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. 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 (OEH, 2013k).

No Rosenberg's Goanna were found during this study, however there is suitable habitat for the species along the Hills M2 Motorway integration works in the vicinity of Darling Mills, Stevenson and Blue Gum Creeks. There are 45 NSW Atlas records for the species with the closest record to the suitable habitat being some 13 kilometres to the north-east. There were no critical breeding habitat features such as termite mounds. Given that there is no suitable breeding habitat to be impacted and 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.

Gang-gang Cockatoo and Gang-gang Cockatoo population in the Hornsby and Ku-ring-gai Local Government Areas

Gang-gang Cockatoo is listed as vulnerable under the TSC Act and the population within Hornsby and Ku-ring-gai LGAs as endangered under the TSC Act.

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 population size is small and estimated to be between 18 to 40 pairs, yet individuals of this population are likely to move outside the 'defined' population boundary in the general area and should still be considered of this population (OEH, 2013l).

Important breeding habitat in the Sydney metropolitan region has been defined as a tree hollow with a minimum diameter of 10 centimetres (OEH, 2013g) and typically occurs in live trees close to water (NSW Scientific Committee, 2008b). 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 Cockatoos were recorded during the field survey. There is some potential foraging habitat and potential breeding habitat at the Hills M2 Motorway integration works and the northern interchange. There are hollow bearing trees at these sites suitable for this species (AECOM, 2014).

An impact assessment under the TSC Act was prepared (refer to **Appendix F**) and it concluded that 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 would not result in a significant impact to this species.

Glossy Black Cockatoo

The Glossy Black-Cockatoo is listed as vulnerable under the TSC Act. 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, 2013e).

In the Sydney metropolitan region important breeding habitat has been defined as tree hollows with a minimum diameter greater than 15 centimetres (OEH, 2013e). 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 (refer to AECOM, 2014 for details). No Glossy Black Cockatoos were observed during the field survey and no evidence of the species utilising the habitat, such as crushed cones of sheoak, were observed where this tree species was present.

An impact assessment for this species was conducted (refer to **Appendix F**) and it concluded that while there was some foraging habitat present, there was no evidence of the species utilising this habitat. Further, the area of potential habitat to be cleared is 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 this species.

Varied Sittella

The Varied Sittella is listed as vulnerable under the TSC Act. 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) and has a widespread range across mainland Australia,

The Varied Sittella has not been recorded within the study area. However there are 23 records of the species within the ten kilometre Wildlife Atlas search area.

An impact assessment for this species was conducted (refer to **Appendix F**) and it concluded that while there was some foraging habitat present, there was no evidence of the 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 this species.

Scarlet Robin

The Scarlet Robin is listed as vulnerable under the TSC Act. In NSW, it occurs from the coast to the inland slopes. The Scarlet Robin lives in dry eucalypt forests and woodlands. The understorey is usually open and grassy with few scattered shrubs. This species lives in both mature and regrowth vegetation. It may also occur in mallee or wet forest communities, or in wetlands and tea-tree swamps.

The Scarlet Robin was not recorded within the project area. However there are 12 records of the species within the ten kilometre Wildlife Atlas search area.

An impact assessment for this species was conducted and it concluded that while there was some foraging habitat present, there was no evidence of the 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 this species.

Flame Robin

The Flame Robin is listed as vulnerable under the TSC Act. Flame Robins prefer moist open forests and grassy woodlands for breeding, often on ridges and slopes (OEH, 2013e). For foraging, this species prefers clearings or areas with open understoreys.

The Flame Robin was not recorded during this study. Also, there were only two records of the species within the ten kilometre Wildlife Atlas search area.

An impact assessment for this species was conducted and it concluded that while there was some foraging habitat present, there was no evidence of the 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 this species.

Barking Owl

The Barking Owl is listed as vulnerable under the TSC Act. 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. The habitat is typically dominated by eucalypts (often Redgum species) (DECC, 2005).

The Barking Owl usually roosts in dense foliage in large trees (Debus, 1997). 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 project could impact on the lifecycle of the Barking Owl by reducing the amount of potential foraging habitat and roosting/breeding habitat. Loss of foraging habitat has the potential to reduce the availability of prey species within a mating pair's territory, which may force individuals to travel greater distances during hunting. The sizes of home ranges are generally unknown for Barking Owl, but like Powerful Owl are likely to be variable and dependent upon quality of habitat. Tree hollows with a diameter greater than 300 millimetres constitute potential primary (breeding) habitat for the 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 and at the northern interchange amongst Blue Gum High Forest (AECOM, 2014). All of the hollows of suitable size are to be retained.

There are a large number (62) of hollow bearing trees that occur within the construction footprint at the Hills M2 Motorway integration works and southern interchange, along the northern interchange.

If a Barking Owl nesting site occurs within the study area or 200 metres from the study area, it may be indirectly impacted through noise, vibration and artificial light during the construction and operation of the project.

During the field survey there was no evidence of nesting by Barking Owls. 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. However, there are 19 records for Barking Owl on the Wildlife Atlas within ten kilometres of the study area. It has been suggested that Barking Owls are itinerant and sporadic inhabitants of the forests east of the Great Dividing Range (David Coombes, Senior Ecologist, pers comm January 2014).

While the project would result in the removal of potential foraging habitat for the Barking Owl, the project has avoided trees containing large hollows and areas of high quality foraging habitat. For areas of habitat that cannot be avoided, a Biodiversity Offset Strategy is being prepared to compensate for the loss of habitat as a result of construction of the project. Barking Owls are ecosystem credit species that are considered to be covered by the credits required for the ecosystems being offset. These offsets would be managed in perpetuity in order to meet the 'improve or maintain' standard. These are discussed in **section 5.2.9**.

Adherence to tree clearance protocols as per the flora and fauna management plan should mitigate impacts to the habitat for these species. Nest boxes were considered for this species; however Roads and Maritime have reported that this species has not used nest boxes provided as mitigation measures on other projects (Roads and Maritime pers comm February 2014).

An impact assessment was conducted under the TSC Act (refer to **Appendix F**) and it concluded that no significant impact is likely. 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 construction footprint has avoided suitably sized hollows.

Powerful Owl

The Powerful Owl is listed as vulnerable under the TSC Act. They require large tracts of forest or woodland but can also occur in fragmented landscapes. As most prey species require hollows and a shrub layer, these are important habitat components for the owl.

Large trees with hollows at least 0.5 metres 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.

The project could impact on the lifecycle of the Powerful Owl by reducing the amount of potential foraging habitat (secondary habitat) and roosting/breeding habitat (primary habitat). Tree hollows with a diameter greater than 300 millimetres constitute potential primary (breeding) habitat for the Powerful Owl. Removal of such habitat may impact the lifecycle of the species by reducing the availability of breeding habitat, which would impact on species fecundity (being the ability to reproduce) in the local area. The greatest concentration of hollow bearing trees was along the Hills M2 Motorway integration works and at the northern interchange amongst Blue Gum High Forest (AECOM, 2014).

If Powerful Owl nesting sites occur within the study area, the species may be indirectly 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 of 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.

During the field survey, there was no evidence of nesting by Powerful Owls however field surveys were primarily conducted in summer when Powerful Owl are not breeding. However, there are 326 records for Powerful Owl on the Wildlife Atlas within ten kilometres of the study area.

Loss of foraging habitat has the potential to reduce the availability of prey species within a mating pair's territory, which may force individuals to travel greater distances during hunting.

While the project would result in the removal of potential foraging habitat for the Powerful Owl, the project would retain trees containing large hollows and areas of high quality foraging habitat. For areas of habitat that cannot be avoided, a Biodiversity Offset Strategy is being prepared to compensate for the loss of habitat as a result of construction of the project. Powerful Owl is an ecosystem credit species which are considered to be covered by the credits required for the ecosystems to be cleared. These offsets would be managed in perpetuity in order to meet the 'improve or maintain' standard.

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. However, the hollow bearing tree survey (AECOM, 2014) identified only four trees with hollows large enough to provide breeding habitat for Powerful Owl. Three of these trees occur at the Hills M2 Motorway integration works area in the vicinity of Darling Mills Creek and the fourth occurs at the

northern interchange in a patch of Blue Gum High Forest near Eastbourne Avenue. These trees have been avoided in the design of the project.

An impact assessment was conducted under the TSC Act (refer to **Appendix F**) and it concluded a significant impact is unlikely. This is on the basis that the species is known to breed within the Darling Mills Creek area (Kavanagh, 2004); however no trees with suitable hollows are to be removed.

Masked Owl

The Masked Owl is listed as vulnerable under the TSC Act and is 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). The Masked Owl is 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). 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. However, there are 21 records for Masked Owl on the Wildlife Atlas within ten kilometres of the study area. This study has concluded on this basis that this species is unlikely to be breeding in the Darling Mills Creek area.

There are a large number of hollow bearing trees that occur within the construction footprint at the Hills M2 Motorway integration works, southern interchange and along the northern interchange.

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

An impact assessment under the TSC Act was carried out for this species (refer to **Appendix F**) and it concluded that there is unlikely to be a significant impact on this species. 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.

Eastern Pygmy-possum

The Eastern Pygmy-possum is listed as vulnerable under the TSC Act. 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.

Small tree hollows are favoured as day nesting sites. However, breeding habitat in Sydney metro areas is defined as trees with hollows greater than two centimetres, loose bark of eucalypts or accumulations of shredded bark in tree forks for nesting (OEH 2013e).

The Eastern Pygmy Possum was not recorded during this field survey. Targeted surveys were not carried out. There are 72 records within the ten kilometre radius Wildlife Atlas search of the study area.

An impact assessment under the TSC Act was carried out (refer to **Appendix F**) and concluded that 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 is to be cleared.

Predominantly cave-roosting bats

The following species of bats have been grouped given the similar habitats utilised and life cycle requirements of the species.

- Large-eared Pied Bat (vulnerable TSC Act and EPBC Act).
- Little Bent-wing Bat (vulnerable TSC Act).
- Eastern Bent-wing Bat (vulnerable TSC Act).
- Southern Myotis (vulnerable TSC Act).

These species are predominantly cave-roosting and breeding (Churchill, 2008).

The project may impact on the life cycles of the 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. 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 Eastern Bent-wing Bat is known to roost within the twin culverts on Devlins Creek under the Hills M2 Motorway (Cumberland Ecology 2012). However, the project is not expected to impact on the maternity roost at the Devlin's Creek culvert.

Care should be taken to avoid all known maternity roosts. Indirect impacts from noise, light and vibrations may impact on the suitability of man-made roosting structures. However, little is known about the indirect impacts on these species.

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. A Microbat Management Plan is recommended for all culverts encountered along the construction footprint, and the disused buildings at the Pioneer Avenue compound.

Significance assessments were undertaken for all four species and an EPBC Impact Assessment was undertaken for Large-eared Pied Bat (refer to **Appendix F** and **Appendix G**). The assessments concluded that a significant impact is unlikely to result as part of the project if mitigation measures listed in **section 5** are implemented.

A Microbat Management Plan is recommended to address these impacts and these three locations and may include monitoring of the culverts for bat activity and exclusion of works during breeding season if present at the time of construction.

Predominantly tree-roosting bats

The following species of bats have been grouped given the similar habitats utilised and life cycle requirements of the species.

- Eastern False Pipistrelle (vulnerable TSC Act).
- Eastern Freetail-bat (vulnerable TSC Act).
- Yellow-bellied Sheathtail-bat (vulnerable TSC Act).
- Greater Broad-nosed Bat (vulnerable TSC Act).

The project may impact on the lifecycles of all of the tree-roosting bats through direct removal of suitable breeding tree hollows or indirect impact on the removal/degradation of foraging habitat. Each of the tree-roosting species is known to occur at times or regularly within the ten 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).

The study area contains suitable hollows for tree-roosting bats and provides foraging habitats at the Hills M2 Motorway integration works area, the southern interchange and the northern interchange. 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 production of noise during construction and on-going vehicular movements could disturb bats roosting in the vicinity of the project. This could be particularly detrimental to tree-roosting bats during spring and summer months while 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. 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 the response of these species to urbanisation remains unknown.

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. As suggested for the cave dwelling bats, a Microbat Management Plan would also be developed and implemented.

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. Given the small amount of vegetation to be removed relative to the vegetation adjacent to the construction footprint, particularly at the Hills M2 Motorway integration works area, the project is unlikely to have a significant impact on the foraging habitat for these species.

Significance assessments were undertaken for all four species (refer to **Appendix F**) 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.

Grey-headed Flying-Fox

The Grey-headed Flying-Fox is listed as vulnerable under the TSC Act and EPBC Act. 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).

The construction footprint would not disturb any known roosting camps. The nearest Grey-headed Flying-fox roosts or "camps" are located:

- At Gordon, located around eight kilometres to the east from the project.
- At Parramatta Park, located to the south-west from the project.

There are several other camps located throughout the Sydney metropolitan area that are located further away from the project.

The Grey-headed Flying-fox has been recorded 1222 times within ten kilometres of the study area. The proposed route includes surface infrastructure along large sections of tunnel. Foraging habitat would be lost through the clearing of vegetation along the Hills M2 Motorway integration works area, the southern interchange and northern interchange. While the vegetation at these sites may be potential foraging habitat, the area of potential foraging habitat to be removed relative to other potential foraging habitat is small.

The significance assessments concluded that a significant impact is unlikely to result as part of the project because no known camps would be disturbed, minimal marginal foraging habitat would be removed and large contiguous vegetation exists adjacent to the areas that would be cleared as a result of the project. 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 foraging habitat from the construction footprint would significantly impact the species lifecycle through a significant 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 affect the lifecycle of this species.

4.2 Migratory and marine species

The literature search has identified 47 migratory species protected under the EPBC Act and the international agreements of CAMBA, JAMBA and RoKAMBA that have previously been recorded within ten kilometres of the study area.

One migratory avian species, *Anthochaera phrygia* (Regent Honeyeater), also listed as Endangered under EPBC Act, may potentially fly over the study area however is unlikely to utilise the study area as the box-ironbark eucalypt woodland habitat for this species is limited.

Lathamus discolor (Swift Parrot) a listed endangered species under both TSC Act and the EPBC Act and marine species under the EPBC Act (although not strictly marine) is likely to only fly over the study area rather than utilise resources and is therefore unlikely to utilise the study area.

No other migratory or marine species are likely to utilise the study area as no suitable habitat for these species exists.

4.3 Wildlife connectivity and habitat fragmentation

Fragmentation of habitat would be minimal across the study area given that the construction footprint is generally following the alignment of the existing road infrastructure.

Barrier effects may occur as a result of the erection of noise walls or other barriers preventing wildlife movement between vegetation fragments. Given that the construction footprint generally follows the existing road infrastructure where barriers are already present, it is not expected that the project would significantly exacerbate the barrier effect.

Wildlife connectivity would not be significantly affected due to the construction footprint generally following the existing road infrastructure alignments during both construction and operation. Furthermore, culverts would provide some wildlife connectivity. The crossing at Darling Mills Creek is an elevated bridge structure with vegetation under the bridge to provide for fauna movement, with mature trees on either side of the bridge crossing, which would provide significant wildlife connectivity, and these features would be retained, though the width of the Hills M2 Motorway would be widened. Small areas of riparian corridors would be affected, namely:

- Cockle Creek (also known as Spring Gully Creek) at the northern interchange at the top of the catchment of Ku-ring-gai Chase National Park, where construction activities would be occurring adjacent to Cockle Creek and a temporary crossing constructed to enable access to the Boundary Road compound (C11).
- Blue Gum, Darling Mills and Stevenson Creeks in Bidjigal Reserve on the Hills M2 Motorway integration works area on the upper tributaries of the Parramatta River catchment. At this location, the bridge would be widened to the south and a small compound would be located in proximity to Darling Mills Creek (reference C2).

However it is unlikely that major impacts on riparian corridors would result as part of the project because the project would be providing only minor additions to infrastructure (eg. bridge footings) relative to the existing infrastructure. Mitigation measures mentioned in **section 5** below would further reduce unavoidable impacts on riparian corridors.

The edge effect is likely to impact on native vegetation through the increased presence of weeds, particularly around the edges of the construction footprint. A particular threatened species likely to be impacted by this effect is *E. purpurascens var. purpurascens* which is found scattered along the Hills M2 Motorway (**Appendix D**). The impacts of weeds on this species are discussed in **section 4.1.1** above. Mitigation measures would need to be implemented to minimise the impact of the edge effect on *E. purpurascens* var *purpurascens*. Such measures include clearance limits, fencing off areas and induction.

4.4 Injury and mortality

Fauna injury or mortality could occur as a result of both the construction and operation of the project. The areas where this might occur are at the Hills M2 Motorway integration works area, southern interchange and the northern interchange. However due to the presence of noise walls along the current M1 Pacific Motorway and Hills M2 Motorway, this is likely to be limited.

During the construction of the project, injury or mortality may occur as a result of vegetation clearing or direct collision with vehicles and equipment within the construction site. Although some mobile species may be able to move away quickly and easily such as some birds, others may be slower to move away or may not relocate at all such as some amphibians, potentially resulting in injury or mortality of the individual.

In connecting the project with the Hills M2 Motorway and the M1 Pacific Motorway, there would be a widening of the road reserve to varying degrees along the project corridor depending on infrastructure requirements. As such, the likelihood of vehicle strike is increased during the operational phase of the motorways as the fauna needs to travel further to cross the motorway.

Although the project may potentially result in some injury or mortality of fauna species, the project is unlikely to cause a significant increase in fauna injury or mortality incidents. This is because most of the carriageways have noise walls in place and cuttings in other areas. These structures are likely to reduce the number and quality of potential crossings.

To minimise risk of injury or mortality of fauna species, appropriate fencing and standard Roads and Maritime mitigation measures have been recommended and are identified in **section 5**.

4.5 Weeds

Weeds were abundant within all sections of the study area with some areas containing prolific weed infestations.

The most common weeds encountered across the study area are shown in **Table 12.**

Table 12: Common weed species encountered in study area

Weed species	Noxious in LGA	Class	Weed of National Significance
Asparagus aethiopicus (Asparagus Fern)	Hornsby	4	✓
Bidens pilosa (Cobblers Pegs)	None in study area	-	×
Cinnamomum camphora (Camphor Laurel)	Hornsby	4	×
Genista monspessulana (Montpellier Broom)	Hornsby	3	✓
Lantana camara (Lantana)	Hornsby	4	✓
Ligustrum lucidum (Large-leaved Privet).	Hornsby	4	×
Ligustrum sinense (Small-leaved Privet).	Hornsby	4	×
Ochna serrulata (Mickey Mouse Plant)	Hornsby	4	×
Rubus fruticosus aggregate species (Blackberry)	Hills and Hornsby	4	×
Verbena bonariensis	Not declared	-	×

The comprehensive list of weeds can be found in **Appendix B**. A total of 126 weeds species were recorded across the site.

Given the high presence of weeds across the whole study area it is very likely that any vegetation disturbance would create conditions where weeds are likely to invade or intensify. This would have a flow on effect on native flora and fauna by reducing quality of habitat, competition for resources and altering the structure and composition of vegetation communities.

Mitigation measures listed in **section 5** would need to be implemented to contain the spread of weeds during the construction of the project.

4.6 Pathogens and animal pests

Pathogens

A number of pathogens are of concern in NSW that have the potential to impact on native flora and fauna. Activities that involve movement of equipment over large areas such as the project are of particular concern given the high potential for pathogen spread over large areas.

Although no sign of pathogen infection was identified during the field survey or literature search it is important to assess the potential impacts of these pathogens and mitigate against their spread. Main pathogens of concern are (Roads and Traffic Authority, 2011):

- Myrtle Rust (*Uredo rangelli*).
- Chytrid Fungus (*Batrachochytrium dendrobatidis*).

A pathogen of lesser concern is Phytophthora (*Phytophthora cinnamomi*).

Myrtle Rust is an air-borne plant fungus that attacks the young leaves, shoot tips and stems of Myrtaceous plants eventually causing plant death. It is spread by movement of contaminated material such as clothing, infected plants, vehicles and equipment etc. The 'introduction and establishment of Exotic Rust Fungi of the order Pucciniales pathogenic on plants of the family Myrtaceae' is a listed Key Threatening Process under the TSC Act (OEH, 2014a). Myrtle Rust was positively identified in assessments completed for the M2 Upgrade project (Roads and Traffic Authority, 2011) although the areas of infected individuals are outside the study area and focused around Devlins Creek.

Chytrid fungus is a water-borne fungus that affects amphibians. It is spread by cross contamination of water bodies and improper handling of frogs. Chytridiomycosis is the infection that causes lethargy, emaciation, skin sloughing and a range of other symptoms that eventually result in death. The infection of frogs by amphibian chytrid fungus causing the disease Chytridiomycosis' is a listed Key Threatening Process under both the EPBC Act and the TSC Act (OEH, 2014b). Chytrid fungus is of particular concern in areas where the threatened Red-crowned Toadlet habitat occurs in the northern extents of the northern interchange study area. There is a potential that the fungus may be introduced into the species' habitat.

Phytophthora is a soil-borne fungus capable of causing tree death (dieback) by attacking the roots of native plants. Spores can be spread over large areas by water, vehicle and machinery movement as well as human and animal movement. 'Dieback caused by Phytophthora' is a listed Key Threatening Process under both the EPBC Act and the TSC Act (OEH, 2014c).

Given that no pathogens have been identified or are likely to occur within the study area it is unlikely that pathogens would have a significant impact on flora and fauna as part of this project, provided the mitigation measures listed in **section 5** are adopted to limit the introduction of pathogens.

Animal Pests

Given the study area is disturbed and within a highly urbanised setting it is likely that animal pests would be present within the study area. Most likely pests are:

- European Red Fox (*Vulpes vulpes*).
- European Rabbit (*Oryctolagus cuniculus*).
- Feral Cat (*Felis catus*).

The European Red Fox can be found in a range of habitats. They prey on medium-sized ground-dwelling and semi-arboreal mammals and ground-nesting birds. 'Predation by the European Red Fox *Vulpes vulpes*' is a Key Threatening Process listed under both the EPBC Act and the TSC Act. Animal scats likely to belong to the European Red Fox were noted within the study area along the Hills M2 Motorway integration works area and northern interchange. The project is not likely to increase the presence of introduced foxes or increase predation of native fauna because no additional tracks will be created which facilitate movement of predators into otherwise uncleared or undisturbed vegetation.

The European Rabbit causes a number of environmental problems in the Australian landscape. The rabbit can increase the likelihood of soil erosion by creating numerous burrows, threaten the survival of a number of native animal species by altering habitat, reducing native food sources, displacing small animals from burrows and attracting introduced predators such as foxes. 'Competition and grazing by the feral European rabbit (*Oryctolagus cuniculus*)' is a listed Key Threatening Process under both the EPBC Act and the TSC Act. Rabbits are known to live within reserves further to the west of the Hills M2 Motorway integration works study area (Col Sutton Park Baulkham Hills), although movement between the reserves is limited given the highly urbanised setting. No evidence of rabbits was noted during the field survey. The project is not likely to increase the presence of the European Rabbit within the study area because the project is removing only small areas of native vegetation and will clear some areas that are heavily weed invaded which are utilised by the European Rabbit.

Cats can be found in almost all terrestrial environments in Australia. Predation by feral cats is a particular problem that affects native fauna such as small mammals (such as rodents, dasyurids, and burramyids) and ground-nesting birds. 'Predation by the feral cat (*Felis catus*)' is a listed Key Threatening Process under both the EPBC Act and the TSC Act. No evidence of feral cats was identified during the field survey however feral and domesticated cats are likely to forage throughout the study area given the extensive areas of surrounding urban development. Given the abundance of cats in the locality, and the nature of the impacts associated with the project, the project is unlikely to increase the abundance of cats, introduce them into new areas, or increase predation pressure on native fauna.

4.7 Bushfire

ELA conducted an assessment on the risk of increased bushfires in the landscape as a result of the project. ELA (2014) concluded that there would not be an increase in the frequency of bushfires arising from the project. Vegetation within the study area exists in an urbanised matrix and fuels are managed by strategically reducing hazards adjacent to assets.

There are no permanent built or inhabited structures within areas surrounded by bush, other than road and drainage infrastructure, therefore no hazard reduction would be required within areas of the Hills M2 Motorway integration works area, southern interchange or northern interchange. The project would not result in impediments to the implementation of bushfire protection measures within the study area. It is possible that activities during the construction (welding) or final use of the above ground part of the assets may result in bushfire igniting and spreading from construction areas. Under section 63 of the *Rural Fires Act 1997*, the obligation to prevent the occurrence and spread of bushfire needs to be factored in. This can be dealt with by emergency management planning, training and escalation protocols on days of increased bushfire risk.

The project would not result in an increased risk of inappropriate fire regimes which may adversely affect the ecological values of the remnant vegetation and associated habitats within the study area and beyond.

4.8 Changes to hydrology

A number of activities may result in impacts to the hydrology and aquatic ecology of creeks in the project area, namely:

- Dewatering, treatment and discharge of groundwater from the tunnel during construction and operation.
- An increase in runoff during construction and operation as a result of increased paved areas.
- Changes to current flow regimes caused by the alterations to existing detention basins and culverts including one new culvert installation.
- The extension to existing crossings that may require partial removal of riparian vegetation.
- A temporary crossing of Cockle Creek to facilitate access to the Junction Road compound (C11). A compound site would be constructed adjacent to the creek with potential need for stabilisation works.

These changes could have the following impacts:

- Darling Mills Creek would receive additional surface flows from the Hills M2 Motorway integration works. There are four existing detention basins scheduled to be upgraded in this section to aid in managing water quality. The Loyalty Road flood retarding basin approximately one kilometre downstream of the Hills M2 Motorway would regulate large flows further downstream.
- Blue Gum Creek would receive additional surface flows from southern interchange and also treated discharge from dewatering the tunnel (deluge and tunnel groundwater). The creek would likely become a perennially flowing creek.
- Tedbury Creek would receive discharge from the construction water treatment plant at the Wilson Road compound (C6).
- A tributary of the Lane Cove River (referred to as the Butterfield Street creek) would receive discharge from the construction water treatment plant at the Trelawney Street compound (C7).
- Coups Creek would also capture some additional surface flows from increased pavement area of the northern interchange but this would not increase volume enough to significantly impact catchment dynamics. It would also receive discharges from the construction water treatment plant at the northern interchange (C9).

- Cockle Creek (also called as Spring Gully Creek) at the northern interchange would capture some additional surface flows from the increase in pavement area but this is unlikely to be an increase in volume that would significantly impact catchment dynamics. A temporary crossing of Cockle Creek upstream of Carrington Park would be constructed to provide access to the Junction Road compound (C11). The compound would be constructed between the creek and the M1 Pacific Motorway. Currently this section of the creek is an artificial channel of stabilised rock realigned between residential properties and the existing M1 Pacific Motorway.

4.8.1 Dewatering, treatment and discharge of groundwater

Groundwater inflows into the tunnel would occur during construction and operation of the project. The rate of inflow is anticipated to reduce over time.

During construction, four water treatment plants would be operational at the following compounds and would be capable of treating up to 10 litres per second:

- The southern interchange compound.
- Wilson Road compound.
- Trelawney Street compound.
- The northern interchange compound.

Based on existing groundwater quality, water treatment would typically involve flocculation to remove total suspended solids, reverse osmosis to reduce salinity and dissolved solids, and correction of pH levels through the addition of lime or acid.

The groundwater inflow rate is anticipated to be 0.09 megalitres per day per kilometre of excavated tunnel. The water treatment plants would also treat construction water and surface water runoff that drains into the tunnels. The total volumes of water treated at the water treatment plants would be dependent on the activities taking place in the tunnel and the stage of construction activity.

Treated water would be used during the construction activities as much as possible for activities such as dust suppression and landscape watering. Surplus treated water would be discharged to the local stormwater system. The water discharge quality would comply with the requirements of an Environment Protection Licence issued for the project. This is anticipated to be consistent with the 80 per cent protection level for freshwater ecosystems (Australian and New Zealand Guidelines for Fresh and Marine Water Quality, ANZECC & ARMCANZ, 2000).

The receiving waters for this discharge are in heavily urbanised, highly disturbed ecosystems with sections piped underground or concrete lined. Due to the topography of the area, the initial discharge locations would be ephemeral and at the top of the catchments. This discharge would ultimately drain into the creeks as specified earlier.

The discharge of treated water would result in a consistent base flow in currently ephemeral streams. It would also result in an increase of the instantaneous peak flow rates in downstream watercourses.

During operation, groundwater ingress into the tunnels would flow by gravity systems to one sump at the tunnel low point, where it would then be pumped to the water treatment plant. The sump within the tunnel drainage system would have a capacity of 420 cubic metres. The tunnel drainage system would also have capacity of 50,000 litres to capture accidental hydrocarbon spillage in the tunnel.

The operational water treatment plant would be designed to treat up to 40 litres per second (around 1050 ML/year). Based on the anticipated groundwater quality, the water treatment methods that would be undertaken include:

- pH adjustment.
- Removal of suspended solids.
- Removal of dissolved solids.
- Brackish water reverse osmosis.
- Dissolved iron removal by oxidising the Ferric ion (Fe3+) to Ferrous (Fe2+) which enables precipitation and physical removal.
- Biocide dosing of iron reducing bacteria.

The tunnel drainage system and operational water treatment plant would also capture and treat:

- Deluge water produced in the unlikely event of an emergency within the tunnels or from regular testing of the system.
- Tunnel washing water as part of regular tunnel maintenance.

In the event of significant rainfall events above the design capacity of the water treatment plant of 40 litres per second, the high flow bypass would be activated. Under this scenario, the first flush would be captured by the treatment plant with subsequent flows bypassing treatment. This is likely to occur in rare events only.

Treated water would be either reused or discharged to the local stormwater system on Gum Grove Place, which in turn discharges into Blue Gum Creek (a tributary of Darling Mills Creek and part of the Upper Parramatta River catchment).

The project has been designed to achieve a maximum water discharge quality equivalent to the 95 per cent protection level specified for freshwater eco-systems in accordance with ANZECC guidelines (ANZECC & ARMCANZ, 2000). The discharge water quality level would be determined in consultation with the NSW Environment Protection Authority during the detailed design phase taking into consideration the current water quality of the receiving watercourses.

The discharge of treated groundwater would increase the flow rates in downstream watercourses, including Blue Gum Creek and Darling Mills Creek. At Blue Gum Creek, existing flows are estimated at around 13 m^3/s during a six month ARI event. The operational water treatment plant at the southern interchange would have an expected maximum release from the tunnel of 0.04m^3/s. Discharge into other creeks from construction water treatment plants at the four construction compounds are expected to be <0.01m^3/s per plant. As the discharge rate is relatively small compared to the existing flow rates, mitigation measures to avoid coincidental release with large rainfall events is not required.

Detailed design of outlets into existing stormwater drainage is not yet available, so it is recommended that a flora and fauna management plan further prescribe:

- Downstream ecological values to be protected, especially in the lower reaches.
- Identify environmental issues (for example, maintenance of dissolved oxygen concentration, specify changes in flow volumes).
- Determine other major natural or anthropogenic factors affecting the creek.
- Define performance targets for releases including emulation of natural flow regimes.
- Design environmentally compatible engineering controls to ensure bed and bank stability at release points and any downstream areas of concern.
- Adopt trigger values and appropriate indicators including biophysical, chemical, toxicant, sediment and geomorphic.
- Determine monitoring schedules and response actions.

4.8.2 Cockle Creek

The section of Cockle Creek near Junction Road runs parallel to Coonanbarra Road at the rear of the residential properties and the M1 Pacific Motorway. The Junction Road compound would be constructed adjacent to this section of Cockle Creek, which would require the construction of a temporary crossing to enable vehicular access from Carrington Road. This would be the form of a piped or box culvert structure, and would be designed to cater for a 1 in 100 year ARI storm event. During detailed design, further work on the footprint of the compound and the crossing would be undertaken, as to what stabilisation works may be required where works are immediate adjacent to Cockle Creek. Erosion and sediment controls would also be designed and installed. The culvert will be designed to allow fish passage.

