



**Chief Scientist
& Engineer**

**Advice on the protection of the Campbelltown Koala
population**

Koala Independent Expert Panel

30 April 2020



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Chief Scientist & Engineer

The Hon Matt Kean MP
Minister for Energy and Environment

The Hon Rob Stokes MP
Minister for Planning and Public Spaces

Dear Ministers

Advice regarding the protection of the Campbelltown Koala population

In December 2019 you requested expert advice on proposed measures to protect the Campbelltown Koala population, specifically on those measures for the proposed Mount Gilead Stage 2 Development and in the draft Cumberland Plain Conservation Plan, including advice on possible east-west corridors linking the Nepean and Georges Rivers.

This report is submitted in fulfilment of the Terms of Reference. An independent expert panel was established to provide the advice chaired by myself and that included Professor Kathy Belov AO (The University of Sydney), Dr Carolyn Hogg (The University of Sydney) and Professor Jonathan Rhodes (The University of Queensland).

In providing its advice the Panel considered the measures proposed in both the Mount Gilead Stage 2 documents and draft Cumberland Plain Conservation Plan, to provide a holistic and consistent approach in the region.

The Panel advises that access to increased (or retained) koala habitat has prima facie benefits for koalas, however, key is whether the retained habitat in east-west corridors between the Nepean and Georges Rivers can be managed such that koalas are not exposed to increased threats such as traffic and dogs, and whether mitigation measures will separate koalas from these threats. Key to the success of this will be ensuring that koalas are separated from the risks that threaten them.

This report provides recommendations to improve the proposed measures and considers a range of possible scenarios for the mitigation approaches proposed, given constraints including those that are geographic in nature. An adaptive management approach is identified as crucial, with consideration of data collection and monitoring requirements, to ensure and demonstrate the effectiveness of mitigation strategies.

Yours sincerely

Dr Chris Armstrong PSM
Deputy NSW Chief Scientist & Engineer
30 April 2020

EXECUTIVE SUMMARY

Urbanisation is one of the main causes of declines in koala populations in NSW. These declines are associated with habitat loss and fragmentation, reduced connectivity or isolation of populations reducing genetic diversity, increasing susceptibility to disease and increasing threats from vehicle strikes and dog attacks.

There is strong evidence that urban development has major impacts for wildlife globally and drives the decline in many species. It then becomes a question of whether the impacts can be mitigated to such a degree so as to reduce them to an acceptable level.

The Macarthur region is host to a historically continuous population of koalas, known as the Campbelltown population. The population of between 250 and 500 individuals is surviving in a landscape that is predominantly native bushland that is connected to rural farmland or peri-urban environment in the vicinity of the Greater Macarthur area. The Campbelltown population is one of the few remaining populations in the Sydney region. The population is considered to be healthy and uniquely Chlamydia free. The main causes of mortality are vehicle strikes and dog attacks. The impact of the widespread 2019/20 bushfires across NSW has increased the comparative importance of this koala population.

The Greater Macarthur region has been declared a growth area to provide homes for Sydney's growing human population. Land use and infrastructure plans for the region are set out in *Greater Macarthur 2040 – An interim plan for the Greater Macarthur Growth Area* (GMGA). There are currently ~3,000 people living between Menangle Park and Appin and with an estimate of another 39,000 new homes the local human population could increase to ~109,000 people over the next 36 years. The development will include new town centres, retail and commercial services, improved transport corridors and schools. A planning principle for the GMGA is the conservation of biodiversity and koala populations.

Biodiversity certification for the GMGA is being sought by two parties: the Campbelltown City Council on behalf Lendlease for a proposed development in Mount Gilead and by the NSW Government for the remainder of the area through the Cumberland Plain Conservation Plan (CPCP). Biodiversity certification identifies, at a regional scale, areas of high conservation values that development should avoid and be protected, areas that can be developed and measures to offset any potential impacts from development.

In December 2019, the Minister for Energy and Environment and the Minister for Planning and Public Spaces requested advice on the protection of the Campbelltown koala population. Specifically, if the (1) the adequacy of the proposed measures for koalas and their consistency with the NSW Koala Strategy and if additional conservation measures are required for the proposed Mount Gilead Stage 2 development and (2) site specific measures required for the CPCP in the GMGA to support the long-term viability of the koala population including an assessment of east-west corridors.

An independent expert panel, chaired by the Deputy NSW Chief Scientist & Engineer, was established to assess the protection measures and provide this advice.

The Panel assessed the adequacy of protection measures proposed in relation to the NSW Koala Strategy, which has the objective of stabilising and increasing koala numbers over the longer-term to ensure genetically diverse and viable populations across NSW. The guiding principles for the Panel were to maximise koala population persistence and abundance, koala habitat amount and connectivity, and minimise contact between koalas and the urban environment to reduce hazards and threats.

Few dense urban new developments in Australia have successfully, over the long term, avoided declining koala populations in the context of rapid growth in urban infrastructure,

dwellings, and the threats that arise from thousands of human residents. Due to the large time lag between new developments and impacts on koala numbers, it may be difficult in the near term to fully understand population impacts caused by urbanisation. Monitoring for population growth may provide a clearer picture of impacts. However, the opportunity presents itself, through forward planning and commitments by parties to protect habitat, mitigate threats and reduce stressors. If this approach is successful, and if it can be monitored, managed and measured, it could show the way for future developments on the rural fringe to minimise the impacts that will arise.

Key to the success of this will be ensuring that koalas are separated from the risks that threaten them, in particular road traffic, and predation by dogs. The proposed high densities for residential and urban development that are proposed makes it unlikely that koalas could persist in the long-term in the urban matrix. Exclusion fencing will be key to keeping them separated from this, as will ongoing observation of the koala population to monitor for disease, indirect stressors such as light and noise, and also to monitor genetic health, population size and distribution.

Habitat and corridor protection in landscapes is not only beneficial to koalas but also other flora and fauna.

The Panel reviewed draft planning proposal information for the MGS2 site and the CPCP area associated with the GMGA. The Panel observes that access to increased (or retained) koala habitat has prima facie benefits for koalas, however, key is whether the retained habitat in east-west corridors between the Nepean and Georges Rivers can be managed such that koalas are not exposed to increased threats such as traffic and dogs, and whether mitigation measures will separate koalas from these threats.

If the removal of key risks cannot be accomplished, then the better management approach would be to monitor the impacts on the koala population and if it declines then consider active management which could include moving koalas between sites for breeding or relocation to safe areas, preferably in the local region. However, if separation from threats can be achieved in the landscape and maintained over the long term, then the better outcome for the koalas, and other flora and fauna, would be to retain the east-west corridors.

Exclusion fencing to prevent koalas accessing Appin Road from the eastern or western side is critical, as is the use of exclusion fencing more broadly to keep koalas separated from dogs and road traffic in the developments. Efforts to sympathetically landscape buffer zones further assists in separating koalas from urban impacts and related stressors, while the approach proposed by the proponents to landscape street scapes and backyards of dwellings so to exclude koala feed trees is welcome, as it removes an attractant for koalas into the urban matrix.

Cooperation, vigilance and participation of the community will be critical, when driving, in checking the integrity of fence lines, in reporting injured or dead animals, keeping dogs enclosed in yards or not taking them into koala areas, maintaining bush regeneration, or even assisting with wildlife counting and monitoring efforts. This is very much in line with the spirit of the NSW Koala Strategy.

This Executive Summary should be read in conjunction with the Findings and Recommendations chapter that follows.

FINDINGS AND RECOMMENDATIONS

Findings

In developing this advice in response to the Review's Terms of Reference, for the proposed developments at the Mount Gilead Stage 2 (MGS2) site and for the draft Cumberland Plains Conservation Plan (CPCP) within the Greater Macarthur Growth Area (GMGA), the Panel has taken a risk-based approach. This advice is based on an assessment of adequacy in terms of the objectives of the NSW Koala Strategy to stabilise and then increase koala numbers over the longer-term, ensuring genetically diverse and viable populations across NSW. In doing so the Panel has considered: hazards and threats to koalas; the benefits of the set of proposed risk mitigation and protection measures; and the costs and disbenefits of measures; residual risks of these measures. The Panel has also considered a range of scenarios to guide its advice on preferred approaches should anticipated outcomes not eventuate.

While the Panel is conscious that it has been asked to provide advice on two distinct development footprints, proceeding under different legislation, at different stages of progress, the Panel is nevertheless keen to highlight the importance of a holistic planning approach. By their very nature, the habitat corridors within the two study areas cross multiple tenures and landscapes, connect internally and with each other. Koalas, in using these corridors, do not recognise lines on maps. Therefore, the Panel report moves between the MGS2 proposal and the CPCP draft planning material fairly freely. While a reader may be interested in one development or another, there is benefit reading them together as a single document. (For the purposes of clarity, the Panel report has adopted a naming convention used in the Figure 5 with six corridors labelled from A to F as you move from north to south, with three corridors A, B, C particularly relevant for MGS2 and four corridors C, D, E and F pertinent for the CPCP planning.)

The Review Terms of Reference seek the Panel's view on the benefit of maintaining an east-west connectivity between the Georges River and Nepean River. The habitat in this region contains high quality feed trees due to the sandstone shale transition forest. The Campbelltown koala population is expanding and therefore, it is essential that this habitat supports the movement of koalas such that dispersing koalas can move through the landscape, can breed to ensure genetic diversity, and can access refugia in times of stress, drought or other threats. Overall, the Panel finds that efforts to increase the availability of habitat while reducing the interface with threats, and maintain genetic and physical health status, are important pillars upon which to plan mitigation measures.

The following findings are laid out corridor-by-corridor, for mitigations and measures in both the sets of north-south and east-west corridors. These are followed by a number of thematic findings of relevance across the landscape.

Georges River Corridor (north south), Mount Gilead vicinity and CPCP planning

The protection of the Georges River corridor, including the creation of the Georges River Koala Reserve, and the replanting of habitat will provide crucial linkage for the koala population of Southern Sydney to the Southern Highlands. While being adjacent to habitat further east in National Parks and Sydney Catchment Special Areas, the habitat in the corridor has a high nutrition value and supports one of the only koala populations in NSW that is thought to be growing and chlamydia free.

The Panel finds the current and proposed efforts to protect and improve the habitat in this corridor to be essential and agrees broadly with the Department's approach. Efforts to protect the habitat and reduce risk to koalas from threats associated with urbanisation using exclusion fencing will be important as the local human population increases with

urbanisation of the region. Regular monitoring and control of predators (such as dogs) within the corridor will be an important ongoing management tool, as will measurements of koala population dynamics.

Arguably, after the establishment of the Georges River Koala Reserve, the most important measure to be delivered for koalas in either the MGS2 plans or the CPCP will be exclusion fencing along Appin Road. Appin Road is currently a hot spot for koala mortality, so the Panel finds the use of fencing to stop koalas entering the road surface from either the east-side or west-side to be a fundamental requirement for the success of protecting koalas in the region.

Crossing structures to traverse Appin Road will also be key if the connectivity to east-west corridors is to be provided, unless intensive active management is to be employed, including translocations for breeding. The crossing infrastructure at locations along the road to facilitate east-west movement could include culverts, underpasses or bridges, while the inclusion of grids and gates will also be necessary to enable the movement of humans and vehicles onto the road while preventing koala access. These crossings are discussed below.

The Panel finds that an additional measure is required in the Georges River Corridor to prevent the development of a koala vehicle collision hotspot. Appin Road crosses the Georges River at Kings Falls Bridge within the corridor east of the Appin township. This location has the potential to create heightened risks for koalas as the number of vehicles increases with urbanisation unless suitable mitigation and crossing structures are developed. An approach using exclusion fencing along this stretch of Appin Road, with the terrain under the bridge modified with appropriate structures to ensure a safe thoroughfare for koalas, would be a valuable pre-emptive measure to prevent road deaths.

