one stratum up to 50% lower or higher than reference. Reduced cover (75-50%) of dominant strata, and/or only two age classes present. Quantities and cover of debris similar to reference.	Moderately modified

Stream Name	Reach	Hydrology	Physical Form	Water Quality & Aquatic Habitat	Streamside Vegetation	Overall Condition
Tedbury Creek	TCC	Creek. 1st order stream (Strahler). Unmodified channel. Numerous low-flow barriers without fish passage. Mostly cleared catchment.	Bank slope = 30-70 degrees. Sheet erosion = <1%. Gully erosion = <1%. Slump erosion = <1%. Undercut erosion = 1-5%.	Average wetted channel width = 0-1 m. Minimum depth of water = Dry. Maximum depth of water = 30-100 cm. Average depth of water = Dry. Velocity = Dry. Turbidity = Moderate. Riffle = 60%. Run = 20%. Pool = 20%. Dominant substrate = Boulder. Subdominant substrate = Cobble. Instream woody debris = Abundant. Aquatic vegetation richness = 0 species. Native aquatic vegetation abundance = Absent. Fish habitat = Class 3 - Minimal fish habitat. Not a key fish habitat. Riparian bird habitat = Good. Frog habitat = Poor.	No or little evidence of broad-scale loss of native vegetation. One or more strata dominated by exotic species, high impact species present. Cover within one stratum up to 50% lower or higher than reference. Reduced cover (75-50%) of dominant strata, and/or only two age classes present. Quantities and cover of debris similar to reference.	Moderately modified
Zig Zag Creek	ZZA	Creek. 2nd order stream (Strahler). Unmodified channel. No barriers to fish passage. Mostly cleared catchment.	Bank slope = >70 degrees. Sheet erosion = <1%. Gully erosion = Slump erosion = 1-5%. Undercut erosion = 1-5%.	Average wetted channel width = 1-3 m. Minimum depth of water = <10 cm. Maximum depth of water = 30-100 cm. Average depth of water = 20-30 cm. Velocity = Medium (0.1-0.3 m/s). Turbidity = Clear. Riffle = 5%. Run = 5%. Pool = 90%. Dominant substrate = Cobble. Subdominant substrate = Pebble. Instream woody debris = Abundant. Aquatic vegetation richness = 0 species. Native aquatic vegetation abundance = Absent. Fish habitat = Class 2 - Moderate fish habitat. Not a key fish habitat. Riparian bird habitat = Excellent. Frog habitat = Good.	No or little evidence of broad-scale loss of native vegetation. Vegetation predominantly native, few weeds and no high impact species. Number of strata and cover within each similar to reference. Dominant strata with reference level of cover and at least three age classes present (juveniles, sub-adults and adults). Quantities and cover of debris similar to reference.	Slightly modified

Photo 1: Blue Gum Creek (reach BGB) a heavily disturbed reach with extensive weed spread.

Photo 2: Blue Gum Creek (reach BGA) a weed dominated reach with bank undercutting seen often along the reach.

Photo 3: Blue Gum Creek (reach BGA) most downstream section of Blue Gum Creek before a road crossing that signifies the beginning of Darling Mills Creek.

Photo 4: Darling Mills Creek (reach DMD) sandstone outcrop outside of the footprint.

Photo 5: Junction of Darling Mills Creek and Bellbird Creek flowing in from the north.

Photo 6: Darling Mills Creek (reach DMC) sand dominated section typically seen along Darling Mills Creek.

Photo 7: Darling Mills Creek, reach DMB, upstream of footprint, typical creek sections of the reach.

Photo 8: Darling Mills Creek, Darling Mills Creek bridge, within the construction footprint of Hills M2 Motorway, photo looking east.

Photo 9: Darling Mills Creek, reach DMA, downstream of footprint, typical riffle sections scattered throughout the reach.

Photo 10: Cockle Creek (reach CCA) start of the creek from a culvert in a heavily urbanised area inside of the footprint of northern interchange.

Photo 11: Cockle Creek (reach CCA) example of the reach, photo taken near Bareena Avenue within the northern interchange footprint.

Photo 12: Cockle Creek (reach CCA) creek section in the vicinity of Carrington Park which the Junction Road compound would be located near.

Photo 13: Cockle Creek (reach CCA) a steep rock drop-off downstream of Carrington Park

Photo 14: Cockle Creek (reach CCB) boulders dominating the landscape downstream of Carrington Park

Photo 15: Cockle Creek (CCC) bedrock dominated section of the creek on the most northern boundary of the northern interchange footprint.