From an impact assessment perspective the ecological values of the creek at the location where the compound is proposed are very low and would not in itself cause significant environmental impacts at this location due to their already degraded nature. However, as the creek enters the Ku-ring-gai Chase National Park there are a number of downstream values that would require careful engineering and management, so as to avoid sediment, nutrient, or hydrological changes to downstream environments.

Piping of a creek can alter water quality of a creek such as water temperature (which in turn affects dissolved oxygen), increased pH due to concrete leaching, and increased water velocity at the point of exit. These impacts are considered minimal for short sections of culvert.

From an ecological perspective the flora and fauna management plan would need to ensure that:

- Appropriate measure such as a settlement basin is in place to ensure the increased water velocity doesn't cause scour and erosion of the downstream reach.
- Ensure header dams and piping maintains current flow regimes and water quality.
- Monitoring and control of weeds into the tributaries containing Red-crowned Toadlet habitat.
- Monitoring of water quality downstream prior to entry into Ku-ring-gai Chase National Park, with appropriate trigger values including biophysical, chemical, toxicant, sediment and geomorphic indicators.

If Cockle Creek is proposed to be returned to its current state ensuing the project completion, the flora and fauna management plan would need to ensure that:

- Plant communities are established rapidly, are species rich and have dense plant cover, so as to provide quick ground-holding characteristics sufficient to withstand flooding and provide a barrier to ongoing weed colonisation.
- Weed spread is controlled from the existing channel and banks.
- The design provides a comparable area of riparian and aquatic habitat of a higher quality than the existing creek.
- The new creek is designed to be to a similar standard to the current condition of the existing Cockle Creek in terms of:
    - Variability in channel cross section.
    - Variability in bed level.
    - Bedrock material.
    - Connectivity of riparian habitat.
- Plant communities are characteristic of those that were present prior to European occupation, namely Hinterland Sandstone Gully Forest.

Specific mitigation measures for Cockle Creek are further defined in **section 5** as part of the flora and fauna management plan.

4.8.3 Impacts resulting from increased runoff

It is understood that the following catchments would receive water running off from roads associated with this project during operation. These include the following:

- Hills M2 Motorway integration works into the Darling Mills Creek catchment.
- Southern interchange into the Blue Gum Creek catchment.
- Wilson Road compound into the Tedbury Creek catchment
- Trelawney Street compound into Lane Cove River catchment.
- Northern interchange into the Coups Creek or Cockle Creek catchments.

Existing impervious surfaces in the study area have altered the flow regime of creeks adjacent to the motorway. Water quality detention basins are being redesigned with capacity to handle additional water from motorway runoff and tunnel dewatering. Four detention basins are proposed to be upgraded within the Hills M2 Motorway study area and one detention basin within the M1 Pacific Motorway study area, which would increase in detention capacity. The increased road surface is unlikely to further alter hydrology in creeks of the study area to a point resulting in impacts on aquatic systems.

During construction and operation of the project, there would be additional runoff from the pavement, which has the potential to result in indirect impacts to aquatic environs through erosion of soils, sedimentation of waterways, bank destabilisation and the potential movement of pollutants. The existing water quality detention basins would be modified to account for changes in contributing pavement area. Due to the constrained project corridor, and in an effort to minimise further disturbance of the native vegetation, the options to better use the storage volume already available should be explored during detailed design.

4.8.4 Waterway crossings

Bridges and arch structures generally have little impact on riparian vegetation, aquatic assemblages and fish passage as they normally involve limited disturbance to the flow or the aquatic habitat of a waterway; whereas culverts create a vastly different stream environment that can alter downstream habitat and create barriers to fish movement (Fairfull 2013). However, the proposed widening of the bridge structures has the potential to result in further incremental degradation of riparian vegetation of these areas.

Extension of road crossings/bridge structures at the following locations are proposed to be extended by one lane (3.5 to 4 metres):

- Yale Close overbridge.
- Barclay Rd Overbridge.
- Darling Mills Creek bridge.

The potential impact of bridge piers is decreased with parallel placement to existing structures. This would not result in changes to flow patterns or localised scour. The detailed design for these structures would need to ensure existing flow regimes are maintained. The principles that will apply in riparian areas are detailed in the mitigation section of the report under the flora and fauna management plan. Construction activities would be in accordance with the flora and fauna management plan and avoid soil erosion and sedimentation. The design and construction considerations for bridges and arches have been included in the mitigation measures detailed in **section 5**.

The extension of culverts may also affect the passage of fish and other aquatic fauna. The most common fish passage problems associated with culverts include: excessive flow velocities within the culvert, inadequate flow depth in the culvert and debris blockage of the culvert (Fairfull and Witheridge, 2003). Four culverts are proposed to be extended within the Hills M2 Motorway study area and one new culvert is proposed to be constructed under M1 Pacific Motorway and Pennant Hills Road to manage flood flow. As the existing culverts present a potential constraint to fish movement, the extension of these barriers is unlikely to substantially alter the current situation. A temporary culvert crossing at Cockle Creek will be required for access to the Junction Road compound. Fish were observed at this location, and barriers to fish movement will be avoided by constructing the culvert invert below base flow levels.

No permanent obstructions to fish movement are expected. Existing waterways pass beneath the motorway via culverts shown in **Figure 7** and road crossings. During low flow conditions, the streams of water flowing through the culverts are broad but very shallow and may limit the passage of some fish species. Higher water velocity and turbulence during rainfall events, and a lack of pooled areas for fish to rest between bouts of swimming may also limit fish movement through the culverts. The extremely low light level inside culverts and under expanded bridges may also create a nonphysical barrier for some fish species that avoid dark areas (Fairfull and Witheridge, 2003).

4.9 Groundwater dependent ecosystems

Some of the vegetation communities along the Hills M2 Motorway between study area 1 and 3 have a high potential for groundwater dependence. If these communities do use groundwater, it is likely to be from a shallow aquifer that is perched above the main Hawkesbury Sandstone Aquifer. This aquifer is probably recharged from rainfall and runoff through gullys and from road surface. The main impact the development could have on the shallow aquifer is a change in recharge patterns through altered

drainage along the road, but this is unlikely to vary much from the current condition imposed by the Hills M2 Motorway.

Construction may also require clearing of some roadside vegetation, some of which may be groundwater dependent.

4.10 Aquatic impacts

The condition of aquatic habitats downstream of the footprint varies from substantially modified to slightly modified (**section 3.4** and **Appendix J).** Upper reaches are heavily disturbed by groundcover and midstorey weeds, incised channels from fast flowing water, and realignment between urban properties and infrastructure. Macrophytes in these small creeks are scarce and only occur in constructed sediment basins. Aquatic fauna present would be restricted to pollution-tolerant and disturbance-tolerant taxa. The risk of increased impacts in these upper reaches is considered minor due to their currently disturbed condition. The greater risk is further downstream in larger creeks with improved habitat value and greater complexity, including pools suitable for fish and turtles (**Figure 14**, **Figure 15** and **Figure 16**). Some of the potential impacts to these waterways are summarised in **Table** 13.

The larger creeks in the catchments (Darling Mills Creek and Lane Cove River) are classed as Type 1 key fish habitat (when applying criteria outlined in Fairfull, 2013), which is described as 'highly sensitive to potential impacts' (**Table 13**). The main traits of freshwater habitats important to fish include pools, riffles, snags, gravel beds, undercut banks, wetlands and riparian vegetation, as well as microhabitats within these zones Fairfull (2013). Impacts in these lower reaches could arise from increased flows (surface runoff and groundwater discharge), which can lead to faster flows, bank erosion, transport of weeds, increased nutrients, algal blooms, and sedimentation of pools and interstitial habitat between cobble/pebble substrate. This in turn can lead to the decrease in habitat for macroinvertebrates, resulting in a shift of the lower order food web. (ie. less food for higher order consumers, such as fish, frogs and turtles). Many of these impacts can be avoided by slowing flows, removing sediment and nutrients, and stabilising banks with riparian vegetation.

Conversely, positive impacts from increased water volume can benefit fish migration, genetic dispersal of organisms and transport of carbon across the landscape. More regular flows can help clean and oxygenate stagnant pools. More consistent flows across rocky substrate can benefit rheophilic organisms. A rise in water levels can inundate trailing vegetation which would create more favourable habitat for macroinvertebrates. If the discharged water quality is adequately controlled, and discharge rates do not exceed habitat requirements of aquatic taxa, then the positive impacts of releasing water into these streams would generally help the food web in a mostly urbanised region.

The smaller tributaries that make up the 1st and 2nd order streams near the construction footprint are not classed as key fish habitat for the purposes of the *Policy and Guidelines for Fish Habitat Conservation and Management* (Fairfull, 2013), which excludes these stream orders (based on the Strahler method) (**Table 13**). The exception is Cockle Creek, which is mapped as a key fish habitat in the Sydney area (DPI, 2010). Nonetheless, fish were observed in several of these streams and their preservation would benefit semi-aquatic fauna, terrestrial flora and fauna; and mitigate any further impacts downstream in Type 1 waterways.

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Table 13: Potential aquatic impacts from construction and operation

Location	Watercourse name	Proposed construction works	Strahler stream order	Riparian condition	Aquatic condition, key fish habitat type and waterway class(Fairfull, 2013)	Potential impacts to watercourse							
						Encroachment into riparian buffer	Loss of riparian habitat	Groundwater discharge	Weed invasion	Polluted surface water runoff	Increased velocity of surface runoff	Surface erosion , increased turbidity and sedimentation	Altered fluvial hydrology
Hills M2 Motorway	Darling Mills Creek	Surface water runoff and treated discharge (flow on from Blue Gum Creek), upgrade of four detention basins and upgrade of Darling Mills Creek bridge.	4th	Moderate	Moderate Type 1 / Class 2	✓	✓	✓	✓	✓	✓	✓	✓
	Blue Gum Creek	Treated water discharge (groundwater, surface and construction) from the project and Hills M2 Motorway.	1st	Degraded	Degraded Not a key fish habitat / Class 3	✓		✓	✓	✓	✓	✓	✓
Northern interchange	Cockle Creek	Temporary crossing of Cockle Creek and receiving small amount of surface runoff.	1st and 2nd	Degraded to Nearly intact	Degraded to Good Mapped as key fish habitat in the Sydney area / Class 2	✓	✓		✓	✓	✓	✓	✓

Location	Watercourse name	Proposed construction works	Strahler stream order	Riparian condition	Aquatic condition, key fish habitat type and waterway class(Fairfull, 2013)	Potential impacts to watercourse							
						Encroachment into riparian buffer	Loss of riparian habitat	Groundwater discharge	Weed invasion	Polluted surface water runoff	Increased velocity of surface runoff	Surface erosion , increased turbidity and sedimentation	Altered fluvial hydrology
	Coups Creek including Arianne Avenue Creek, Exeter Street Creek and Lane Cove River	Surface water runoff from the northern interchange and treated water discharge (construction only) into Coups Creek.	1st, 2nd and 3rd	Degraded to Moderate	Degraded to Moderate Lane Cove River (Type 1 / Class 2) Arianne Ave Creek (Not a key fish habitat / Class 4) Exeter St Creek (Not a key fish habitat / Class 4) Coups Creek (Not a key fish habitat / Class 3).					✓	✓	✓	✓

Location	Watercourse name	Proposed construction works	Strahler stream order	Riparian condition	Aquatic condition, key fish habitat type and waterway class(Fairfull, 2013)	Potential impacts to watercourse							
						Encroachment into riparian buffer	Loss of riparian habitat	Groundwater discharge	Weed invasion	Polluted surface water runoff	Increased velocity of surface runoff	Surface erosion , increased turbidity and sedimentation	Altered fluvial hydrology
Trelawney Street compound	Butterfield Street Creek including Lane Cove River	Treated groundwater discharge into Butterfield Street Creek (construction only) which flows into Lane Cove River.	1st, 2nd and 3rd	Degraded to Moderate	Degraded to Moderate Lane Cove River (Type 1 / Class 2) Butterfield St Creek (Not a key fish habitat / Class 4)			✓			✓	✓	✓
Wilson Road compound	Tedbury Creek including Zig Zag Creek	Treated groundwater discharge (construction only) into Tedbury Creek flowing into Zig Zag Creek.	1st and 2nd	Degraded to Moderate	Degraded to Moderate Tedbury Creek (Not a key fish habitat / Class 3) Zig Zag Creek (Not a key fish habitat / Class 2)			✓			✓	✓	✓

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4.11 Noise, vibration and light

Indirect impacts on biodiversity caused by noise, vibration and light as part of the construction of the project as well as permanent changes in noise or lighting impacts as a result of the operation of the project are likely. Certain threatened species are particularly vulnerable to these indirect impacts.

Threatened species most at risk from indirect noise, vibration and light impacts are:

- Nocturnal birds (such as Powerful Owl and Barking Owl) may be impacted by daily construction noise and light at night time which could affect their behaviour.
- Bats (such as Long-eared Pied Bat and Eastern Bent-wing Bat) and nocturnal mammals within the study area could be impacted by increased construction noise during the day and increased light at night during the construction phase of the project and during operational phases if incorrect spectrum lighting is used.
- Diurnal birds may be indirectly impacted by noise during project construction. Species such as small woodland birds (e.g. Flame and Pink Robin) are known to be impacted by noise associated with roads (Reijnen et al, 1995).

Noise and vibration impacts as a result of construction are likely to affect fauna species that rely on sound to communicate or are nocturnal and sleep during the day when construction activities are at their peak. These may include bats and other nocturnal mammals and diurnal and nocturnal birds.

Operational noise, which would be continuous, is not likely to significantly impact on any threatened fauna species given that the majority of the new operation would be in tunnel (underground) and unlikely to impact fauna on the surface. Potential increased road traffic due to the changes along the M1 Pacific Motorway and the Hills M2 Motorway is not expected to substantially increase noise levels and therefore should not increase the impacts on fauna.

Changes to the availability of light as a result of the project may potentially impact both flora and fauna species. The potential impacts are likely to be a result of:

- Altering light regimes affecting plant growth.
- Overshadowing of flora species by noise walls and other structures.
- Changes to micro-climates caused by overshadowing or increased light potentially increasing the likelihood of weed invasion.
- Affecting typical nocturnal fauna behaviour through increase of light at night.
- Light spectrums that cause insect avoidance.

This assessment was done on the basis that lighting is to be fitted across the whole construction footprint during construction and operation.

Detailed impacts of noise, vibration and light for each species identified here can be found in impact **sections 4.1.1** to **4.1.2** above as well as the impact assessments found in **Appendix F** and **Appendix G**. In general the impact assessments concluded that noise, vibration and light are unlikely to have a significant impact on the diurnal and nocturnal threatened birds and diurnal and nocturnal mammals in the study area, because these areas already receive these types of indirect impacts, and mitigation measures would be enacted by the project. Similarly these indirect impacts are unlikely to result in significant impacts on the amphibians and reptiles that have the potential to occur in the study area.

4.12 Impact on relevant Key Threatening Processes

A number of Key Threatening Processes have been identified for the project. The activities associated with the project would either contribute to the Key Threatening Processes (known) or may potentially contribute to the Key Threatening Processes (potential). These are listed in **Table 14**.

Table 14: Known and potential Key Threatening Processes and impacts on biodiversity

Key Threatening Process	Relevance to the project	Potential or known
Alteration to the natural flow regimes of rivers, streams, floodplains & wetlands (TSC Act)	Additional flows are expected for some streams, as decribed in section 4.8. As the discharge rate is relatively small compared to the existing flow rates, mitigation measures to avoid coincidental release with large rainfall events is not required	Known – but small effect
Clearing of native vegetation (TSC Act) Land clearance (EPBC Act)	Clearing of vegetation including native vegetation would be undertaken as part of the project as outlined in **Table 11**. There would be a need to offset the loss of native vegetation in accordance to the Guideline for Biodiversity Offsets (Roads and Maritime Services 2011). This is discussed in **section 5**.	Known
Infection of frogs by amphibian chytrid causing the disease chytridiomycosis (TSC Act) Infection of amphibians with chytrid fungus resulting in chytridiomycosis (EPBC Act)	Habitats have been recorded for one threatened frog within the study area; Red-crowned Toadlet at the northern extent of the construction footprint at the northern interchange. Movement of vehicles, equipment and people during the construction phase carries a risk of introduction and spread of the chytrid fungus in these habitats and impacting on the threatened frog species. With the implementation of appropriate mitigation measures listed in **section 5** the risk is considered to be low.	Potential
Infection of native plants by *Phytophthora cinnamomi* (TSC Act)	Movement of vehicles, equipment and people during the construction phase carries a risk of introduction and spread of the plant pathogen *Phytophthora cinnamomi.* Presence of the plant pathogen within the study area is unknown. With the implementation of appropriate mitigation measures listed in **section 5** the risk is considered to be low.	Potential
Introduction and establishment of Exotic Rust Fungi of the order Pucciniales pathogenic on plants of the family Myrtaceae (TSC Act)	Movement of vehicles, equipment and people during the construction phase carries a risk of introduction and spread of 'Myrtle Rust'. Presence of Myrtle Rust within the study area is unknown although a case has been recorded along the Hills M2 Motorway outside of the boundaries of the study area (Roads and Traffic Authority 2011). With the implementation of appropriate mitigation measures listed in **section 5** the risk is considered to be low.	Potential

Key Threatening Process	Relevance to the project	Potential or known
Invasion and establishment of exotic vines and scramblers (TSC Act)	Exotic vines and scramblers are present within the study area in particular associated with riparian vegetation or in wetted areas such as Blue Gum Creek, the northern and southern interchanges. Movement of vehicles, equipment and people during the construction phase carries a risk of introduction and spread of these exotic vines and scramblers and well as disturbing intact vegetation can increase the risk of weed infestations. Appropriate mitigation measures are to be implemented to limit the spread of weeds and reduce the risk of weed infestations of areas.	Potential
Invasion, establishment and spread of *Lantana camara* (TSC Act)	*L. camara* is present at numerous locations within the study area. Movement of vehicles, equipment and people carries a risk of introduction and spread of *L. camara* into unaffected areas. Appropriate mitigation measures are to be implemented to limit the spread of weeds and reduce the risk of weed infestations of areas.	Potential
Loss of Hollow-bearing Trees (TSC Act)	The project would result in permanent removal or lopping of up to 62 hollow bearing trees (AECOM, 2014). There would be a need to offset the loss of hollow-bearing trees through the installation of nest boxes in accordance to the Guideline for Biodiversity Offsets (Roads and Maritime, 2011). This is discussed further in **section 5**.	Known

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5 Mitigation measures

5.1 Avoidance measures

Avoidance measures incorporated into the project are characterised by:

- Route selection
- Route alignment and placement of ancillary facilities
- Underground tunnelling

Chapter 4 of the environmental impact statement for the project provides discussion on the route option selection process for the project. Discussion of the route options within this technical working paper focuses on matters relevant to biodiversity impacts only.

5.1.1 Route Selection

Various alternative route alignments were considered during feasibility studies. To determine a preferred corridor, 17 broad alignments were identified and grouped into three strategic corridor options (A, B and C), with a number of the options suggested by members of the community during the consultation process (SKM 2004).

Type A corridors included more easterly alignment options, which generally formed a southern extension of the M1 Pacific Motorway corridor to connect with the Hills M2 Motorway. All Type A corridor options would be mostly in tunnel under existing roads and / or residential areas.

Type B corridors included alignment options within the central study area that connected the Sydney Orbital between Pennant Hills Road and Dean Park to the M1 Pacific Motorway between Wahroonga and the Hawkesbury River. Type B corridor options generally consisted of above ground sections and tunnels under existing residential areas.

Type C corridors included more westerly options which connected the Sydney Orbital between Windsor Road and Dean Park with the M1 Pacific Motorway north of the Hawkesbury River. All Type C corridor options consisted of above ground and tunnelled sections, and a major new crossing of the Hawkesbury River. It was also assumed that some tunnel sections would be required under Marramarra National Park.

The shorter, Type A option between the southern end of the M1 Pacific Motorway connecting south to the Hills M2 Motorway was preferred based on a number of factors including environmental concerns. These included:

- The Type B corridors would have resulted in ecological impacts associated with an interchange with the M1 Pacific Motorway at Berowra.
- The Type B corridors would have impacted native vegetation to the west of the M1 Pacific Motorway.
- The Type C corridors would have connected around Calga and need to cross the Hawkesbury River and Marramarra National Park
- The Type C corridors had a significant amount of native vegetation clearance through remote and contiguous conservation reserves and introduced the prospect of significant imposts on habitats and connectivity.

The Type A corridor chosen had the smallest ecological footprint when evaluated at a desktop level.

5.1.2 Route Options

Subsequently four more detailed options for the Type A connections were investigated (AECOM 2013 – see **Figure 12**). The purple and blue route options were preferred based on social and environmental grounds, including the significant benefit to people living and working along Pennant Hills Road as a result of the significant traffic relief to Pennant Hills Road (AECOM 2013). The option selected was found to perform better in terms of social and environmental impacts and avoided impacts on Lane Cove National Park.

Impacts on ecological values are predominately avoided by the underground tunnel. This limits ecological impacts to the two interchanges, construction and operational ancillary sites and dewatering activities during construction and operation. Avoidance measures within the M2 Motorway integration works, southern interchange, northern interchange and M1 Pacific Motorway are not practicable due to the need for these interchanges to be located in proximity to existing infrastructure.

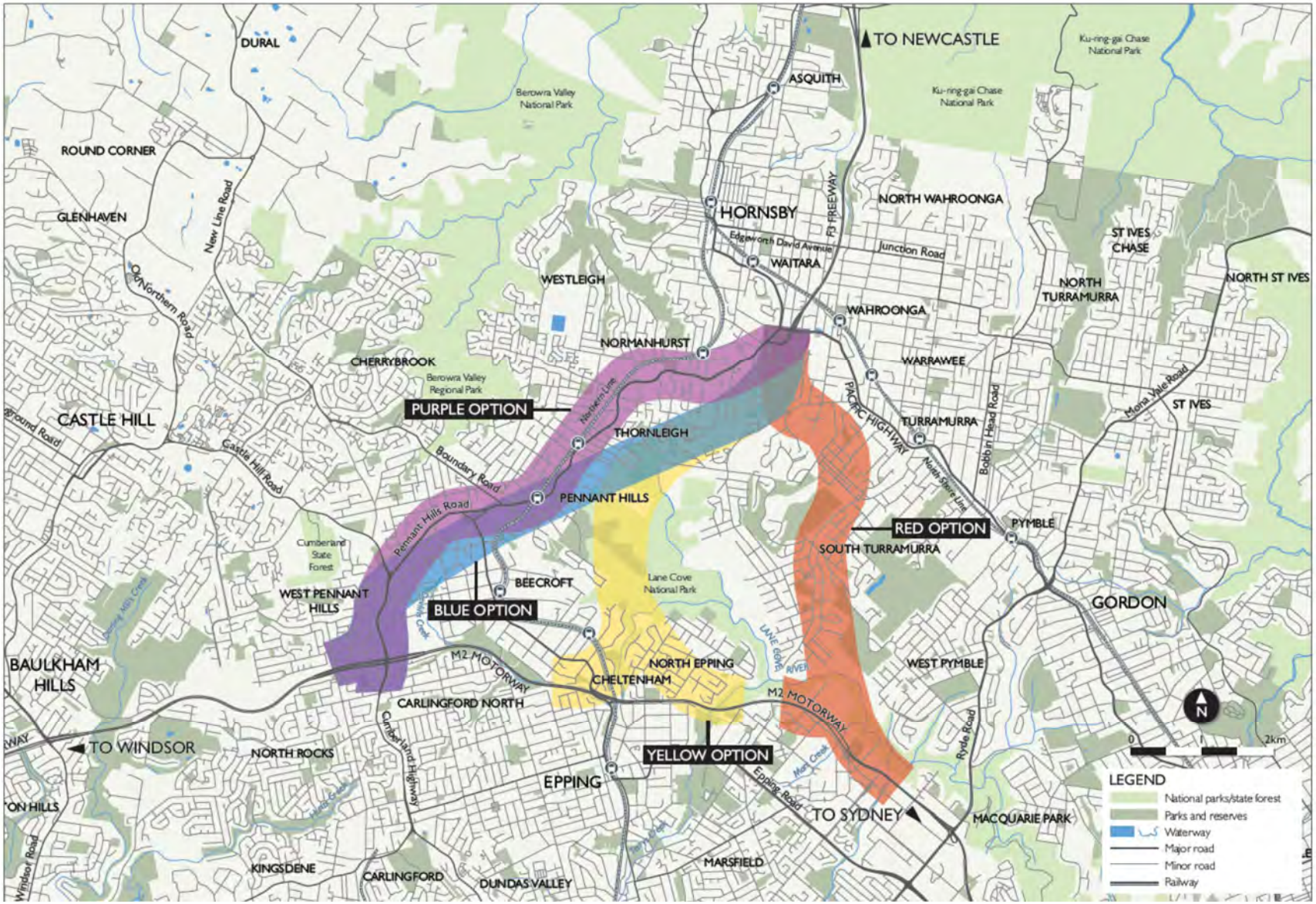

Figure 12: Type A options (source: SKM 2004)

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5.2 Mitigation measures

Mitigation measures aim to reduce the ecological impacts of the proposal to the greatest extent practicable.

5.2.1 Standard mitigation measures

The mitigation and management measures would be detailed within a flora and fauna management plan, which would be prepared with consideration to the Roads and Maritime Biodiversity Guidelines – Protecting and managing biodiversity on RTA projects (the Biodiversity Guidelines) (Roads and Traffic Authority, 2011). The measures would include, but are not limited, to the following:

- The disturbance and clearance of established vegetation would be minimised as far as reasonable and feasible.
- Pre-clearing surveys would be undertaken prior to the commencement of construction by a suitably qualified ecologist to identify the presence of hollow bearing trees and other habitat features, and threatened flora and fauna. This would be undertaken in accordance with Guide 1 of the Biodiversity Guidelines.
- Exclusion zones would be identified to protect vegetation accidental damage. This would be undertaken in accordance with Guide 2 of the Biodiversity Guidelines.
- Clearing of vegetation and the removal of bushrock would be undertaken in accordance with Guide 4 of the Biodiversity Guidelines to manage risks to fauna during vegetation clearing activities.
- Where reasonable and feasible, topsoil and habitat elements (such as woody debris and bushrock) would be stored and reused on site, or in adjacent bushland in accordance with Guide 5 of the Biodiversity Guidelines.
- Cuttings or seed material may also be gathered from the construction footprint for re-establishment works for native vegetation and landscaping plant stock.
- Areas of native vegetation, including riparian zones, would be re-established following the completion of construction activities in these areas. This would be undertaken in accordance with a flora and fauna management plan (as detailed in **section 5.5.2** and in accordance with Guide 3 of the Biodiversity Guidelines.
- Weed spread would be managed in accordance with Guide 6 of the Biodiversity Guidelines, which would include ensuring machinery is cleaned prior to entering construction sites, and the active management of weeds within the construction footprint prior to vegetation clearing.
- The identification of pathogens would be undertaken as part of pre-clearing inspections. In the event that pathogens are identified within the construction footprint, appropriate mitigation measures would be identified and implemented in accordance with Guide 7 of the Biodiversity Guidelines.
- Any handling of fauna would be carried out by appropriately licenced person and undertaken in accordance with Guide 9 of the Biodiversity Guidelines.
- Works within aquatic habitats or riparian zones would be undertaken to limit impacts on aquatic flora and fauna, and their habitats, and impacts on riparian areas. This would be undertaken in accordance with Guide 10 of the Biodiversity Guidelines. These mitigation measures are applied to the identified and assessed impacts in **Table 15**.

5.2.2 Project specific measures

Project specific measures are recommended for species where impacts would remain after the implementation of measures detailed in **section 5.2.1**, or where additional mitigation measures would further reduce the ecological impact. The project specific mitigation measures are controls or protocols which would seek to further reduce impact on threatened species, native vegetation, or riparian and aquatic habitats

Epacris purpurascens var. purpurascens establishment or relocation

The project would remove plants of *E. purpurascens* var. *purpurascens* and potential habitat for this species. This assessment concluded that a significant impact to this species was likely and therefore measures need to be undertaken to address this impact.

The suite of mitigation measures could include translocation and seed soil bank propagation for the population of regenerating *E. purpurascens* var. *purpurascens* which would otherwise be impacted upon and lost. This species appears to prefer disturbed areas and the larger area to be cleared of plants consists of soil that was placed during the M2 Upgrade and was not part of a formal salvage operation. If relocation is selected as part of the measure, the plants should not be located in areas likely to impacted by future transport or other land use requirements (for example, ideally a disturbed area inside an offset site secured for the project).

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

Microbat Management Plan

Mitigation measures are recommended for the microbats which are predominantly cave-roosting and breeding:

- Large-eared Pied Bat (vulnerable TSC Act and EPBC Act).
- Little Bent-wing Bat (vulnerable TSC Act).
- Eastern Bent-wing Bat (vulnerable TSC Act).
- Southern Myotis (vulnerable TSC Act).

The Eastern Bent-wing Bat is known to roost within the twin culverts on Devlins Creek under the Hills M2 Motorway (Cumberland Ecology 2012), which would not be impacted by the project. It is unknown if this species, and the other species identified above utilise culverts (or other resources such as the abandoned buildings at the Pioneer Avenue compound) within the construction footprint, as it was not possible to undertake targeted survey. However, the culverts within the construction footprint provide suitable habitat for microbats.

On this basis, the preparation of a Microbat Management Plan is recommended and may include measures such as:

- Monitoring of culverts and buildings prior to construction (or demolition in the case of the abandoned buildings at the Pioneer Avenue compound) to gauge dynamics of the potential roost sites and if any uptake by bats in the interim has occurred in the structures. Monitoring should include roost monitoring and Anabat echolocation monitoring points. This would occur six months prior to construction through to the end of construction. If the monitoring finds that bat species are not roosting in the culverts or Pioneer Avenue buildings then mitigation measures during and after

construction for the relevant structures would not be required for the predominately cave-dwelling bats.

- During construction, appropriate exclusion zones would be maintained and night works managed in proximity to culverts or buildings at Pioneer Avenue would be adjusted during breeding and lactation periods for any microbats that found to be using the culvert(s). The exclusion zone or excluded activities would be determined through the management plan.
- Prior to and during demolition of Pioneer Avenue buildings, ecologists would monitor for bats.
- Prior to and during construction, ecologists would access the culverts to monitor any new bat colonies in the culverts.
- Prior to and during construction, roost management measures would be implemented including passive exclusion (eg. installation of one-way flaps at potential grab hole locations), monitoring and site management.
- Reduce disturbance due to light and noise including appropriate direction and type of artificial lighting, noise attenuation and direction of noise.
- Provision of nest boxes to provide alternate roosting opportunities.

The suggested mitigation measures identified assume that these species may be present. The measures are generally consistent with those utilised in the M2 Upgrade project, which essentially entailed temporarily excluding microbats from the potential roost sites, and not carrying out noisy and/or vibration intensive works in the vicinity of any culverts where the presence of hibernating microbats had been confirmed (Cumberland Ecology, 2011). With implementation of these mitigation measures, significant impacts on these species can be avoided.

Nest Boxes

The project would result in the removal of a number of hollow bearing trees, some of which have hollows that indicate signs of usage (see Hollow Bearing Tree Report (AECOM, 2014)). The hollow bearing tree survey (AECOM, 2014) indicated that there would be an unspecified number of nest boxes within the Hills M2 Motorway integration works area that would be removed. It is assumed that these nest boxes were placed in this location as an offset to a previous project and therefore would need to be replaced. Additional nest box installation would be required for:

- Compensatory replacement of any nest boxes located with the construction area.
- Compensatory replacement of hollow-bearing trees identified in Hollow Bearing Tree survey (AECOM, 2014).