Nepean River Corridor (north-south), Mount Gilead and CPCP planning

Koala habitat in river and creek valleys provides important refugia and resilience to warming and drying climates, a characteristic that is likely to become increasingly important with climate change. The majority of the corridors discussed in this Review are riverine, which includes that along the Nepean. This north-south corridor has been identified as a primary corridor by the Department. It contains high quality habitat and connects populations to the south east in the Sydney Catchment and then further to the Southern Highlands.

The habitat associated with the Nepean River has been identified in the draft CPCP material as a strategic conservation area, and possible protections will include Biodiversity Stewardship Agreements (BSA). The Panel agrees with this approach. Additional pockets of habitat that could be replanted or improved have been identified by the Department and the Panel encourages these efforts as well.

The Panel recommends the establishment of exclusion fencing to separate koalas from threats associated with urban development, particularly from dogs and cars. While it is expensive to install and maintain fencing, these costs are small relative to the scale of the development and investment that will occur in the region over the next 36 years.

The Panel notes a particular concern regarding the Nepean Corridor, which is to prevent a functional 'dead-end' at its north end. Observing maps and images of the northern reach of the corridor, it appears to end in the vicinity of the MGS2 site where the Hume Highway crosses the Nepean River. Wildlife corridors that end with no connection to other habitat can be a considerable risk, in particular where the habitat exposes wildlife to threats, and in doing so can create population sinks, where wildlife kills occur, causing vacancies in the location which subsequently attract more animals.

Corridor A – Menangle Creek to Noorumba (east west), Mount Gilead development

It is the functional role that habitat in Mount Gilead site plays in connecting the north end of the Nepean Corridor in an easterly direction that means protecting corridor structures at

MGS2 is critical, preventing an isolated population at Nepean. Two corridors are the focus of protection in the MGS2 proponents: Corridor A in the north and Corridor B further south.

The proponents have approval for the protection of habitat in the Noorumba Biobank site to offset the Mount Gilead Stage 1 (MGS1 development). The site is bordered to the north by Campbelltown suburbs, to the south by MGS1 future dwellings, to the east by Appin Road and to the west by dwellings, farmland and a narrow (<85 m) wildlife corridor.

The proponents of MGS2 view the Noorumba site as part of the corridor for koala east-west movement. However, to achieve this an effective koala crossing (one that has been shown to be used by koalas elsewhere) is needed between the two sides of Appin Road. The Panel holds reservations that the proponent's preferred approach for a koala crossing (a tree-top bridge structure) will be used by koalas. Koalas primarily move on the ground between trees, and so crossings that enable this are found by the Panel to be preferred. These could include culverts or underpasses under the road, or wide overpasses or land bridges. The Panel has been informed by the proponent and others that the local topography at Noorumba does not lend itself to having a culvert built under the road.

The Panel has set out scenarios for this corridor given the tree-top bridge may not be functional, including exploring other crossing structures. The Panel finds that if the Noorumba crossing of Appin Road is not feasible, then the site would become functionally fragmented and not perform as an east-west corridor. If this were to occur, the Panel finds that monitoring of the Noorumba site would be required, combined with active management of koalas in that location to avoid genetic bottlenecks and to facilitate movement of young koalas to other areas. Monitoring for predators would also be required with the development of exclusion fencing increasingly needed as the human population increases in the adjacent suburb.

If the Noorumba site can be secured with an Appin Road crossing effective for koalas, then exclusion fencing between habitat and threats would still be required. Efforts to widen the corridors should also be made, while it is acknowledged that there are constraints with corridor widening west of Noorumba due to land use and tenure issues. Narrow corridors with open vegetation, without exclusion fencing place koalas at risk of exposure to threats such as roaming dogs and foxes, so fencing should be pursued. If fencing is not feasible, then buffer zones (~60 m wide) containing non-feed trees, and with monitoring to track predators, and population dynamics to understand these outcomes will be needed. Management decisions regarding the koala population in this area will be informed by those data, and responses could include further active management or even relocation to more suitable habitat.

Corridor B – Woodhouse Creek to Beulah (east west), Mount Gilead development

The proponents of MGS2 have identified the Corridor B route to be important for koalas and other wildlife through the proposed development. A conceptual drawing of a possible Appin Road underpass crossing has been provided to the Panel, with the crossing emerging adjacent to (not within) the Beulah site. The Panel finds that this is a well-conceived structure and is likely to be used by koalas. Should planning activities continue to progress, the Panel believes that discussions with Transport for NSW (TfNSW) should occur to gain more detail of the specific requirements for the site on Appin Road including road uses and utilities associated with the roadway.

The Panel agrees that the protection of habitat along Woodhouse Creek to secure corridors is fundamental to the viability of the corridor. However, the Panel disagrees that post-and-rail fences should be used between the koala habitat and the suburban landscape which includes a range of threats and stressors for koalas. This will not reduce threats at the koala habitat-urban interface. The Panel finds that here, as with other locations in the landscape, exclusion fencing should be used to separate koalas from threats and hazards. Koala exclusion fencing can successfully prevent koalas leaving the corridor and walking onto

roads and meeting neighbourhood dogs. Exclusion fencing will also prevent dogs from entering the habitat.

The Panel finds that the functional roles of Asset Protection Zones (APZ) and of buffer zones to protect koalas are different, and as such need to be differentiated in the design of the interface. APZs serve a role of protecting people and property from bushfire hazard, while buffers associated with koala protection reduce the impact of threats, light and noise on koalas. The goal being to reduce stress on koalas which has general health benefits and impacts on mortality and breeding rates. For this reason, the Panel finds that buffers should be more clearly defined in MGS2 material in terms of their purpose, with buffers being in place on both sides of the corridor and be in addition to APZs (see Figure 10).

As a general rule for this Review, in this region with growing urbanisation and an additional 110,000 human inhabitants, buffers should be at least 30 m wide from the edge of existing corridor habitat, occur on both sides of the corridor, and have exclusion fencing at their edge, with koala feed trees allowed to grow to the fence, with a suitable distance between trees and fencing to prevent fallen boughs creating damage to the fence.

The APZ should be in the development footprint, not the koala corridor/buffer, and the APZ should be on the development side of the exclusion fence. The APZ, unlike the buffer, could accommodate roadways and parks. People would be permitted into the koala buffer, but dogs would be prohibited from entering through the exclusion fence area.

Not all locations will accommodate exclusion fencing, with steep terrain being incompatible. In these cases where exclusion fencing is not achievable, then a wider koala buffer (~60 m) should be established that does not include koala food trees. While the buffer in this case is designed to both discourage koalas from passing through it to reach the development footprint, it is also designed to keep stressors such as light and noise from disturbing and possibly stressing koalas and other threats at a greater distance. Therefore, these buffers should not have roads, playgrounds or picnic areas included in their boundaries, and dogs should not be permitted. The buffer will need monitoring in place to identify incursion by dogs. The APZ (bushfire protection) here, as with other locations, should be considered additional to the buffer, but could include structures such as roads and playgrounds etc. Where a road is passing in the vicinity of a koala corridor where there is no exclusion fencing, then the vehicle speed limit should be reduced to a maximum of 40 km/h, and with the installation of traffic calming devices and signage.

A number of different reports have been produced over time that aim to provide measurements for the scale or width of corridors – these are summarised and discussed in Chapter 2. These analyses tend to calculate the average width of a corridor over an area, and range from 300 m to 425 m. Every opportunity to maintain or increase the width of corridors should be taken and work to understand whether there is a minimum width to make a viable corridor, as well as how this minimum is affected by vegetation density of the corridor and urban density of the surrounding developments. The Panel notes that some stakeholders have recommended a minimum width of 200m. It is noted that within MGS2, in both Corridor A and B, there are locations with narrow widths – including 85 m in Corridor A and 115 m in Corridor B. Efforts to widen the habitat in these areas is important and this could contribute to addressing any koala habitat offset deficits (koala credits) if possible.

It is noted that koalas move through a range of different densities of habitat including between trees in open ground. The Panel notes that due to the range of linear infrastructure running perpendicular to the corridors through the GMGA, for gas and electricity transmission, where vegetation is generally absent, koalas will have to traverse these areas. The Panel finds that this could create a location of increased risk from predators, if these easements are not as well fenced as the corridor areas. The Panel would see great merit in proponents looking to options, in discussion with TransGrid (transmission) and Jemena (natural gas) as appropriate, for installing gates in these areas to enable access to pipes and

wires in the corridor while preventing dog incursion. Monitoring in these areas for threats and population response may be required for adaptive management.

As addressed above, the importance of the Mount Gilead site to the east-west movement of koalas is amplified by its location at the north end of the Nepean corridor. Koalas currently can move through the landscape in an easterly direction towards the Georges River. However, once housing development occurs along the western flank of the MGS2 site, the route for koalas to move east or west will be through a narrow strip of habitat at the confluence of the Nepean River and Menangle Creek. However, the Panel notes that planning for future transport corridors (Figure 1) includes an indicative transport corridor to potentially run through this strip of habitat, while the MGS2 biodiversity certification application and conceptual plans illustrate (Figure 2 and Figure 8) this habitat being potentially surrounded by three roads. The biodiversity certification application notes two elevated bridge crossings and possibly a third, designed to maintain vegetation and koala movement. Some clarity needs to be provided as to the vision for this linking habitat, including whether all three bridges would be built at the same time, and some insights into whether koalas would use this area of the landscape with this density of infrastructure. The Panel notes that other wildlife also benefit from corridors. If koalas don't use this connection, options may potentially be needed to confirm the ongoing viability of the link between Corridor B and the northern end of the Nepean Corridor at Menangle Creek.

Corridor C – Nepean Creek to Beulah (east west), Mount Gilead development and draft CPCP plans

Should Corridor B become secured, the relative importance of Corridor C is reduced in terms of its function in connecting the Beulah Biobank site to the northern end of the Nepean Corridor. Notwithstanding this, the biodiversity certification application does identify the koala movement corridor along Corridor C, as well as the Mallaty Creek Corridor D with widths ranging from 100-200 m. However, if koala connectivity at the Nepean River and Menangle Creek confluence is temporarily or permanently broken (during the construction of the bridges, or if koalas do not use them), the role of Corridor C will need to be revisited, as it would provide other possible linkages between Beulah and the Nepean River. It is acknowledged that linear infrastructure currently does, and is further planned to, transect Corridor C, so an assessment would need to be made as to which corridor and infrastructure would be more accommodating to koala habitat. The level of protection offered to Corridor C will depend on its eventual role vis-à-vis a temporary or permanent linkage to the Nepean. However, until that connectivity issue is resolved, the Panel finds it sensible to preserve the habitat in Corridor C, monitor koala population dynamics and threats, and have management actions informed by this monitoring.

This corridor provides an example of where planning considerations across both MGS2 and CPCP need to be considered jointly, as decisions in one footprint impact the relative priority of approaches in the other planning area.

Corridor D – Mallaty Creek to Georges River (east west), CPCP plans

Corridor D is similar to Corridor C in that its potential importance is dependent on connectivity scenarios that will play out in another corridor. Corridor E contains a large area of koala habitat that reaches east toward Appin Road, but where there is nevertheless a potential barrier to linking across Appin Road. Corridor D has fewer barriers to crossing Appin Road and therefore may provide a more achievable crossing. In discussions with Department officials, their preferred approach would be to secure a Corridor E crossing and have that be designated as the koala corridor.

Therefore, the Panel finds that there are benefits to preserving Corridor D as koala corridor until and unless a Corridor E crossing can be guaranteed. This would require an under-road solution at Corridor E under Appin Road such as a culvert, a structure type that koalas are known to use. Once clarity about crossing feasibility and functionality at Corridor E is

decided, then further decisions can be taken on the long-term role of Corridor D for koala movement.