Photo 16: Cockle Creek (CCD) key fish habitat pool downstream of the northern interchange footprint

Photo 17: Cockle Creek (CCD) typical section of the reach showing diversity of habitat

Photo 18: Tedbury Creek (reach TCA) highly eroded section, downstream of the Wilson Road compound footprint

Photo 19: Tedbury Creek (reach TCB) rock drop off signalling change in form from a highly eroded section of Tedbury Creek to a more stable sandstone dominated section

Photo 20: Tedbury Creek (reach TCC) typical section of the reach

Photo 21: Tedbury Creek (reach TCC) potential fish habitat in a large pool

Photo 22: Zig Zag Creek (reach ZZA) junction of Zig Zag Creek and Berowra Creek, far downstream of the Wilson Road compound footprint

Photo 23: Butterfield Street Creek (reach BSA) small pool of water where *Limnodynastes peronii* (Striped Marsh Frog) was heard calling,

Photo 24: Butterfield Street Creek (reach BSB) immediately after the culvert under Comenarra Parkway

downstream of Trelawney Street footprint	
	
Photo 25: Exeter Road Creek (ERA) outside of the project footprint. The small creek is mostly located on private residential land	**Photo 26:** Arianna Avenue Creek (AAC) outside of the project footprint. The creek is mostly located on private residential land shown by a fence across a creek
	
Photo 27: Coups Creek (COA) typical landscape of Coups Creek	**Photo 28:** Coups Creek (COA) fish pool
	
Photo 29: Lane Cove River (LCA) transition from Coups Creek into Lane Cove River	**Photo 30:** Lane Cove River (LCB) typical landscape of Lane Cove River, which was mainly dry at the time of the survey

Appendix K: *Epacris purpurascens* var. *purpurascens* locations

K.1 Background

Epacris purpurascens var. *purpurascens* is an erect shrub, 50 -180 cm high, with a peak flowering period of July to September (NPWS 2002a).

The species was initially identified in AECOM (2010) during inspections for the M2 Upgrade Project Ecological Assessment, and systematic surveys within the Hills M2 Motorway corridor were undertaken by Cumberland Ecology in June/ July 2012 (Cumberland Ecology 2012).

This species was detected during the survey performed by Eco Logical Australia ecologists for this project in December 2013. The outcomes of these surveys are provided in this appendix.

K.2 Results

The Cumberland Ecology (2012) survey located 180 *Epacris purpurascens* var. *purpurascens* individuals at six sites along the Hills M2 Motorway (**Table 32**). Plants were individually tagged, global positioning system (GPS) locations for patch locations were recorded via hand-held GPS at either end of the patch, and accuracy of GPS points varied from 8 – 12 metres (Cumberland Ecology 2012). The location of the sites with regards to the construction footprint, based on the Cumberland Ecology survey and figures, is shown in **Figure 21 - Figure 24**.

Eco Logical Australia detected *Epacris purpurascens* var. *purpurascens* individuals at, or in proximity to, Cumberland Ecology (2012) sites 1, 2, 3, 4, and 5. The Cumberland Ecology survey was broader in extent than for this survey, as it extended along the Hills M2 Motorway corridor (Cumberland Ecology 2012). Of the six sites identified in Cumberland Ecology (2012), one site (site number six) occurs to the east of Pennant Hills Road, was beyond the study area for this report. Thus, Cumberland Ecology (2012) detected 154 plants within the study area for this report, based on a total of 180 plants identified, less the 26 plants at site six (**Table 32**).

The counts performed by Eco Logical Australia ecologists identified and counted 88 *Epacris purpurascens* var. *purpurascens* individuals within the study area for this report. This count was performed in December 2012, which is outside of the July to September flowering period. The Eco Logical Australia survey detected a site with two *Epacris purpurascens* var. *purpurascens* individuals in proximity to Darling Mills Creek and Renown Road, north of the Hills M2 Motorway (**Table 32**), which had not been detected by Cumberland Ecology (2012).

For Cumberland Ecology sites 2, 3, and 4, Eco Logical Australia located *Epacris purpurascens* var. *purpurascens* individuals in the vicinity of the Cumberland Ecology sites although for all of these sites some individuals were located outside of the sites. No individuals were located within Cumberland Ecology site four by Eco Logical Australia within areas which had been fenced to deter access and trampling of *Epacris purpurascens* var. *purpurascens.* It is possible that the plants may have been present and not been detected.