The need, number and location of nest boxes required would be confirmed based on the final disturbance footprint and guided by Guide 8 of the Biodiversity Guideline.

Native vegetation rehabilitation

The flora and fauna management plan would identify areas identified for native vegetation rehabilitation in addition to landscaped areas detailed in the Urban Design and Landscape Plan. The plan would specify how native vegetation in proximity to the construction footprint is to be protected and managed so as to prevent development impacts, and where appropriate, how areas would be rehabilitated with native vegetation. Areas to be managed via the flora and fauna management plan include (but are not limited to):

- Vegetation adjacent to Hills M2 Motorway.
- *Epacris purpurascens* var. *purpurascens* establishment, recruitment and relocation/translocation.
- Northern interchange, such as the northern interchange compound and the Junction Road compound.

Implementation of flora and fauna management plan, with respect to native rehabilitation, is to span the construction period through to the post-construction period. The flora and fauna management plan would provide specifications and guidelines on the following aspects:

- Area(s) of native vegetation, regeneration and restoration which are the subject of the flora and fauna management plan.
- Management of native vegetation through the construction works period and details of the rehabilitation works to be performed.
- Recommended performance criteria for rehabilitation works.
- Where appropriate, details of topsoil harvesting, storage and future reuse and areas where logs and felled trees may be reused.

Riparian management

The flora and fauna management plan would be prepared to include guidance for disposing of excess water from the tunnel and road run off both during and post construction. This plan should also include strategies for minimising the impacts of creek crossings, streamside vegetation clearing, and weed encroachment on aquatic and riparian ecosystems. This plan would identify sensitive receivers downstream and enable detailed design of detention basins, water sensitive urban design features and riparian discharges to be integrated.

The flora and fauna management plan would include measures to minimise the impacts on all riparian vegetation and aquatic environments such as:

- Potential chemical pollutants (eg. fuels, oils, lubricants, paints etc) would be stored in appropriate containers within bunded areas within construction compounds to minimise the risk of the pollution of aquatic environments.
- Waterway crossings, structures, bridges and culverts (including temporary creek crossings) would be designed in accordance with the relevant sections of *Policy and Guidelines for Fish Habitat Conservation and Management – 2013 update* (Fairfull, 2013) and in Guide 10 of the Biodiversity Guidelines.
- Works around waterways would be managed to retain bank stability and prevent erosion.

- Water quality would be protected through the implementation of suitable erosion and sediment control measures in accordance with Managing Urban Stomrwater – Soils and Construction, Volume 2D, Main Road Construction (Department of Environment and Climate Change, 2008).
- Bridge piers or foundations are located outside main waterway channel(s).
- Where practical, culverts would be aligned with the downstream channel to minimise bank erosion.
- Riparian areas disturbed during the works would be reinstated and replanted as quickly as possible with the aim of providing a net long term biodiversity benefit.
- Where practicable and feasible, temporary bunds would be used to maintain flow throughout construction.

Water treatment associated with the discharge of groundwater inflow from the tunnel(s) is to:

- Avoid impacts on drainage lines vegetated with native vegetation communities to the greatest extent practicable.
- Use water quality treatment devices, such as sediment basins to reduce sediment and pollutant loads.
- Treat groundwater inflows during operation to achieve discharge water quality levels that would be determined in consultation with the NSW EPA during detailed design, taking into consideration the current water quality of the receiving watercourses.
- Monitor and maintain water quality treatment devices to achieve appropriate water quality levels for the life of the project.

Modification to existing detention basins along the project corridor should:

- Minimise further disturbance of the established vegetation.
- Wherever practical, options to better use the storage volume already available within detention basins should be explored during detailed design.

The relevant ecological impacts and associated mitigation measures and protocols (standard and project specific) are identified in **Table 15**. It is anticipated that the standard control measures (ie. inductions etc) would be incorporated in a flora and fauna management plan.

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Table 15: Mitigation measures

Impact	Flora and fauna management plan / standard mitigation measures	Project Specific	Responsibility	Timing*
Vegetation				
Clearing of native vegetation	• Inductions • Pre-clearing process • Exclusion zones • Clearing of vegetation and removal of bushrock • Re-use of woody debris and bushrock • Weed management • Nest boxes • Fauna handling • Pathogen management • Aquatic habitats and riparian zones	• Native vegetation management measures	Environmental representative and construction contractor	Pre-construction Construction
Run off	• Erosion and sedimentation controls • Aquatic habitats and riparian zones • Re-establishment of native vegetation	• Riparian management and mitigation measures	Construction contractor	Pre-construction Construction Operation
Discharge from water treatment plants	• Erosion and sedimentation controls • Aquatic habitats and riparian zones • Re-establishment of native vegetation	• Riparian management and mitigation measures	Construction contractor	Construction Operation
Spread of weeds	• Weed management • Re-establishment of native vegetation where possible to limit weed spread	• Riparian management and mitigation measures	Environmental representative and construction contractor	Construction Operation
Spread of pathogens	• Pathogen management		Construction contractor	Construction

Impact	Flora and fauna management plan / standard mitigation measures	Project Specific	Responsibility	Timing*
Threatened flora				
Loss of *Epacris purpurascens* var. *purpurascens*	• Inductions • Pre-clearing process • Exclusion zones • Clearing Vegetation and removal of bushrock • Weed management • Pathogen management	• Epacris relocation	Environmental representative and construction contractor	Pre-construction Construction
Potential loss of *Hibbertia superans*	• Inductions • Pre-clearing process • Exclusion zones • Clearing vegetation and removal of bushrock • Weed management • Pathogen management	• Native vegetation management measures	Environmental representative and construction contractor	Pre-construction Construction
Threatened fauna				
Loss of native fauna from clearance	• Clearing vegetation and removal of bushrock • Fauna handling	• Riparian management measures	Environmental representative and fauna handlers	Construction
Loss of habitat for fauna	• Re-establishment of native vegetation • Re-use of woody debris and bushrock	• Native vegetation management measures	Environmental representative, construction contractor and nest box installers	Pre-construction Construction Operation
Loss of hollow bearing trees	• Pre-clearing process • Clearing vegetation and removal of bushrock • Re-use of woody debris and bushrock • Nest boxes	• Additional next boxes	Environmental representative, construction contractor and nest box installers	Construction Operation

Impact	Flora and fauna management plan / standard mitigation measures	Project Specific	Responsibility	Timing*
Impact on culverts and disused buildings with potential threatened bat habitat	• Pre-clearing process • Bat roost boxes	• Microbat Management Plan	Environmental representative, construction contractor and nest box installers	Pre-construction Construction Operation
Potential impacts on Red-crowned Toadlet habitat to east of M1 Pacific Motorway north of northern Interchange (from weed spread)	• Weed management (extended to monitor and manage weeds to north of footprint) • Sediment and erosion control plans	• Riparian management measures	Environmental representative and construction contractor	Construction Operation
Piping or box culvert of Cockle Creek south of Carrington Park	• Inductions • Pre-clearing process • Exclusion zones • Clearing Vegetation and removal of bushrock • Re-use of woody debris and bushrock • Weed Management • Fauna Handling • Pathogen Management • Aquatic habitat and riparian zones • Sediment and erosion control plans	• Riparian management measures	Environmental representative and construction contractor	Pre-construction Construction Operation

* The three categories for timing are:

- Pre-construction = Work in respect of the project that includes design, survey, acquisitions, fencing, investigative drilling or excavation, building/road dilapidation surveys, minor clearing (except where threatened species, populations or ecological communities would be affected), establishing ancillary facilities such as site compounds or other relevant activities determined to have minimal environmental impact (e.g. minor access tracks and adjustments to services/utilities etc).
- Construction = All work in respect of the project other than that defined as a preconstruction activity/work.
- Operation = The operation of the project, but not including commissioning trials of equipment, or temporary use of parts of the project during construction.

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5.2.3 Offsets

Although avoidance and mitigation measures have been considered and implemented during the design of the project, impacts on native vegetation (including Endangered Ecological Communities) and threatened flora have been identified that require offsetting.

The project is subject to two offsetting policies and/or principles including:

- EPBC Act Environmental Offsets Policy (DSEWPaC, 2012a).
- NSW offset principles for major projects (state significant development and state significant infrastructure) (OEH, 2013n).

As EPBC Act impacts are not expected to significantly impact listed species, the EPBC Act Environmental Offsets Policy (DSEWPaC, 2012a) is not considered relevant to the project. This policy is applicable for projects deemed 'controlled actions' that trigger significant impact on matters of national significance.

The NSW offset principles for major projects (state significant development and state significant infrastructure) (OEH, 2013n) are:

1. Before offsets are considered, impacts must first be avoided and unavoidable impacts minimised through mitigation measures. Only then should offsets be considered for the remaining impacts.
2. Offset requirements should be based on a reliable and transparent assessment of losses and gains.
3. Offsets must be targeted to the biodiversity values being lost or to higher conservation priorities.
4. Offsets must be additional to other legal requirements.
5. Offsets must be enduring, enforceable and auditable.
6. Supplementary measures can be used in lieu of offsets.
7. Offsets can be discounted where significant social and economic benefits accrue to NSW as a consequence of the proposal

It is noted that at the time of writing, the Draft NSW Biodiversity Offsets Policy for Major Projects and associated Draft Framework for Biodiversity Assessment*:* For assessing and offsetting state significant development and state significant infrastructure had been released for public exhibition (until 9 May 2014), but was not current NSW government policy. The Draft Framework for Biodiversity Assessment proposed a new methodology for the assessment of biodiversity offsets, but the associated credit calculator had not been finalised. For this reason, this technical working paper assessed the type and quantum of credits through the use of the BioBanking Assessment Methodology (BBAM) to quantify the impacts of the proposal. It is noted that 'red flags', which are defined as "an area of land with high biodiversity conservation values" under the BBAM methodology are identified in **Appendix H.1**, but are not applicable to major projects.

An Offset Strategy would be prepared which would address NSW offsetting requirements, using the methodology relevant at the time to quantify the order of offset and identify suitable sites. The Offset Strategy would assess all biodiversity values including ecosystems, presence of fauna habitat elements, and *Epacris purpurascens* var. *purpurascens*. The local loss of hollow bearing trees and existing nest boxes along the Hills M2 Motorway integration works area would also compensated (see previous section). The Offset Strategy would include:

- Identification of the methodology, and relevant data used to determine the required offset.
- Details of the available offset measures that have been selected to compensate for the loss of threatened species and EECs.
- The decision making process to select the final suite of offset measures (taking into account property availability and suitability).

A Biodiversity Offset Assessment has been conducted for the project, and provides an assessment of the scope and nature of ecological offset(s) to be delivered as part of the project according to the BBAM. The assessment will be reviewed and refined in consultation with OEH and NSW Department of Planning and Environment as part of the Biodiversity Offset Strategy. The Biodiversity Offset Strategy would be submitted to NSW Department of Planning and Environment.

A BioBanking Assessment has been undertaken in accordance with the BBAM and Credit Calculator Operational Manual (DECC 2009a & OEH 2012). The Credit Calculator used for the assessment was Version 2.0. The full technical details of the assessment methodology utilised are provided in Appendix H. Provided below are the results of the credit calculations, including the number of credits required and credit profile information.

The credit report identifies that 280 ecosystem credits are required for the clearance associated with the project (**Table 16**). Based on an average 9.3 credits generated per hectare of Biobank site (based on the OEH credit converter), this would require an estimated 30.1 hectares of offset lands. The quantum and location of offsets would be confirmed in the Offset Strategy.

Table 16: Summary of biometric vegetation types and credits required

Biometric Vegetation Type	Mapped Vegetation Community	Area Impacted (ha)	# Credits Required
Sydney Blue Gum - Blackbutt - Smooth-barked Apple moist shrubby open forest on shale ridges of the Hornsby Plateau, Sydney Basin	Blue Gum High Forest	2.81	163
Sydney Peppermint - Smooth-barked Apple - Red Bloodwood shrubby open forest on slopes of moist sandstone gullies, eastern Sydney Basin	Coastal Enriched Sandstone Moist Forest Coastal Sandstone Gallery Rainforest Coastal Enriched Sandstone Dry Forest	0.20	8
Red Bloodwood - Smooth-barked Apple shrubby forest on shale or ironstone of coastal plateaux, Sydney Basin	Coastal Shale-Sandstone Forest Regeneration - Native	1.90	90
Smooth-barked Apple - Red Bloodwood - Sydney Peppermint heathy open forest in sandstone gullies of western Sydney, Sydney Basin	Hinterland Sandstone Gully Forest	0.72	19
Total		5.63	280

The Sydney Turpentine-Ironbark Forest vegetation community at the Wilson Road compound, and the areas mapped as Blue Gum individuals, would require confirmation as to whether it is present, and if so, calculation of the amount of offset required, as plot/transects could not be conducted due to no access to the site(s).

Offset calculation outcomes for threatened species which require species credits are:

- 1,767 *Epacris purpurascens* var*. purpurascens* credits. 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 may be undertaken for this project.
- 67 credits for the Gang-gang Cockatoo population in the Hornsby and Ku-ring-gai local government areas Endangered Population
- Four microchiropteran bat species which have species credit components under the BioBanking methodology may occur within the study area (Large-eared Pied Bat, Little Bent-wing Bat, Eastern Bent-wing Bat, Southern Myotis), but none of these species are known to be impacted by the project. Furthermore, it is considered that direct and indirect impacts on culverts or abandoned buildings with potential roosting habitat, hollow bearing trees or nest boxes will be mitigated by the relocation of nest boxes and provision of additional nest boxes such that offsets specific to these species will not be required.

As identified above, the EPBC Act Offsets policy is not considered to be relevant to this project, as it is not considered likely that the project will constitute a controlled action under the EPBC Act. This is because this assessment has concluded that there will be no impact to the listed species Grey-headed Flying Fox, and that the ecological communities Blue Gum High Forest and Sydney Turpentine Ironbark Forest do not meet EPBC Act definitions.

The proposal is reviewed against the OEH (2013n) *NSW offset principles for major projects (state significant development and state significant infrastructure)* in **Table 17** below, and based on this review the offsets proposed are considered to be compliant with these principles.

Table 17: Review against OEH *Principles for the use of Biodiversity Offsets in NSW*

No.	Policy	Response
1	Before offsets are considered, impacts must first be avoided and unavoidable impacts minimised through mitigation measures. Only then should offsets be considered for the remaining impacts.	Aspects relating to avoidance (route selection and tunnelling) and mitigation (Standard RMS and project specific) have been addressed in this technical working paper.
2	Offset requirements should be based on a reliable and transparent assessment of losses and gains.	As the *Framework for Biodiversity Assessment* methodology was not adopted at the time of preparation or this technical working paper, the BBAM methodology has been used to assess the type and quantum of offsets which may be required.
3	Offsets must be targeted to the biodiversity values being lost or to higher conservation priorities.	Offsets will be targeted towards the ecological values impacted or to higher conservation priorities where exact “like-for-like” outcomes are not reasonably available. The nature of the offset(s) to be delivered will be confirmed in the Offset Strategy.
4	Offsets must be additional to other legal requirements.	Offset will be supplementary to other programs. The offset will be additional to other legal requirements.
5	Offsets must be enduring, enforceable and auditable.	The mechanism for delivery of the offsets will be identified in the Offset Strategy. It is anticipated that where possible offsets will be delivered via BioBanking Agreement(s), which are readily enforceable. Other options for delivery of some offsets may be pursued where BioBanking credits cannot be obtained or are not practicable (for example via a Conservation Agreement).
6	Supplementary measures can be used in lieu of offsets.	At this stage supplementary measures are not proposed, but the final nature of the offsets will be confirmed in the Offset Strategy.
7	Offsets can be discounted where significant social and economic benefits accrue to NSW as a consequence of the proposal	The nature of any discounting of offsets due to significant social and economic benefits accruing to NSW would be the subject of discussions with NSW Department of Planning and Environment.

6 Significance assessments

State significant impact assessments were undertaken for two EECs, five threatened flora and 20 threatened fauna (including one endangered population) listed under Schedules 1 and 2 of the TSC Act (see **Table 18** and **Appendix F**). These impact assessments followed the heads of consideration as outlined in the Draft *Guidelines for Threatened Species Assessment* (DEC 2004).

Table 18: Summary of findings of TSC Act significant assessments

Threatened species, or communities	Significance assessment questions						Likely significant impact?
	a	b	c	d	e	f	
Blue Gum High Forest	**X**	**Y**	**X**	**N**	**N**	**N**	**Y**
Sydney Turpentine Ironbark Forest	X	N	X	N	N	N	N
Callistemon linearifolius	N	N	N	N	N	N	N
Darwinia biflora	N	N	N	N	N	N	N
Epacris purpurascens var. *purpurascens*	**Y**	**Y**	N	**Y**	N	N	**Y**
Hibbertia superans	N	N	Y	N	N	N	N
Syzygium paniculatum	N	N	N	N	N	N	N
Red-crowned Toadlet	N	N	N	N	N	N	N
Barking Owl	N	N	N	N	N	N	N
Masked Owl	N	N	N	N	N	N	N
Powerful Owl	N	N	N	N	N	N	N
Woodland birds	N	N	N	N	N	N	N
Tree roosting bats	N	Y	N	N	N	N	N
Cave dwelling bats	N	Y	N	N	N	N	N
Grey-headed Flying Fox	N	N	N	N	N	N	N
Eastern Pygmy Possum	N	N	N	N	N	N	N

Notes: Y= Yes (negative impact), N= No (no or positive impact), X= not applicable,

As outlined in Section 5, unavoidable impacts on Blue Gum High Forest and *Epacris purpurascens* var. *purpurascens* would need to addressed in the an Offset Strategy. Commonwealth significant impact assessments were undertaken for two threatened flora species and two threatened fauna species listed under the EPBC Act (See **Table 19** and **Appendix G**).

Table 19: Summary of findings of EPBC Act significant assessments

Threatened species, or communities	Important population[1]	Likely significant impact?
Darwinia biflora	Unlikely	N
Syzygium paniculatum	N	N
Large-eared Pied Bat	N	N
Grey-headed Flying Fox	N	N

1. Important Population as determined by the *Environment Protection and Biodiversity Conservation Act 1999*, is one that for a vulnerable species:

   a is likely to be key source populations either for breeding or dispersal
   b is likely to be necessary for maintaining genetic diversity
   c is at or near the limit of the species range.

The assessments of significance concluded that no EPBC Act listed species or communities are considered likely to be significantly impacted by the project. As such a referral to the Commonwealth Department of the Environment (DotE) is not required for the project.

7 Conclusion

A substantial body of information exists for the study area given the location of the project in Sydney. The literature and the project specific ecological surveys carried out for this assessment provides a high level of confidence that biodiversity values have been adequately considered.

In line with the NSW Government principles for assessing impacts to biodiversity and determining acceptable offsets for State significant infrastructure projects, the project has demonstrated avoidance of biodiversity values. Avoidance is evident in the following project actions:

- Selection of an ecologically sensitive route alignment avoiding large impacts on National Parks and the Hawkesbury River.
- Selection of tunnelling avoiding impacts to native vegetation communities and Lane Cove National Park.
- Through road design avoiding impacts to Blue Gum High Forest and Sydney Turpentine Ironbark Forest EECs at southern interchange.
- The design of the northern interchange (M1 Pacific Motorway) has also been altered to avoid Red-crowned Toadlet habitat.
- The design of the Hills M2 Motorway integration works has been altered to avoid impacting in situ *Epacris purpurascens* var. *purpurascens* on the northern boundary of the study area, as well as three hollow bearing trees with large hollows which may be suitable nest sites for Powerful Owls.

The use of underground tunnels avoids impacts along much of the route. The construction footprint assessed has included all the currently known areas required for construction and operation of the project, including: excavation, spoil placement, machinery and access roads. Indirect impacts considered in assessing the extent and severity of impacts include: ecological connectivity, injury and mortality, weeds, pathogens, hydrological changes, bushfire risks, noise, vibration and light.

A total of 5.87 hectares of direct impacts on native vegetation communities associated with the proposed construction footprint have been identified (see **Table 11**), comprised of:

- 2.81 hectares of Blue Gum High Forest (CEEC TSC Act only).
- 0.01 hectares of Coastal Enriched Sandstone Dry Forest.
- 0.15 hectares of Coastal Enriched Sandstone Moist Forest.
- 0.03 hectares of Coastal Sandstone Gallery Rainforest.
- 1.71 hectares of Coastal Shale/Sandstone Forest.
- 0.72 hectares of Hinterland Sandstone Gully Forest.
- 0.10 hectares of Sydney Turpentine-Ironbark Forest (EEC TSC Act only).
- 0.07 hectares of planted *Syzygium paniculatum* (Lilly Pilly).
- 0.19 hectares of regeneration native vegetation.

Although ELA identified several patches of Blue Gum High Forest across the study area that satisfied TSC Act listing requirements, no Blue Gum High Forest patches being impacted by the project met the EPBC Act definition. This includes Blue Gum High Forest at the southern and northern interchanges and at the ancillary facilities sites.

Three TSC Act listed plant species have been identified within the study area: *Epacris purpurascens* var. *purpurascens, Hibbertia superans* and *Syzygium paniculatum.* For these species, the project would:

- Clear around 106 individuals *of E. purpurascens* var. *purpurascens* on the southern side of the Hills M2 Motorway integration works area. This population is associated with previous restoration, is fenced and within a previous construction footprint. Around 76 additional individuals are in situ habitat on the northern side of the Hills M2 Motorway. Areas outside the road corridor also contain habitat that supports this species.
- Remove small patches of *Syzygium paniculatum* that were found at the northern interchange and southern interchange. However, these individuals have been planted (commonly used in landscaping in the Sydney region) and assessment considered the impacts to be not significant.
- Retain four *Hibbertia superans* plants that were found on the northern side of the Hills M2 Motorway integration works area outside the project construction footprint.

No other threatened flora species were detected.

A number of threatened fauna species have been identified as potentially occurring, and impacts on these species have been assessed. Specific mitigation measures have been developed for Red-crowned Toadlet (*Pseudophryne australis*) and Eastern Bent-wing Bat (*Miniopterus schreibersii oceanensis)*. Significant impacts on all threatened fauna species have been avoided through environmental design, construction management protocols or further mitigated to reduce the frequency, intensity and/or duration of impacts.

No EPBC Act listed species or communities are considered at risk from the project and as such a referral under the EPBC Act to the Commonwealth Department of the Environment (DotE) is not required.

Impacts on partially groundwater dependent ecosystems and riparian values from changes in surface water flows are unlikely to vary much from the current drainage imposed by the Hills M2 Motorway. Potential downstream impacts on Blue Gum Creek from the discharge of treated tunnel water would be further mitigated in the flora and fauna management plan. Impacts to aquatic habitat further downstream can be mitigated by slowing flows, removing sediment and nutrients, and stabilising banks with riparian vegetation.

A fauna and flora environmental management plan would include standard Roads and Maritime mitigation measures to minimise ecological impacts. Additionally, project specific mitigation measures further reduce unavoidable impacts to the greatest extent possible. Specific measures may include:

- Relocation of *E. purpurascens* var. *purpurascens* to a more suitable long term site.
- Additional compensatory nest boxes.
- A Microbat Management Plan is recommended to address these impacts and may include monitoring of the culverts and disused buildings at Pioneer Avenue compound for bat activity and exclusion of works during breeding season if present at the time of construction.
- Native vegetation management measures, as detailed in a flora and fauna management plan, for areas to be rehabilitated including (but not limited to): northern interchange, southern interchange and areas adjacent to the Hills M2 Motorway integration works area.

- Riparian mitigation and management measures to minimise the impacts on riparian vegetation and aquatic environments, including water quality controls and bank stability, as detailed within flora and fauna management plan.

An Offset Strategy would be prepared in accordance with NSW offsetting principles for SSI for residual impacts to biodiversity. The strategy would aim to compensate for the loss of native vegetation, endangered ecological communities and threatened species habitat which the project cannot avoid and where mitigation measures are not capable of maintaining ecological values over the longer term. The quantum of offsets would be determined using an appropriate assessment methodology, and would seek to deliver offsets by conserving and providing for in perpetuity ecological management.

The project has avoided biodiversity impacts to the maximum extent possible via route selection, adoption of underground tunnels in the design. Further design iterations which have been informed by this assessment have further avoided threatened flora and fauna habitats, and large stands of Blue Gum High Forest CEEC and Sydney Turpentine Ironbark Forest EECs. A range of standard and project specific mitigation measures are proposed to further reduce identified impacts and to manage environmental values within the study area both during and post construction.

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Appendix A: Likelihood of occurrence

Provided below are the likelihood tables for threatened species listed under the NSW TSC Act and Commonwealth EPBC Act. Species, populations and communities considered to have the potential, are likely or are known to occur are highlighted blue.

The analysis of the likelihood of occurrence table included previous surveys conducted by Eco Logical Australia (ELA).

Key to the table:

- TSC Act = Listing under the *Threatened Species Conservation Act 1995*
- EPBC Act = Listing under the *Environment Protection and Biodiversity Conservation Act 1999*
- CE = Critically Endangered
- E = Endangered (EPBC Act)
- E1 = Endangered (TSC Act)
- E2 = Endangered Population (TSC Act)
- E4 = Extinct (TSC Act)
- V = Vulnerable
- M = Migratory (EPBC Act)
- Mar = Marine (EPBC Act)

Species name	Common name	TSC Act	EPBC Act	Habitat associations	Number of Atlas records	Likelihood of occurrence in the study area
Acacia bynoeana	Bynoe's Wattle	E	V	*Acacia bynoeana* is found in central eastern NSW, from the Hunter District (Morisset) south to the Southern Highlands and west to the Blue Mountains, and has recently been found in the Colymea and Parma Creek areas west of Nowra. It is found in heath and dry sclerophyll forest, typically on a sand or sandy clay substrate, often with ironstone gravels (DECC 2007).	39	Unlikely - little ironstone gravels found within the Hills M2 Motorway tie in works study area
Acacia gordonii	-	E	E	*Acacia gordonii* is restricted to the north-west of Sydney, occurring in the lower Blue Mountains in the west, and in the Maroota/Glenorie area in the east, within the Hawkesbury, Blue Mountains and Baulkham Hills local government areas. Grows in dry sclerophyll forest and heathlands amongst or within rock platforms on sandstone outcrops (DECC 2007).	3	Unlikely – verified in field assessment
Acacia pubescens	Downy Wattle	V	V	*Acacia pubescens* occurs on the NSW Central Coast in Western Sydney, mainly in the Bankstown-Fairfield-Rookwood area and the Pitt Town area, with outliers occurring at Barden Ridge, Oakdale and Mountain Lagoon. It is associated with Cumberland Plains Woodlands, Shale / Gravel Forest and Shale / Sandstone Transition Forest growing on clay soils, often with ironstone gravel (NPWS 1997; Benson and McDougall 1996).	43	Unlikely – verified in field assessment
Acacia terminalis subsp. *terminalis*	Sunshine Wattle	V	V	Confined to the coastal area of the Sydney and Illawarra regions. Populations are known between northern Sydney and Maroota in the north-west. New population discovered at Croom Reserve near Albion Park in Shellharbour LGA in August 2011. Formerly recorded around the Parramatta River and Port Jackson region including Five Dock, Bellevue Hill and Manly (OEH 2014). Occurs on shaley/lateritic soils over sandstone and shale/sandstone transition soils on ridgetops and upper slopes amongst woodlands. Also recorded in Illawarra Lowland Grassy Woodland habitat at Albion Park on the Illawarra coastal plain (OEH 2014).	8	Unlikely – verified in field
Allocasuarina glareicola	-	-	E	*Allocasuarina glareicola* is primarily restricted to the Richmond district on the north-west Cumberland Plain, with an outlier population found at Voyager Point. It grows in Castlereagh woodland on lateritic soil (DECC 2007).	EPBC	Unlikely – verified in field
Ancistrachne maidenii	-	V	-	Restricted to northern Sydney, around St Albans - Mt White - Maroota - Berowra areas and to the Shannon Creek area south-west of Grafton. Habitat requirements appear to be specific, with populations occurring in distinct bands in areas associated with a transitional geology between Hawkesbury and Watagan soil landscapes (OEH 2014).	7	Unlikely – verified in field

Species name	Common name	TSC Act	EPBC Act	Habitat associations	Number of Atlas records	Likelihood of occurrence in the study area
Asterolasia elegans	-	E	E	Occurs north of Sydney, in the Baulkham Hills, Hawkesbury and Hornsby local government areas. Also likely to occur in the western part of Gosford local government area. Known from only seven populations, only one of which is wholly within a conservation reserve. Occurs on Hawkesbury sandstone in sheltered forests on mid- to lower slopes and valleys (OEH 2014).	EPBC	Unlikely – verified in field
Caladenia tessellata	Thick Lip Spider Orchid	E	V	The Thick Lip Spider Orchid is known from the Sydney area (old records), Wyong, Ulladulla and Braidwood in NSW. Populations in Kiama and Queanbeyan are presumed extinct. It was also recorded in the Huskisson area in the 1930s. The species occurs on the coast in Victoria from east of Melbourne to almost the NSW border. Generally found in grassy sclerophyll woodland on clay loam or sandy soils, though the population near Braidwood is in low woodland with stony soil (OEH 2014).	7	Unlikely – verified in field
Callistemon linearifolius	Netted Bottlebrush	V	-	*Callistemon linearifolius* has been recorded from the Georges River to Hawkesbury River in the Sydney area, and north to the Nelson Bay area of NSW, growing in dry sclerophyll forest (DECC 2007). For the Sydney area, recent records are limited to the Hornsby Plateau area near the Hawkesbury River (DECC 2007).	121	**Potential** – suitable habitat in the Hills M2 Motorway integration works study area
Camarophyllopsis kearneyi	-	E	-	Fungus. Known only from its type locality in Lane Cove Bushland Park in the Lane Cove local government area in the Sydney metropolitan region (OEH 2014).	1	Unlikely
Cryptostylis hunteriana	Leafless Tongue Orchid	V	V	*Cryptostylis hunteriana* is known from a range of vegetation communities including swamp-heath and woodland (DECC 2007). The larger populations typically occur in woodland dominated by *Eucalyptus sclerophylla* (Scribbly Gum), *E. sieberi* (Silvertop Ash), *Corymbia gummifera* (Red Bloodwood) and *Allocasuarina littoralis* (Black Sheoak); where it appears to prefer open areas in the understorey of this community and is often found in association with the *C. subulata* (Large Tongue Orchid) and the *C. erecta* (Tartan Tongue Orchid) (DECC 2007).	1	Unlikely – verified in field assessment
Darwinia biflora	-	V	V	*Darwinia biflora* is an erect or spreading shrub to 80cm high associated with habitats where weathered shale capped ridges intergrade with Hawkesbury Sandstone, where soils have high clay content (NPWS 1997).	904	**Potential** – suitable habitat along Hills M2 Motorway integration works

Species name	Common name	TSC Act	EPBC Act	Habitat associations	Number of Atlas records	Likelihood of occurrence in the study area
Darwinia peduncularis	-	V	-	*Darwinia peduncularis* occurs as local disjunct populations in coastal NSW in the Blue Mountains, Brooklyn, Berowra, Galston Gorge, Hornsby, Bargo River, Glen Davis, Mount Boonbourwa and Kings Tableland, and usually grows on or near rocky outcrops on sandy, well drained, low nutrient soil over sandstone (DECC 2007).	45	Unlikely – verified in field.
Deyeuxia appressa	-	E	E	A highly restricted NSW endemic known only from two pre-1942 records in the Sydney area. Was first collected in 1930 at Herne Bay, Saltpan Creek, off the Georges River, south of Bankstown. Was then collected in 1941 from Killara, near Hornsby. Has not been collected since and may now be extinct in the wild due to the level of habitat loss and development that has occurred within these areas (OEH 2014).	3	Unlikely – verified in field
Dillwynia tenuifolia	-	V	-	The core distribution is the Cumberland Plain from Windsor and Penrith east to Dean Park near Colebee. Other populations in western Sydney are recorded from Voyager Point and Kemps Creek in the Liverpool LGA, Luddenham in the Penrith LGA and South Maroota in the Baulkham Hills Shire. Disjunct localities outside the Cumberland Plain include the Bulga Mountains at Yengo in the north, and Kurrajong Heights and Woodford in the Lower Blue Mountains (OEH 2014).	11	Unlikely – verified in field
Diuris bracteata	-	E	Ext	For over 100 years *Diuris bracteata* was known only from the original collection made near Gladesville in northern Sydney. The complete absence of records for most of the 20th Century resulted in this species being listed as 'presumed extinct' on Part 4 of Schedule 1 of the Threatened Species Conservation Act. In recent years, however, extant populations from north-west of Gosford have been recorded and this area is now the only known area of occurrence of the species. All known plants fall within the Gosford and Wyong Local Government Areas. Dry sclerophyll woodland and forest with a predominantly grassy understorey (OEH 2014).	1	No – verified in field
Epacris purpurascens var. *purpurascens*	-	V	-	*Epacris purpurascens* var. *purpurascens* has been recorded between Gosford in the north to Avon Dam in the south, in a range of habitats, but most have a strong shale soil influence (DECC 2007).	328	**Known -** located within Hills M2 Motorway integration works study area
Eucalyptus camfieldii	Camfield's Stringybark	V	V	*Eucalyptus camfieldii* is associated with shallow sandy soils bordering coastal heath with other stunted or mallee eucalypts, often in areas with restricted drainage and in areas with laterite influenced soils, thought to be associated with proximity to shale (DECC 2007).	82	Unlikely - verified in field assessment

Species name	Common name	TSC Act	EPBC Act	Habitat associations	Number of Atlas records	Likelihood of occurrence in the study area
Eucalyptus nicholii	Narrow-leaved Black Peppermint	V	V	*Eucalyptus nicholii* naturally occurs in the New England Tablelands of NSW, where it occurs from Nundle to north of Tenterfield. Grows in dry grassy woodland, on shallow and infertile soils, mainly on granite (DECC 2007). This species is widely planted as an urban street tree and in gardens but is quite rare in the wild (DECC 2007). Plantings undertaken for horticultural and aesthetic purposes are not considered threatened species under the TSC Act.	17	Unlikely – out of natural range
Eucalyptus scoparia	Wallangarra White Gum	E	V	Known in NSW only from the Tenterfield district where it is very uncommon. Grows on rocky hillsides in shrubby woodland close to granite outcrops.	4	Unlikely – out of natural range
Eucalyptus sp. Cattai	*Eucalyptus* sp. Cattai	E	-	*Eucalyptus* sp. Cattai occurs in the area between Colo Heights and Castle Hill, north western Sydney. It occurs as a rare emergent in scrub, heath and low woodland on sandy soils, usually as isolated individuals or occasionally in small groups. The sites at which it occurs are generally flat and on ridge tops and associated soils are laterised clays overlying sandstone (DECC 2007).	44	Unlikely – verified in field assessment
Galium australe	Tangled Bedstraw	E	-	*Galium australe* is known from the Towamba Valley near Bega, Lake Yarrunga near Kangaroo Valley, Cullendulla Creek Nature Reserve near Batemans Bay, Conjola National Park, Swan Lake near Swanhaven, and the Big Hole in Deua National Park. Tangled Bedstraw was recorded historically from the Clyde River near Batemans Bay and the Mongarlowe area near Braidwood (DECC 2007). The species also occurs beside Lake Windemere in Jervis Bay, is widespread in Victoria and is also found in South Australia and Tasmania (DECC 2007). In NSW Galium australe has been found in moist gullies of tall forest, *Eucalyptus tereticornis* forest, coastal Banksia shrubland, and *Allocasuarina nana* heathland, while in other states the species is found in a range of near-coastal habitats, including sand dunes, sand spits, shrubland and woodland.	7	Unlikely – verified in field.
Genoplesium baueri	Bauer's Midge Orchid	E	E	Known from coastal areas from northern Sydney south to the Nowra district. Previous records from the Hunter Valley and Nelson Bay are now thought to be erroneous. Grows in shrubby woodland in open forest on shallow sandy soils.	28	Unlikely – verified in field.