In the event that Corridor D is designated as the koala corridor for east-west movement, then the approach described above should be deployed, with exclusion fencing between the corridor buffer and APZ, where the APZ is outside the exclusion fencing in the development footprint, and koala feed trees can extend to the exclusion fence (with a setback to avoid damage). Where exclusion fencing is not feasible a wider 60 m buffer should be installed, separate to the APZ, where non-feed trees are used in the buffer, and where nearby traffic has a maximum 40km/h speed limit. Monitoring for population dynamics, threats and other attributes to inform management decisions, such as mitigations or active management of populations. Corridor D is narrower than E, and some replanting in D would be needed to increase the width of the corridor, as it only approximately 200 m – 300 m wide, rather than the average 390 m to 425 m proposed by stakeholders. The use of this new habitat as BSA offsets could be explored if this scenario were to play out.

Corridor E – Ousedale Creek (east-west), CPCP plans

Corridor E is the preferred east-west link for the areas in the draft CPCP plans, because it has the most habitat. As discussed above, there are questions about habitat being extended to Appin Road, due to the numerous suburban and rural properties between the habitat edge and road surface, on both the east and west sides. The Panel agrees that discussions with TfNSW on these potential crossings at D and E should occur early in the planning phase before any final decisions regarding primary Corridor designation are made between Corridors D and E.

The Panel agrees that the same approaches to separating koalas from threats should be deployed across the landscape. The team developing the CPCP has mapped the terrain and feasibility of deploying fences, which shows minimal locations where fences are not feasible for Corridor E. The Panel recognises that fencing construction and upkeep is not a trivial cost, so where possible fencing should be laid in a relatively straight line to minimise its length between two points and minimise costs and improve the feasibility of maintenance. As with other locations, the design of buffers should take into account the presence /absence of koala exclusion fencing, and the distance to local roads, and with the APZ outside of the exclusion fence. Monitoring of population dynamics, animal health, threats should be undertaken and inform decision making. Active management of koalas, including to improve genetic health through breeding and relocation/translocation and pest control will also, in combination with habitat protection, connectivity across the landscape and separation from threats provide the koalas with the best chance of their population growing in this corridor.

Corridor F – Elladale Creek and Simpsons Creek to the colliery (east-west), CPCP plans

While Corridor F contains a considerable area of koala habitat that enhances the functionality of the Nepean River Corridor to support koala populations, it does not provide a link towards the east. Therefore, the Panel agrees with the draft CPCP preferred approach for the koalas in this area to be protected from threats using exclusion fencing and buffers, as described above, and could include some replanting efforts to infill habitat in order to reduce the edge:area ratio. Active management would be required here, given the lack of multiple exits to the corridor, so as to prevent it becoming a population sink should predators or fire become an issue within the corridor.

Construction

Early implementation of koala habitat planting can lead to trees being at a more mature stage by the time they are needed for mitigation purposes. The region-wide planning approach occurring at the beginning of the process for the GMGA aids this preparedness.

A Construction Environmental Management Plan (CEMP) and a Koala Management Plan (KMP) should be developed by the proponent and approved through a Commonwealth process. This would include processes to protect koalas during construction and operational phases of the development. Material provided by the proponent indicates that an onsite ecologist would be present through the duration of pre-clearance surveys and clearing works, tree-felling protocols would be used, and education programs for construction workers would be provided etc.

Some complex areas with multiple civil construction developments have been identified in this Review, which interface with the dwelling development footprints and the environmental lands. These areas, such as that described at the Menangle Creek and Nepean River confluence, need to be carefully planned to enable ongoing connectivity to be provided between the Georges River and the Nepean River, some scenario fallback positions have been identified by the Panel. Similarly, the selection of preferred east-west corridors is dependent on securing a suitable connection across Appin Road, as is the role of the Noorumba Biobank site – will it be a part of a functional Corridor A (with an Appin Road crossing) or an enclosed actively managed site (without an Appin Road crossing)? All these issues and their implications need to be considered at a regional scale across the GMGA and over the timeframe for development.

Suburban design

The Panel has also reviewed the approach to urban design to better provide for safe koala habitation. The Panel agrees with the proposed approaches of not including koala food tree species in backyards and streetscapes, as they can be an attractant to koalas to leave their domain and enter higher risk areas (especially for urban development at the densities proposed). The Panel heard of experiences further north in Campbelltown where a small group of three female koalas is understood to inhabit bushland, that is separated from other bush by human residences. However, this site, the Panel understands, is also a location for a high number of koala deaths as young koalas are likely to disperse from this habitat to reach the distant feed trees.

Proposed rules for fences in suburban backyards to prevent escape of dogs and entry of koalas is important, as are other mitigations proposed such as ropes to assist koalas to escape from backyard swimming pools.

MGS2 has proposed speed limits of 50km/h on local roads. The Panel agrees that this would be suitable provided koala exclusion fencing is deployed. For those locations where exclusion fencing is not in place and only buffers are used, then a speed limit of 40km/h should be set and traffic calming (speedhumps, chicanes, signs) be used.

Adaptive and active management

While planning over a large regional area provides a more holistic perspective of how communities, environment and infrastructure will function and interact, the long timeframes and complex interdependencies mean that there is still uncertainty. To manage this uncertainty, as it relates to decisions about protecting koalas and their habitat in the context of the urbanisation of the GMGA, the Panel supports the principle of utilising adaptive management strategies to guide risk management and to improve practice. This is also one of the seven principles for the draft Koala Plan of Management Guidelines as part of the new Koala SEPP. Adaptive management relies on the ongoing collection of information and data that informs future decisions about management, responding to threats as they emerge for acute issues, or changing the direction of management approaches to address longer term threats. This relies on appropriately targeted monitoring activities and the development of thresholds and targets and triggers to guide decisions.

In line with the approach recommended in the NSW Koala Strategy and elaborated in the draft NSW Koala Monitoring Framework, the Panel finds that monitoring efforts ranging from the deployment of monitoring devices to community surveys can all play a role in growing

the information available for decisions. Monitoring should be undertaken at the koala population level, and on a site by site basis. Developers should fund the cost of this activity. The Panel has noted the concept of a 'monitoring trust' for the GMGA to support efforts into the future.

Monitoring informs decision making in the short and long-term, to address acute threats and to improve design and management practices for subsequent rolling construction and development phases for future suburb development stages. Efforts can include: population monitoring (dynamics); genetics sampling; disease monitoring; tests for chlamydia; predator threat monitoring (including at the entrances of bridges and underpasses); infrastructure integrity (holes in fences); movement trackers (predators); location sensors – movement of koalas through landscape; koala counting and surveys; the monitoring of mitigation effectiveness.

These can inform management decisions, including active management programs which are important where a population is isolated in a fragmented patch of habitat. Management decisions can include: vaccinations; fence repair; predator capture; relocation, translocation for breeding and gene dispersal; and education and social engagement programs.

Catch and release efforts with koalas can enable health checks, genetic sampling, vaccination for chlamydia and possibly koala retrovirus (KoRV), and the attachment of sensors to monitor the movement of koalas through the landscape.

Monitoring can also provide insights into how the response of koalas to landscapes change over time and generations, including changes in use of landscape, or whether different character traits of koalas emerge such as being more resilient and less stressed to urban growth. Such information can be used to inform other planning and development proposals into the future.

Reporting data and information once data is collected, and analysed against triggers for adaptive management, should then be reported in the public literature as soon as possible but within three years. Tissue sample collection should be provided to the NSW Koala Biobank.

The recent 2019/2020 bushfires, including in nearby regions to the Campbelltown koala population such as Balmoral, highlight the importance of management of the bushland to reduce the chance and intensity of fires, although it is noted that the close proximity of these corridors to human inhabitants will mean that particular focus on fire prevention will already be in place.

Recommendations

Recommendation 1 – Georges River Koala Reserve

The Georges River Koala Reserve should be protected and revegetated as set out in the draft CPCP, ensuring that revegetation is undertaken in such a manner as to ensure long term sustainability (i.e. species are planted to maintain genetic diversity and minimise kinship to ensure reproduction). Connectivity and threats should be considered within this corridor. Fencing should be placed on Appin Road and a connectivity structure be developed with the bridge over the Georges River.

Recommendation 2 – Connectivity and habitat

East-west corridors within the Greater Macarthur Growth Area can provide connectivity and biodiversity values for flora and fauna species. Not all the identified corridors are suitable to provide connectivity for koalas, but the habitat should be protected for koala habitat, biodiversity values and amenity in the region.

- a) Within the proposed Mount Gilead development:
 - The Menangle Creek to Noorumba Reserve corridor (A) should be used for koala movement if:

- a connectivity structure can feasibly be constructed on Appin Road. The proposed tree-top bridge is not likely to be adequate and would not be used by koalas. A land bridge should be considered to allow koalas and other fauna to cross Appin Road, an example of this is being developed for wallabies at Mona Vale.
 - If the crossing is not feasible, the koala habitat at Noorumba will be isolated and not function as connected koala habitat, therefore should be fenced off at Appin Road. In this case, the koalas within this fragmented area will need to be actively managed.
 - The Woodhouse Creek to Beulah Reserve corridor (B) is an important northern connection for the koala population between the Georges River Reserve and the Nepean Corridor and should be retained. The proposed measures to protect the habitat in the corridor are currently not adequate and should be improved with the measures outlined in c). The underpass near Beulah Reserve as proposed by Lendlease should be constructed.
 - Close attention should be paid to test the feasibility of the design of the koala connectivity at the confluence of Menangle Creek and Nepean River, near the Hume Highway and possibly under three bridges.
- b) Within the Greater Macarthur Growth Area covered in the draft Cumberland Plain Conservation Plan:
- The Ouesdale Creek to Appin North Corridor (E) should be secured as the east – west corridor to connect the Georges River Reserve and Nepean Corridors. A suitable crossing structure (e.g. culvert) should be constructed at Appin Road.
 - The Mallaty Creek to Georges River Corridor (D) should be fenced if feasible and protected in the event that suitable land cannot be purchased to finalise corridor E. If a crossing at E cannot be progressed, then an underpass across Appin Road should be developed at Corridor D. The measures to protect the corridors as in c) should be applied.
 - If a crossing at Corridor E is secured and crossing at Appin Road for Corridor D not pursued, then a decision would need to be made based on the risk/benefits of maintaining the koalas and mitigation measures in Corridor D without a crossing at Appin Road.
 - The habitat in Corridor F should be protected including with exclusion fencing to minimise risks from threats, and with monitoring of risks to avoid a population sink.
- c) Habitat within identified corridors should be:
- protected (especially from development creep)
 - widened through revegetation (average size 390 to 425 m)
 - include a buffer on either side of the corridor habitat that is at least 30 m wide from the corridor to the exclusion fence with feed trees permitted in this buffer area
 - include, between the buffer area and the urban areas, koala proof fencing to prevent the movement of koalas out of the corridor into urban areas (with trees more than 3 m from the fencing to avoid damage) and the movement of domestic dogs (amongst other potential threats) into the corridor
 - for sites where exclusion fencing is infeasible due to steep terrain, then additional buffer width should be utilised (buffer ~60 m), with a traffic speed limit of 40 km/h and predator / dog monitoring
 - asset protection zone is outside the exclusion fencing, within the development footprint

Further, connectivity structures within corridors should also be assessed including local roads and other infrastructure (e.g. the Upper Canal).

Recommendation 3 – Monitoring and adaptive management

Monitoring should be undertaken to enable adaptive management of the koala population in the proposed Mount Gilead Stage 2 development and in the draft Cumberland Plain Conservation Plan.