Table 32: Summary of survey results for *Epacris purpurascens* var. *purpurascens*

Cumberland Ecology (2012) Results							ELA December 2013 survey (number of individuals)
Cumberland Site Number	**No. of Individuals**	**No. of Adults**	**No. of Juveniles**	**% Juveniles**	**Size Range (cm)**	**Condition of Habitat**	
n/a	No Epacris purpurascens from this site were reported in Cumberland Ecology (2012). The site is on the northern side of Hills M2 Motorway, south of Darling Mills Creek, and Renown Road, near Eco Logical Australia Plot 24 (refer to Appendix D)						2
1 (**Figure 21**)	25	17	8	32	24-170	Intact vegetation, low weed invasion, evidence of trespass	14
2 (**Figure 22**)	87	22	65	75	6-167	Cleared rocky basin, some native canopy regeneration occurring	1, plus 7 individuals between sites 2 and 3
3 (**Figure 22**)	19	9	10	53	15-137	Insecure vegetation patch, adjacent to cleared area, moderate weed invasion, altered flow regime	52 (to the east of Cumberland site 3)
4 (**Figure 22**)	4	4	0	0	80-180	Intact vegetation, low weed invasion, good condition	4 (to the east of Cumberland site 4)
5 (**Figure 23**)	19	18	1	5	33-176	Low weed invasion currently but weed seedlings detected adjacent	8
6 (**Figure 24**)	26	15	11	42	20-125	Intact vegetation, low levels of weed invasion, some weed seedlings detected nearby, evidence of trespass and direct impacts to the species.	n/a - outside of study area for this report
Total	180	85	95	53	6-180	-	88

There are a number of potential reasons for the differences in the results of the Cumberland Ecology (2012) and Eco Logical Australia surveys. The Cumberland Ecology survey was conducted in June/July 2012, and thus survey conditions to detect individuals would have been enhanced. Furthermore, Cumberland Ecology (2012) was conducting survey specifically targeting *Epacris purpurascens* var. *purpurascens*, and included tagging, measuring and counting of individuals detected. In contrast, the survey conducted by Eco Logical Australia was a rapid survey, and was outside of the flowering period for this species. Therefore there is potential that individuals detected by Cumberland Ecology may have been missed in the Eco Logical Australia survey.

It is also noted that the boundaries between the Hills M2 Motorway corridor and adjoining properties is not clear in the field, as this boundary is not fenced. Thus, it is unknown whether the Cumberland Ecology (2012) survey may have counted and marked individuals outside of the Hills M2 Motorway. Eco Logical Australia's survey extended outside of the Hills M2 Motorway corridor in the vicinity of sites two and three, but until the construction footprint is marked out with survey pegs it will not be possible to accurately count the number of *Epacris purpurascens* var. *purpurascens* individuals directly within the footprint.

It is also possible that plant distribution or numbers may have changed over the period between surveys. It is possible that individuals at site 4 may have perished (noting that this site is on the northern side of the Hills M2 Motorway and will not be impacted by the proposed construction footprint). The location of individuals outside of the habitat extent mapped by Cumberland Ecology (2012) may mean that *Epacris purpurascens* var. *purpurascens* has colonised these areas since the Cumberland Ecology (2012) survey, or it may be that they were not detected, especially as some sites are at the very edge of the study area for that report.

K.3 Impact on *Epacris purpurascens* var. *purpurascens*

Of the sites identified it is the Cumberland Ecology sites two and three which may be impacted by the proposed construction footprint, which is site two with 87 individuals, and site 3 with 19 individuals, for a total estimated impact of 106 individuals, consisting of 31 adults and 75 juveniles (**Table 32**). The Eco Logical Australia survey identified 60 individuals in these locations, some of which may be outside of the construction footprint. It is noted that these are surveys of the same species, but at different points in time, and therefore some individuals may have been counted in both surveys, or may be different plants due to deaths or recruitment.

Given the differences between the survey results, based on a precautionary approach the counts from the detailed Cumberland Ecology (2012) survey have been utilised for impact assessment, as they have higher population counts than the observations from the Eco Logical Australia survey.

Further additional survey is recommended to determine the distribution of this species within and beyond the road corridor in order to better quantify the significance of the direct and indirect impacts, and to identify suitable relocation sites.