Species name	Common name	TSC Act	EPBC Act	Habitat associations	Number of Atlas records	Likelihood of occurrence in the study area
Genoplesium plumosum	Tallong Midge Orchid	E	E	*Genoplesium plumosum* occurs on very shallow soils overlying flat to gently sloping sheets of sandstone, with low scrub/heath dominated by Violet Kunzea (*Kunzea parvifolia*), Common Fringe-myrtle (*Calytrix tetragona*) and Eggs and Bacon (*Dillwynia* sp.), with scattered shrubs of Hairpin Banksia (*Banksia spinulosa*), Black She-oak (*Allocasuarina littoralis*), Bitter Cryptandra (*Cryptandra amara*), Slender Wattle (*Acacia elongata*), Narrow-leaf Geebung (*Persoonia linearis*), Coral Heath (*Epacris microphylla*) and a Beard Heath (*Leucopogon* sp.) (NPWS 2002). The habitat is surrounded by Brittle Gum (*Eucalyptus mannifera*) and Scribbly Gum (*E. rossii*) low woodland, with Argyle Apple (*E. cinerea*) present at some sites (NPWS 2002).	2	Unlikely – verified in field assessment
Grammitis stenophylla	Narrow-leaf Finger Fern	E	-	In NSW, *Grammitis stenophylla* has been found on the south, central and north coasts, and as far west as Mount Kaputar National Park near Narrabri, in moist places, usually near streams, on rocks or in trees, in rainforest and moist eucalypt forest (DECC 2007).	11	Unlikely - out of range
Grevillea caleyi	Caley's Grevillea	E	E	*Grevillea caleyi* is restricted to an eight kilometre square area around Terrey Hills, approximately 20 kilometre north of Sydney. It occurs in three major areas of suitable habitat, namely Belrose, Ingleside and Terrey Hills / Duffys Forest within the Ku-ring-gai, Pittwater and Warringah local government areas. It occurs on ridgetops between elevations of 170 to 240 m asl, on laterite soils in open or low open forests, generally dominated by *Eucalyptus sieberi, Corymbia gummifera* and *E. haemastoma* (DECC 2007).	158	Unlikely – verified in field assessment
Grevillea juniperina subsp. *juniperina*	Juniper-leaved Grevillea	V	-	*Grevillea juniperina* subsp. *juniperina* is endemic to Western Sydney, centred on an area bounded by Blacktown, Erskine Park, Londonderry and Windsor with outlier populations at Kemps Creek and Pitt Town. It grows on reddish clay to sandy soils derived from Wianamatta Shale and Tertiary alluvium, typically containing lateritic gravels (DECC 2007).	8	Unlikely – verified in field assessment
Grevillea parviflora subsp. *parviflora*	Small-flower grevillea	V	V	*Grevillea parviflora* subsp. *parviflora* is sporadically distributed throughout the Sydney Basin mainly around Picton, Appin and Bargo. Separate populations are also known further north from Putty to Wyong and Lake Macquarie and Cessnock and Kurri Kurri. It grows in sandy or light clay soils over thin shales, often with lateritic ironstone gravels. It often occurs in open, slightly disturbed sites such as tracks (DECC 2007).	EPBC	Unlikely – verified in field assessment

Species name	Common name	TSC Act	EPBC Act	Habitat associations	Number of Atlas records	Likelihood of occurrence in the study area
Grevillea parviflora subsp. *supplicans*	-	E	-	Has a very restricted known distribution (approximately 8 by 10 km) and is confined to the north-west of Sydney near Arcadia and the Maroota–Marramarra Creek area, in Hornsby and Baulkham Hills local government areas. It is known from only a few locations, one of which is in the southern portion of Marramarra National Park. Occurs in heathy woodland associations on skeletal sandy soils over massive sandstones. Local observations (by Douglas) do not support the description by Olde & Marriott (1995) of its habitat as "wet heath", rather that this taxon is strongly associated with clay-capped ridged of the Lucas Heights and Faulconbridge soil landscapes, but that it is quite restricted within these areas, suggesting it has a preference for yellow clays with periodically impeded drainage (OEH 2014).	7	Unlikely – verified in field assessment
Grevillea shiressii	-	V	V	*Grevillea shiressii* occurs along creek banks in wet sclerophyll forest, on sandy soil on Hawkesbury sandstone, restricted to the Gosford area (DECC 2007).	-	Unlikely – verified in field assessment
Haloragis exalata subsp. *exalata*	Wingless Raspwort	V	V	*Haloragis exalata* has been recorded in 4 widely scattered localities in eastern NSW; the Central Coast, South Coast and North Western Slopes botanical subdivisions of NSW; where it appears to require protected and shaded damp situations in riparian habitats (DECC 2007).	EPBC	Unlikely – verified in field assessment
Haloragodendron lucasii	-	E	E	Known locations of this species are confined to a very narrow distribution on the north shore of Sydney. *Haloragodendron lucasii* is associated with low woodland on sheltered slopes near creeks on moist loamy sand on bench below small sandstone cliff lines, with continuous seepage (Benson and McDougall 1997).	36	Unlikely - no suitable habitat of low woodland or seepage zones near sandstone cliffs found during field assessment.
Hibbertia puberula	-	E	-	*Hibbertia puberula* extends from Wollemi National Park south to Morton National Park and the south coast near Nowra. Early records of this species are from the Hawkesbury River area and Frenchs Forest in northern Sydney, South Coogee in eastern Sydney, the Hacking River area in southern Sydney, and the Blue Mountains. Habitats are typically dry sclerophyll woodland communities, although heaths are also occupied. One of the recently (2012) described subspecies also favours upland swamps and occurs on sandy soil often associated with sandstone, or on clay. (OEH 2014).	EPBC	Unlikely – verified in field

Species name	Common name	TSC Act	EPBC Act	Habitat associations	Number of Atlas records	Likelihood of occurrence in the study area
Hibbertia superans	-	E		*Hibbertia superans* mainly occurs in the north west Sydney region between Baulkham Hills and Wisemans Ferry, with a disjunct occurrence near Mt Boss (inland from Kempsey) on the Mid North Coast of NSW. In the Sydney region it occurs in dry sclerophyll forest on sandstone ridgetops while the northern occurrence is on granite (DECC 2007).	218	**Known –**4 plants found within Hills M2 Motorway integration works study area.
Hygrocybe anomala var. *ianthinomarginata*	-	V	-	A fungus. Type locality, Lane Cove Bushland Park, Lane Cove Local Government Area. Other records from Royal and Blue Mountains NPs. Occurs in gallery warm temperate forests associated with alluvial sandy soils of the Hawkesbury Soil Landscapes with naturally low fertility and erodible (OEH 2014).	1	Unlikely – little suitable habitat
Hygrocybe aurantipes	-	V	-	A fungus. Type locality, Lane Cove Bushland Park, Lane Cove Local Government Area. Other records from Blue Mountains National Park (Mt Wilson) and Hazelbrook. Occurs in gallery warm temperate forests associated with alluvial sandy soils of the Hawkesbury Soil Landscapes with naturally low fertility and erodible (OEH 2014).	1	Unlikely – little suitable habitat
Hygrocybe austropratensis	-	E	-	Only know from type locality at Lane Cove Bushland Park, Lane Cove Local Government Area. Occurs in gallery warm temperate forests associated with alluvial sandy soils of the Hawkesbury Soil Landscapes with naturally low fertility and erodible (OEH 2014).	1	Unlikely – little suitable habitat
Hygrocybe collucera	-	E	-	Only know from type locality at Lane Cove Bushland Park, Lane Cove Local Government Area. Occurs in gallery warm temperate forests associated with alluvial sandy soils of the Hawkesbury Soil Landscapes with naturally low fertility and erodible (OEH 2014).	1	Unlikely – little suitable habitat
Hygrocybe griseoramosa	-	E	-	Only know from type locality at Lane Cove Bushland Park, Lane Cove Local Government Area. Occurs in gallery warm temperate forests associated with alluvial sandy soils of the Hawkesbury Soil Landscapes with naturally low fertility and erodible (OEH 2014).	1	Unlikely – little suitable habitat
Hygrocybe lanecovensis	-	E	-	Only know from type locality at Lane Cove Bushland Park, Lane Cove Local Government Area. Occurs in gallery warm temperate forests associated with alluvial sandy soils of the Hawkesbury Soil Landscapes with naturally low fertility and erodible (OEH 2014).	1	Unlikely – little suitable habitat

Species name	Common name	TSC Act	EPBC Act	Habitat associations	Number of Atlas records	Likelihood of occurrence in the study area
Hygrocybe reesiae	-	V	-	Type locality, Lane cove Bushland Park, Lane Cove Local Government Area. Also recorded from Blue Mountains National Park in the Hazelbrook area. Also found in Tasmania. Occurs in gallery warm temperate forests associated with alluvial sandy soils of the Hawkesbury Soil Landscapes with naturally low fertility and erodible (OEH 2014).	1	Unlikely – little suitable habitat
Hygrocybe rubronivea	-	V	-	Known in a few locations including in Lane Cove Bushland Park and the Blue Mountains in NSW and in areas of south-east Queensland. However little information exists for populations outside Lane Cove Bushland Park. Occurs in gallery warm temperate forests associated with alluvial sandy soils of the Hawkesbury Soil Landscapes (OEH 2014).	1	Unlikely – little suitable habitat
Kunzea rupestris	-	V	V	Restricted, with most locations in the Maroota - Sackville - Glenorie area and one outlier in Ku-ring-gai Chase National Park, all within the Central Coast botanical subdivision of NSW. Currently known to exist in 20 populations, 6 of which are reserved. Grows in shallow depressions on large flat sandstone rock outcrops. Characteristically found in short to tall shrubland or heathland (OEH 2014).	2	No – verified in field
Lasiopetalum joyceae	-	V	V	*Lasiopetalum joyceae* grows in ridgetop woodland, heath, woodland or open scrub, often with a clay influence (NPWS 1997).	73	Unlikely – verified in field assessment
Leptospermum deanei	-	V	V	*Leptospermum deanei* has been recorded in Hornsby, Warringah, Ku-ring-gai and Ryde local government areas, in woodland on lower hill slopes or near creeks, at sites with sandy alluvial soil or sand over sandstone (DECC 2007). It has also been recorded in riparian scrub dominated by *Tristaniopsis laurina* and *Baeckea myrtifolia*; woodland dominated by *Eucalyptus haemastoma*; and open forest dominated by *Angophora costata, Leptospermum trinervium* and *Banksia ericifolia* (DECC 2007).	26	Unlikely – verified in field assessment.
Melaleuca biconvexa	Biconvex Paperbark	V	V	*Melaleuca biconvexa* occurs in coastal districts and adjacent tablelands from Jervis Bay north to the Port Macquarie district. It grows in damp places often near streams (PlantNet 2011).	1	Unlikely – no suitable habitat.
Melaleuca deanei	Deane's Paperbark	V	V	Found in heath on sandstone (DECC 2007), and also associated with woodland on *broad* ridge tops and slopes on sandy loam and lateritic soils (Benson and McDougall 1998).	115	Unlikely – verified in field assessment

Species name	Common name	TSC Act	EPBC Act	Habitat associations	Number of Atlas records	Likelihood of occurrence in the study area
Microtis angusii	Angus's Onion Orchid	E	E	Currently known from only one site at Ingleside, north of Sydney. A collection previously thought to be this species was made from Sunny Corner 100 km west of Sydney, but has since been confirmed as being genetically distinct and may possibly be a subspecies. It is not easy to define the preferred natural habitat of this orchid as the Ingleside location is highly disturbed (OEH 2014).	EPBC	Unlikely – verified in field assessment
Pelargonium sp. *striatellum*	Omeo Stork's-bill	E	E	Known from only 3 locations in NSW, with two on lake-beds on the basalt plains of the Monaro and one at Lake Bathurst. A population at a fourth known site on the Monaro has not been seen in recent years. The only other known population is at Lake Omeo, Victoria. It occurs at altitudes between 680 to 1030 m. It is known to occur in the local government areas of Goulburn-Mulwaree, Cooma-Monaro, and Snowy River, but may occur in other areas with suitable habitat; these may include Bombala, Eurobodalla, Palerang, Tumbarumba, Tumut, Upper Lachlan, and Yass Valley local government areas. It has a narrow habitat that is usually just above the high-water level of irregularly inundated or ephemeral lakes, in the transition zone between surrounding grasslands or pasture and the wetland or aquatic communities (OEH 2014).	EPBC	No – verified in field assessment
Persoonia hirsuta	Hairy Geebung	E	E	*Persoonia hirsuta* occurs from Singleton in the north, south to Bargo and the Blue Mountains to the west (DECC 2007). It grows in dry sclerophyll eucalypt woodland and forest on sandstone (PlantNet 2011).	38	Unlikely – verified in field assessment
Persoonia mollis subsp. *maxima*	-	E	E	Deep gullies or on the steep upper hillsides of narrow gullies incised from Hawkesbury Sandstone, characterised by steep sideslopes, rocky benches and broken scarps, with creeks fed by small streams and intermittent drainage depressions. Occurrences of this plant have been recorded on the dry upper-hillsides of gullies and in more exposed aspects *E. haemastoma* (Scribbly Gum), *E. punctata* (Grey Gum)) (NPWS 1999).	377	Unlikely – verified in field assessment
Persoonia nutans	Nodding Geebung	E	E	Associated with dry woodland, Castlereagh Scribbly Gum Woodland, Agnes Banks Woodland and sandy soils associated with tertiary alluvium, occasionally poorly drained (Benson and McDougall 2000). Endemic to the Western Sydney (Benson and McDougall 2000).	4	Unlikely – verified in field assessment
Pimelea curviflora var. *curviflora*	-	V	V	*Pimelea curviflora* var. *curviflora* is confined to the coastal area of Sydney between northern Sydney in the south and Maroota in the north-west. It grows on shaley/lateritic soils over sandstone and shale/sandstone transition soils on ridgetops and upper slopes amongst woodlands (DECC 2007). Associated with the Duffys Forest Community, shale lenses on ridges in Hawkesbury sandstone geology (Pittwater Council 2000).	125	Unlikely – no suitable habitat.

Species name	Common name	TSC Act	EPBC Act	Habitat associations	Number of Atlas records	Likelihood of occurrence in the study area
Pimelea spicata	Spiked Rice-flower	E	E	In western Sydney, *Pimelea spicata* occurs on an undulating topography of well-structured clay soils, derived from Wianamatta shale (DEC 2004). It is associated with Cumberland Plains Woodland (CPW), in open woodland and grassland often in moist depressions or near creek lines (*Ibid.*). Has been located in disturbed areas that would have previously supported CPW (*Ibid.*).	140	Unlikely – verified in field assessment and little suitable habitat
Pomaderris prunifolia	*P. prunifolia* in the Parramatta, Auburn, Strathfield and Bankstown Local Government Areas	E2	-	This Endangered Population of *Pomaderris prunifolia* is only known from three sites in the Parramatta, Auburn, Strathfield and Bankstown local government areas (at Rydalmere, within Rookwood Cemetery and at The Crest of Bankstown) in Western Sydney. It grows in disturbed areas on sandstone or shale soils (DECC 2007).	4	Unlikely – verified in field assessment
Prostanthera marifolia	Seaforth Mintbush	CE	CE	*Prostanthera marifolia* is currently only known from the northern Sydney suburb of Seaforth and has a very highly restricted distribution. It occurs in localised patches in or in close proximity to the Duffys Forest EEC. It grows on deeply weathered clay-loam soils associated with ironstone and scattered shale lenses (DECC 2007).	4	Unlikely – out of range.
Pterostylis gibbosa	Illawarra Greenhood	E	E	Known from a small number of populations in the Hunter region (Milbrodale), the Illawarra region (Albion Park and Yallah) and the Shoalhaven region (near Nowra). It is apparently extinct in western Sydney which is the area where it was first collected (1803). All known populations grow in open forest or woodland, on flat or gently sloping land with poor drainage (OEH 2014).	EPBC	No –verified in field assessment
Pterostylis nigricans	Dark Greenhood	V	-	Known in NSW from a small number of populations on the North Coast north from about Coffs Harbour. A recently discovered population at Kurnell also appears to be this species which extends its range considerably to the south. Plants grow in coastal heath either in deep sandy soils or rarely in rocky areas with sandstone outcrops (Sydney/Kurnell population).	1	Unlikely – verified in field assessment

Species name	Common name	TSC Act	EPBC Act	Habitat associations	Number of Atlas records	Likelihood of occurrence in the study area
Pterostylis saxicola	Sydney Plains Greenhood	E	E	Most commonly found growing in small pockets of shallow soil in depressions on sandstone rock shelves above cliff lines. The vegetation communities above the shelves where Pterostylis saxicola occurs are sclerophyll forest or woodland on shale/sandstone transition soils or shale soils. Restricted to western Sydney between Freemans Reach in the north and Picton in the south. There are very few known populations and they are all very small and isolated (OEH 2012).	EPBC	Unlikely – verified in field assessment
Pultenaea parviflora	-	E	V	May be locally abundant, particularly within scrubby/dry heath areas within Castlereagh Ironbark Forest and Shale Gravel Transition Forest on tertiary alluvium or laterised clays (DECC 2007).	1	Unlikely – verified in field assessment
Sarcochilus hartmannii	Hartman's Sarcochilus	V	V	From the Richmond River in northern NSW to Gympie in south-east Queensland. Favours cliff faces on steep narrow ridges supporting eucalypt forest and clefts in volcanic rock from 500 to 1,000 m in altitude. Also found occasionally at the bases of fibrous trunks of trees, including cycads and grass-trees (OEH 2014).	1	No – far outside natural range – questionable record
Streblus pendulinus	Siah's Backbone	-	E	On the Australian mainland, Siah's Backbone is found in warmer rainforests, chiefly along watercourses. The altitudinal range is from near sea level to 800 m above sea level. The species grows in well-developed rainforest, gallery forest and drier, more seasonal rainforest (SEWPaC 2012).	EPBC	Unlikely – verified in field assessment
Syzygium paniculatum	Magenta Lilly Pilly	V	V	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 (DECC 2007).	20	**Known** - planted specimens identified in the field assessment at the northern and southern interchanges
Tetratheca glandulosa	-	V	V	Associated with ridgetop woodland habits on yellow earths (Travers Morgan 1991) also in sandy or rocky heath and scrub (NPWS 1997). Often associated with sandstone / shale interface where soils have a stronger clay influence (NPWS 1997). Flowers July to November.	478	Unlikely – verified in field assessment

Species name	Common name	TSC Act	EPBC Act	Habitat associations	Number of Atlas records	Likelihood of occurrence in the study area
Triplarina imbricata	Creek Triplarina	E	E	Found only in a few locations in the ranges south-west of Glenreagh and near Tabulam in north-east NSW. Along watercourses in low open forest with Water Gum (*Tristaniopsis laurina*) (DECC 2007).	4	Unlikely – verified in field assessment
Wahlenbergia multicaulis	Tadgell's Bluebell in the local government areas of Auburn, Bankstown, Baulkham Hills, Canterbury, Hornsby, Parramatta and Strathfield	E2	-	This Endangered Population of *Wahlenbergia multicaulis* occurs at a number of locations in western and northern Sydney on the Central Coast. It usually occurs in damp, disturbed sites and is found in a variety of habitats including forest, woodland, scrub, grassland and the edges of watercourses and wetlands (DECC 2007).		Unlikely – verified in field
Wilsonia backhousei	Narrow-leafed Wilsonia	V	-	In NSW, *Wilsonia backhousei* is found on the coast between Mimosa Rocks National Park and Wamberal north of Sydney (Nelson's Lake, Potato Point, Sussex Inlet, Wowly Gully, Parramatta River at Ermington, Clovelly, Voyager Point, Wollongong and Royal National Park). It grows on the margins of salt marshes and lakes (DECC 2007).	93	Unlikely – no suitable habitat in the study area
Zannichellia palustris	-	E	-	In NSW, known from the lower Hunter and in Sydney Olympic Park. Grows in fresh or slightly saline stationary or slowly flowing water (OEH 2014).	4	No – no suitable habitat in study area
AMPHIBIANS						
Heleioporus australiacus	Giant Burrowing Frog	V	V	Forages in woodlands, wet heath, dry and wet sclerophyll forest (Ehmann 1997). Associated with semi-permanent to ephemeral sand or rock based streams (Ehmann 1997), where the soil is soft and sandy so that burrows can be constructed (Environment Australia 2000).	29	Unlikely – habitat limited due to heavy modification and quality of watercourses in study area

Species name	Common name	TSC Act	EPBC Act	Habitat associations	Number of Atlas records	Likelihood of occurrence in the study area
Litoria aurea	Green and Golden Bell Frog	E1	V	This species has been observed utilising a variety of natural and man-made waterbodies (Pyke & White 1996; Pyke and White 1996) such as coastal swamps, marshes, dune swales, lagoons, lakes, other estuary wetlands, riverine floodplain wetlands and billabongs, stormwater detention basins, farm dams, bunded areas, drains, ditches and any other structure capable of storing water (DECC 2009). Fast flowing streams are not utilised for breeding purposes by this species (Mahony 1999). Preferable habitat for this species includes attributes such as shallow, still or slow flowing, permanent and/or widely fluctuating water bodies that are unpolluted and without heavy shading (DEC 2005). Large permanent swamps and ponds exhibiting well-established fringing vegetation (especially bulrushes–Typha sp. and spikerushes–Eleocharis sp.) adjacent to open grassland areas for foraging are preferable (Ehmann 1997; Robinson 2004). Ponds that are typically inhabited tend to be free from predatory fish such as *Gambusia holbrooki* (Mosquito Fish) (DEC 2005; NPWS 2003). Formerly distributed from the NSW north coast near Brunswick Heads, southwards along the NSW coast to Victoria where it extends into east Gippsland. Records from west to Bathurst, Tumut and the ACT region. Since 1990 there have been approximately 50 recorded locations in NSW, most of which are small, coastal, or near coastal populations. These locations occur over the species' former range, however they are widely separated and isolated. Large populations in NSW are located around the metropolitan areas of Sydney, Shoalhaven and mid north coast (one an island population). There is only one known population on the NSW Southern Tablelands. Inhabits marshes, dams and stream-sides, particularly those containing *Typha* spp. (Bullrushes) or *Eleocharis* spp. (Spikerushes).	11755	Unlikely – habitat in some vegetated detention basins along Hills M2 Motorway integration works study area where *Eleocharis* and other fringing vegetation were found. However survey that met OEH guidelines conducted in 2011 for the M2 Upgrade did not find this species at this site, therefore unlikely.
Litoria littlejohni	Littlejohn's Tree Frog	V	V	Littlejohn's Tree Frog has a distribution that includes the plateaus and eastern slopes of the Great Dividing Range from Watagan State Forest (90 km north of Sydney) south to Buchan in Victoria. The majority of records are from within the Sydney Basin Bioregion with only scattered records south to the Victorian border and this species has not been recorded in southern NSW within the last decade. Records are isolated and tend to be at high altitude. This species breeds in the upper reaches of permanent streams and in perched swamps (OEH 2014).	EPBC	Unlikely – verified in field assessment

Species name	Common name	TSC Act	EPBC Act	Habitat associations	Number of Atlas records	Likelihood of occurrence in the study area
Litoria raniformis	Growling Grass Frog	E	V	Relatively still or slow-flowing sites such as billabongs, ponds, lakes or farm dams, especially where Typha sp., Eleocharis sp. and Phragmites sp. (Bulrushes) are present (DECC 2007; Ehmann 1997). This species is common in lignum shrublands, black box and River Red Gum woodlands, irrigation channels and at the periphery of rivers in the southern parts of NSW (DECC 2007). This species occurs in vegetation types such as open grassland, open forest and ephemeral and permanent non-saline marshes and swamps (DECC 2007). Open grassland and ephemeral permanent non-saline marshes and swamps have also been associated with this species (Ehmann 1997).	EPBC	Unlikely – verified in field assessment
Mixophyes balbus	Stuttering Frog	E	V	Stuttering Frogs occur along the east coast of Australia from southern Queensland to north-eastern Victoria. Considered to have disappeared from Victoria and to have undergone considerable range contraction in NSW, particularly in south-east NSW. It is the only Mixophyes species that occurs in south-east NSW and in recent surveys it has only been recorded at three locations south of Sydney. The Dorrigo region, in north-east NSW, appears to be a stronghold for this species. Found in rainforest and wet, tall open forest in the foothills and escarpment on the eastern side of the Great Dividing Range (OEH 2014).	EPBC	Unlikely – verified in field assessment
Pseudophryne australis	Red-crowned Toadlet	V	-	Red-crowned Toadlets are found in steep escarpment areas and plateaus, as well as low undulating ranges with benched outcroppings on Triassic sandstones of the Sydney Basin (DECC 2007). Within these geological formations, this species mainly occupies the upper parts of ridges, usually being restricted to within about 100 metres of the ridgetop. However they may also occur on plateaus or more level rock platforms along the ridgetop (DECC 2007). Associated with open forest to coastal heath (Ehmann 1997). Utilises small ephemeral drainage lines which feed water from the top of the ridge to the perennial creeks below for breeding, and are not usually found in the vicinity of permanent water (Ehmann 1997). Breeding sites are often characterised by clay-derived soils and generally found below the first sandstone escarpment in the talus slope (NPWS 1997).	314	**Potential** – suitable habitat near Northern Interchange and in Hills M2 Motorway integration works study area.
FISH						
Epinephelus daemelii	Black Rockcod	-	V	The NSW coastline forms the species' main range, both in Australia and internationally. Black cod are known to occur to some degree in all six NSW Marine Parks – Lord Howe, Cape Byron, Solitary Island, Port Stephens, Jervis Bay and Batemans Bay (SEWPAC 2012).	EPBC	No – no habitat in study area.