This monitoring should:

- be consistent across the region to ensure data and adaptive management strategy outcomes are comparable
- include trigger levels that enable actions for adaptive management e.g. increased vehicle strikes, increased dog attacks or disease prevalence. (As part of the planning process, targets should be set to gauge success.)
- align with best practice and the NSW Koala Monitoring Framework (as part of the NSW Koala Strategy) and data made available through the SEED portal and any tissue samples provided to the NSW Koala Biobank
- be funded by developers through the establishment of a monitoring trust
- monitor the movement of koalas in the region and understand use of the corridors and connectivity structures, the NSW Government should investigate the development of implantable sensor technologies, such as through the NSW Smart Sensing Network.

Recommendation 4 – disease prevention

Koalas that are captured and/or handled as part of a monitoring program or those that are rehabilitated and released back into the Campbelltown population should be vaccinated against chlamydia. If a joint vaccine for chlamydia and KoRV is available this should be used. Koalas with no microchip or other identifying features that are captured should have a tissue sample taken for genetic analysis, with the tissue samples lodged with the NSW Koala Biobank.

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1 INTRODUCTION

On 9 December 2019, the Minister for Energy and Environment and the Minister for Planning and Public Spaces requested that the Deputy Chief Scientist & Engineer chair an independent expert panel (the Panel) to provide advice regarding the protection of the Campbelltown koala population.

This advice was to include:

- The adequacy of the proposed measures, by the property group Lendlease, for koala conservation on the land referred to as Mount Gilead Stage 2 (MGS2) and the consistency of these measures with the NSW Koala Strategy (the Strategy)
- What, if any, additional conservation measures are considered necessary
- What, if any, site specific measures for koala species should be incorporated into the Cumberland Plain Conservation Plan (CPCP) for the Greater Macarthur Growth Area (GMGA) to support the long-term viability of the koala population.
- Whether east-west corridors linking the Nepean and Georges Rivers can contribute to the conservation of the Campbelltown Koala population; and if so, which east-west corridors and what measures should be taken to ensure their effectiveness.

The full Terms of Reference are at Appendix 1.

This report constitutes the Panel's advice on the Terms of Reference and provides a review of the adequacy of the proposed protection measures for koalas as part of the MGS2 development and the draft CPCP plans viewed by the Panel to date. 'Adequacy' in the Panel's report has been defined in terms of the objective of the NSW Koala Strategy to "*stabilise and then increase koala numbers over the longer-term, ensuring genetically diverse and viable populations across New South Wales*" (NSW Government, 2018).

The Panel has assessed the measures to protect koalas in the GMGA considering those proposed in the biodiversity certification application for MGS2 and in the draft CPCP documentation to ensure a consistent approach in the region.

This report provides recommendations to improve the proposed measures and considers a range of possible scenarios for the mitigation approaches proposed, given constraints including those that are financial and geographic in nature. An adaptive management approach is identified as crucial, with consideration of data collection and monitoring requirements, to ensure and demonstrate the effectiveness of mitigation strategies.

This chapter provides an overview of proposed urban development in the GMGA, as well as relevant legislation and guidelines, an overview of the Campbelltown Koala population and a description of threats and impacts to koala populations from urbanisation.

1.1 DEVELOPMENT IN GREATER MACARTHUR

The population of Greater Sydney is growing and is expected to reach 8 million people by 2038, with the population of Campbelltown growing from 740,000 in 2016 to 1.1 million by 2036 to over 1.5 million by 2056 (DPIE, 2020a; GSC, 2020). The *Greater Sydney Region Plan: A Metropolis of Three Cities* (GSC, 2018), developed by the Greater Sydney Commission, provides a vision to support the growing population of Sydney dividing the region into three cities – the Western Parkland City, Central River City and the Eastern Harbour City.

The Western Sydney City Deal, signed in March 2018, is a partnership between the Commonwealth Government, NSW Government and eight local governments (Blue

Mountains, Camden, Campbelltown, Fairfield, Hawkesbury, Liverpool, Penrith and Wollondilly) to deliver the Western Sydney Parkland City (WSCD, 2020). The Deal includes measures to improve transport and connectivity, education, the environment, jobs and housing.

In November 2018, the NSW Department of Planning and Environment (now the Department of Planning, Industry and Environment, 'the Department') released *Greater Macarthur 2040 – An interim plan for the Greater Macarthur Growth Area*, a land use and infrastructure implementation plan for future development in the region (DPIE, 2018). Greater Macarthur 2040 includes a draft Structure Plan and responds to the NSW Government's commitment that land east of Appin Road will be retained as Environmental Conservation and for a koala reserve. The proposed structure plan for the GMGA is at Figure 1.

In 2019, the NSW Government declared Greater Macarthur as a Growth Area and amended the *State Environment Planning Policy (Sydney Region Growth Centres) 2006* to reflect this declaration (DPIE, 2020b). A planning principle of the *Greater Macarthur 2040* is that "conservation of biodiversity and koala colonies will be at the heart of the Growth Area". The Department is finalising *Greater Macarthur 2040* in response to feedback from the community and proposes to update the Structure Plan to align with the final CPCP and its conservation boundaries.

An estimated 39,000 new homes are proposed in the land release area of Greater Macarthur, (15,000 in North Gilead Precinct (of which, 1,700 is already re zoned), 4,000 in Menangle Park, 5,000 in North Appin and 15,000 in Appin) , and will also include new town centres, retail and commercial services, improved transport corridor and schools (DPIE, 2018). This will change this area from a peri-urban and rural area to urban, with the population increasing from ~3,000 to ~109,000 people when the region is developed (DPIE, 2018).¹

Under the Western Sydney City Deal, there is a commitment for strategic assessment under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) to protect the environment and streamline environmental approvals for development (NSW Government, 2020a). This includes the GMGA as well as the Greater Penrith to Easter Creek Investigation Area, Western Sydney Aerotropolis and the Wilton Growth Area. The CPCP is being developed by the Department to conduct strategic assessment under the EPBC Act as well as identifying the areas within the growth areas that will be certified for development under the NSW *Biodiversity Conservation Act 2016* (BC Act).

The Mount Gilead development has been proposed as two stages – Stage 1 (MGS1) and Stage 2 (MGS2). Lendlease Communities Pty Ltd (Lendlease) has proposed a second stage residential development in Gilead (Stage 2) within the GMGA, and which is the subject of this review. Lendlease's Stage 1 development also known as Mount Gilead, and is already rezoned for urban development, is being marketed by Lendlease as Figtree Hill (Lendlease, 2020a). Within the GMGA, biodiversity certification for Stage 1 Gilead was initiated prior to the start of the strategic assessment. Both MGS1 and MGS2 sites are not within the area subject to the draft CPCP, and due to legislative transitional arrangements will be assessed under the NSW *Threatened Species Conservation Act 1995* (TSC Act). Note, both stages of the development are subject to assessment and approval under the EPBC Act.

In July 2018, Campbelltown City Council as the planning authority, applied for Biodiversity Certification of the MGS1 land on behalf of Lendlease and certification was conferred in June 2019. In August 2019, Campbelltown City Council, on behalf of Lendlease, Campbelltown Council applied for Biodiversity Certification of land in MGS2.

¹ This is based on 39,000 homes and an estimated average household of 2.8 people (DPIE, 2020e)

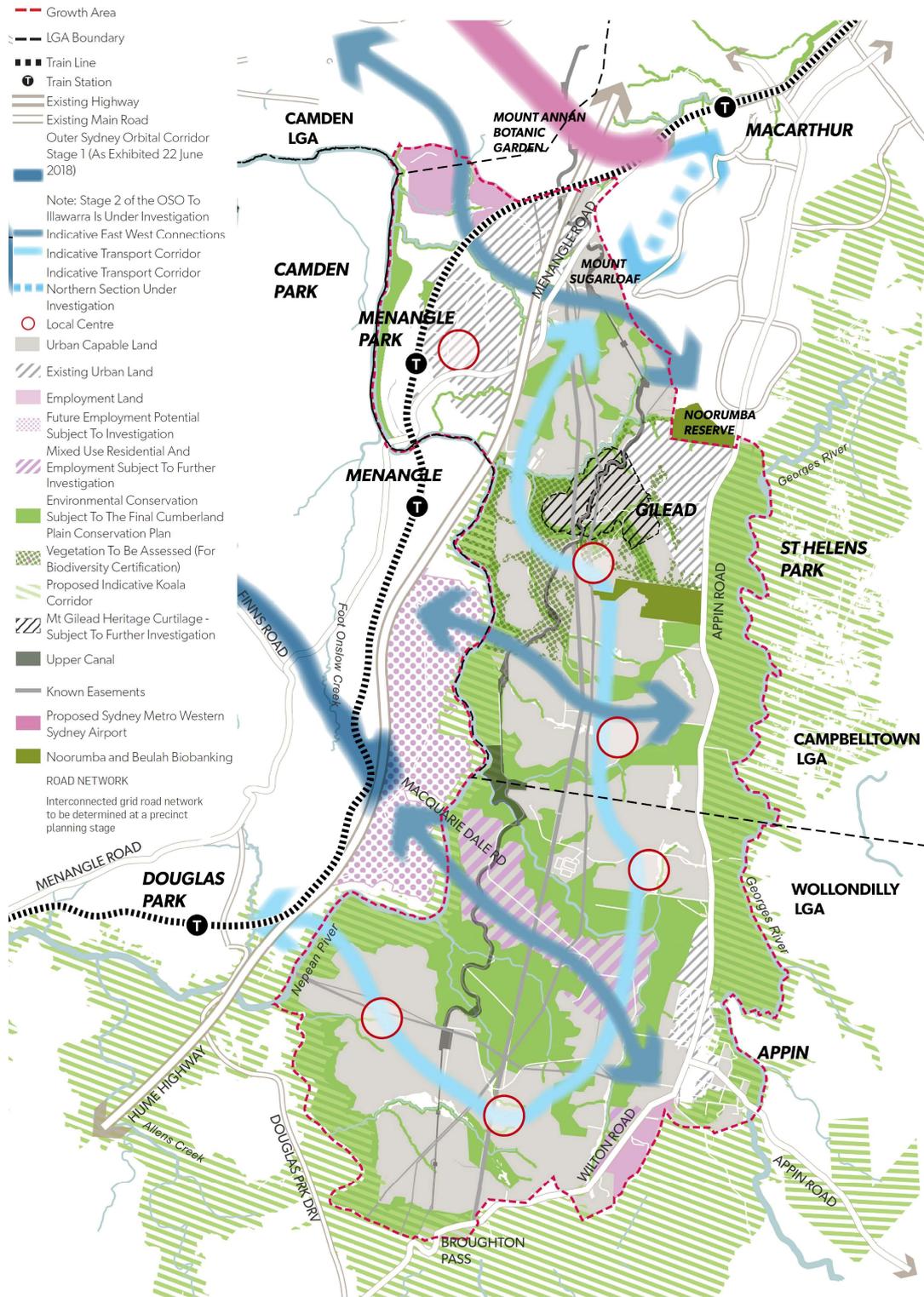


Figure 1: Proposed structure plan for the Greater Macarthur Growth Area

Source: DPIE (2018)

1.1.1 Draft Cumberland Plain Conservation Plan

The Department has undertaken strategic conservation planning to develop the CPCP in response to the rapid growth of Western Sydney. The Plan is being developed to address strategic biodiversity certification provisions under the BC Act and strategic assessment under the EPBC Act, identifying strategically important biodiversity areas within the Cumberland subregion to offset the biodiversity impacts of future urban development. It aims to facilitate the biodiversity approvals required to deliver four Western Sydney growth areas and supporting major transport infrastructure.

Three sub-plans are included to provide details on the implementation of the CPCP, and actions to deliver its commitments. These are:

- Sub-Plan A: Conservation Program and Implementation – the proposed conservation program and its implementation as well as how the Plan will meet its vision and objectives
- Sub-Plan B: Evaluation – the monitoring, evaluation and reporting framework, and how adaptive management will ensure the ongoing effectiveness of the conservation program
- Sub-Plan C: Koalas – protection of the koala population in Western Sydney and how the Plan supports other government initiatives to protect koalas.