Figure 1. Location of Epacris purpurascencs var. purpurascens populations and habitat

Figure 21: Epacris purpurascens site 1.

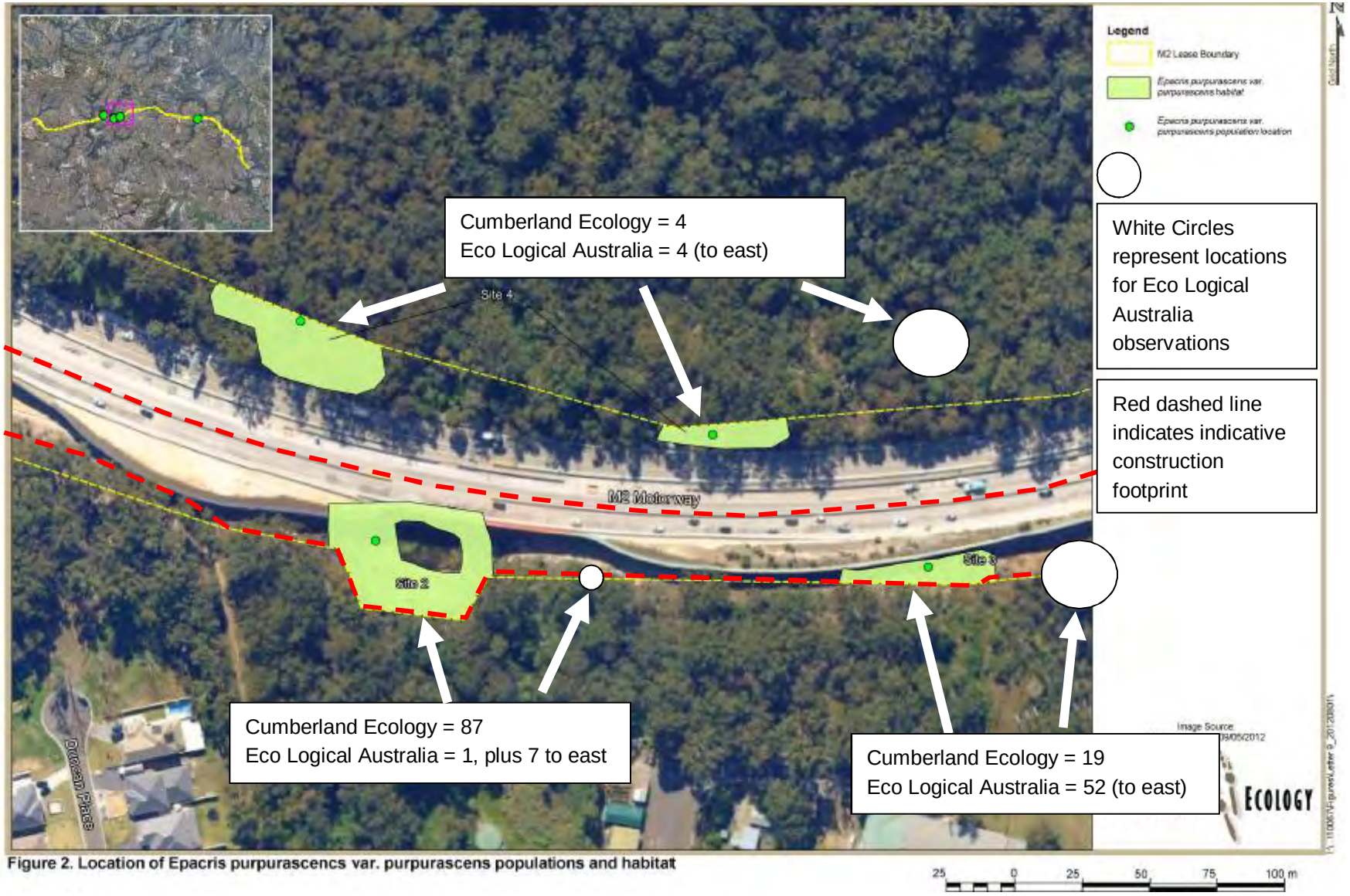

Figure 2. Location of Epacris purpurascencs var. purpurascens populations and habitat

Figure 22: Epacris purpurascens sites 2, 3 and 4.

Figure 23: Epacris purpurascens site 5.

Figure 24: Epacris purpurascens site 6 (outside of the NorthConnex construction footprint).

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