Species name	Common name	TSC Act	EPBC Act	Habitat associations	Number of Atlas records	Likelihood of occurrence in the study area
Macquaria australasica	Macquarie Perch	E (under FM Act 1994)	E	Habitat for the Macquarie perch is bottom or mid-water in slow-flowing rivers with deep holes, typically in the upper reaches of forested catchments with intact riparian vegetation. Macquarie perch also do well in some upper catchment lakes. In some parts of its range, the species is reduced to taking refuge in small pools which persist in midland–upland areas through the drier summer periods.	EPBC	No – no habitat in study area
Prototroctes maraena	Australian Grayling	-	V	The historic distribution of the Australian Grayling included coastal streams from the Grose River southwards through NSW, Vic. and Tas. On mainland Australia, this species has been recorded from rivers flowing east and south of the main dividing ranges. This species spends only part of its lifecycle in freshwater, mainly inhabiting clear, gravel-bottomed streams with alternating pools and riffles, and granite outcrops but has also been found in muddy-bottomed, heavily silted habitat. Grayling migrate between freshwater streams and the ocean and as such it is generally accepted to be a diadromous (migratory between fresh and salt waters) species.	EPBC	No – no habitat in study area
REPTILES						
Hoplocephalus bungaroides	Broad-headed Snake	E	V	The Broad-headed Snake is largely confined to Triassic and Permian sandstones, including the Hawkesbury, Narrabeen and Shoalhaven groups, within the coast and ranges in an area within approximately 250 km of Sydney. It shelters in rock crevices and under flat sandstone rocks on exposed cliff edges during autumn, winter and spring (OEH 2014).	EPBC	Unlikely – verified in field assessment.
Varanus rosenbergi	Rosenberg's Goanna	V	-	Associated with Sydney sandstone woodland and heath land. Rocks, hollow logs and burrows are utilised for shelter (Environment Australia 2000). Terrestrial termitaria are required for reproduction (King and Green 1999).	45	**Potential** - may occur within Hills M2 Motorway integration works study area.
AVES (diurnal birds)						

Species name	Common name	TSC Act	EPBC Act	Habitat associations	Number of Atlas records	Likelihood of occurrence in the study area
Anthochaera phrygia	Regent Honeyeater	E1	E1, Mi	Regent Honeyeaters mostly occur in dry box-ironbark eucalypt woodland and dry sclerophyll forest associations, wherein they prefer the most fertile sites available, e.g. along creek flats, or in broad river valleys and foothills. In NSW, riparian forests containing *Casuarina cunninghamiana* (River Oak), and with *Amyema cambagei* (Needle-leaf Mistletoe), are also important for feeding and breeding. At times of food shortage (e.g. when flowering fails in preferred habitats), Honeyeaters also use other woodland types and wet lowland coastal forest dominated by *Eucalyptus robusta* (Swamp Mahogany) or E. maculata (Spotted Gum) (Franklin et al. 1989; Geering & French 1998; Ley & Williams 1992; Oliver et al. 1999; Webster & Menkhorst 1992). Regent Honeyeaters sometimes occur in coastal forest, especially in stands dominated by Swamp Mahogany and Spotted Gum, but also in those with Southern Mahogany *E. botryoides*, and in those on sandstone ranges with banksias Banksia in the understorey (Franklin et al. 1989; Higgins et al. 2001; Menkhorst 1997c). They have been recorded in open forest including forest edges, wooded farmland and urban areas with mature eucalypts (Garnett 1993). The Regent Honeyeater primarily feeds on nectar from box and ironbark eucalypts and occasionally from banksias and mistletoes (NPWS 1995). As such it is reliant on locally abundant nectar sources with different flowering times to provide reliable supply of nectar (Environment Australia 2000). In NSW, most records are scattered on and around the Great Dividing Range, mainly on the North-West Plains, North-West Slopes and adjacent Northern Tablelands, to west of Armidale; the Central Tablelands and Southern Tablelands regions; and the Central Coast and Hunter Valley regions. The species is concentrated around two main locations, the Capertee Valley and the Bundarra-Barraba area, but Honeyeaters are also recorded along the coast in the Northern Rivers and Mid-North Coast Regions, and in the Illawarra and South Coast Regions, from Nowra south to Moruya, where small numbers are recorded in most years (D. Geering 1997, unpublished data; Higgins et al. 2001; Webster & Menkhorst 1992).	25	Unlikely – limited habitat in the study area; may occasionally fly over area.
Botaurus poiciloptilus	Australasian Bittern	E	E	Australasian Bitterns are widespread but uncommon over south-eastern Australia. In NSW they may be found over most of the state except for the far north-west. Favours permanent freshwater wetlands with tall, dense vegetation, particularly Typha spp. (Bullrushes) and Eleocharis spp. (Spikerushes) (OEH 2014).	5	No – no suitable habitat in study area

Species name	Common name	TSC Act	EPBC Act	Habitat associations	Number of Atlas records	Likelihood of occurrence in the study area
Burhinus grallarius	Bush Stone-curlew	E	-	The Bush Stone-curlew is found throughout Australia except for the central southern coast and inland, the far south-east corner, and Tasmania. Only in northern Australia is it still common however and in the south-east it is either rare or extinct throughout its former range. Inhabits open forests and woodlands with a sparse grassy groundlayer and fallen timber (OEH 2014).	1	No – no suitable habitat in study area
Callocephalon fimbriatum	Gang-gang Cockatoo population in the Hornsby and Ku-ring-gai local government areas	E2	-	The Gang-gang Cockatoo population was once widespread in Sydney region (NSW SC 2011). This population now inhabits urban bushland and reserves within the Hornsby and Ku-ring-gai local government areas including Lane Cove N.P and Pennant Hills Park (NSW SC 2011). This is the last known breeding population within Sydney Metropolitan area (NSW SC 2011).	47	**Likely** – forested areas across the study area have potential to provide habitat.
Callocephalon fimbriatum	Gang-gang Cockatoo	V	-	During summer in dense, tall, wet forests of mountains and gullies, alpine woodlands (Morcombe 2004). In winter they occur at lower altitudes in drier more open forests and woodlands, particularly box-ironbark assemblages (Shields & Chrome 1992). They sometimes inhabit woodland, farms and suburbs in autumn/winter (Simpson & Day 2004).	55	**Likely** - forested areas across the study area have potential to provide habitat.
Calyptorhynchus lathami	Glossy Black-Cockatoo	V	-	Associated with a variety of forest types containing *Allocasuarina* species, usually reflecting the poor nutrient status of underlying soils (Environment Australia 2000; NPWS 1997; DECC 2007). Intact drier forest types with less rugged landscapes are preferred (DECC 2007). Nests in large trees with large hollows (Environment Australia 2000).	109	**Potential** – suitable habitat with *Allocasuarina* species along portions of the Hills M2 Motorway integration works study area.
Circus assimilis	Spotted Harrier	V	-	The Spotted Harrier occurs throughout the Australian mainland, except in densely forested or wooded habitats of the coast, escarpment and ranges, and rarely in Tasmania. Individuals disperse widely in NSW and comprise a single population. Occurs in grassy open woodland including Acacia and mallee remnants, inland riparian woodland, grassland and shrub steppe. It is found most commonly in native grassland, but also occurs in agricultural land, foraging over open habitats including edges of inland wetlands (OEH 2014).	1	No – no suitable habitat in study area

Species name	Common name	TSC Act	EPBC Act	Habitat associations	Number of Atlas records	Likelihood of occurrence in the study area
Climacteris picumnus victoriae	Brown Treecreeper (eastern subspecies)	V	-	The eastern subspecies lives in eastern NSW in eucalypt woodlands through central NSW and in coastal areas with drier open woodlands such as the Snowy River Valley, Cumberland Plains, Hunter Valley and parts of the Richmond and Clarence Valleys. Found in eucalypt woodlands (including Box-Gum Woodland) and dry open forest of the inland slopes and plains inland of the Great Dividing Range; mainly inhabits woodlands dominated by stringybarks or other rough-barked eucalypts, usually with an open grassy understorey, sometimes with one or more shrub species; also found in mallee and *Eucalyptus camaldulensis* (River Red Gum) (OEH 2014).	1	No – no suitable habitat in study area
Daphoenositta chrysoptera	Varied Sittella	V	-	Varied Sitellas are endemic and widespread in mainland Australia. Varied Sitellas are found in eucalypt woodlands and forests throughout their range. They prefer rough-barked trees like stringybarks and ironbarks or mature trees with hollows or dead branches (BIB, 2006)	23	**Potential** - suitable habitat of rough barked trees may occur Hills M2 Motorway integration works study area.
Dasyornis brachypterus	Eastern Bristlebird	E	E	The distribution of the Eastern Bristlebird has contracted to three disjunct areas of south-eastern Australia: southern Queensland/northern NSW, the Illawarra Region and in the vicinity of the NSW/Victorian border. Habitat is characterised by dense, low vegetation including heath and open woodland with a heathy understorey; in northern NSW occurs in open forest with tussocky grass understorey; all of these vegetation types are fire prone (OEH 2014).	EPBC	No – no suitable habitat.
Ephippiorhynchus asiaticus	Black-necked Stork	E	-	NSW, the species becomes increasingly uncommon south of the Northern Rivers region, and rarely occurs south of Sydney. Since 1995, breeding has been recorded as far south as Buladelah. Black-necked Storks are mainly found on shallow, permanent, freshwater terrestrial wetlands, and surrounding marginal vegetation, including swamps, floodplains, watercourses and billabongs, freshwater meadows, wet heathland, farm dams and shallow floodwaters, as well as extending into adjacent grasslands, paddocks and open savannah woodlands. They also forage within or around estuaries and along intertidal shorelines, such as saltmarshes, mudflats and sandflats, and mangrove vegetation (OEH 2014).	1	No – no suitable habitat in study area

Species name	Common name	TSC Act	EPBC Act	Habitat associations	Number of Atlas records	Likelihood of occurrence in the study area
Epthianura albifrons	White-fronted Chat	V	-	The White-fronted Chat is found across the southern half of Australia, from southernmost Queensland to southern Tasmania, and across to Western Australia as far north as Carnarvon. Found mostly in temperate to arid climates and very rarely sub-tropical areas, it occupies foothills and lowlands up to 1000 m above sea level. In NSW, it occurs mostly in the southern half of the state, in damp open habitats along the coast, and near waterways in the western part of the state. Along the coastline, it is found predominantly in saltmarsh vegetation but also in open grasslands and sometimes in low shrubs bordering wetland areas. Gregarious species, usually found foraging on bare or grassy ground in wetland areas, singly or in pairs. They are insectivorous, feeding mainly on flies and beetles caught from or close to the ground (OEH 2014).	208	No – no suitable habitat in study area
Epthianura albifrons	White-fronted Chat population in the Sydney Metropolitan Catchment Management Area	E	-	Regularly observed in the saltmarsh of Newington Nature Reserve (with occasional sightings from other parts of Sydney Olympic Park and in grassland on the northern bank of the Parramatta River). Current estimates suggest this population consists of 8 individuals. Regularly observed in the saltmarsh and on the sandy shoreline of a small island of Towra Point Nature Reserve. This population is estimated to comprise 19-50 individuals (OEH 2014).	208	No – no suitable habitat in study area
Falco hypoleucos	Grey Falcon	E1	-	Distribution of the Grey Falcon is patchy throughout NSW, although the main distribution is within the Murray-Darling Basin and occasionally east of the Great Dividing Range (OEH 2012). Forages over low-lying vegetation in arid and semi-arid regions along watercourses and grasslands (OEH 2012). It relies on open water to target its prey (OEH 2012).	1	Unlikely – no suitable habitat in the study area
Falco subniger	Black Falcon	V	-	The Black Falcon has broad range across inland regions New South Wales, where it has a sparse distributed. However, there are reports of 'Black Falcons' occurring on the tablelands and along the NSW coast. These reports are likely to represent Brown Falcons. In New South Wales there is assumed to be a single population that is continuous with a broader continental population, given that falcons are highly mobile, commonly travelling over hundreds of kilometres (Marchant & Higgins 1993).	1	Unlikely – no suitable habitat in the study area

Species name	Common name	TSC Act	EPBC Act	Habitat associations	Number of Atlas records	Likelihood of occurrence in the study area
Glossopsitta pusilla	Little Lorikeet	V	-	In New South Wales Little Lorikeets are distributed in forests and woodlands from the coast to the western slopes of the Great Dividing Range, extending westwards to the vicinity of Albury, Parkes, Dubbo and Narrabri. Little Lorikeets mostly occur in dry, open eucalypt forests and woodlands. They have been recorded from both old-growth and logged forests in the eastern part of their range, and in remnant woodland patches and roadside vegetation on the western slopes. They feed primarily on nectar and pollen in the tree canopy, particularly on profusely-flowering eucalypts, but also on a variety of other species including melaleucas and mistletoes. On the western slopes and tablelands White Box *Eucalyptus albens* and Yellow Box *E. melliodora* are particularly important food sources for pollen and nectar respectively.	21	Unlikely – although suitable habitat within Hills M2 Motorway integration works study works study area and northern interchange study area, species is likely to only flyover area rather than utilise resources
Haematopus fuliginosus	Sooty Oystercatcher	V	-	A coastal species that inhabits rock coastlines, coral cays, reefs and occasionally sandy beaches and Marchant & Higgins 1993; Simpson & Day 1999).	4	No. Habitat not suitable.
Haematopus longirostris	Pied Oystercatcher	E1	-	Roosts and forages on sandy beaches, sand banks, mudflats and estuaries (Marchant & Higgins 1993, Simpson & Day 1999).	1	No. Habitat not suitable.
Hieraaetus morphnoides	Little Eagle	V	-	The Little Eagle is widespread in mainland Australia, central and eastern New Guinea. The Little Eagle is seen over woodland and forested The population of Little Eagle in NSW is considered to be a single population (DECCW 2010). This species was recently listed as vulnerable due to a moderate reduction in population size based on geographic distribution and habitat quality (NSWSC 2010).lands and open country, extending into the arid zone. It tends to avoid rainforest and heavy forest (BIB, 2006).	19	Unlikely. Habitat not suitable.
Ixobrychus flavicollis	Black Bittern	V	-	Occurs in both terrestrial and estuarine wetlands generally in areas of permanent water and dense vegetation (DECC 2007). In areas with permanent water it may occur in flooded grassland, forest, woodland, rainforest and mangroves (DECC 2007)	7	No. Habitat not suitable.

Species name	Common name	TSC Act	EPBC Act	Habitat associations	Number of Atlas records	Likelihood of occurrence in the study area
Lathamus discolor	Swift Parrot	E	E1, Ma	Breeds in Tasmania between September and January. Feeds mostly on nectar, mainly from eucalypts, but also eats psyllid insects and lerps, seeds and fruit. Migrates to mainland in autumn, where it forages on profuse flowering Eucalypts. Favoured feed trees include winter flowering species such as Swamp Mahogany (*Eucalyptus robusta*), Spotted Gum (*Corymbia maculata*), Red Bloodwood (*C. gummifera*), Mugga Ironbark (*E. sideroxylon*), White Box (*E. albens*) and Forest Red Gum (*E. tereticornis*) (DECC 2007). Box-ironbark habitat in drainage lines and coastal forest in NSW is thought to provide critical food resources during periods of drought or low food abundance elsewhere (Mac Nally et al. 2000).	39	Unlikely – although suitable habitat within Hills M2 Motorway integration works study area and northern interchange study area, species is likely to only flyover area rather than utilise resources
Lophoictinia isura	Square-tailed Kite	V	-	In coastal areas associated tropical and temperate forests and woodlands on fertile soils with an abundance of passerine birds (Marchant & Higgins 1993, DECC 2007). May be recorded inland along timbered watercourses (DECC 2007). In NSW it is commonly associated with ridge or gully forests dominated by Woollybutt (*Eucalyptus longifolia*), Spotted Gum (*E. maculata*), or Peppermint Gum (*E. elata*, *E. smithii*) (DECC 2007).	2	Unlikely. Habitat not suitable.
Melanodryas cucullata cucullata	Hooded Robin	V	-	The Hooded Robin is widespread, found across Australia, except for the driest deserts and the wetter coastal areas - northern and eastern coastal Queensland and Tasmania. The south-eastern form (subspecies cucullata) is found from Brisbane to Adelaide and throughout much of inland NSW, with the exception of the extreme north-west, where it is replaced by subspecies picata. Two other subspecies occur outside NSW. Prefers lightly wooded country, usually open eucalypt woodland, acacia scrub and mallee, often in or near clearings or open areas (OEH 2014).	1	Unlikely – habitat not suitable in study area
Melithreptus gularis gularis	Black-chinned Honeyeater (eastern subspecies)	V	-	Predominantly associated with box-ironbark association woodlands and River Red Gum (NSW Scientific Committee, 2001). Also associated with drier coastal woodlands of the Cumberland Plain and the Hunter, Richmond and Clarence Valleys (NSW Scientific Committee, 2001).	3	Unlikely. Habitat not suitable.
Neophema pulchella	Turquoise Parrot	V	-	The Turquoise Parrot's range extends from southern Queensland through to northern Victoria, from the coastal plains to the western slopes of the Great Dividing Range. Lives on the edges of eucalypt woodland adjoining clearings, timbered ridges and creeks in farmland (OEH 2014).	3	Unlikely – habitat not suitable in study area

Species name	Common name	TSC Act	EPBC Act	Habitat associations	Number of Atlas records	Likelihood of occurrence in the study area
Nettapus coromandelianus	Cotton Pygmy-goose	E	-	Although once found from north Queensland to the Hunter River in NSW, the Cotton Pygmy-Goose is now only a rare visitor to NSW. Uncommon in Queensland. Habitat includes freshwater lakes, lagoons, swamps and dams, particularly those vegetated with waterlilies and other floating and submerged aquatic vegetation (OEH 2014).	4	Unlikely – habitat not suitable in study area
Pandion cristatus	Eastern Osprey	V	-	Eastern Ospreys are found right around the Australian coast line, except for Victoria and Tasmania. They are common around the northern coast, especially on rocky shorelines, islands and reefs. The species is uncommon to rare or absent from closely settled parts of south-eastern Australia. There are a handful of records from inland areas. Favour coastal areas, especially the mouths of large rivers, lagoons and lakes (OEH 2014).	3	Unlikely – habitat not suitable in study area
Petroica boodang	Scarlet Robin	V	-	The Scarlet Robin is found in south-eastern and south-western Australia, as well as on Norfolk Island. In Australia, it is found south of latitude 25°S, from south-eastern Queensland along the coast of New South Wales (and inland to western slopes of Great Dividing Range) to Victoria and Tasmania, and west to Eyre Peninsula, South Australia; it is also found in south-west Western Australia. The Scarlet Robin lives in open forests and woodlands in Australia, while it prefers rainforest habitats on Norfolk Island. During winter, it will visit more open habitats such as grasslands and will be seen in farmland and urban parks and gardens at this time (BIB, 2006).	12	**Potential -** suitable habitat within Hills M2 Motorway integration works study area
Petroica phoenicea	Flame Robin	V	-	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. The species is also found in Tasmania. Flame Robins prefer forests and woodlands up to about 1800 m above sea level.	2	**Potential -** suitable habitat within Hills M2 Motorway integration works study area.
Petroica rodinogaster	Pink Robin	V	-	The Pink Robin is found in Tasmania and the uplands of eastern Victoria and far south-eastern NSW, almost as far north as Bombala. On the mainland, the species disperses north and west and into more open habitats in winter, regularly as far north as the ACT area, and sometimes being found as far north as the central coast of NSW. Inhabits rainforest and tall, open eucalypt forest, particularly in densely vegetated gullies. Breeds between October and January and can produce two clutches in a season.	1	Unlikely. Habitat not suitable.

Species name	Common name	TSC Act	EPBC Act	Habitat associations	Number of Atlas records	Likelihood of occurrence in the study area
Pomatostomus temporalis temporalis	Grey-crowned Babbler (eastern subspecies)	V	-	In NSW, the eastern sub-species occurs on the western slopes of the Great Dividing Range, and on the western plains reaching as far as Louth and Balranald. It also occurs in woodlands in the Hunter Valley and in several locations on the north coast of NSW. It may be extinct in the southern, central and New England tablelands. Inhabits open Box-Gum Woodlands on the slopes, and Box-Cypress-pine and open Box Woodlands on alluvial plains (OEH 2014).	1	No – no suitable habitat in study area
Polytelis swainsonii	Superb Parrot	V	V	The Superb Parrot is found throughout eastern inland NSW. On the South-western Slopes their core breeding area is roughly bounded by Cowra and Yass in the east, and Grenfell, Cootamundra and Coolac in the west. Birds breeding in this region are mainly absent during winter, when they migrate north to the region of the upper Namoi and Gwydir Rivers. The other main breeding sites are in the Riverina along the corridors of the Murray, Edward and Murrumbidgee Rivers where birds are present all year round. Mainly inhabits forests and woodlands dominated by eucalypts, especially *Eucalyptus camaldulensis* (River Red Gums) and box eucalypts such as *Eucalyptus melliodora* (Yellow Box) or *E. microcarpa* (Grey Box). The species also seasonally occurs in *Callitris* (Box-pine) and *Acacia pendula* (Boree) woodlands (Webster 1988, 1998). They forage at or near the ground. Nest in hollows.	3	Unlikely. Habitat not suitable.
Ptilinopus superbus	Superb Fruit-Dove	V	-	Inhabits rainforest and similar closed forests where it forages high in the canopy, eating the fruits of many tree species such as figs and palms (DECC 2007). It may also forage in eucalypt or acacia woodland where there are fruit-bearing trees (*ibid.*). Part of the population is migratory or nomadic (*ibid.*). At least some of the population, particularly young birds, moves south through Sydney, especially in autumn (*ibid.*). Breeding takes place from September to January (*ibid.*). Will feed in adjacent mangroves or eucalypt forests (Blakers et al. 1984).	18	Unlikely. Habitat not suitable.
Stagonopleura guttata	Diamond Firetail	V	-	Typically found in grassy eucalypt woodlands, but also occurs in open forest, mallee, Natural Temperate Grassland, and in secondary grassland derived from other communities (DECC 2007). It is often found in riparian areas and sometimes in lightly wooded farmland (DECC 2007). Appears to be sedentary, though some populations move locally, especially those in the south (DECC 2007).	1	Unlikely. Habitat not suitable.

Species name	Common name	TSC Act	EPBC Act	Habitat associations	Number of Atlas records	Likelihood of occurrence in the study area
Sternula albifrons	Little Tern	E	-	In NSW, it arrives from September to November, occurring mainly north of Sydney, with smaller numbers found south to Victoria. It breeds in spring and summer along the entire east coast from Tasmania to northern Queensland, and is seen until May, with only occasional birds seen in winter months. Almost exclusively coastal, preferring sheltered environments; however may occur several kilometres from the sea in harbours, inlets and rivers (with occasional offshore islands or coral cay records) (OEH 2014).	4	No – no suitable habitat in study area
Sternula nereis nereis	Fairy Tern	-	V	The subspecies has been known from New South Wales (NSW) in the past, but it is unknown if it persists there. The Fairy Tern (Australian) nests on sheltered sandy beaches, spits and banks above the high tide line and below vegetation. The subspecies has been found in embayments of a variety of habitats including offshore, estuarine or lacustrine (lake) islands, wetlands and mainland coastline (DEWPAC 2014)	EPBC	No – no suitable habitat in study area.
Stictonetta naevosa	Freckled Duck	V	-	The Freckled Duck is found primarily in south-eastern and south-western Australia, occurring as a vagrant elsewhere. It breeds in large temporary swamps created by floods in the Bulloo and Lake Eyre basins and the Murray-Darling system, particularly along the Paroo and Lachlan Rivers, and other rivers within the Riverina. The duck is forced to disperse during extensive inland droughts when wetlands in the Murray River basin provide important habitat. The species may also occur as far as coastal NSW and Victoria during such times. Prefer permanent freshwater swamps and creeks with heavy growth of Cumbungi, Lignum or Tea-tree. During drier times they move from ephemeral breeding swamps to more permanent waters such as lakes, reservoirs, farm dams and sewage ponds (OEH 2014).	1	No – no suitable habitat in study area
AVES (nocturnal birds)						
Ninox connivens	Barking Owl	V	-	Associated with a variety of habitats such as savanna woodland, open eucalypt forests, wetland and riverine forest. The habitat is typically dominated by Eucalypts (often Redgum species), however often dominated by Melaleuca species in the tropics (DECC 2007). It usually roosts in dense foliage in large trees such as River She-oak (*Allocasuarina cunninghamiana*), other *Casuarina* and *Allocasuarina*, eucalypts, *Angophora*, *Acacia* and rainforest species from streamside gallery forests (NPWS 2003). It usually nests near watercourses or wetlands (NPWS 2003) 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).	19	**Potential -** suitable habitat within Hills M2 Motorway integration works area, and northern interchange

Species name	Common name	TSC Act	EPBC Act	Habitat associations	Number of Atlas records	Likelihood of occurrence in the study area
Ninox strenua	Powerful Owl	V	-	Powerful Owls are associated with a wide range of wet and dry forest types with a high density of prey, such as arboreal mammals, large birds and flying foxes (Environment Australia 2000, Debus & Chafer 1994). Large trees with hollows at least 0.5 metres deep are required for shelter and breeding (Environment Australia 2000).	326	**Potential -** suitable habitat within Hills M2 Motorway integration works area and northern interchange
Tyto novaehollandiae	Masked Owl	V	-	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).	21	**Potential -** suitable habitat within Hills M2 Motorway integration works area, and northern interchange
Tyto longimembris	Eastern Grass Owl	V	-	Eastern Grass Owls have been recorded occasionally in all mainland states of Australia but are most common in northern and north-eastern Australia. In NSW they are more likely to be resident in the north-east. Eastern Grass Owl numbers can fluctuate greatly, increasing especially during rodent plagues. Eastern Grass Owls are found in areas of tall grass, including grass tussocks, in swampy areas, grassy plains, swampy heath, and in cane grass or sedges on flood plains (OEH 2014).	1	No – no suitable habitat in study area
Tyto tenebricosa	Sooty Owl	V	-	Sooty Owls are associated with tall wet old growth forest on fertile soil with a dense understorey and emergent tall *Eucalyptus* species (Environment Australia 2000, Debus 1994). Pairs roost in the daytime amongst dense vegetation, in tree hollows and sometimes in caves. The Sooty Owl is typically associated with an abundant and diverse supply of prey items and a selection of large tree hollows (Debus 1994, Garnett 1993, Hyem 1979).	2	Unlikely – little closed forest across study area. Forest type in study area is more open and tends to be drier and not old growth.

Species name	Common name	TSC Act	EPBC Act	Habitat associations	Number of Atlas records	Likelihood of occurrence in the study area
MAMMALIA - terrestrial (excluding bats)						
Cercartetus nanus	Eastern Pygmy-possum	V	-	The Eastern Pygmy Possum occurs in wet and dry eucalypt forest, subalpine woodland, coastal banksia woodland and wet heath (Menkhorst & Knight 2004). Pygmy-Possums feed mostly on the pollen and nectar from banksias, eucalypts and understorey plants and will also eat insects, seeds and fruit (Turner & Ward 1995). The presence of Banksia sp. and Leptospermum sp. are an important habitat feature (DECC 2007). Small tree hollows are favoured as day nesting sites, but nests have also been found under bark, in old birds' nests and in the branch forks of tea-trees (Turner & Ward 1995).	72	**Potential** – feed trees present in Hills M2 Motorway integration works study area.
Dasyurus maculatus	Spotted-tailed Quoll Spotted-tailed Quoll (SE mainland population)	V -	- E	The Spotted-tailed Quoll inhabits a range of forest communities including wet and dry sclerophyll forests, coastal heathlands and rainforests (Mansergh 1984; DECC 2007j), more frequently recorded near the ecotones of closed and open forest and in NSW within 200 kilometres of the coast. Preferred habitat is mature wet forest (Belcher 2000b; Green & Scarborough 1990; Watt 1993), especially in areas with rainfall 600 mm/year (Edgar & Belcher 2008; Mansergh 1984). Unlogged forest or forest that has been less disturbed by timber harvesting is also preferable (Catling et al. 1998, 2000). This species requires habitat features such as maternal den sites, an abundance of food (birds and small mammals) and large areas of relatively intact vegetation to forage in (DECC 2007). Maternal den sites are logs with cryptic entrances; rock outcrops; windrows; burrows (Environment Australia 2000).	40	Unlikely – some habitat in area but limited suitable undisturbed forest and close proximity to urban interface across study area.
Isoodon obesulus	Southern Brown Bandicoot (eastern)	E1	E1	This species is associated with heath, coastal scrub, sedgeland, heathy forests, shrubland and woodland on well drained, infertile soils, within which they are typically found in areas of dense ground cover. Suitable habitat includes patches of native or exotic vegetation which contain understorey vegetation structure with 50–80 per cent average foliage density in the 0.2–1 metres height range. This species is thought to display a preference for newly regenerating heathland and other areas prone to fire, but requires a mosaic of burnt and unburnt areas for survival (Menkhorst & Seebeck 1990).	346	Unlikely – limited heathy forests across the study area

Species name	Common name	TSC Act	EPBC Act	Habitat associations	Number of Atlas records	Likelihood of occurrence in the study area
Perameles nasuta	Long-nosed Bandicoot population in inner western Sydney	E	-	The exact area occupied by the population is not clearly defined, and includes the local government areas (LGA) of Marrickville and Canada Bay, with the likelihood that it also includes Canterbury, Ashfield and Leichhardt LGAs. Future research may better define the population and possibly indicate a wider distribution. This population is disjunct from the nearest records of the Long-nosed Bandicoot, which occur north of the Parramatta River or much further south at Holsworthy Military Reserve. Shelter mostly under older houses and buildings and forage in parkland and back-yards. There are apparently no large blocks of suitable habitat, likely to support a large source population, on the Cooks River to the south, or along the southern foreshore of Parramatta River and Sydney Harbour to the north (OEH 2014).	2	No – out of range for this population
Petaurus australis	Yellow-bellied Glider	V	-	This species is restricted to tall mature forests, preferring productive tall open sclerophyll forests with a mosaic of tree species including some that flower in winter (Environment Australia 2000, Braithwaite 1984, Davey 1984, Kavanagh 1984; DECC 2007). Large hollows within mature trees are required for shelter, nesting and breeding (Henry and Craig 1984; DECC 2007).	21	Unlikely – limited large patches of habitat across the study area
Petrogale penicillata	Brush-tailed Rock-wallaby	E	V	The range of the Brush-tailed Rock-wallaby extends from south-east Queensland to the Grampians in western Victoria, roughly following the line of the Great Dividing Range. However the distribution of the species across its original range has declined significantly in the west and south and has become more fragmented. In NSW they occur from the Queensland border in the north to the Shoalhaven in the south, with the population in the Warrumbungle Ranges being the western limit. Occupy rocky escarpments, outcrops and cliffs with a preference for complex structures with fissures, caves and ledges, often facing north (OEH 2014).	EPBC	No – no suitable habitat
Phascolarctos cinereus	Koala	V	V	Associated with both wet and dry Eucalypt forest and woodland that contains a canopy cover of approximately 10 to 70% (Reed et al. 1990), with acceptable Eucalypt food trees. Some preferred Eucalyptus species are: *Eucalyptus tereticornis*, *E. punctata*, *E. cypellocarpa*, *E. viminalis*	50	Unlikely – limited suitable habitat across the study area.
Phascolarctos cinereus	Koala in the Pittwater Local Government Area	E	-	The endangered population occurs within the Pittwater Local Government Area, with most recent records occurring on the Barrenjoey Peninsula.	1	No – out of range for this population

Species name	Common name	TSC Act	EPBC Act	Habitat associations	Number of Atlas records	Likelihood of occurrence in the study area
Potorous tridactylus *Potorous tridactylus tridactylus*	Long-nosed Potoroo Long-nosed Potoroo (SE Mainland Population)	V -	- V	Associated with dry coastal heath and dry and wet sclerophyll forests (Strahan 1998) with dense cover for shelter and adjacent more open areas for foraging (Menkhorst & Knight 2004).	EPBC	No – limited suitable habitat in study area and close proximity to urban interface
Pseudomys novaehollandiae	New Holland Mouse	-	V	A small burrowing native rodent with a fragmented distribution across Tasmania, Victoria, New South Wales and Queensland. Inhabits open heathlands, open woodlands with a heathland understorey and vegetated sand dunes. A social animal, living predominantly in burrows shared with other individuals. The home range of the New Holland Mouse ranges from 0.44 ha to 1.4 ha and the species peaks in abundance during early to mid stages of vegetation succession typically induced by fire (SEWPaC 2012)	7	No – limited suitable habitat in study area and close proximity to urban interface
MAMMALIA - terrestrial (bats)						
Chalinolobus dwyeri	Large-eared Pied Bat	V	V	The Large-eared Pied Bat has been recorded in a variety of habitats, including dry sclerophyll forests, woodland, sub-alpine woodland, edges of rainforests and wet sclerophyll forests (Churchill 1998; DECC 2007). This species roosts in caves, rock overhangs and disused mine shafts and as such is usually associated with rock outcrops and cliff faces (Churchill 1998; DECC 2007).	3	**Potential** -, although species not found, based on culvert/building assessments, suitable habitat is present along northern interchange, Hills M2 Motorway integration works, and Pioneer Avenue compound study areas.