A *Cumberland Plain Assessment Report* has been prepared for the Department (Biosis & Open Lines Environmental Consulting, 2020). The report provides the Biodiversity Conservation Assessment Report (BCAR) (in accordance with the BC Act) and a Strategic Assessment Impact Report (under the EPBC Act). It is noted in this report that *“As the proposed development has been determined by the NSW Environment Minister to be considered for approval under a ‘strategic biodiversity certification’, the offset rules under the BC Regulation do not apply and the Minister can determine any measure to be a conservation measure”*.

The Koala Sub-Plan provides a number of specific commitments and actions for protecting the koala population from development in the Wilton and GMGA (NSW Government, 2020c). The conservation program for koalas will:

- establish the Georges River Koala Reserve east of Appin Road from Kentlyn through to Appin protecting up 1,800 ha of koala habitat and movement corridors (including ecological restoration)
- protect vegetation through environmental zoning in potential east-west koala movement corridors between the Georges and Nepean Rivers
- ecological restoration of koala habitat within the CPCP’s strategic conservation area
- mitigate indirect and prescribed impacts from urban and transport development on koalas including exclusion fencing
- manage landscape threats e.g. fire, weed and pest management
- building capacity and supporting stakeholders, including leveraging existing programs including the NSW Koala Strategy and SoS to raise community awareness, undertake research and support koala health and welfare

The CPCP also includes a monitoring and adaptive management plan. Specific measures in the draft CPCP are discussed in their relevant sections in Chapter 2.

1.1.2 Mount Gilead Stage 2 development

The proposed MGS2 development is a 332.17 ha urban development project (total area of MGS2, including native vegetation, is 672.57 ha), west of Appin Road and the approved

MGS1 development (Figure 2). Figure 3 shows a master plan for both stages of the development. The site is in the area identified for future growth as part of the GMGA. The proposed development includes low and medium residential development² with associated infrastructure, retail, educational facilities, public spaces, active and passive open spaces and conservation lands. MGS2 is expected to deliver 4,500 lots and is proposed to commence from 2024 and take up to 10 years to complete over 7 stages.

The proposed development site is bound by the Nepean River and Hume Highway/ Motorway to the west, rural land to the north and south and the approved MGS1 to the east. The Upper Canal³ runs through the site as well as easements for electricity and the eastern gas pipeline. The Woodhouse, Nepean and Menangle Creeks flow north and west through the site to the Nepean River. The south east site boundary abuts the Beulah Biobank site and there are several registered Biobank sites to the west as a part of MGS1 and the Noorumba Reserve in the north east.

The site contains remnant patches of native vegetation, heavily vegetated riparian corridors and gullies, and agricultural land that has a long history of disturbance associated with cattle grazing and horse agistments since the 1850's. The site is currently zoned rural and is used for pivot irrigation, cropping, cattle grazing and horse agistment. Despite the history of anthropogenic land use, koalas still persist in this area and use it as a corridor.

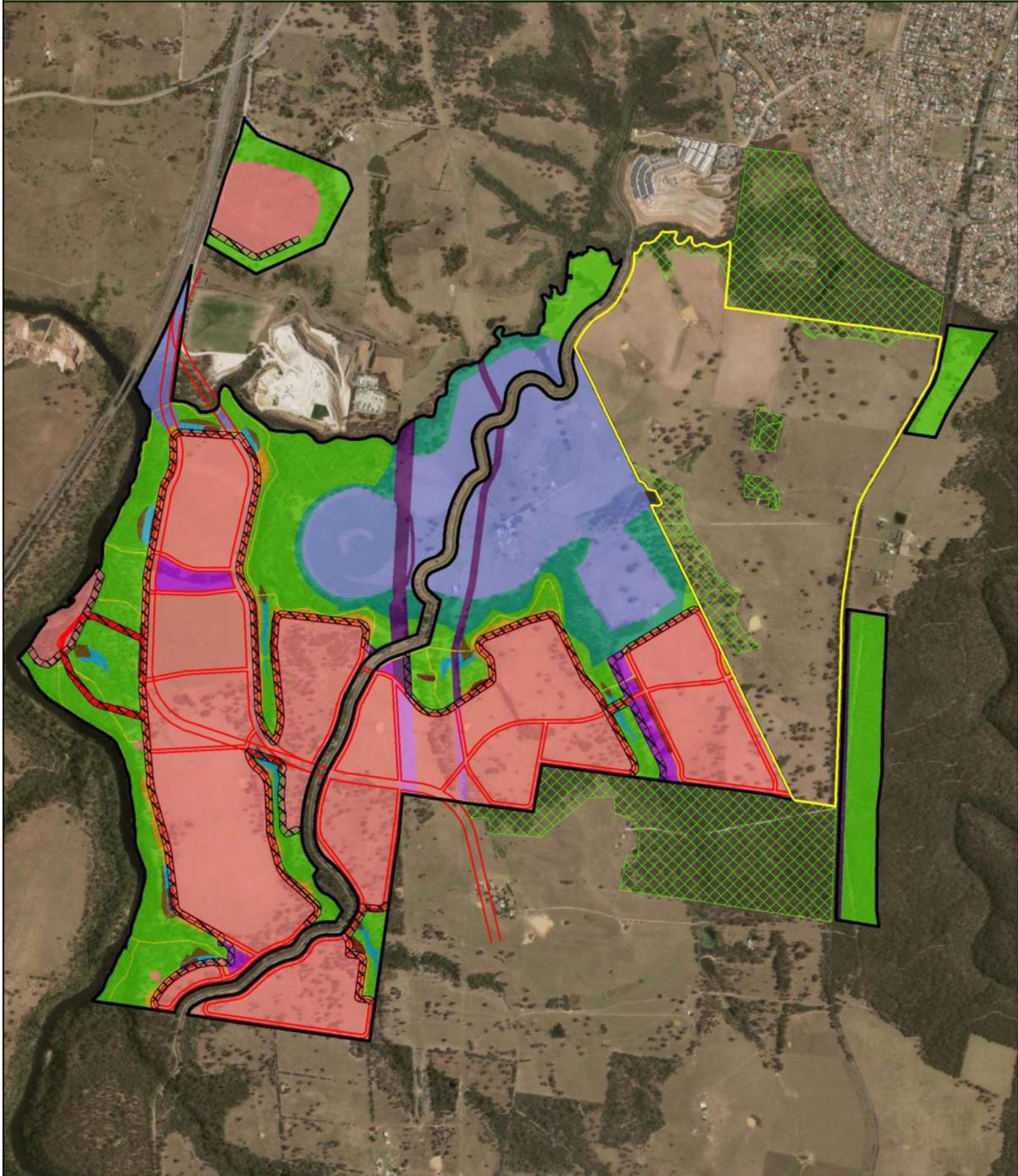
The native vegetation communities are comprised of five biometric vegetation types, which include two listed as endangered ecological communities under the TSC Act and the EPBC Act (Cumberland Plain woodland, and Shale Sandstone Transition forest) and one listed as endangered under the TSC Act and is being considered for a listing under the EPBC Act. There are also five flora and fauna species that have been assessed under the BCAM due to impacts on habitat: the koala, squirrel glider, Cumberland Plain land snail, southern Myotis and the hairy-stemmed shrub brown pomaderris (*Pomaderris brunnea*).

A MGS2 Biocertification Assessment Report (BCAR) and Biodiversity Certification Strategy have been prepared for Lendlease by Eco Logical Australia, and is being used to seek biodiversity certification for the proposed development. This was submitted by Campbelltown City Council to the Department in August 2019 and will be assessed using the BC Act transitional arrangements, meaning that it will still be assessed by a BCAM under the TSC Act. The BCAM determines whether biodiversity certification will improve or maintain biodiversity values. i.e. the method to assess loss of biodiversity values on the land proposed for certification and the impact of the proposed conservation measures.

² Low density is 15 - 25 dwellings/ha and medium density is 25 - 35 dwellings/ha

³ The Upper Canal was built in the 1880s and is still the only way of transferring water to Sydney from the four Upper Nepean dams (Cataract, Cordeaux, Avon and Nepean) (WaterNSW, 2020). The system is managed by the Sydney Catchment Authority on behalf of WaterNSW and is listed on the NSW State Heritage Register, which means The Upper Canal is protected by the Heritage Act 1977 and its 2010 amendments (DPIE, 2020g).

Biodiversity Certification Assessment Area



Legend				0 150 300 600 Metres
Biodiversity Certification Assessment Area Stage 2	Development	Conservation	Retained	Datum/Projection: GDA 1994 MGA Zone 56
Mt Gilead Stage 1	Asset Protection Zone	Conservation (Homestead)	Local Open Space	
Red Flag EEC Buffer	Bio-Retention Basin	Online Detention Basin	Existing Easement	eco logical AUSTRALIA A TETRA TECH COMPANY
Existing Conservation Areas	Easement - Development	Online Detention Basin Embankment		
Roads	Walking Track			
				Prepared by: MF Date: 2/07/2019

Figure 2: Mount Gilead Stage 2 Concept Plan

Source: Eco Logical Australia (2017)

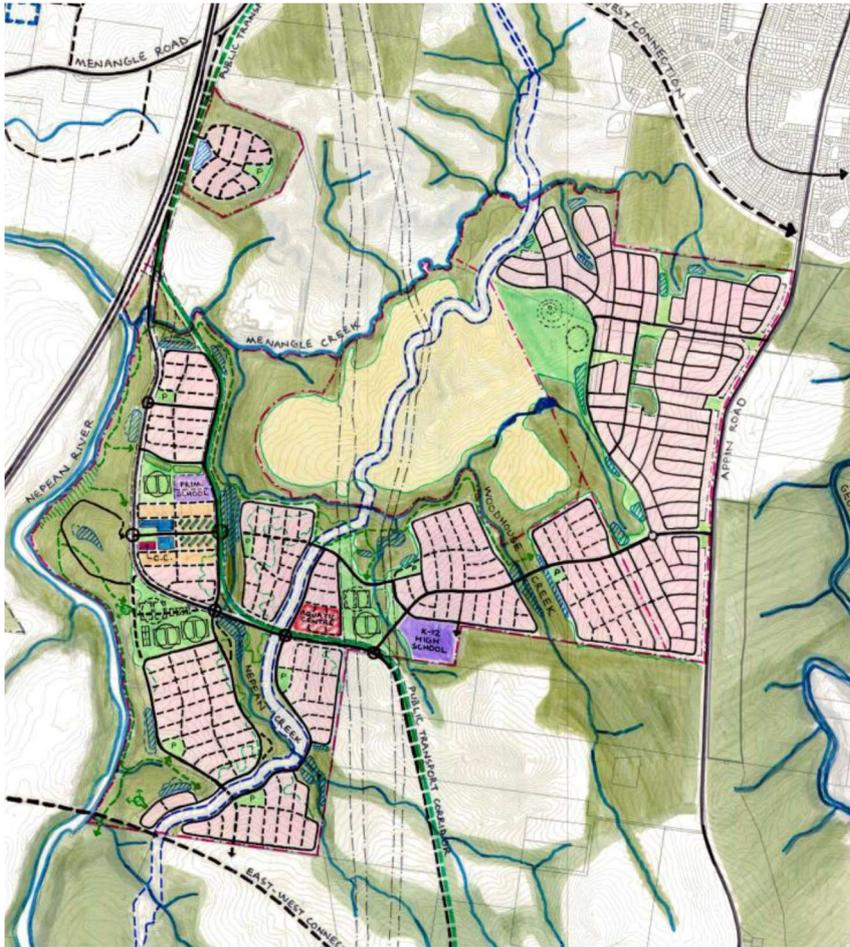


Figure 3: Mount Gilead Stage 1 and 2 Master Plan

Source: Lendlease (2020b)

The BCAR states that there 332.17 ha (~50%) of the assessment area that will be directly impacted, of which 76.89 ha is mapped as native vegetation and threatened species habitat (Table 1). The BCAR has estimated that 72.22 ha of koala habitat will be impacted: 6.29 ha of high, 12.78 ha of moderate and 36.19 ha of low-quality habitat.