Species name	Common name	TSC Act	EPBC Act	Habitat associations	Number of Atlas records	Likelihood of occurrence in the study area
Falsistrellus tasmaniensis	Eastern False Pipistrelle	V	-	Prefers moist habitats with trees taller than 20m (DECC 2007). Roosts in tree hollows but has also been found roosting in buildings or under loose bark (DECC 2007).	21	**Potential** – some suitable habitat found along Hills M2 Motorway integration works study area near creeks
Miniopterus australis	Little Bent-wing Bat	V	-	Prefers well-timbered areas including rainforest, wet and dry sclerophyll forests, *Melaleuca* swamps and coastal forests (Churchill 1998). This species shelter in a range of structures including culverts, drains, mines and caves (Environment Australia 2000). Relatively large areas of dense vegetation of wet sclerophyll forest, rainforest or dense coastal banksia scrub are usually found adjacent to caves in which this species is found (DECC 2007). Breeding occurs in caves, usually in association with *M. schreibersii* (Environment Australia 2000, DECC 2007).	14	**Potential** - although species not found, based on culvert/building assessments, suitable habitat is present along northern interchange, Hills M2 Motorway integration works, and Pioneer Avenue compound study areas.
Miniopterus schreibersii oceanensis	Eastern Bent-wing Bat	V	-	Associated with a range of habitats such as rainforest, wet and dry sclerophyll forest, monsoon forest, open woodland, paperbark forests and open grassland (Churchill 1998). It forages above and below the tree canopy on small insects (AMBS 1995, Dwyer 1995, Dwyer 1981). Will utilise caves, old mines, and stormwater channels, under bridges and occasionally buildings for shelter (Environment Australia 2000, Dwyer 1995).	162	**Likely** - based on culvert/building assessments, suitable habitat is present along northern interchange, Hills M2 Motorway integration works, and Pioneer Avenue compound study areas.

Species name	Common name	TSC Act	EPBC Act	Habitat associations	Number of Atlas records	Likelihood of occurrence in the study area
Mormopterus norfolkensis	Eastern Freetail-bat	V	-	Most records of this species are from dry eucalypt forest and woodland east of the Great Dividing Range (Churchill 1998). Individuals have, however, 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). Primarily roosts in hollows or behind loose bark in mature eucalypts, but have been observed roosting in the roof of a hut (Environment Australia 2000; Allison & Hoye 1998).	47	**Potential** – some suitable habitat found along Hills M2 Motorway integration works study area near creeks
Myotis macropus	Southern Myotis	V	-	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 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).	20	**Potential** - although the species was not found, based on culvert/building assessments, suitable habitat is present along northern interchange, Hills M2 Motorway integration works, and Pioneer Avenue compound study areas.
Pteropus poliocephalus	Grey-headed Flying-Fox	V	V	Inhabits a wide range of habitats including rainforest, mangroves, paperbark forests, wet and dry sclerophyll forests and cultivated areas (Churchill 1998, Eby 1998). Camps are often located in gullies, typically close to water, in vegetation with a dense canopy (Churchill 1998).	1222	**Likely** – suitable habitat present at Northern Interchange, Hills M2 Motorway integration works study area a. No camps detected during field assessment.

Species name	Common name	TSC Act	EPBC Act	Habitat associations	Number of Atlas records	Likelihood of occurrence in the study area
Saccolaimus flaviventris	Yellow-bellied Sheathtail-bat	V	-	Found in almost all habitats, from wet and dry sclerophyll forest, open woodland (Churchill 1998), open country, mallee, rainforests, heathland and waterbodies (SFNSW 1995). Roosts in tree hollows; may also use caves; has also been recorded in a tree hollow in a paddock (Environment Australia 2000) and in abandoned sugar glider nests (Churchill 1998). The Yellow-bellied Sheathtail-bat is dependent on suitable hollow-bearing trees to provide roost sites, which may be a limiting factor on populations in cleared or fragmented habitats (Environment Australia 2000).	10	Potential – some suitable habitat found along Hills M2 Motorway integration works study area near creeks and near northern interchange
Scoteanax rueppellii	Greater Broad-nosed Bat	V		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 forests (Hoye & Richards 1998). Within denser vegetation types 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 & Richards 1998).	15	**Potential** – some suitable habitat found along Hills M2 Motorway integration works study area near creeks
INVERTEBRATES						
Meridolum corneovirens	Cumberland Plain Land Snail	E		Associated with open eucalypt forests, particularly Cumberland Plain Woodland (CPW) described in Benson (1992). Found under fallen logs, debris and in bark and leaf litter around the trunk of gum trees or burrowing in loose soil around clumps of grass (NPWS 1997; Rudman 1998). Urban waste may also form suitable habitat (NSW NPWS 1997; Rudman 1998).	69	No. Habitat not suitable, no CPW present.
Migratory terrestrial species						
Haliaeetus leucogaster	White-bellied Sea-Eagle	-	M	Forages over large open fresh or saline waterbodies, coastal seas and open terrestrial areas (Marchant & Higgins 1993, Simpson & Day 1999). Breeding habitat consists of tall trees, mangroves, cliffs, rocky outcrops, silts, caves and crevices and is located along the coast or major rivers. Breeding habitat is usually in or close to water, but may occur up to a kilometre away (Marchant & Higgins 1993).		Unlikely – no suitable habitat

Species name	Common name	TSC Act	EPBC Act	Habitat associations	Number of Atlas records	Likelihood of occurrence in the study area
Hirundapus caudacutus	White-throated Needletail	-	M	Forages aerially over a variety of habitats usually over coastal and mountain areas, most likely with a preference for wooded areas (Marchant & Higgins 1993; Simpson & Day 1999). Has been observed roosting in dense foliage of canopy trees, and may seek refuge in tree hollows in inclement weather (Marchant & Higgins 1993).	-	Unlikely -
Merops ornatus	Rainbow Bee-eater	-	M	Resident in coastal and subcoastal northern Australia; regular breeding migrant in southern Australia, arriving September to October, departing February to March, some occasionally present April to May. Occurs in open country, chiefly at suitable breeding places in areas of sandy or loamy soil: sand-ridges, riverbanks, road-cuttings, sand-pits, occasionally coastal cliffs.	-	Unlikely – limited suitable habitat.
Monarcha melanopsis	Black-faced Monarch	-	M	Rainforest and eucalypt forests, feeding in tangled understorey (Blakers et al. 1984).	-	Unlikely – limited suitable habitat.
Monarcha trivirgatus	Spectacled Monarch	-	M	The Spectacled Monarch prefers thick understorey in rainforests, wet gullies and waterside vegetation, as well as mangroves.	-	Unlikely – limited suitable habitat.
Myiagra cyanoleuca	Satin Flycatcher	-	M	Wetter, denser forest, often at high elevations (Simpson & Day 2004).	-	Unlikely – limited suitable habitat.
Rhipidura rufifrons	Rufous Fantail	-	M	The Rufous Fantail is a summer breeding migrant to southeastern Australia (Morcombe, 2004). The Rufous Fantail is found in rainforest, dense wet eucalypt and monsoon forests, paperbark and mangrove swamps and riverside vegetation (Morcombe, 2004). Open country may be used by the Rufous Fantail during migration (Morcombe, 2004).	-	Unlikely – limited suitable habitat.
Anthochaera phrygia	Regent Honeyeater	E1	E1, Mi	SEE DIURNAL BIRDS ABOVE	15	Unlikely – limited habitat in study area

Species name	Common name	TSC Act	EPBC Act	Habitat associations	Number of Atlas records	Likelihood of occurrence in the study area
Migratory wetland species						
Ardea alba	Great Egret	-	M	The Great Egret is common and widespread in Australia (McKilligan, 2005). The Eastern Great Egret has been reported in a wide range of wetland. These include swamps and marshes; margins of rivers and lakes; damp or flooded grasslands, pastures or agricultural lands; reservoirs; sewage treatment ponds; drainage channels; salt pans and salt lakes; salt marshes; estuarine mudflats, tidal streams; mangrove swamps; coastal lagoons; and offshore reefs (Kushlan & Hancock 2005; Marchant & Higgins 1993; Martínez-Vilalta & Motis 1992). The species usually frequents shallow waters. It forages in a wide range of wet and dry habitats including permanent and ephemeral freshwaters, wet pasture and estuarine mangroves and mudflats (McKilligan, 2005).	EPBC	No – no habitat in study area,
Ardea ibis	Cattle Egret	-	M	Cattle Egrets forage on pasture, marsh, grassy road verges, rain puddles and croplands, but not usually in the open water of streams or lakes and they avoid marine environments (McKilligan, 2005). Some individuals stay close to the natal heronry from one nesting season to the next, but the majority leaves the district in autumn and return the next spring. Cattle Egrets are likely to spend the winter dispersed along the coastal plain and only a small number have been recovered west of the Great Dividing Range (McKilligan, 2005).	EPBC	No – no habitat in study area,
Arenaria interpres	Ruddy Turnstone	-	M	It is found in most coastal regions, with occasional records of inland populations (Higgins & Davies 1996). It strongly prefers rocky shores or beaches where there are large deposits of rotting seaweed (SEWPAC 2013).	EPBC	No – no habitat in study area,
Calidris acuminata	Sharp-tailed Sandpiper	-	M	In Australasia, the Sharp-tailed Sandpiper prefers muddy edges of shallow fresh or brackish wetlands, with inundated or emergent sedges, grass, saltmarsh or other low vegetation. This includes lagoons, swamps, lakes and pools near the coast, and dams, waterholes, soaks, bore drains and bore swamps, saltpans and hypersaline salt lakes inland. They also occur in saltworks and sewage farms (DSEWPAC 2013).	EPBC	No – no habitat in study area,
Calidris canutus	Red Knot	-	M	In Australasia the Red Knot mainly inhabit intertidal mudflats, sandflats and sandy beaches of sheltered coasts, in estuaries, bays, inlets, lagoons and harbours; sometimes on sandy ocean beaches or shallow pools on exposed wave-cut rock platforms or coral reefs (SEWPAC 2013).	EPBC	No – no habitat in study area,

Species name	Common name	TSC Act	EPBC Act	Habitat associations	Number of Atlas records	Likelihood of occurrence in the study area
Calidris ferruginea	Curlew Sandpiper	E	M	The Curlew Sandpiper is distributed around most of the coastline of Australia (including Tasmania). It occurs along the entire coast of NSW, particularly in the Hunter Estuary, and sometimes in freshwater wetlands in the Murray-Darling Basin. Inland records are probably mainly of birds pausing for a few days during migration. The Curlew Sandpiper breeds in Siberia and migrates to Australia where it generally occupies littoral and estuarine habitats, and in New South Wales is mainly found in intertidal mudflats of sheltered coasts. It also occurs in non-tidal swamps, lakes and lagoons on the coast and sometimes the inland (OEH 2014).	250	No – no suitable habitat in study area
Calidris ruficollis	Red-necked Stint	-	M	In Australasia, the Red-necked Stint is mostly found in coastal areas, including in sheltered inlets, bays, lagoons and estuaries with intertidal mudflats, often near spits, islets and banks and, sometimes, on protected sandy or coralline shores (SEWPAC 2013).	EPBC	No – no habitat in study area,
Calidris tenuirostris	Great Knot	V	M	In NSW, the species has been recorded at scattered sites along the coast to about Narooma. It has also been observed inland at Tullakool, Armidale, Gilgandra and Griffith. Occurs within sheltered, coastal habitats containing large, intertidal mudflats or sandflats, including inlets, bays, harbours, estuaries and lagoons. Often recorded on sandy beaches with mudflats nearby, sandy spits and islets and sometimes on exposed reefs or rock platforms (OEH 2014).	1	No – no suitable habitat in study area
Charadrius bicinctus	Double-banded Plover	-	M	The Double-banded Plover is found on littoral, estuarine and fresh or saline terrestrial wetlands and also saltmarsh, grasslands and pasture. It occurs on muddy, sandy, shingled or sometimes rocky beaches, bays and inlets, harbours and margins of fresh or saline terrestrial wetlands such as lakes, lagoons and swamps, shallow estuaries and rivers (SEWPAC 2013).	EPBC	No – no habitat in study area,
Charadrius leschenaultii	Greater Sand-plover	V	M	The Greater Sand-plover breeds in central Asia from Armenia to Mongolia, moving further south for winter. In Australia the species is commonly recorded in parties of 10-20 on the west coast, with the far northwest being the stronghold of the population. The species is apparently rare on the east coast, being found usually singly. In NSW, the species has been recorded between the northern rivers and the Illawarra, with most records coming from the Clarence and Richmond estuaries. Almost entirely restricted to coastal areas in NSW, occurring mainly on sheltered sandy, shelly or muddy beaches or estuaries with large intertidal mudflats or sandbanks (OEH 2014).	1	No – no suitable habitat in study area

Species name	Common name	TSC Act	EPBC Act	Habitat associations	Number of Atlas records	Likelihood of occurrence in the study area
Charadrius mongolus	Lesser Sand-plover	V	M	The Lesser Sand-plover breeds in central and north eastern Asia, migrating further south for winter. In Australia the species is found around the entire coast but is most common in the Gulf of Carpentaria, and along the east coast of Queensland and northern NSW. Individuals are rarely recorded south of the Shoalhaven estuary, and there are few inland records. Almost entirely coastal in NSW, favouring the beaches of sheltered bays, harbours and estuaries with large intertidal sandflats or mudflats; occasionally occurs on sandy beaches, coral reefs and rock platforms (OEH 2014).	1	No – no suitable habitat in study area
Gallinago hardwickii	Latham's Snipe	-	M	A variety of permanent and ephemeral wetlands, preferring open fresh water wetlands with nearby cover (Marchant and Higgins 1993).	EPBC	No – no habitat in study area,
Heteroscelus brevipes	Grey-tailed Tattler	-	M	The Grey-tailed Tattler is often found on sheltered coasts with reefs and rock platforms or with intertidal mudflats. It can also be found at intertidal rocky, coral or stony reefs as well as platforms and islets that are exposed at low tide. It has been found around shores of rock, shingle, gravel or shells and also on intertidal mudflats in embayments, estuaries and coastal lagoons, especially fringed with mangroves (SEWPAC 2013).	EPBC	No – no habitat in study area,
Limosa lapponica	Bar-tailed Godwit	V	M	Mainly coastal, usually sheltered bays, estuaries and lagoons with large intertidal mudflats or sandflats. Breeds in Northern Russia, Scandinavia, NW Alaska (DEH 2005).	EPBC	No – no habitat in study area,
Limosa limosa	Black-tailed Godwit	-	M	In Australia the Black-tailed Godwit has a primarily coastal habitat environment. The species is commonly found in sheltered bays, estuaries and lagoons with large intertidal mudflats or sandflats, or spits and banks of mud, sand or shell-grit; occasionally recorded on rocky coasts or coral islets (SEWPAC 2013).	13	No – no habitat in study area,
Numenius madagascariensis	Eastern Curlew	-	M	Intertidal coastal mudflats, coastal lagoons, sandy spits (DEH 2005). Breeds in Russia, NE China (ibid).	EPBC	No – no habitat in study area,
Numenius minutus	Little Curlew	-	M	The Little Curlew is most often found feeding in short, dry grassland and sedgeland, including dry floodplains and blacksoil plains, which have scattered, shallow freshwater pools or areas seasonally inundated (SEWPAC 2013).	EPBC	No – no habitat in study area,
Numenius phaeopus	Whimbrel	-	M	The Whimbrel is often found on the intertidal mudflats of sheltered coasts. It is also found in harbours, lagoons, estuaries and river deltas, often those with mangroves, but also open, unvegetated mudflats. It is occasionally found on sandy or rocky beaches, on coral or rocky islets, or on intertidal reefs and platforms (SEWPAC 2013).	EPBC	No – no habitat in study area,

Species name	Common name	TSC Act	EPBC Act	Habitat associations	Number of Atlas records	Likelihood of occurrence in the study area
Pluvialis fulva	Pacific Golden Plover	-	M	In non-breeding grounds in Australia this species usually inhabits coastal habitats, though it occasionally occurs around inland wetlands. Pacific Golden Plovers usually occur on beaches, mudflats and sandflats (sometimes in vegetation such as mangroves, low saltmarsh such as Sarcocornia, or beds of seagrass) in sheltered areas including harbours, estuaries and lagoons, and also in evaporation ponds in saltworks (SEWPAC 2013).	EPBC	No – no habitat in study area,
Rostratula australis	Painted Snipe (Australian subspecies)	E	E, M	Prefers fringes of swamps, dams and nearby marshy areas where there is a cover of grasses, lignum, low scrub or open timber (OEH 2012). Nests on the ground amongst tall vegetation, such as grasses, tussocks or reeds (ibid.). Breeding is often in response to local conditions; generally occurs from September to December (OEH 2012). Forages nocturnally on mud-flats and in shallow water (OEH 2012). Feeds on worms, molluscs, insects and some plant-matter (ibid.).	EPBC	No – no habitat in study area,
Tringa stagnatilis	Marsh Sandpiper	-	M	The Marsh Sandpiper lives in permanent or ephemeral wetlands of varying salinity, including swamps, lagoons, billabongs, saltpans, saltmarshes, estuaries, pools on inundated floodplains, and intertidal mudflats and also regularly at sewage farms and saltworks (SEWPAC 2013).	EPBC	No – no habitat in study area,
Xenus cinereus	Terek Sandpiper	V	M	The two main sites for the species in NSW are the Richmond River estuary and the Hunter River estuary. The latter has been identified as nationally and internationally important for the species. Favours mudbanks and sandbanks located near mangroves, but may also be observed on rocky pools and reefs, and occasionally up to 10 km inland around brackish pools (OEH 2014).	1	No – no suitable habitat in study area
Migratory Marine Species						
Diomedea dabbenena	Tristan Albatross	-	E, M	Marine Forager	EPBC	No – no habitat in study area,
Diomedea epomophora epomophora	Southern Royal Albatross	-	V, M	Marine forager	EPBC	No – no habitat in study area,
Diomedea epomophora sanfordi	Northern Royal Albatross	-	E, M	Marine forager	EPBC	No – no habitat in study area,
Diomedea exulans antipodensis	Antipodean Albatross	V	V, M	Marine forager	EPBC	No – no habitat in study area,

Species name	Common name	TSC Act	EPBC Act	Habitat associations	Number of Atlas records	Likelihood of occurrence in the study area
Diomedea exulans	Wandering Albatross	E	V, M	Marine forager	1	No – no suitable habitat in study area
Diomedea exulans exulans	Tristan Albatross	-	E, M	Marine forager	EPBC	No – no habitat in study area,
Diomedea exulans gibsoni	Gibson's Albatross	V	V, M	Marine forager	EPBC	No – no habitat in study area,
Limicola falcinellus	Broad-billed Sandpiper	V	M	The eastern form of the Broad-billed Sandpiper breeds in northern Siberia before migrating southwards in winter to Australia (DECC 2007). In Australia, Broad-billed Sandpipers over-winter on the northern coast, particularly in the north-west, with birds located occasionally on the southern coast (DECC 2007). In NSW, the main site for the species is the Hunter River estuary, with birds occasionally reaching the Shoalhaven estuary (DECC 2007). There are few records for inland NSW (DECC 2007). Broad-billed Sandpipers favour sheltered parts of the coast such as estuarine sandflats and mudflats, harbours, embayments, lagoons, saltmarshes and reefs as feeding and roosting habitat (DECC 2007). Occasionally, individuals may be recorded in sewage farms or within shallow freshwater lagoons (DECC 2007). Broad-billed Sandpipers roost on banks on sheltered sand, shell or shingle beaches.	3	No. Habitat not suitable.
Macronectes giganteus	Southern Giant-Petrel	E	E, M	Marine Forager	EPBC	No – no habitat in study area,
Macronectes halli	Northern Giant-Petrel	V	V, M	Marine Forager	EPBC	No – no habitat in study area,
Thalassarche bulleri	Buller's Albatross	-	V, M	Marine Forager	EPBC	No – no habitat in study area,
Thalassarche cauta cauta	Shy Albatross, Tasmanian Shy Albatross	V	V, M	Marine Forager	EPBC	No – no habitat in study area,
Thalassarche cauta salvini	Salvin's Albatross	-	V, M	Marine Forager	EPBC	No – no habitat in study area,

Species name	Common name	TSC Act	EPBC Act	Habitat associations	Number of Atlas records	Likelihood of occurrence in the study area
Thalassarche cauta steadi	White-capped Albatross	-	V, M	Marine Forager	EPBC	No – no habitat in study area,
Thalassarche eremita	Chatham Albatross	-	E, M	Marine Forager	EPBC	No – no habitat in study area,
Thalassarche melanophris	Black-browed Albatross	V	V, M	Marine Forager	EPBC	No – no habitat in study area,
Thalassarche melanophris impavida	Campbell Albatross	-	V, M	Marine Forager	EPBC	No – no habitat in study area,
Thalassarche steadi	White-capped Albatross	-	V, M	Marine Forager	EPBC	No – no habitat in study area,

Appendix B: Flora species recorded

The flora lists include species recorded from (ELA 2013b).

Table 20: Native flora species list recorded during the field survey

	Scientific Name	**Common Name**
1	*Acacia baileyana* #	Cootamundra Wattle
2	*Acacia binervia*	Coast Myall
3	*Acacia brownii*	Heath Wattle
4	*Acacia decurrens*	Black Wattle
5	*Acacia linearis*	
6	*Acacia linifolia*	
7	*Acacia longifolia subsp. longifolia*	Sydney Golden Wattle
8	*Acacia myrtifolia*	Red-stemmed Wattle
9	*Acacia parramattensis*	Parramatta Wattle
10	*Acacia podalyriifolia* #	Queensland silver-wattle
11	*Acacia* sp. #	
12	*Acacia suaveolens*	
13	*Acacia ulicifolia*	Prickly Moses
14	*Acianthus* sp.	
15	*Acmena smithii*	Lilly Pilly
16	*Adiantum aethiopicum*	Common maidenhair
17	*Adiantum formosum*	Black stem maidenhair
18	*Allocasuarina littoralis*	Black She-oak
19	*Allocasuarina* sp.	
20	*Allocasuarina torulosa*	Forest Oak
21	*Angophora bakeri*	Narrow-leaved Apple
22	*Angophora costata*	Sydney Red Gum
23	*Angophora floribunda*	Rough-barked Apple
24	*Angophora subvelutina*	Broad-leaved Apple
25	*Anisopogon avenaceus*	Oat Speargrass
26	*Aotus* sp.	
27	*Aristida* sp.	
28	*Aristida vagans*	Threeawn Speargrass
29	*Arthropodium milleflorum*	Pale Vanilla-lily
30	*Asperula conferta*	Common Woodruff
31	*Asplenium australasicum*	Bird's Nest Fern
32	*Astroloma* sp.	
33	*Austrodanthonia* sp.	
34	*Austrostipa pubescens*	
35	*Austrostipa* sp.	
36	*Austrostipa verticillata*	Slender Bamboo Grass
37	*Axonopus fissifolius*	Narrow-leafed Carpet Grass
38	*Banksia ericifolia*	Heath-leaved Banksia

	Scientific Name	**Common Name**
39	*Banksia integrifolia*	Coast Banksia
40	*Banksia serrata*	Old-man Banksia
41	*Banksia spinulosa*	Hairpin Banksia
42	*Billardiera scandens*	Hairy Apple Berry
43	*Blechnum nudum*	Fishbone Water Fern
44	*Bossiaea heterophylla*	Variable Bossiaea
45	*Bossiaea obcordata*	Spiny Bossiaea
46	*Brachychiton acerifolius* #	Flame Tree
47	*Brachychiton populneus* ssp. *Populneus*	Kurrajong
48	*Breynia oblongifolia*	Coffee Bush
49	*Brunoniella pumilio*	Dwarf Brunoniella
50	*Burchardia umbellata*	
51	*Bursaria spinosa*	Blackthorn
52	*Caladenia* sp.	
53	*Callerya* sp.	Wisteria
54	*Callicoma serratifolia*	Black Wattle
55	*Callistemon* sp. #	
56	*Calochilus* sp.	
57	*Calochlaena dubia*	Rainbow Fern
58	*Calotis cuneifolia*	Burr Daisy
59	*Cassytha glabella*	
60	*Cassytha pubescens*	
61	*Casuarina cunninghamiana*	River Oak
62	*Caustis flexuosa*	Curly Wig
63	*Centella asiatica*	Indian Pennywort
64	*Ceratopetalum apetalum*	Coachwood
65	*Ceratopetalum gummiferum*	New South Wales Christmas-bush
66	*Cheilanthes sieberi* subsp. *sieberi*	Poison Rock Fern
67	*Cissus hypoglauca*	Water Vine
68	*Cissus* sp.	
69	*Clematis aristata*	Old Man's Beard
70	*Clematis glycinoides*	Headache Vine
71	*Commelina cyanea*	Native Wandering Jew
72	*Convolvulus erubescens*	Blushing Bindweed
73	*Cordyline* sp.	
74	*Correa reflexa*	
75	*Corybas* sp.	
76	*Corymbia citriodora* #	Lemon-scented Gum
77	*Corymbia gummifera*	
78	*Corymbia maculata*	Spotted Gum
79	*Crowea saligna*	
80	*Cryptostylis* sp.	
81	*Cyathea australis*	Black Tree-fern

	Scientific Name	Common Name
82	*Cyathochaeta diandra*	
83	*Cynodon dactylon*	Couch
84	*Desmodium brachypodum*	Large Tick-trefoil
85	*Desmodium* sp.	
86	*Desmodium varians*	Slender Tick-trefoil
87	*Dianella caerulea* var. *caerulea*	Blue Flax Lily
88	*Dianella longifolia* var. *longifolia*	
89	*Dianella revoluta*	Blueberry Lily
90	*Dianella* sp.	
91	*Dichelachne micrantha*	Shorthair Plumegrass
92	*Dichelachne* sp.	
93	*Dichondra repens*	Kidney Weed
94	*Dichopogon fimbriatus*	Nodding Chocolate Lily
95	*Digitaria parviflora*	Small-flowered Finger Grass
96	*Dillwynia retorta*	
97	*Dipodium punctatum*	
98	*Dodonaea triquetra*	Large-leaf Hop-bush
99	*Doryphora sassafras*	
100	*Drosera peltata*	
101	*Echinopogon caespitosus*	
102	*Echinopogon ovatus*	Forest Hedgehog Grass
103	*Echinopogon* sp.	
104	*Einadia hastata*	Berry Saltbush
105	*Elaeocarpus reticulatus*	Blueberry Ash
106	*Eleocharis* sp.	
107	*Entolasia marginata*	Bordered Panic
108	*Entolasia stricta*	
109	*Epacris pulchella*	Wallum Heath
110	*Epacris purpurascens var. purpurascens*	
111	*Eragrostis* sp.	
112	*Eriostemon australasius*	
113	*Eucalyptus agglomerata*	Blue-leaved Stringybark
114	*Eucalyptus amplifolia*	Cabbage Gum
115	*Eucalyptus botryoides*	Bangalay
116	*Eucalyptus crebra*	Narrow-leaved Ironbark
117	*Eucalyptus haemastoma*	Scribbly Gum
118	*Eucalyptus microcorys*	Tallowwood
119	*Eucalyptus paniculata*	Grey Ironbark
120	*Eucalyptus pilularis*	Blackbutt
121	*Eucalyptus piperita*	Sydney Peppermint
122	*Eucalyptus racemosa*	Narrow-leaved Scribbly Gum
123	*Eucalyptus resinifera*	Red Mahogany
124	*Eucalyptus saligna*	Sydney Blue Gum

	Scientific Name	Common Name
125	*Eucalyptus* sp. #	
126	*Eucalyptus tereticornis*	Forest Red Gum
127	*Euchiton* sp.	
128	*Euchiton sphaericus*	
129	*Eustrephus latifolius*	Wombat Berry
130	*Exocarpos cupressiformis*	Cherry Ballart
131	*Ficus rubiginosa*	Port Jackson Fig
132	*Geitonoplesium cymosum*	Scrambling Lily
133	*Geranium solanderi*	Native Geranium
134	*Glochidion ferdinandi*	Cheese Tree
135	*Glycine clandestina*	
136	*Glycine microphylla*	Small-leaf glycine
137	*Glycine* sp.	
138	*Glycine tabacina*	
139	*Gonocarpus teucrioides*	Raspwort
140	*Goodenia hederacea*	Forest Goodenia
141	*Goodenia* sp.	
142	*Grevillea linearifolia*	Linear-leaf Grevillea
143	*Grevillea robusta* #	Silky Oak
144	*Grevillea sericea*	Pink Spider Flower
145	*Guioa semiglauca*	Guioa
146	*Hakea dactyloides*	Finger Hakea
147	*Hakea salicifolia*	Willow-laved Hakea
148	*Hakea sericea*	Needlebush
149	*Hardenbergia violacea*	
150	*Hibbertia aspera*	Rough Guinea Flower
151	*Hibbertia empetrifolia*	
152	*Hibbertia linearis*	
153	*Hibbertia riparia*	Erect Guinea-flower
154	*Hibbertia scandens*	Climbing Guinea flower
155	*Hibbertia superans*	
156	*Hibbertia* sp.	
157	*Homalanthus populifolius*	Bleeding Heart
158	*Hovea linearis*	
159	*Hydrocotyle* sp.	
160	*Hypericum gramineum*	Small St. John's Wort
161	*Imperata cylindrica*	Blady Grass
162	*Indigofera australis*	Australian Indigo
163	*Isopogon anemonifolius*	Broad-leaf Drumsticks
164	*Juncus usitatus*	
165	*Kennedia rubicunda*	Dusky Coral Pea
166	*Kunzea ambigua*	Tick Bush
167	*Lambertia formosa*	Mountain Devil

	Scientific Name	Common Name
168	*Lasiopetalum ferrugineum*	
169	*Laxmannia gracilis*	Slender Wire Lily
170	*Lepidosperma filiforme*	
171	*Lepidosperma gunnii*	
172	*Lepidosperma laterale*	
173	*Leptomeria acida*	Native Currant
174	*Leptospermum polyanthum*	
175	*Leptospermum trinervium*	
176	*Lepyrodia scariosa*	
177	*Leucopogon juniperinus*	Prickly Beard-heath
178	*Leucopogon lanceolatus*	
179	*Lindsaea linearis*	Screw Fern
180	*Lindsaea microphylla*	Lacy Wedge Fern
181	*Lindsaea* sp.	
182	*Lissanthe strigosa*	Peach Heath
183	*Livistona australis*	Cabbage Fan Palm
184	*Logania albiflora*	
185	*Lomandra cylindrica*	Needle Mat-Rush
186	*Lomandra filiformis* subsp. *coriacea*	
187	*Lomandra filiformis* subsp. *filiformis*	Wattle Mat-rush
188	*Lomandra glauca*	Pale Mat-rush
189	*Lomandra gracilis*	
190	*Lomandra longifolia*	Spiny-headed Mat-rush
191	*Lomandra multiflora* subsp*. multiflora*	Many-flowered Mat-rush
192	*Lomandra obliqua*	
193	*Lomandra* sp.	
194	*Lomatia myricoides*	River Lomatia
195	*Lomatia silaifolia*	Crinkle Bush
196	*Maytenus silvestris*	Narrow-leaved Orangebark
197	*Melaleuca erubescens*	
198	*Melaleuca sp. #*	
199	*Melia azedarach*	White Cedar
200	*Micrantheum ericoides*	
201	*Microlaena stipoides*	Weeping Grass
202	*Morinda jasminoides*	Sweet Morinda
203	*Myrsine howittiana*	Brush Muttonwood
204	*Myrsine sp.*	Muttonwood
205	*Myrsine variabilis*	
206	*Notelaea longifolia*	Large Mock-olive
207	*Opercularia diphylla*	
208	*Oplismenus aemulus*	Australian Basket Grass
209	*Oplismenus imbecillis*	Creeping Beard Grass
210	*Oplismenus* sp.	