Table 1: Mount Gilead Stage 2 BCAR assessment area

Source: Eco Logical Australia (2017) and Lendlease (2020b)

Area	Size
Total land assessed	627.57 ha
Native vegetation	265.81 ha
Exotic vegetation & cleared land	406.76 ha
Total assessed land impacted	332.17 ha (~50% of total area)
Impacted native vegetation & threatened species habitat	76.89 ha
Koala habitat impacted	72.22 ha
Total assessed permanently protected	201.81 ha (~30% of total area)
Generate ecosystem credit (Biobank)	197.46 ha
Red flag vegetation conservation area buffer	4.35 ha

Permanently protected and managed habitat for conservation totals 201.81 ha (197.46 ha of which will generate ecosystem credits (i.e. Biobanks), the remaining 4.35 ha being a red flag vegetation conservation area buffers), with five Biobanks sites to be registered in the area:

Browns Bush, Mount Gilead Homestead, Woodhouse Creek, Nepean and Medhurst biobank sites.

This includes the restoration of native vegetation (200.42 ha), with 38.9 ha fully restored, 37.21 ha enhanced and 124.31 ha of minor restorations (Lendlease, 2020b).⁴ Additionally, 138.59 ha of land will be retained as public open space and existing easements. There is a further 16.96 ha that will be used for establishment of detention basins (1.9 ha), wide bush walking track through the koala habitat (1.05 ha), modification of existing habitat to establish bushfire Asset Protection Zones (APZs) (14.01 ha).

Other specific measures to protect koalas as described in the BCAR and supplementary material provided to the Panel are discussed in relevant sections in Chapter 2.

1.2 LEGISLATION, GUIDELINES AND INITIATIVES

There are a number of Federal and State legislative instruments that apply to the conservation of koalas and their habitat in NSW. This section outlines the specific legislation, guidelines and instruments of relevance to the Panel when considering aspects of MGS2 and the CPCP and is not an exhaustive examination of all legislation related to the protection of koalas.

1.2.1 Environment Protection and Biodiversity Conservation Act (1999) [Cth]

The combined koala populations of Queensland, New South Wales and the Australian Capital Territory are listed as 'vulnerable' under the EPBC Act, requiring project proponents to consider whether their project will have a significant impact on important koala populations in these jurisdictions. If a project has or will have a significant impact, the EPBC Act requires the project to be referred for a decision by the Federal Environment Minister on whether the project is a 'controlled action'. If unsure, project proponents may refer the project to the Minister.

1.2.2 Biodiversity Conservation Act 2016 [NSW] and repealed Threatened Species Conservation Act 1995 [NSW]

The BC Act replaced the repealed TSC Act on 25 August 2017. The BC Act lists koalas as 'vulnerable', due to their decline in numbers from multiple threats (i.e. habitat loss, fragmentation and loss; disease; vehicle strike; predation; etc.), resulting in development proposals that impact koalas being more rigorously assessed. The primary purpose of the BC Act is to "*maintain a healthy, productive and resilient environment for the greatest well-being of the community, now and into the future, consistent with the principles of ecologically sustainable development*" (DPIE, 2019a).

Strategic biodiversity certification (under both the BC Act and repealed TSC Act) identifies, at a regional scale, areas of high conservation value that should be avoided or protected, areas that can be developed (once certified) and measures to offset any potential impact of development. In effect, the strategic biodiversity certification removes the need for site-by-site assessment of the threatened species, populations or ecological communities if any proposed development falls within the biodiversity certified land, as the strategic biodiversity certification examines any biodiversity measures at a landscape scale.⁵

⁴ Full restoration – Cleared land/pasture (low quality habitat) fully restored to high quality habitat. Enhanced restoration – Low quality habitat that will be enhanced to create high quality habitat. Minor restoration – High quality habitat that will be subject to weed and feral animal control to improve and maintain habitat quality.

⁵ Under Part 7AA of the TSC Act, this relates to; projects under Part 3A, infrastructure under Part 5.1, development under Part 4 and activities under Part 5 of the *Environmental Planning and Assessment Act 1979* (EP&A Act); and, the *Native Vegetation Act 2003* does not apply

The biodiversity certification scheme under the repealed TSC Act allowed only planning authorities⁶ to apply to the Minister of the Environment to have biodiversity certification conferred to an area where the biodiversity outcomes were improved or maintained, with the Biodiversity Certification Assessment Methodology (BCAM) providing the method of assessment.

In establishing the new biodiversity certification scheme, the BC Act allows both planning authorities and individuals to seek certification using the Biodiversity Assessment Method (BAM) for specific types of development proposals, with the aim to prove adequacy of conservation measures to the Minister.⁷

There are transitional arrangements for previous biodiversity certified land under the TSC Act. As set out in the *Biodiversity Conservation (Savings and Transitional) Regulation 2017*, development applications set out prior to the commencement of the BC Act will be considered under the previous legislation (i.e. the TSC Act).

Biodiversity Offsets Scheme

Under the previous TSC Act biobanking allowed for 'biodiversity credits' to be generated on a voluntary basis and sold to the market in order for developers and landowners to offset their impacts on biodiversity. The BC Act, with the associated *Biodiversity Conservation Regulation 2017*, takes a similar approach in establishing the Biodiversity Offset Scheme⁸, a statutory framework to assess the impacts or likely impacts of development and associated native vegetation and habitat clearing activities on biodiversity, moving through a hierarchy of avoiding, minimizing and/or offsetting these impacts (DPIE, 2019b). This Scheme allows for potential adverse impacts on biodiversity at the site of development to be offset by the protection or improvement of the environment at other sites in-perpetuity. Offsets are predicated at both the State and Federal level to be used only when efforts have been made to either avoid or mitigate environmental impacts.

The Scheme establishes biodiversity stewardship sites (via agreements between the landholder and the Minister), the creation of biodiversity credits and a system for these to be traded, prescriptions for biodiversity impact assessments and reports by accredited persons, and the establishment of the BAM.⁹

The BAM provides a consistent method for biodiversity assessment on sites to be developed and/or cleared, guidance on avoiding or minimizing potential impacts on biodiversity, and the residual number and class of credits (either ecosystem or species credits) that are required to be offset to achieve an outcome of 'no net loss' of biodiversity. The BAM is applied by an accredited assessor and is informed by the Biodiversity Assessment Method Operational Manual and the metrics within. This leads to the development of Biodiversity Development Assessment Reports (BDARs), Biodiversity Certification Assessment Reports (BCARs) and Biodiversity Stewardship Site Assessment Reports, depending on the intent of the proponent.

It is the BDAR/BCAR that is submitted as a component of the application for development, with the BCAR usually reserved for larger, multi-staged development proposals.

The BAM is also used to assess the establishment of an area as a biodiversity stewardship site that generates offset credits for the landholder to sell to those who need to purchase credits to offset their impacts. Similar to the BDAR/BCAR, a Biodiversity Stewardship Site Assessment Report is developed that outlines the class (species or ecosystem credits) and

⁶ A planning authority under the TSC Act means the Minister for Planning, local councils, a determining authority, the Secretary of the Department of Planning and Environment, or any other person or body declared by the regulations to be a planning authority

⁷ Development proposals include those identified in the EP&A Act (Part 4, Part 5), BC Act (Part 5 Activity, Div. 2, Section 7.14(1), 8.2 and 8.7(1)), *Local Land Services Act 2013* (Part 5A, Div. 6), *SEPP (Vegetation in Non-Rural Areas) 2017*

⁸ BC Act, Part 6

⁹ BC Act, Part 6, Cl. 6.2

number of credits generated if the site is approved under a Biodiversity Stewardship Agreement (BSA).

BSAs have also replaced BioBanking Agreements that were established under the repealed TSC Act. Existing BioBanking agreements, such as those identified in MGS1 and MGS2, remain in place and will be managed as BSAs by the Biodiversity Conservation Trust (BCT_.

1.2.3 State Environmental Planning Policy (Koala Habitat Protection)

The listing of koalas as vulnerable means they must be considered under the NSW *Environmental Planning and Assessment Act (1979)* (EP&A Act) when preparing environmental planning instruments and when undertaking development assessments. The EP&A Act is the legislative tool that sets out how planning occurs in NSW, including environmental planning instruments¹⁰ such as State Environmental Planning Policies (SEPPs).¹¹

SEPP (Koala Habitat Planning) 2019 ('Koala SEPP') repealed and replaced the former *SEPP 44 – Koala Habitat Protection* on 1 March 2020, and has two primary aims: to assist in the preparation of Comprehensive Koala Plans of Management (CKPoMs) and to standardize the process for preparing, assessing and implementing development applications for applicants and consenting authorities. The Koala SEPP includes a draft Koala Habitat Protection Guideline, applicable to proponents where land is over 1 hectare and identified on the Koala Development Application Map (if there is no approved council KPOM applying to the land).

1.2.4 Campbelltown Comprehensive Koala Plan of Management

The draft and revised 2018 Campbelltown CKPoM has been prepared in accordance with the NSW Koala Recovery Plan (2008) and SEPP 44 to “*provide for the long-term maintenance of a viable, free-ranging koala population in the Campbelltown LGA*”. The Campbelltown CKPoM aims to enable persistence of a koala population of at least 300 koalas in the area with the increased human population and safeguard the future of the Campbelltown koala population through regulatory and non-regulatory mechanisms (Phillips, 2018). The Panel understands that the Council has submitted the Campbelltown CKPoM to the Department for approval by the Secretary and is currently under consideration, noting that the NSW Government released a new Koala Habitat Protection SEPP March 2020.

1.2.5 NSW Koala Strategy and Saving our Species

The NSW Koala Strategy (the ‘Strategy’) was released in May 2018. The Strategy responded to the recommendations of the NSW Chief Scientist and Engineer’s 2016 *Independent Review into the Decline of Koala Populations in Key Areas of NSW* (CSE, 2016).

The objective of the Strategy is to stabilise and then increase koala numbers over the longer-term, ensuring genetically diverse and viable populations across NSW. The Strategy includes several actions to be undertaken over three years under four pillars: koala habitat conservation, conservation through community action, safety and health of koala populations and building our knowledge.

The Saving our Species (SoS) program in the Department is a statewide program that aims to secure threatened plants and animals in the wild of NSW for 100 years. This program includes the SoS Iconic Koala Project and includes the Southern Highlands Koala Conservation Project to improve habitat and reduce impacts in the region (DPIE, 2020f).

¹⁰ EP&A Act, Division 3.2

¹¹ EP&A Act, Division 3.3

1.2.6 Inquiry into Koala Populations and Habitat in New South Wales

On 20 June 2019, an inquiry into Koala Populations and Habitat in New South Wales (the Koala Inquiry) was established in the Legislative Council of the NSW Parliament. The Committee aims to report on actions, policies and funding by the NSW Government to ensure the sustainability of koala populations and habitats in NSW. This includes the examination of key habitat, population trends, and threats; resourcing and adequacy of protections; the effectiveness of current legislative conservation measures and the impact of regulatory reforms and programs (particularly around forestry in NSW); and, understanding the impact of climate change on koalas and their distribution. The inquiry will conduct 10 hearings between 16 August 2019 and 8 April 2020 and is accepting public submissions (Parliament of New South Wales, 2020). The Committee is expected to submit its report by 15 June 2020.

1.3 KOALAS IN NEW SOUTH WALES

Koalas are one of Australia's most iconic species, recognisable around the world and a major tourist attraction (DPIE, 2020c). Historically koalas were distributed throughout the woodlands and forests of NSW, however, they are now threatened across their range from impacts such as habitat loss and fragmentation (such as from urban development and agriculture), vehicle strikes, dog attacks (both domestic and wild dogs), drought, bushfires, disease (e.g. Chlamydia), and climate change (CSE, 2016). Most koala populations in NSW now survive in fragmented and isolated habitat and in many cases are subject to intense development pressures (CSE, 2016). Koalas are listed as 'vulnerable' in NSW and needing protection under both state and federal legislation.¹² Koala numbers and distribution have declined over time, with an estimate of 36,000 koalas in NSW (CSE, 2016; Adams-Hosking, 2017).

The 2019-20 bushfires in NSW were unprecedented in their scale and intensity. The extended 2019-20 bushfire season has devastated a significant area of koala habitat (as at 3 February 2020, over 3.5 million hectares or 25% of moderate to highly suitable koala habitat had been affected) and we are yet to fully understand what the impact has been on koala numbers. A recent report by Lane, Wallis, and Phillips (2020), that analysed koala records and the extent of the bushfire, found that over the preceding three koala generations the NSW koala population has declined by at least 28.52% and may be as large as 65.95%. The report also notes that the ongoing threat of climate change and its associated impacts (e.g. more frequent and intense bushfires) will severely affect koala populations and increase the risk of localised extinction events. Further work is underway to provide a picture of the impact of the bushfires on koala numbers, distribution, demographics and condition.

1.3.1 Campbelltown Koala population

The Campbelltown koala population is a historically continuous population of (Hagan, Phalen, & Close, In prep.) which is one of the few remaining populations in the Sydney region (Phillips, 2020). This population includes koalas in the Campbelltown and Wollondilly Local Government Areas (LGAs). The likely extent of the population has been estimated to be east to the coast, south from Holsworthy until it connects with koalas in the Southern Highlands and some distance to the west (it is unknown if the Hume Highway poses a barrier to movement) (Biosis & Open Lines Environmental Consulting, 2020).

1.3.1.1 Koala Population status and health

The population is considered to be stable and increasing (Close, Ward, & Phalen, 2017), recovering from historical impacts. The population is small, between 250 and 500 individuals and is found at low density (~0.1 koalas per hectare) (Hagan et al., In prep.). These

¹² Note legislation and that they are also listed as vulnerable in Queensland and the ACT.

estimates were made prior to the 2019/20 bushfires, however the majority of the region was not affected.

As with many koala populations across Australia, the Campbelltown population is genetically distinct from others. The most closely related population to Campbelltown is the Southern Highlands, showing gene flow between these populations but it is separate from the Blue Mountains population (DPIE, 2020c). Although the Campbelltown population has lower genetic diversity than the Blue Mountains (from 4,606 single-nucleotide polymorphisms, SNPs) it has less inbreeding than the Blue Mountains population indicating gene flow with the Southern Highlands (Kjeldsen et al., 2019).

The population has remained relatively free from Chlamydia infection (Hagan et al., In prep.). However, there is widespread infection in the Southern Highlands population, and it is believed that this infection could move north into the population due to connectivity between the populations. The koala retrovirus, KoRV-A is prevalent in the population, however KoRV-B is found at low (Hagan et al., In prep.).

1.3.1.2 Local koala habitat

The *Conserving Koalas in the Wollondilly and Campbelltown Local Government Areas* (DPIE, 2019c) identified high-quality koala habitat, core koala habitat, koala movement corridors and koala roadkill hotspots in the region (Figure 4). The report found:

- A long-established association between koala presence and vegetation that grows on high fertility soils, such as shale and shale transition soils and the habitat that is present on these soils are considered high quality habitat.
- There are seven preferred food tree species in the region: grey gum (*Eucalyptus (E.) punctate*), white stringybark (*E. globoidea*), woollybutt (*E. longifolia*), forest red gum (*E. tereticornis*), grey iron bark (*E. paniculata*), blackbutt (*E. pilularis*) and green wattle (*Acacia decurrens*).
- The koala habitat in the region is highly fragmented with large patches of core habitat on the eastern edge of the Cumberland Plain.
- The only other core habitat is the remaining areas of Shale Sandstone transition forest along the Nepean River and its tributaries, but this habitat is more limited in extent and in linear in configuration. There are a number of resident koalas in this habitat and it is therefore thought this habitat is important for koala persistence in the region.

This report also identified primary, secondary and tertiary koala movement corridors that have been determined for the region, based on metrics including the area of core koala habitat it contained, width, and level of connectivity (Figure 4). These are described further in Section 2.3.

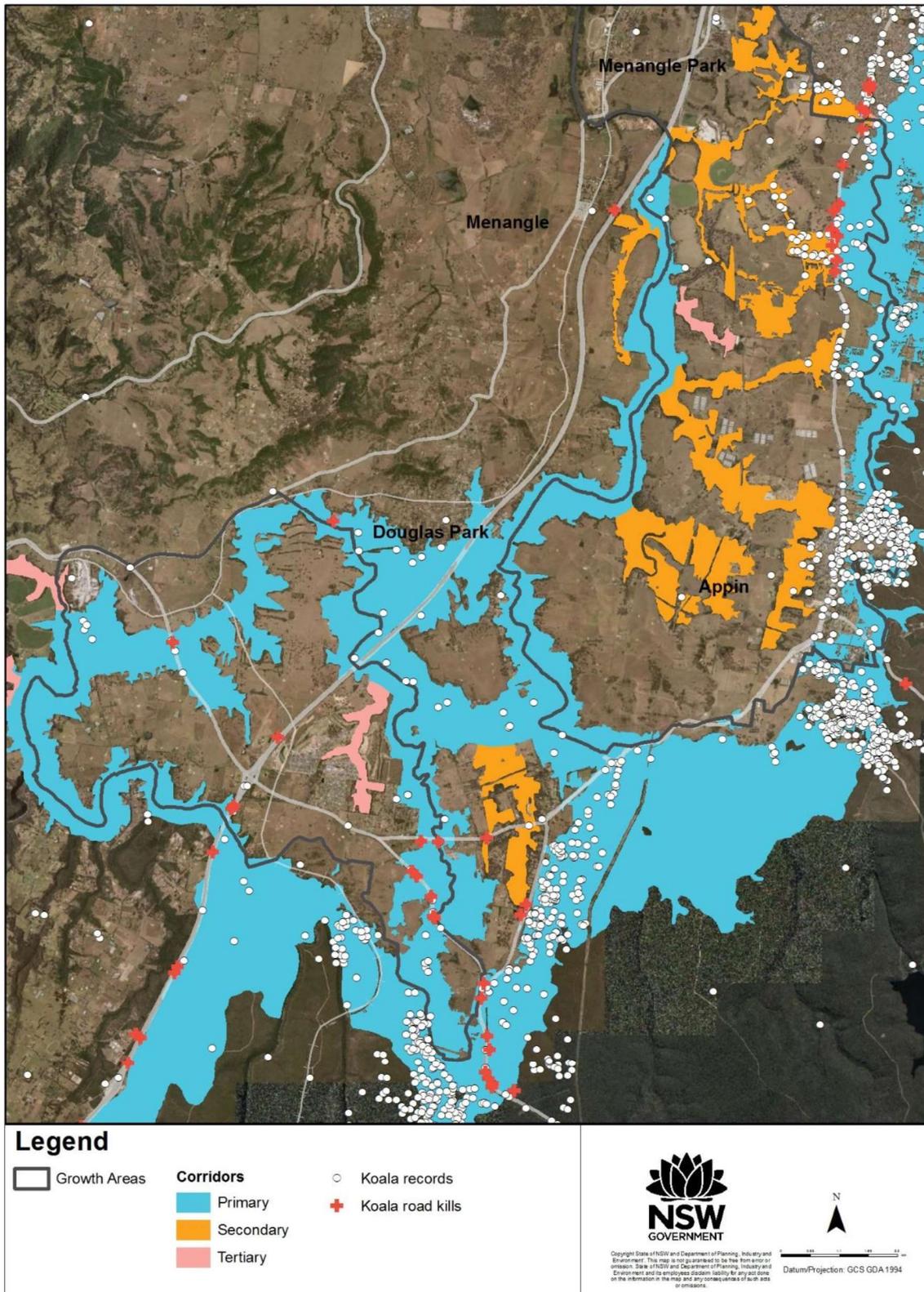


Figure 4: Rankings for koala corridors across the Wilton and Greater Macarthur Growth Areas

Note that koala records shown are sightings and do not indicate koala densities
 Source: DPIE (2019c)

Threats and stressors

The current main threats and stressors to the population are:

- **Habitat fragmentation and loss:** Agriculture and urbanisation has led to the loss and fragmentation of habitat across the region. Local core koala habitat is currently maintaining the population and the rural landscape is permitting koalas to move between these core koala habitats. A principal threat to the biodiversity values of the Cumberland subregion is the further loss and fragmentation of habitat from clearing for urban development and agricultural land uses (DECCW, 2011; Biosis & Open Lines Environmental Consulting, 2020), including illegal clearing. High density residential development, as opposed to the current rural landscape, in much of the area between core habitats will place significant pressure on smaller, narrower corridors that link koala populations.
- **Vehicle strike:** Vehicle strike hotspots occur where roads dissect koala habitat, areas of heavy traffic flow and higher speed limits and along koala dispersal routes. There are a number of identified hotspots along Appin Road (Figure 4). This is currently one of the main reasons for admission (41%) to the Avian, Reptile and Exotic Pet Hospital Camden and the main cause of death for koalas in the area (Hagan et al., In prep.).
- **Dog attacks:** Another main cause for hospital admission (11%), with dispersing males and younger (i.e. less than 3 years of age) koalas subject to greater predation risk by domestic dogs (Hagan et al., In prep.).
- **Disease (*Chlamydia*):** The population is healthy and *Chlamydia* infection has not been detected (Hagan et al., In prep.). However, there is widespread infection in the Southern Highlands population, and it is believed that there is the potential for the infection to move north into the Campbelltown population.
- **Stressors:** light and noise can pose indirect threats to koalas by increasing stress levels which in turn can lead to changed patterns of behavior, avoidance of exposed habitat, increased propensity to disease.

1.4 KOALAS AND URBAN DEVELOPMENT

Threats in urban areas for koalas in urban areas include: habitat loss and fragmentation; increased risk of predation by both domestic and roaming dogs; increased risk of vehicle strike mortality, potentially increased risk of disease expression, and backyard swimming pools (with the risk of drowning). Many of these threats are greatest and further exacerbated at the interface between native habitat and anthropogenic land use.

There is good evidence that where urban development interfaces with koala populations and their habitat that this results in declines in koala populations. In particular, rapid declines in koala numbers have been experienced in NSW and Queensland in high-density urban and remnant source populations that have undergone conversions from agriculture to urban environments (McAlpine et al., 2006; Adams-Hosking, 2017).

In South East Queensland populations of koalas have declined rapidly over the past 20 years due to urban development. Rhodes et al. (2015) show that some koala populations in South East Queensland have declined as much 80% over the preceding 20 years, despite attempts to reduce habitat loss through the planning regulation. Rhodes et al. (2011) and Beyer et al. (2018) show that high threat levels from disease, dog predation, and vehicle collisions associated with urban development, on top of habitat loss, are key drivers of decline in these urban environments. In particular, these studies highlight that it is the cumulative effect of multiple threats that drives declines in koala populations. Although, Beyer et al. (2018) show that these populations can be recovered by intensive management

of multiple threats, such intensive management is unlikely to be feasible in the long-term, especially over broader areas.