	Scientific Name	**Common Name**
211	*Oxalis perennans*	
212	*Ozothamnus diosmifolius*	Rice Flower
213	*Pandorea pandorana*	Wonga Wonga Vine
214	*Pandorea pandorana* subsp. *pandorana*	Wonga Wonga Vine
215	*Parsonsia straminea*	Common Silkpod
216	*Paspalidium distans*	
217	*Patersonia glabrata*	Leafy Purple-flag
218	*Patersonia sericea*	Silky Purple-flag
219	*Persicaria* sp.	
220	*Persoonia laurina*	Laurel Geebung
221	*Persoonia laurina* subsp. *laurina*	
222	*Persoonia levis*	Broad-leaved Geebung
223	*Persoonia linearis*	Narrow-leaved Geebung
224	*Persoonia pinifolia*	Pine-leaved Geebung
225	*Petrophile pulchella*	Conesticks
226	*Petrophile sessilis*	Conesticks
227	*Phragmites australis*	Common Reed
228	*Phyllanthus hirtellus*	Thyme Spurge
229	*Phyllanthus* sp.	
230	*Pimelea linifolia*	Slender Rice Flower
231	*Pittosporum revolutum*	Wild Yellow Jasmine
232	*Pittosporum undulatum*	Native Daphne
233	*Platylobium formosum*	Handsome Flat Pea
234	*Plectranthus parviflorus*	Cockspur Flower
235	*Poa affinis*	
236	*Poa labillardierei*	Tussock
237	*Poa* sp.	
238	*Podolobium ilicifolium*	Prickly Shaggy Pea
239	*Polyscias sambucifolia*	Elderberry Panax
240	*Pomaderris discolor*	
241	*Pomax umbellata*	
242	*Poranthera microphylla*	
243	*Pratia purpurascens*	Whiteroot
244	*Pseuderanthemum variabile*	Pastel Flower
245	*Pteridium esculentum*	Common Bracken
246	*Pterostylis longifolia*	Tall Greenhood
247	*Pterostylis* sp.	
248	*Ptilothrix deusta*	
249	*Pultenaea daphnoides*	Large-leaf Bush-pea
250	*Rubus parvifolius*	
251	*Rumex brownii*	Swamp Dock
252	*Schizaea bifida*	Forked Comb Fern
253	*Sigesbeckia orientalis* subsp. *orientalis*	Indian Weed

	Scientific Name	Common Name
254	*Smilax glyciphylla*	Sweet Sarsaparilla
255	*Solanum prinophyllum*	Forest Nightshade
256	*Sporobolus* sp.	
257	*Stylidium graminifolium*	Grass Triggerplant
258	*Stylidium lineare*	Narrow-leaved Triggerplant
259	*Syncarpia glomulifera*	Turpentine
260	*Synoum glandulosum*	Scentless Rosewood
261	*Telopea speciosissima*	Waratah
262	*Tetragonia tetragonioides* #	New Zealand Spinach
263	*Themeda australis*	Kangaroo Grass
264	*Thysanotus tuberosus*	Common Fringe Lily
265	*Trema tomentosa*	Native Peach
266	*Tricoryne elatior*	Yellow Autumn-lily
267	*Tristania neriifolia* #	Water Gum
268	*Tylophora barbata*	Bearded Tylophora
269	*Urtica incisa* #	Stinging Nettle
270	*Veronica plebeia*	Trailing Speedwell
271	*Viola hederacea*	Ivy-leaved Violet
272	*Wahlenbergia gracilis*	Sprawling Bluebell
273	*Xanthorrhoea arborea*	
274	*Xanthorrhoea minor*	
275	*Xanthorrhoea* sp.	
276	*Xanthosia pilosa*	Woolly Xanthosia
277	*Xanthosia tridentata*	Rock Xanthosia
278	*Xylomelum pyriforme*	Woody Pear
279	*Zieria smithii*	Sandfly Zieria
280	*Zieria* sp.	
281	*Zornia* sp.	
282	Little cream flower	Yet to be identified

# Denotes native planted or non-indigenous to the area

Table 21: Exotic species list recorded during the field survey

	Scientific Name	**Common Name**
1	*Acer negundo*	Box-elder Maple
2	*Agapanthus* sp.	
3	*Ageratina adenophora*	Crofton Weed
4	*Ageratina riparia*	Creeping Crofton Weed
5	*Aira* sp.	
6	*Aloe* sp.	
7	*Anagallis arvensis*	Scarlet Pimpernel
8	*Andropogon virginicus*	Whisky Grass
9	*Anredera cordifolia*	Madeira Vine
10	*Araujia sericifera*	Moth Vine
11	*Arctotheca calendula*	Cape Weed
12	*Asparagus aethiopicus*	Aparagus Fern
13	*Asparagus asparagoides*	Bridal Creeper
14	*Asparagus plumosus*	Climbing Asparagus Fern
15	*Asphodelus fistulosus*	Onion Weed
16	*Avena barbata*	
17	*Avena fatua*	Wild Oats
18	*Bidens pilosa*	Cobblers Pegs
19	*Brassica* sp.	
20	*Briza maxima*	Quaking Grass
21	*Briza minor*	Shivery Grass
22	*Briza subaristata*	
23	*Bromus catharticus*	Prairie Grass
24	*Bromus diandrus*	Great Brome
25	*Bromus* sp.	
26	*Cardamine* sp.	
27	*Cardiospermum grandiflorum*	Balloon Vine
28	*Carex* sp.	
29	*Celtis sinensis*	Japanese Hackberry
30	*Centaurium* sp.	
31	*Cestrum parqui*	Green Cestrum
32	*Chloris* sp.	
33	*Chlorophytum comosum*	Spider Plant
34	*Cinnamomum camphora*	Camphor Laurel
35	*Cirsium vulgare*	Spear Thistle
36	*Conyza bonariensis*	Flaxleaf Fleabane
37	*Conyza* sp.	
38	*Cortaderia selloana*	Pampas Grass
39	*Cosmos bipinnatus*	
40	*Cotoneaster glaucophyllus*	Cotoneaster
41	*Crataegus monogyna*	Hawthorn
42	*Cyperus* sp.	

	Scientific Name	Common Name
43	*Cytisus scoparius*	Scotch Broom
44	*Ehrharta erecta*	Panic Veldtgrass
45	*Eragrostis curvula*	African Lovegrass
46	*Erigeron Karvinskianus*	Seaside Daisy
47	*Erythrina x sykesii*	Coral Tree
48	*Euphorbia peplus*	Petty Spurge
49	*Foeniculum vulgare*	Fennel
50	*Galium aparine*	Goosegrass
51	*Gamochaeta calviceps*	Cudweed
52	*Genista monspessulana*	Montpellier Broom
53	*Geranium* sp.	
54	*Gomphocarpus fruticosus*	Narrow-leaved Cotton Bush
55	*Hedera helix*	English Ivy
56	*Hedychium gardnerianum*	Ginger Lily
57	*Hypericum perforatum*	St John's Wort
58	*Hypochaeris radicata*	Catsear
59	*Ipomoea indica*	Morning Glory
60	*Jacaranda mimosifolia*	Jacaranda
61	*Jasminum* sp.	
62	*Juncus* sp.	
63	*Lantana camara*	Lantana
64	*Ligustrum lucidum*	Large Leaved Privet
65	*Ligustrum sinense*	Small Leaved Privet
66	*Lilium formosanum*	Formosan Lily
67	*Lolium perenne*	Perennial Ryegrass
68	*Lonicera japonica*	Japanese Honeysuckle
69	*Lotus* sp.	
70	*Medicago* sp.	
71	*Modiola caroliniana*	Red-flowered Mallow
72	*Modiola* sp.	
73	*Monstera deliciosa*	Fruit Salad Plant
74	*Nandina domestica*	Japanese Sacred Bamboo
75	*Nephrolepis cordifolia*	Fishbone Fern
76	*Nerium oleander*	Oleander
77	*Nothoscordum borbonicum*	Onion Weed
78	*Ochna serrulata*	Mickey Mouse Plant
79	*Olea europaea* subsp. *cuspidata*	African Olive
80	*Opuntia stricta*	Common Prickly Pear
81	*Oxalis* sp.	
82	*Paronychia brasiliana*	Chilean Whitlow Wort
83	*Paspalum dilatatum*	Paspalum
84	*Passiflora edulis*	Common Passionfruit
85	*Passiflora* sp.	

	Scientific Name	Common Name
86	*Pennisetum clandestinum*	Kikuyu
87	*Pennisetum villosum*	Feathertop
88	*Phalaris aquatica*	Phalaris
89	*Phoenix canariensis*	Canary Island Date Palm
90	*Pinus radiata*	Radiata Pine
91	*Plantago lanceolata*	Lamb's Tongues
92	*Ranunculus* sp.	
93	*Rhaphiolepis indica*	Indian Hawthorn
94	*Ricinus communis*	Castor Oil Plant
95	*Rubus* sp.	Blackberry
96	*Rumex* sp.	
97	*Senecio angulatus*	
98	*Senecio madagascariensis*	Fireweed
99	*Senecio* sp.	
100	*Senna pendula*	Bird-of-Paradise Shrub
101	*Senna* sp.	
102	*Sida rhombifolia*	Paddy's Lucerne
103	*Solanum chenopodioides*	Whitetip Nightshade
104	*Solanum jasminoides*	Potato Vine
105	*Solanum mauritianum*	Wild Tobacco Bush
106	*Solanum nigrum*	Black-berry Nightshade
107	*Solanum pseudocapsicum*	Madeira Winter
108	*Solanum* sp.	
109	*Sonchus asper*	Prickly Sowthistle
110	*Sonchus oleraceus*	Common Sowthistle
111	*Sonchus* sp.	
112	*Sporobolus* sp.	
113	*Stellaria media*	Common Chickweed
114	*Stenotaphrum secundatum*	Buffalo Grass
115	*Taraxacum officinale*	Dandelion
116	*Tradescantia fluminensis*	Wandering Jew
117	*Trifolium repens*	White Clover
118	*Trifolium* sp.	
119	*Verbena bonariensis*	Purpletop
120	*Vicia* sp.	
121	*Vinca major*	Blue Periwinkle
122	*Viola odorata*	Sweet Violet
123	*Viola* sp.	
124	*Vulpia myuros*	
125	*Watsonia meriana var. bulbillifera*	Bulbil Watsonia
126	*Xanthium spinosum*	Bathurst Burr

Appendix C: Fauna species recorded

The fauna list includes species recorded from (AECOM 2014).

Table 22: Fauna species list recorded during the field survey

	Common Name	Scientific Name	Observation Type
1	Australian Brush-turkey	*Alectura lathami*	AECOM 2014
2	Australian King Parrot	*Alisterus scapularis*	O
3	Australian Magpie	*Cracticus tibicen*	O
4	Australian Raven	*Corvus coronoides*	O
5	Australian Wood Duck	*Chenonetta jubata*	AECOM 2014
6	Azure Kingfisher	*Alcedo azurea*	W
7	Bell Miner	*Manorina melanophrys*	W
8	Black-faced Cuckoo-shrike	*Coracina novaehollandiae*	O
9	Black-shouldered Kite	*Elanus axillaris*	AECOM 2014
10	Brush Turkey	*Alectura lathami*	O
11	Brush-tailed Possum	*Trichosurus vulpecula*	Scats
12	Channel-Billed Cuckoo	*Scythrops novaehollandiae*	W
13	Chestnut Teal	*Anas castanea*	AECOM 2014
14	Common Myna*	*Acridotheres tristis*	O
15	Common Starling*	*Sturnus vulgaris*	AECOM 2014
16	Crested Pigeon	*Ocyphaps lophotes*	AECOM 2014
17	Crimson Rosella	*Platycercus elegans*	AECOM 2014
18	Delicate skink	*Lampropholis delicata*	O
19	Dusky Woodswallow	*Artamus cyanopterus*	AECOM 2014
20	Eastern Spinebill	*Acanthorhynchus tenuirostris*	AECOM 2014
21	Eastern Water Dragon	*Physignathus lesueurii*	AECOM 2014
22	Eastern Snake-necked Turtle	*Chelodina (Chelodina) longicollis*	AECOM 2014
23	Eastern Water Skink	*Eulamprus quoyii*	O
24	European Hare*	*Lepus europaeus*	O
25	Galah	*Eolophus roseicapillus*	AECOM 2014
26	Grey Butcherbird	*Cracticus torquatus*	W
27	Grey Fantail	*Rhipidura albiscapa*	AECOM 2014
28	Laughing Kookaburra	*Dacelo novaeguineae*	W
29	Leaden Flycatcher	*Myiagra rubecula*	AECOM 2014
30	Lewin's Honeyeater	*Meliphaga lewinii*	AECOM 2014
31	Long-finned Eel	*Anguilla reinhardtii*	O
32	Magpie-lark	*Grallina cyanoleuca*	O

33	Masked Lapwing	*Vanellus miles*	O
34	Noisy Miner	*Manorina melanocephala*	O
35	Pacific Black Duck	*Anas superciliosa*	O
36	Pied Currawong	*Strepera graculina*	W
37	Rainbow Lorikeet	*Trichoglossus haematodus*	O
38	Red-bellied Black snake	*Pseudechis porphyriacus*	O
39	Red-rumped Parrot	*Psephotus haematonotus*	AECOM 2014
40	Silvereye	*Zosterops lateralis*	AECOM 2014
41	Spotted Turtle-dove	*Spilopelia chinensis*	O
42	Sulphur-crested Cockatoo	*Cacatua galerita*	W
43	Superb Fairy-wren	*Malurus cyaneus*	O
44	Superb Lyrebird	*Menura novaehollandiae*	AECOM 2014
45	Swamp Wallaby	*Wallabia bicolor*	O
46	Water Dragon	*Physignathus lesueurii*	O
47	Welcome Swallow	*Hirundo neoxena*	AECOM 2014
48	White-browed Scrubwren	*Sericornis frontalis*	AECOM 2014
49	Willie Wagtail	*Rhipidura leucophrys*	O
50	Yellow-tailed Black- Cockatoo	*Calyptorhynchus funereus*	AECOM 2014
51	Yellow-tufted Honeyeater	*Lichenostomus melanops*	AECOM 2014

*Denotes invasive species, O denotes observed, W denotes heard. AECOM 2014 means recorded during that survey.

Appendix D: Aquatic Maps and Terrestrial Map Series

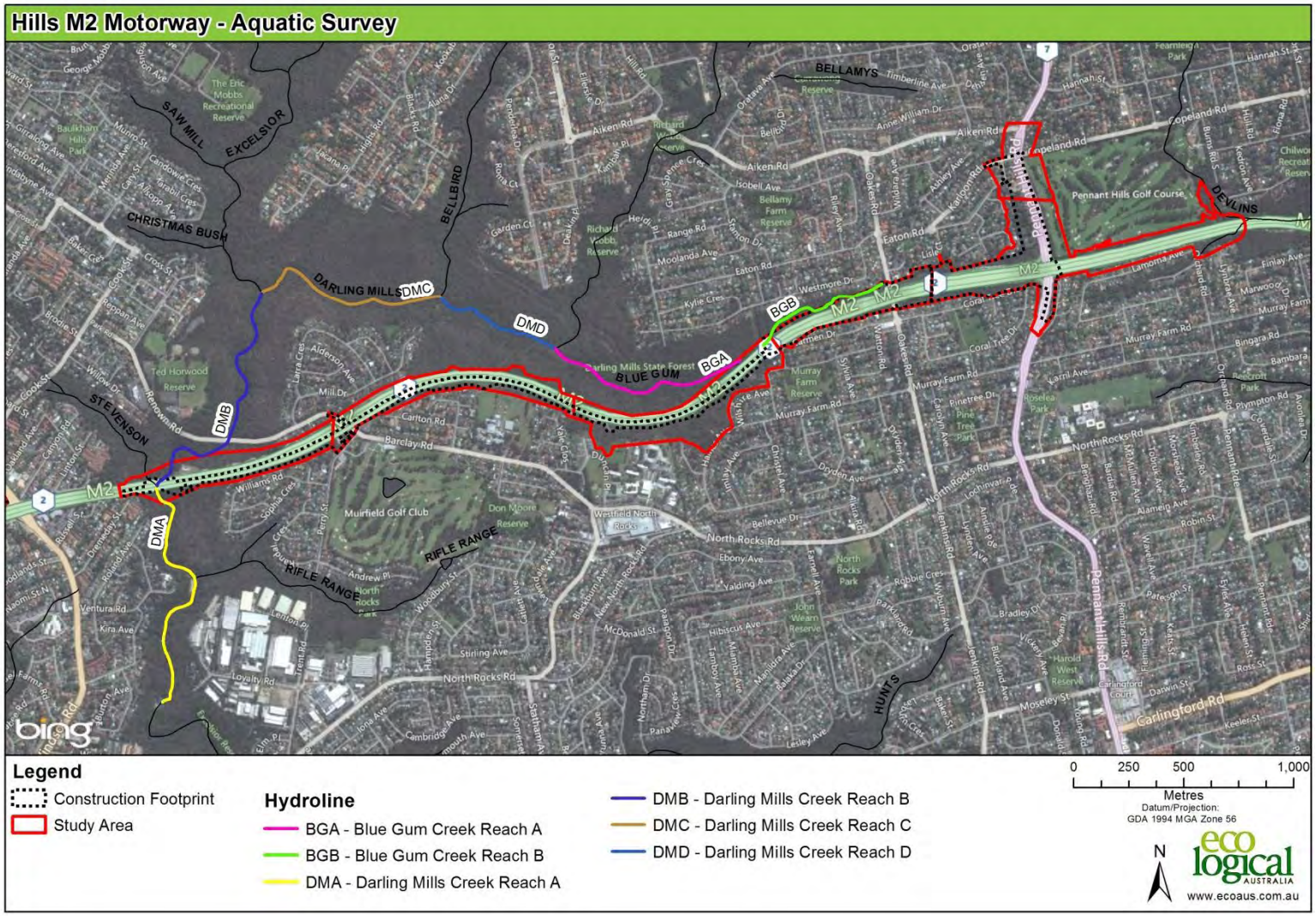


Figure 13: Blue Gum Creek and Darling Mills Creek

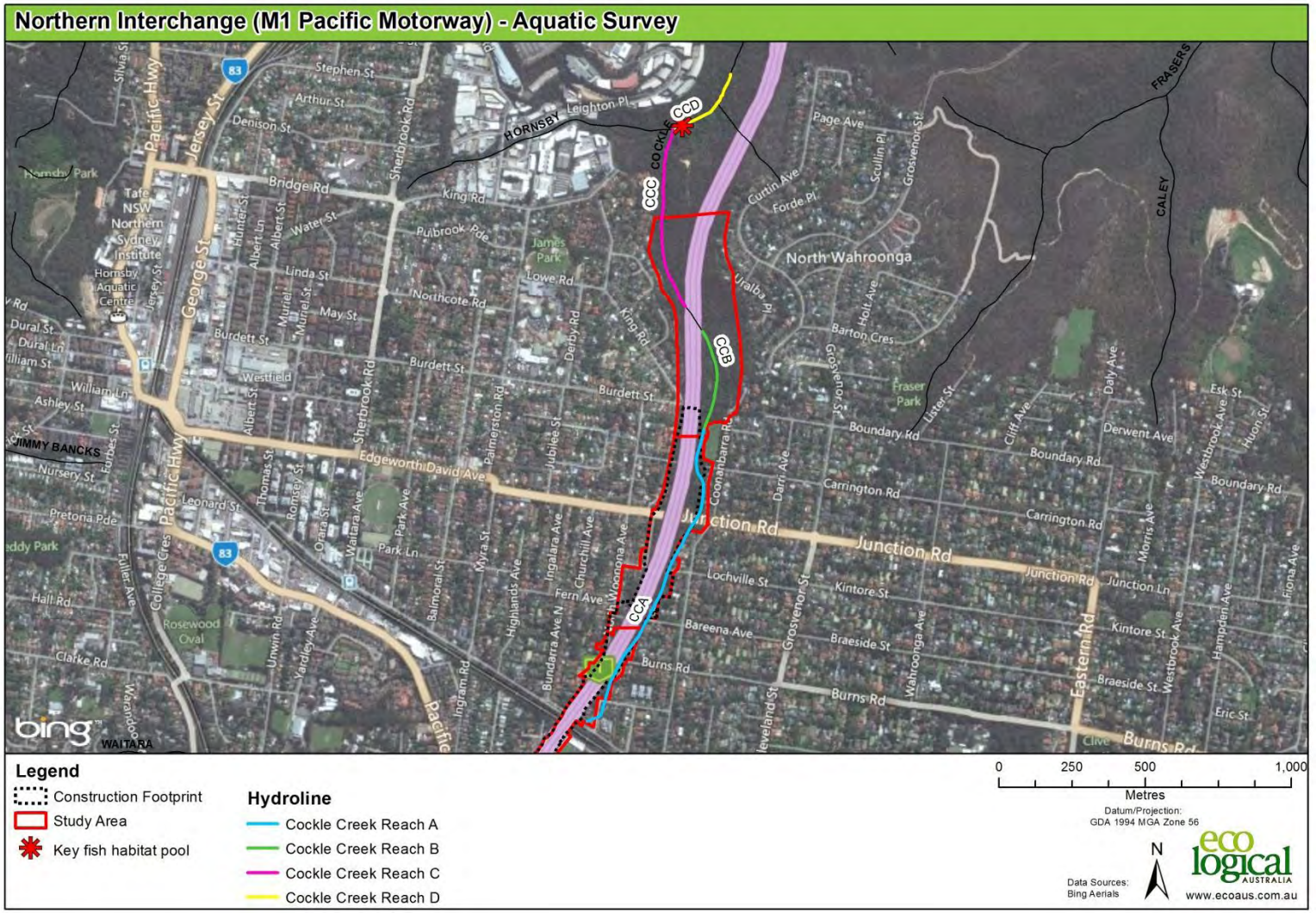


Figure 14: Cockle Creek

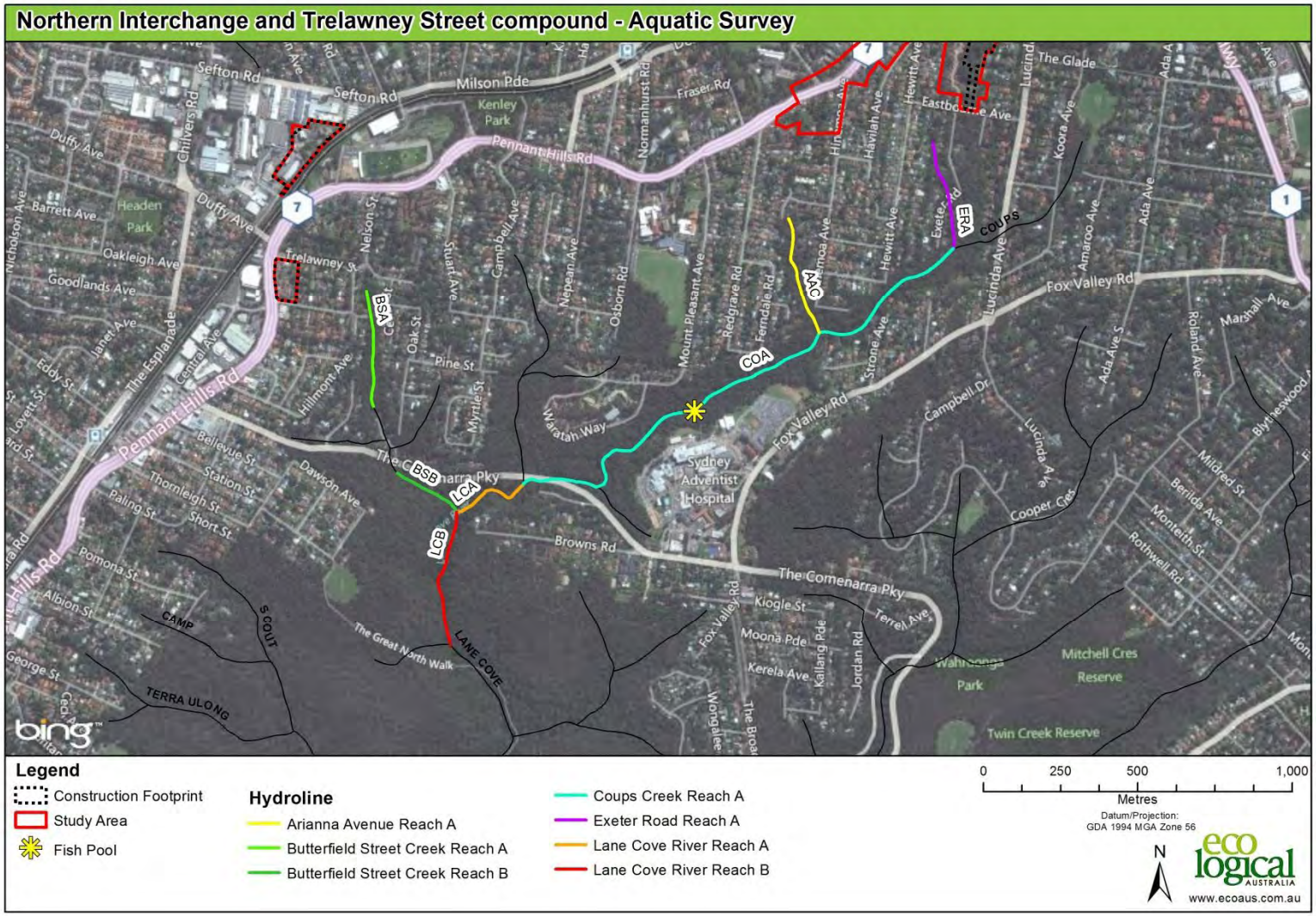


Figure 15: Coups Creek and Butterfield Street Creek

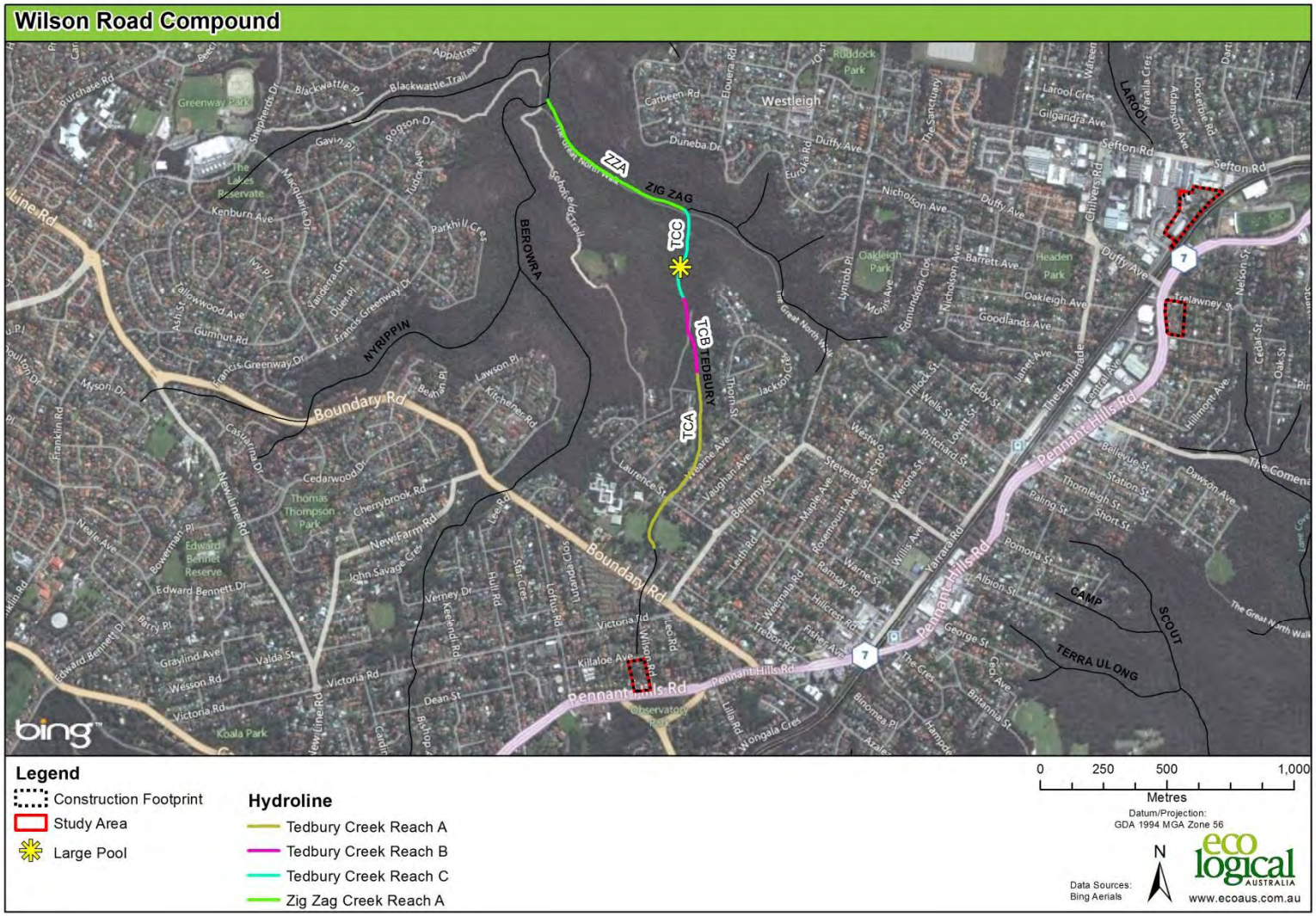


Figure 16: Tedbury Creek and Zig Zag Creek

Vegetation and Significant Biodiversity

Southern Interchange 1

Legend

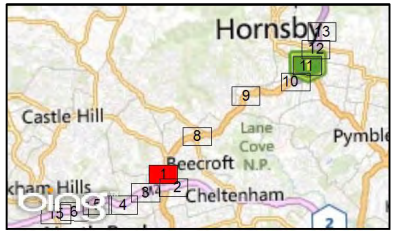
- Study Area
- Construction Footprint
- Culverts
- *Epacris purpurascens var. purpurascens*
- *Hibbertia superans*
- ELA Plots & Transects

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

N

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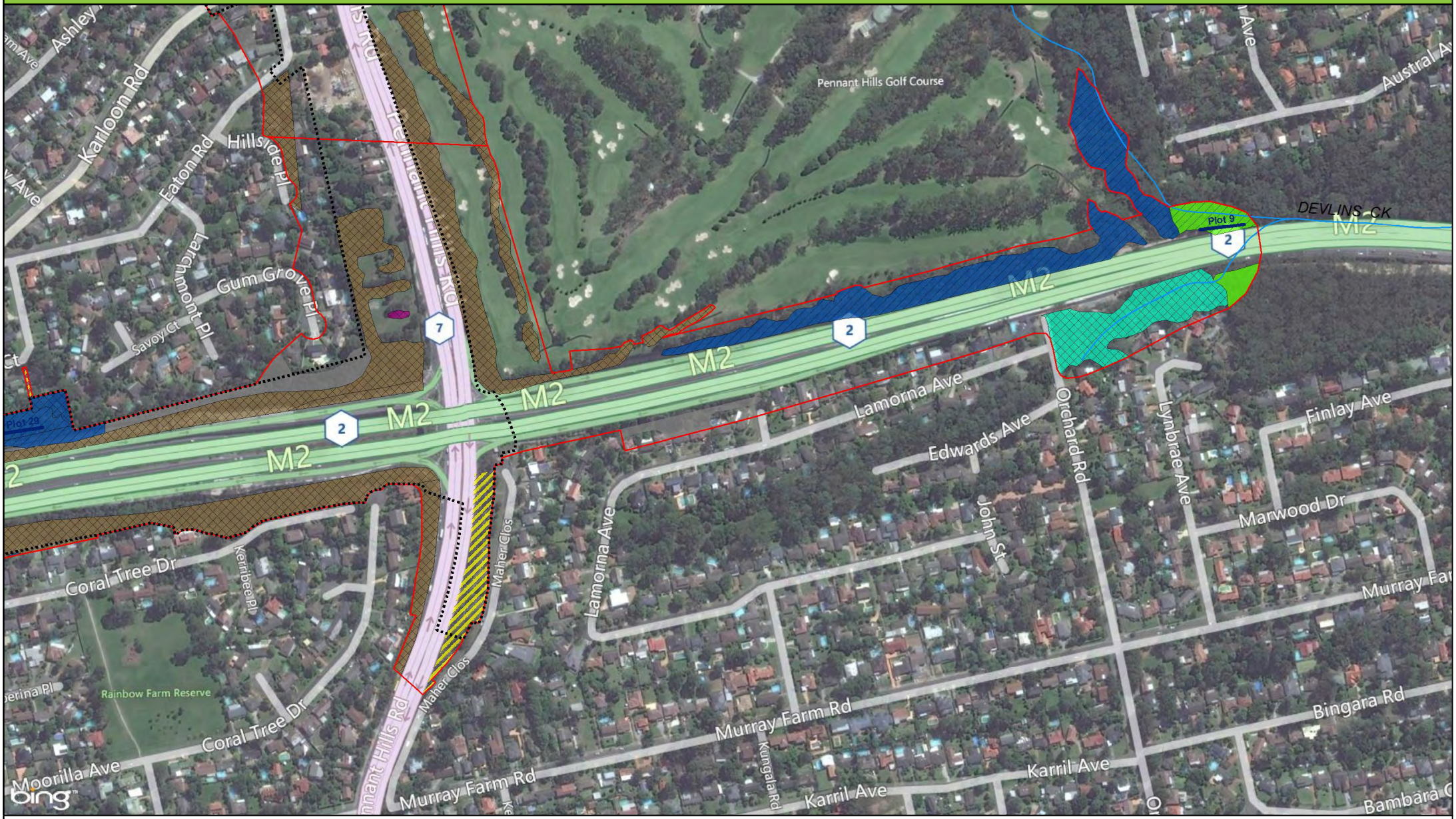
Vegetation and Significant Biodiversity

Southern Interchange 2



Legend

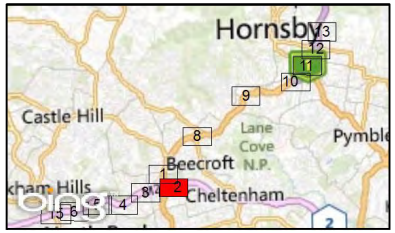
- Study Area
- Construction Footprint
- Culverts
- *Epacris purpurascens var. purpurascens*
- *Hibbertia superans*
- ELA Plots & Transects

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



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Metres

Datum/Projection:
GDA 1994 MGA Zone 56

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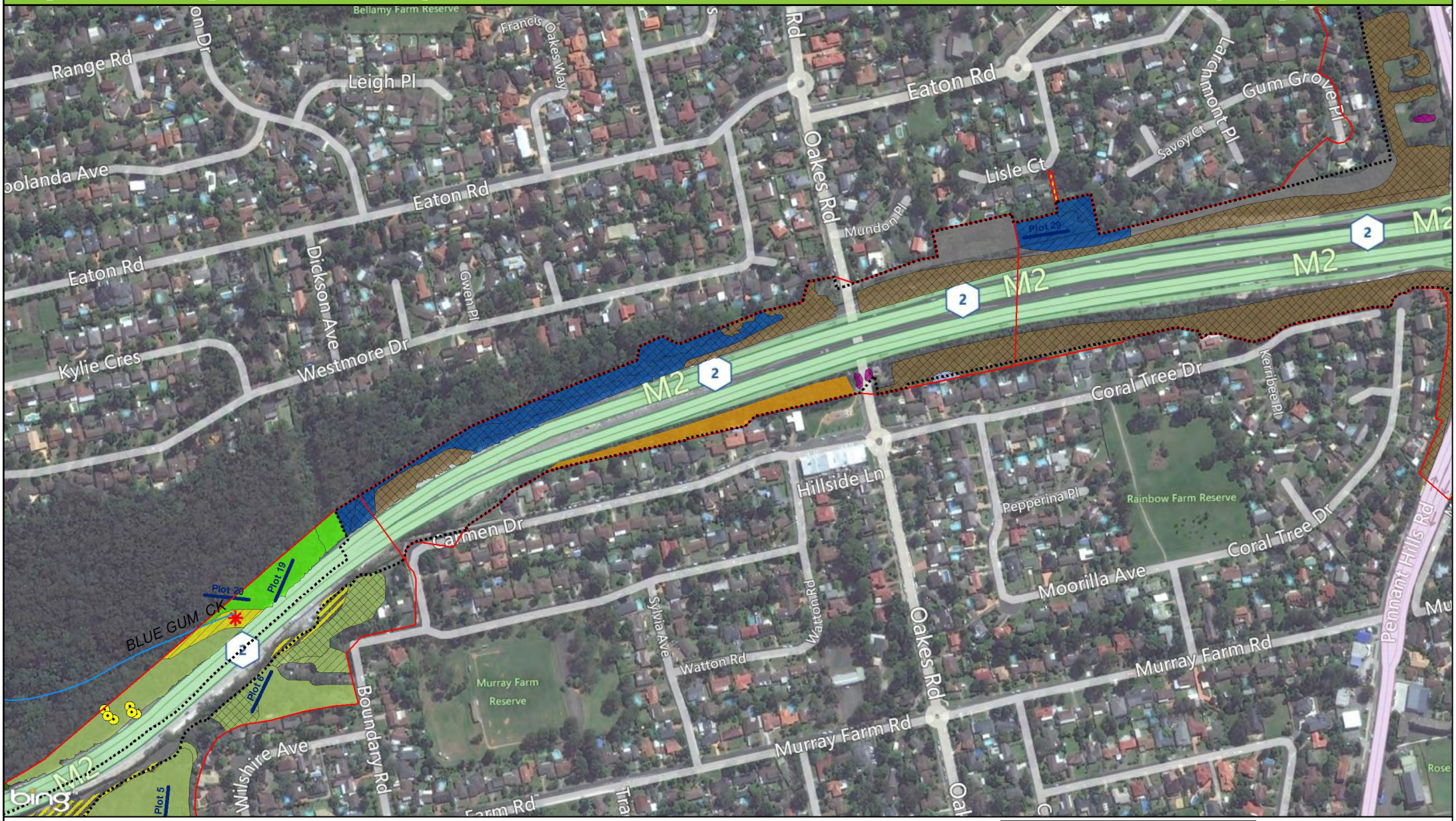
Vegetation and Significant Biodiversity

Hills M2 Motorway Integration Works 1



Legend

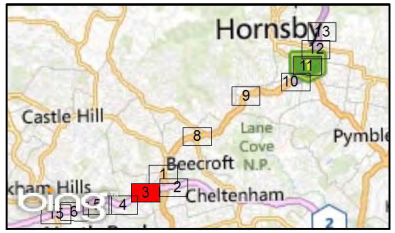
- Study Area
- Construction Footprint
- Culverts
- *Epacris purpurascens var. purpurascens*
- *Hibbertia superans*
- ELA Plots & Transects

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



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Metres

Datum/Projection:
GDA 1994 MGA Zone 56

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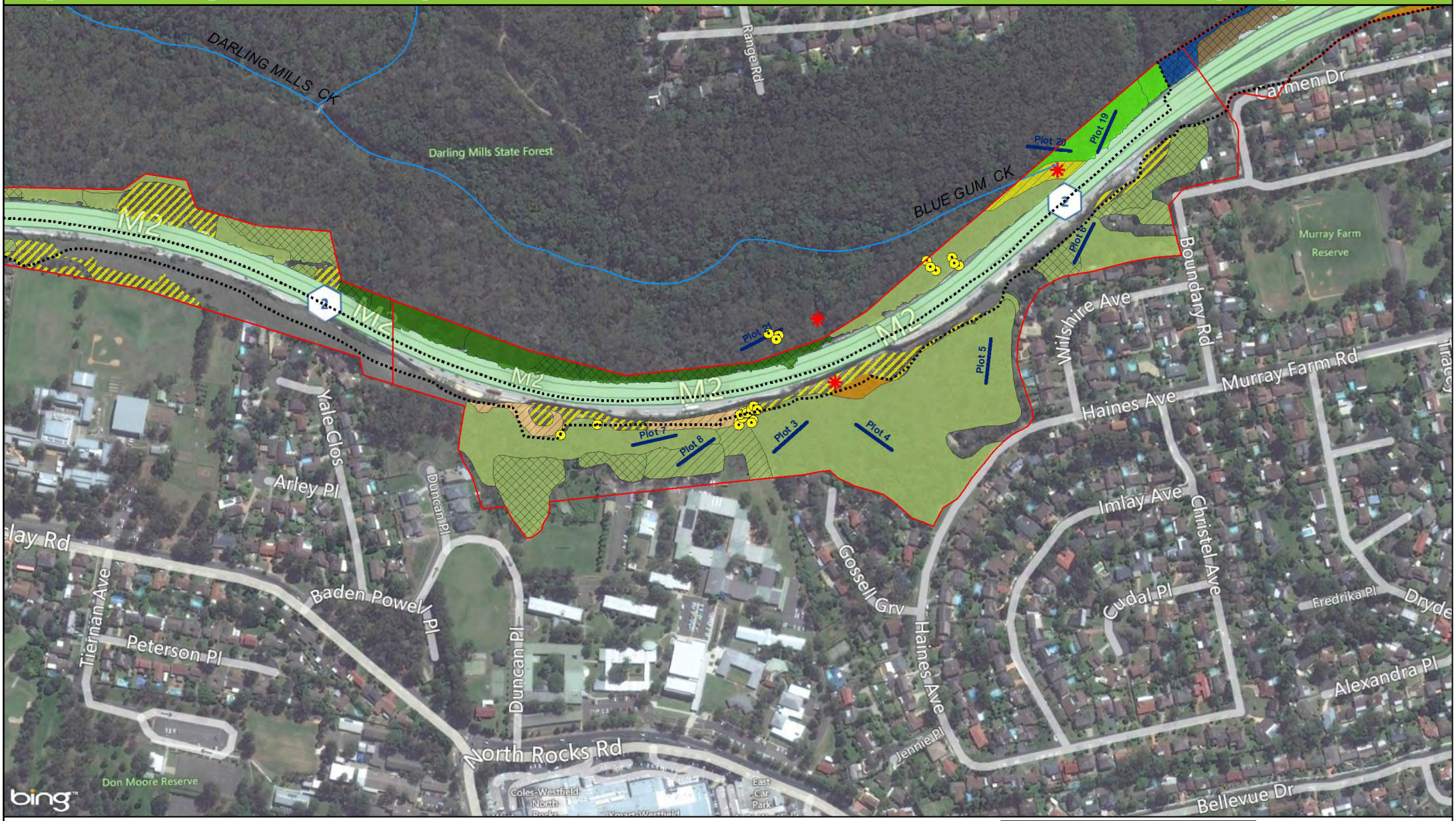
Vegetation and Significant Biodiversity

Hills M2 Motorway Integration Works 2



Legend

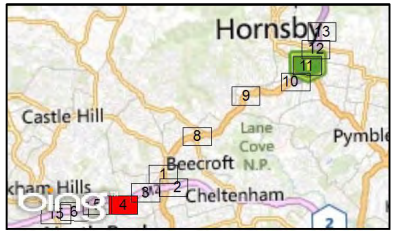
- Study Area
- Construction Footprint
- Culverts
- *Epacris purpurascens var. purpurascens*
- *Hibbertia superans*
- ELA Plots & Transects

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



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Metres

Datum/Projection:
GDA 1994 MGA Zone 56

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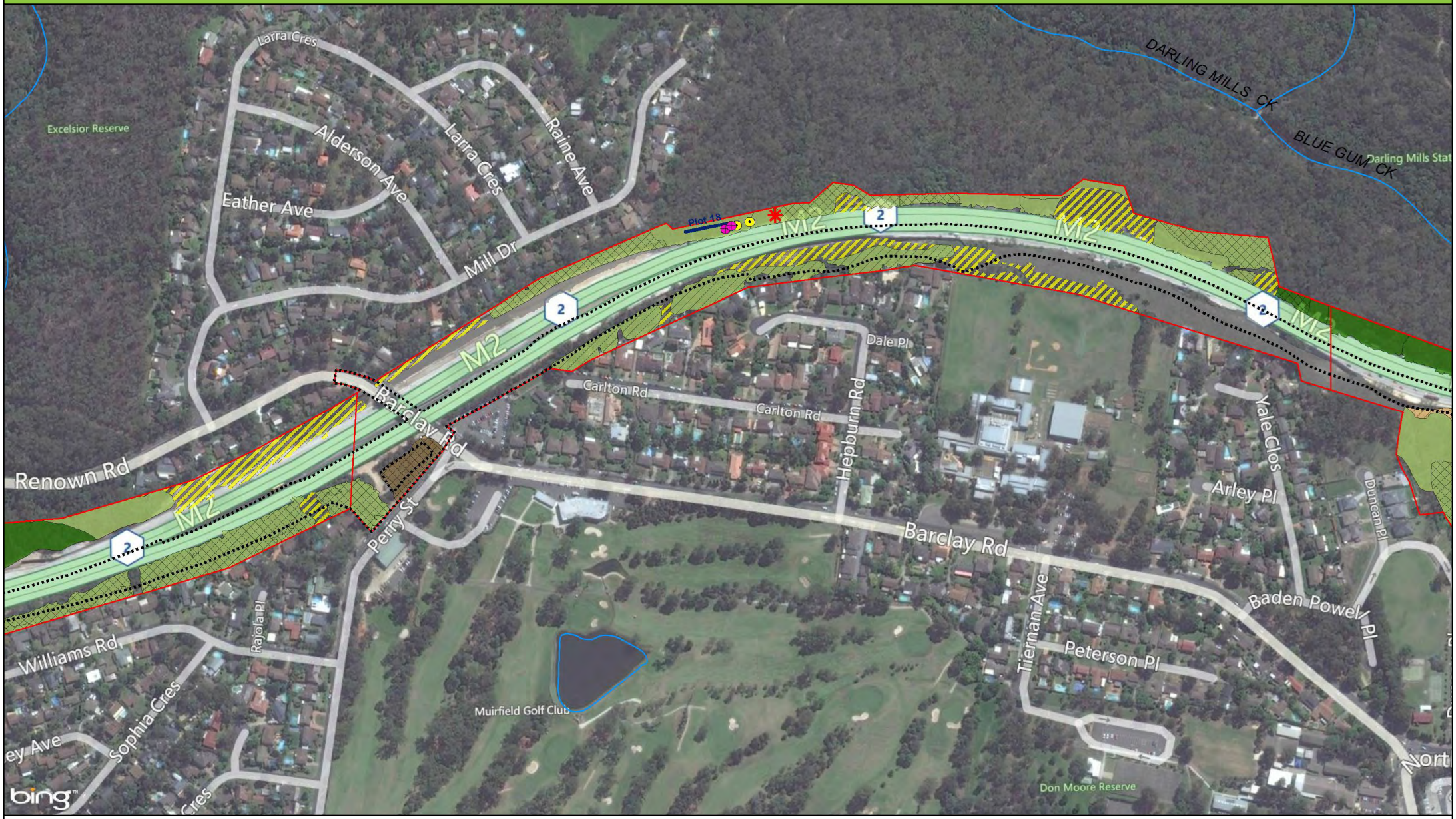
Vegetation and Significant Biodiversity

Hills M2 Motorway Integration Works 3



Legend

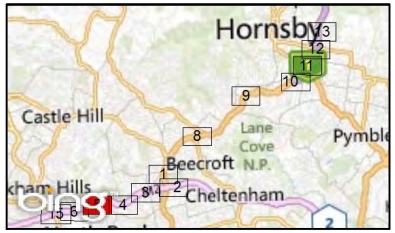
- Study Area
- Construction Footprint
- Culverts
- *Epacris purpurascens var. purpurascens*
- *Hibbertia superans*
- ELA Plots & Transects

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



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Metres

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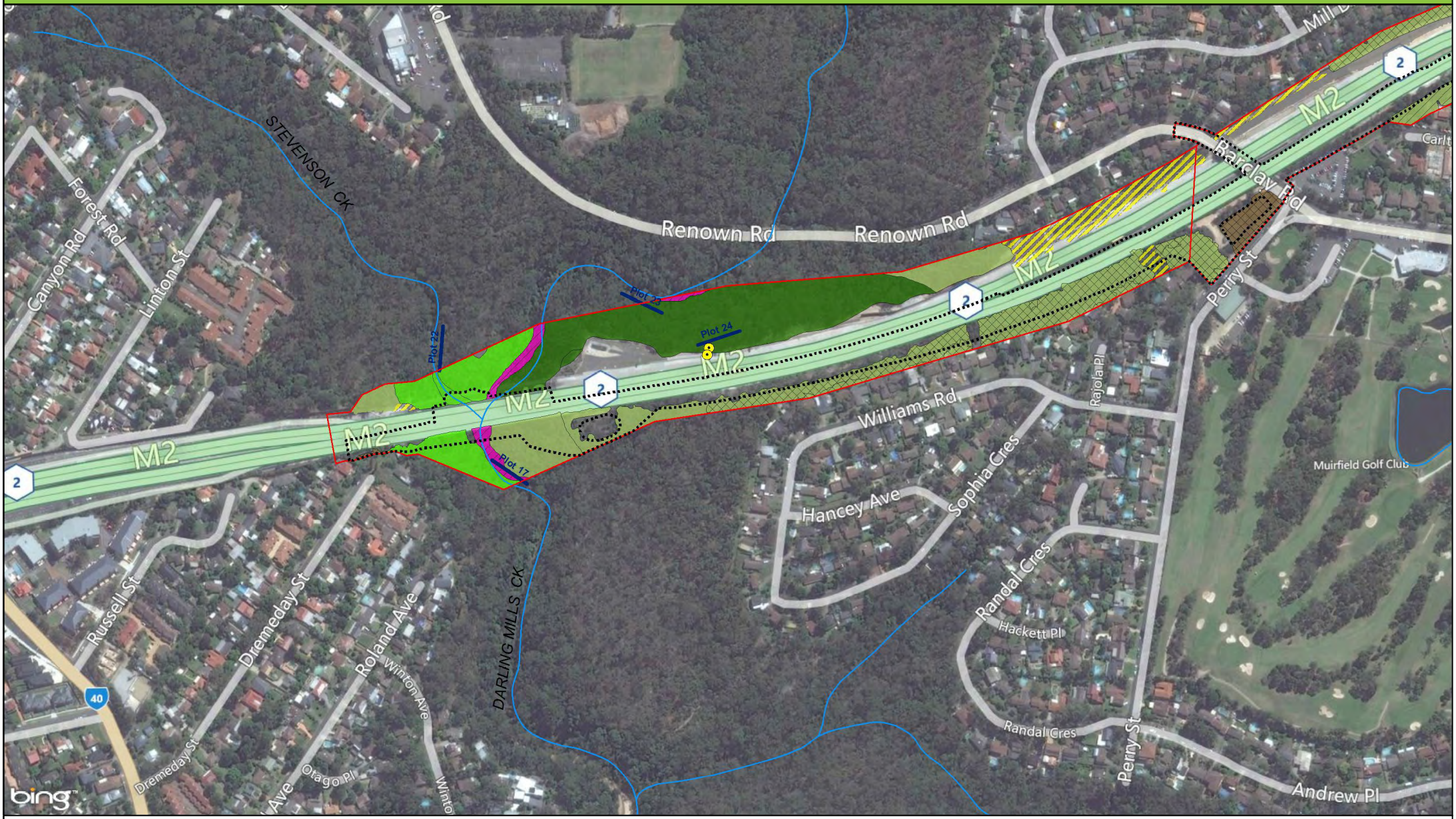
Vegetation and Significant Biodiversity

Hills M2 Motorway Integration Works 4



Legend

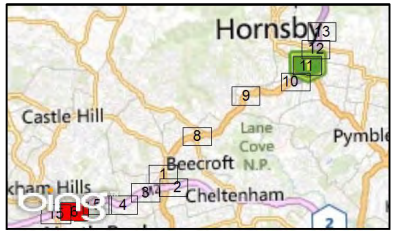
- Study Area
- Construction Footprint
- Culverts
- *Epacris purpurascens var. purpurascens*
- *Hibbertia superans*
- ELA Plots & Transects

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



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Metres

Datum/Projection:
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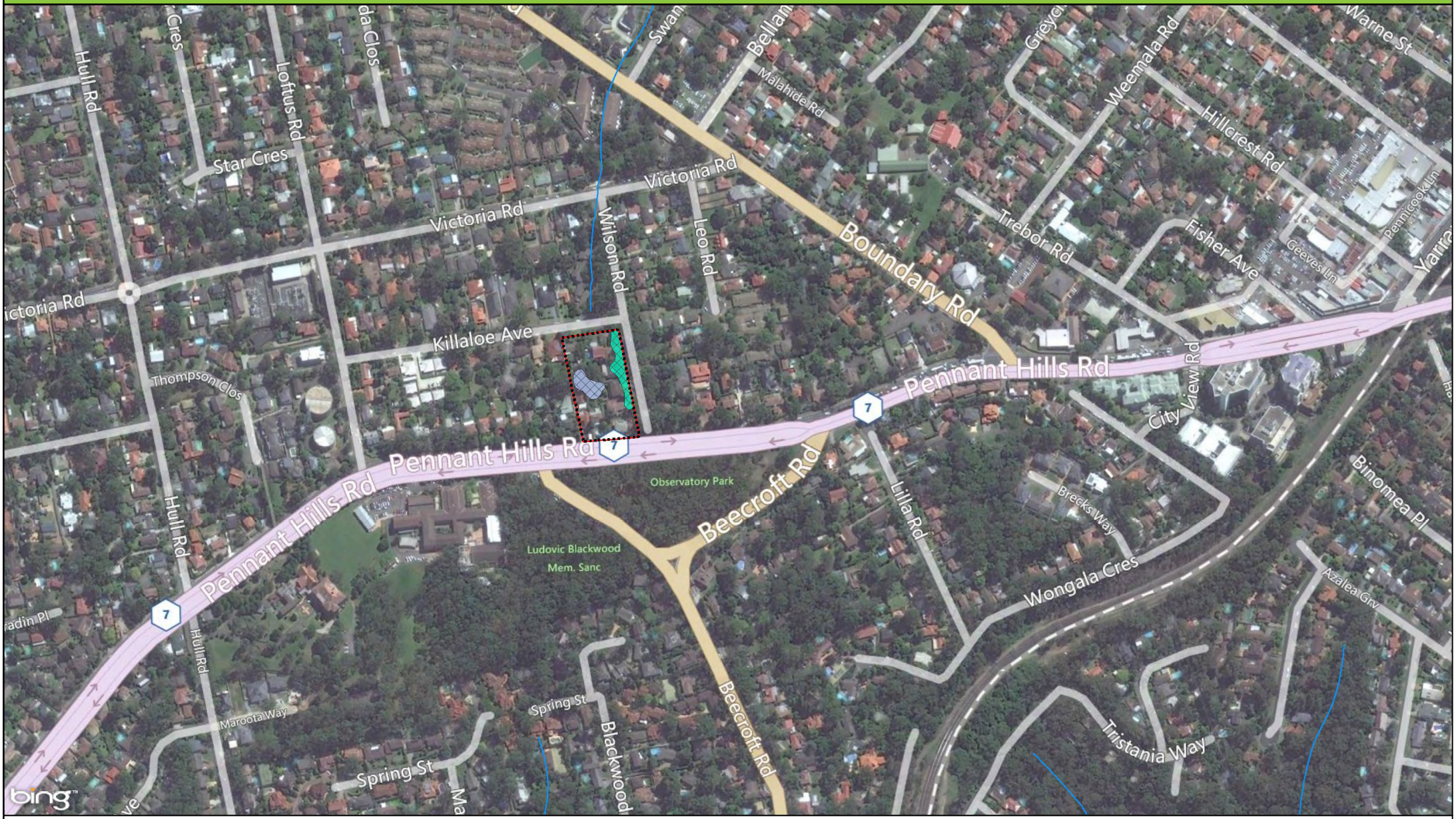
Vegetation and Significant Biodiversity

Wilson Road Compound



Legend

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

Vegetation Type

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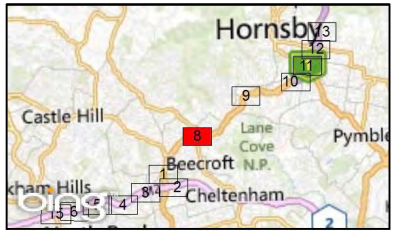
- Sandstone Blackbutt Woodland
- Sydney Turpentine Ironbark Forest
- Syzygium paniculatum (Lilly Pilly) (planted)
- Not surveyed
- Regeneration - Exotic
- Regeneration - Native
- Urban Native/Exotic
- Weeds and Exotics

Vegetation Condition

- Good
- Moderate
- Poor



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Metres

Datum/Projection:
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Vegetation and Significant Biodiversity

Pioneer Ave & Trelawney Street Compound

Legend

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

Vegetation Type

- Blue Gum High Forest
- Blue Gum Individuals
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- Coastal Enriched Sandstone Moist Forest
- Coastal Sandstone Gallery Rainforest
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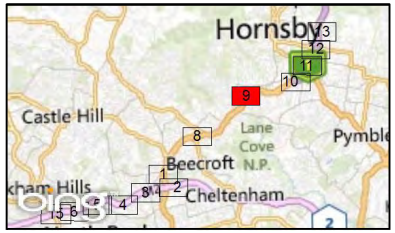
- Syzygium paniculatum (Lilly Pilly) (planted)
- Not surveyed
- Regeneration - Exotic
- Regeneration - Native
- Urban Native/Exotic
- Weeds and Exotics

Vegetation Condition

- Good
- Moderate
- Poor



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Metres

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Vegetation and Significant Biodiversity

Northern Interchange 1

Legend

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

Vegetation Type

- Blue Gum High Forest
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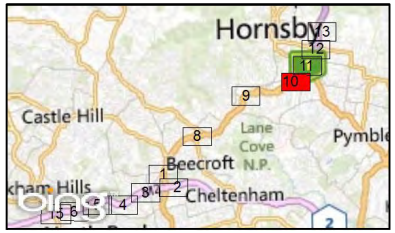
- Syzygium paniculatum (Lilly Pilly) (planted)
- Not surveyed
- Regeneration - Exotic
- Regeneration - Native
- Urban Native/Exotic
- Weeds and Exotics

Vegetation Condition

- Good
- Moderate
- Poor



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Metres

Datum/Projection:
GDA 1994 MGA Zone 56

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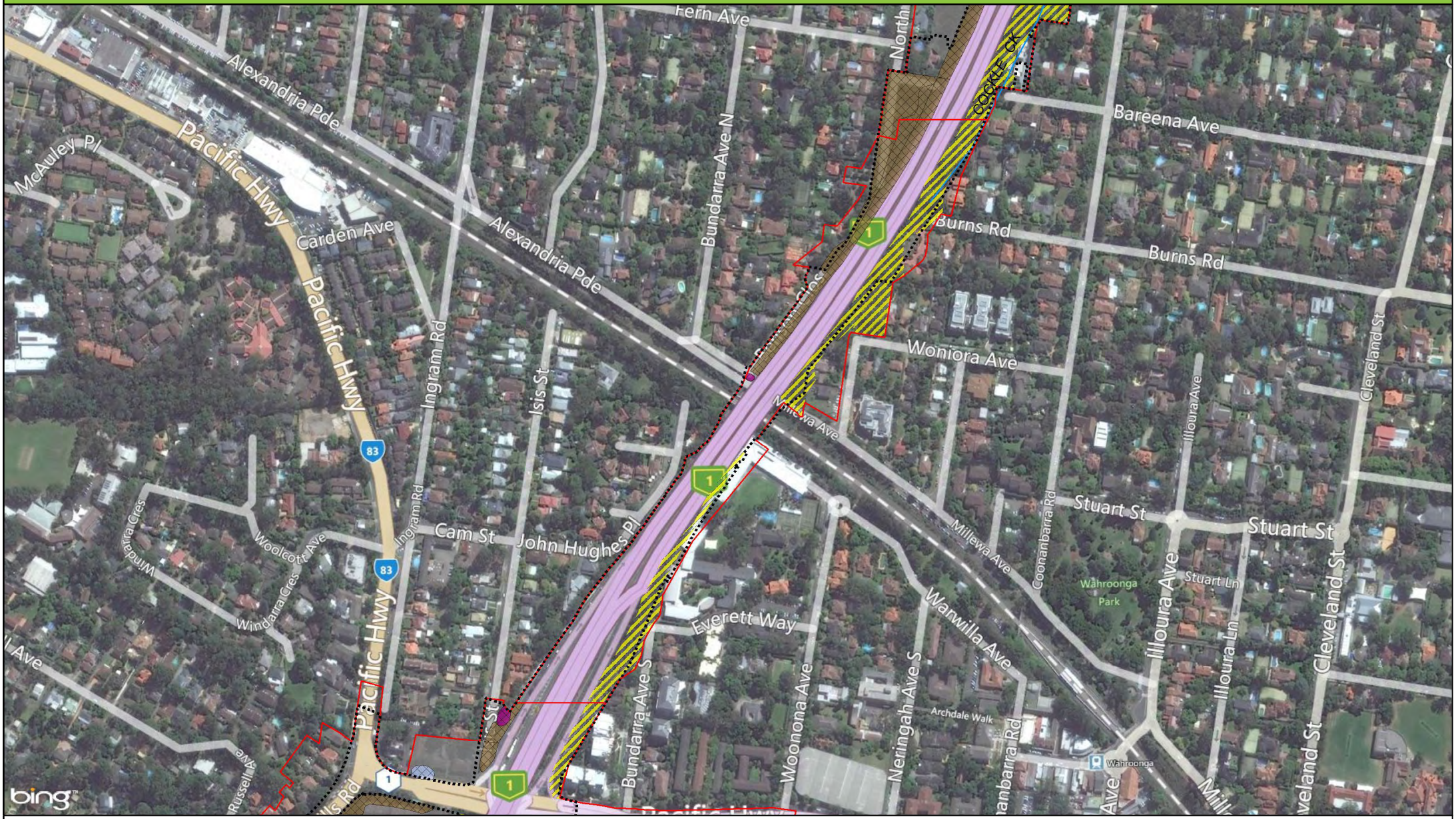
Vegetation and Significant Biodiversity

Northern Interchange 2



Legend

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

Vegetation Type

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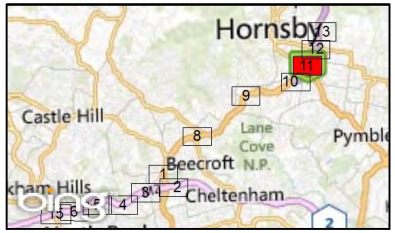
- Syzygium paniculatum (Lilly Pilly) (planted)
- Not surveyed
- Regeneration - Exotic
- Regeneration - Native
- Urban Native/Exotic
- Weeds and Exotics

Vegetation Condition

- Good
- Moderate
- Poor



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Metres

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Vegetation and Significant Biodiversity

Northern Interchange 3

Legend

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

Vegetation Type

- Blue Gum High Forest
- Blue Gum Individuals
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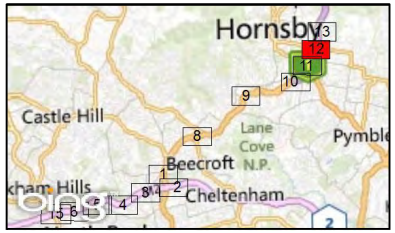
- Sydney Turpentine Ironbark Forest
- Syzygium paniculatum (Lilly Pilly) (planted)
- Not surveyed
- Regeneration - Exotic
- Regeneration - Native
- Urban Native/Exotic
- Weeds and Exotics

Vegetation Condition

- Good
- Moderate
- Poor



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Metres

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