Research in NSW also shows evidence of declines in koala populations in urban areas (Smith & Smith, 1990; Lunney et al., 2002), but these declines may be potentially mitigated to some extent when urban areas are connected to large areas non-urban occupied koala habitat (Lunney et al., 2010; Lunney et al., 2016).

Threats to koalas inhabiting an increasingly urbanised environment are also further complicated by climate change and extreme climatic events, in particular drought and prolonged high temperatures. Current climate change projections predict hotter and drier climates, and this can limit the koalas current range. The koala's range is predicted to contract east and south to more mesic regions (Adams-Hosking et al., 2011). Riverine vegetation is critical refugia habitat in times of drought and is the source habitat for koala populations post-drought. In landscapes where the primary habitat is limited by habitat loss and fragmentation, population decline is imminent.

From these findings above, we can conclude that there is a need to promote efforts in the GMGA to: maximise habitat area; minimise habitat fragmentation; increase habitat quality and resilience of habitat to climate impacts; minimise edge lengths and interface with threats; monitor and mitigate predation from dogs and threats from roads.

The riverine characteristics of the corridors along the Nepean and Georges Rivers, as well as the creeks running through the landscape are noteworthy and underpin some of the important contribution that this landscape could play to the Campbelltown koala population and their role in future droughts, warming climate and bushfire, with connectivity providing routes of escape from threats. Maintaining connectivity of habitat helps avoid the creation of dead ends where koalas face threats without routes of escape, and thus become population sinks where koalas continue to move into an area but are killed by threats.

1.5 PANEL AND REVIEW PROCESS

An Independent Expert Panel was established to provide advice. The Panel, consisted of some members of the Independent Expert Advisory Panel for the NSW Koala Strategy and included:

- Dr Chris Armstrong PSM, Deputy Chief Scientist & Engineer (Chair)
- Professor Kathy Belov AO, Professor of Comparative Genomics and Pro Vice-Chancellor Global Engagement, School of Life and Environmental Sciences, The University of Sydney
- Dr Carolyn Hogg, Senior Research Manager, Australasian Wildlife Genomics Group, School of Life and Environmental Sciences, The University of Sydney
- Professor Jonathan Rhodes, School of Earth and Environmental Sciences, Faculty of Science, The University of Queensland

The Office of the Chief Scientist and Engineer provided secretariat support.

In providing its advice the Panel has reviewed a number of reports and documents, this has included those listed in the Terms of Reference as well as the draft CPCM, supplementary material and reports provided by Lendlease, the draft Campbelltown CKPoM (Phillips, 2018), draft Koala Habitat Protection Guidelines (developed under the new SEPP Habitat Protection 2019) and other relevant reports and research articles.

On 14 February 2020 the Panel conducted a site visit to the proposed Mount Gilead development site. The Panel also met with representatives from the Department (Biodiversity and Conservation Division, Climate Change and Sustainability group, and the Conservation and Analysis Unit), Campbelltown City Council (including Dr Stephen Phillips

as the author of the draft Campbelltown CKPoM), Lendlease and their consultants including Eco Logical Australia and EMM Consulting.

The Panel would like to thank Associate Professor David Phalen and Jessica Hagan from the Koala Health Hub, School of Life and Environmental Sciences, The University of Sydney for providing background information and data on the Campbelltown Koala population.

An Inquiry into Koala Populations and Habitat in NSW is currently being conducted and is due to report by 15 June 2020 (Parliament of New South Wales, 2020). As part of this, on 25 October 2019 the Committee visited the proposed Mount Gilead development sites and hearings on that day discussed the development (Parliament of New South Wales, 2019). A number of submissions to the Inquiry relevant to the Mount Gilead development were also received. Hearings by and submissions to the Inquiry relevant to the Panels Terms of Reference have been considered.

2 ANALYSES OF MITIGATION APPROACHES PROPOSED FOR KOALAS IN THE GREATER MACARTHUR GROWTH AREA

The Review Terms of Reference requests advice on the ‘adequacy’ of the proposed measures for koala conservation. The Panel has defined ‘adequacy’ in terms of the primary objective of the NSW Koala Strategy, which is for protection measures to “*stabilise and increase koala numbers over the longer-term, ensuring genetically diverse and viable populations across New South Wales*” (NSW Government, 2018).

This Chapter sets out the Panel’s assessment of the proposed koala protection measures put forward by Lendlease proponents for the proposed MGS2 development, and as set out in the draft CPCP documentation. For clarity of the discussion, the overall assessment and approach is presented first, Section 2.1 provides a wholistic view of the risks, mitigations and a number of possible scenarios to be considered through implementation. This is followed by a discussion and assessment of measures to offset and protect koala habitat, to support koala habitat corridors, connectivity and minimise edge effects as well as monitoring and adaptive management.

2.1 RISK BASED ANALYSIS AND ASSESSMENT OF POSSIBLE SCENARIOS

To promote the longevity and health of koalas in the Campbelltown region, with the goal of maintaining and improving the population (as established in the NSW Koala Strategy), the Panel views it as important to minimise the contact of koalas to hazards and threats, and also to maximise as far as possible the availability of koala habitat.

No matter what approach is taken, a fundamentally important step forward will be to fence off access by koalas to the surface of Appin Road from the east and west side. This stretch of road is a major contributor to koala mortality in the region. Further discussion below assumes that exclusion fencing is used on both sides of Appin Road.

The goal of the biodiversity certification for the MGS2 and CPCP is to enable the koala populations to exist in this increasingly urban environment and deploy a range of habitat of protection and hazard reduction mitigations (See Sections 2.2, 2.3 and 2.4 for more details). Section 2.1.1 illustrates the cumulative benefit of using a range of habitat and connectivity measures, as well as risk management process to reduce threats. Section 2.1.2 goes into more detail on the factors the Panel sees as important for success if koalas are to be kept across the landscape, and Section 2.1.3 provides a scenario framework for mitigations, in the light of possible future outcomes of choices - related to: the securing safe and efficacious crossings across Appin Road; and the implementation of exclusion fencing along corridors.

2.1.1 Approaches whereby koalas remain in east-west corridors

The Terms of Reference for the review, requests in part, that the Panel to provide advice on “*whether east-west corridors linking the Nepean and Georges Rivers can contribute to the conservation of the Campbelltown koala population*”. The identified corridors are shown in Figure 5.

Access to increased (or retained) koala habitat has *prima face* benefits for koalas, however, key is whether the retained habitat is managed in a way that exposes koalas to the increased threats that urbanisation will bring to the region (traffic and dogs), or whether the installation, upkeep and management of mitigation measures will occur so that the koalas are separated from these threats in perpetuity.

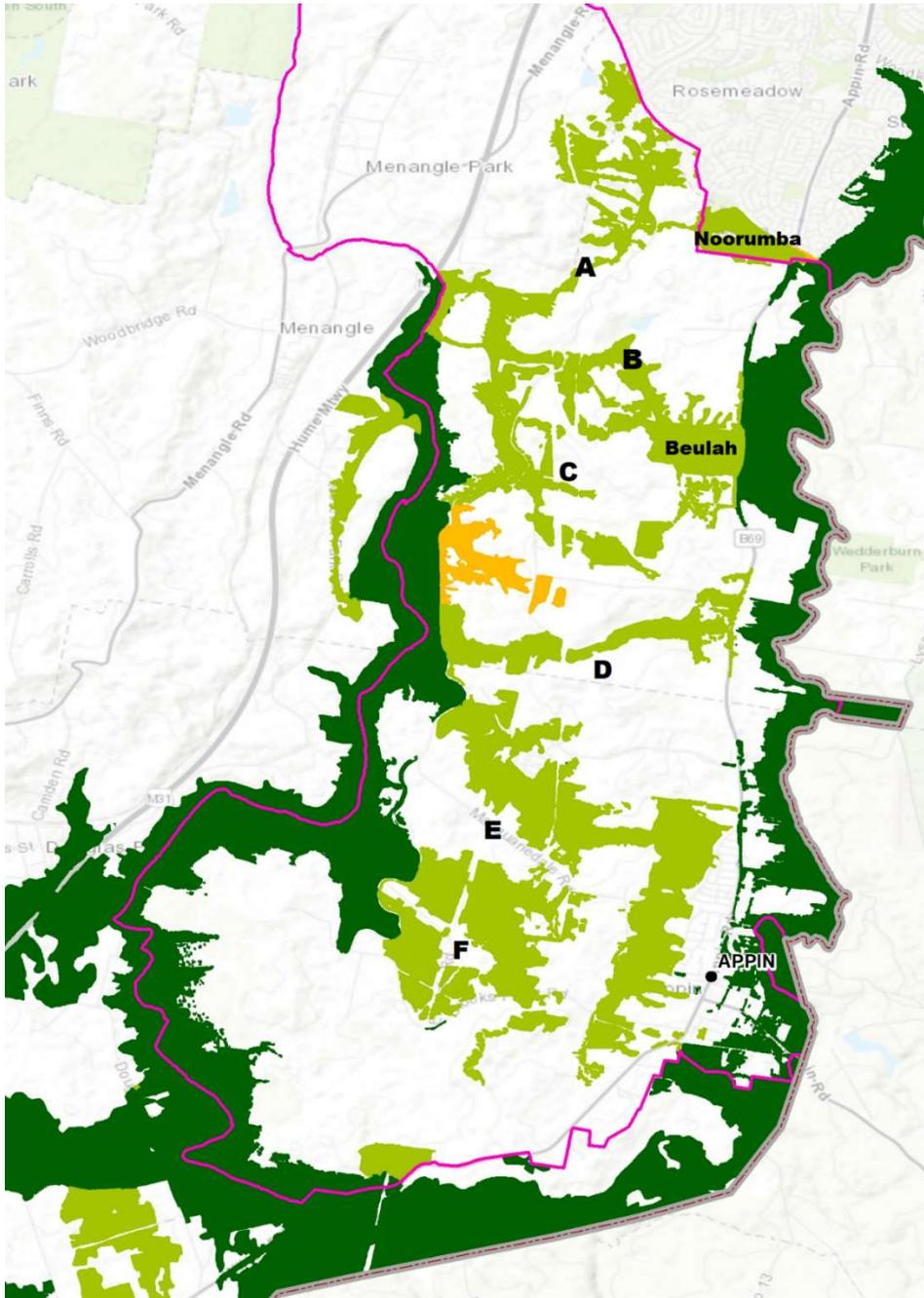


Figure 5: Potential wildlife corridors connecting Nepean River to Georges River

A) Menangle Creek to Noorumba B) Woodhouse Creek to Beulah C) Nepean Creek to Beulah D) Mallaty Creek to Georges River E) Ousedale Creek to Appin North F) Elladale Creek and Simpsons Creek to the colliery
 Source: DPIE (2020e)

If the removal of key risks cannot be accomplished, then the better management approach would be to monitor the impacts on the koala population and if it declines then consider active management which could include moving koalas between sites for breeding or relocation to safe areas, etc, preferably in the local region where there are ‘safe’ places. However, if separation from threats can be achieved in the landscape and maintained over the long term, then the better outcome for the koalas, and other flora and fauna, would be to retain the east-west corridors.

The scenarios in Figure 6 provide options based on the willingness of stakeholders to invest in ongoing threat mitigation infrastructure and management approaches and the likely impact on the koala population.

2.1.1.1 Koalas remain – east-west corridor and north-south corridors

Error! Reference source not found. illustrates the range of planning mitigations that can be deployed with increasing effectiveness. All options assume exclusion fencing on both sides of Appin Road.

- **Pathway 1** - habitat is protected, but there are not crossings over or under Appin Road and corridors are not fenced – as a result koala numbers would decline due to reduced connectivity and increased threats.
- **Pathway 2** - habitat is protected and there are utilised connectivity structures (e.g. underpass) at Appin Road, but there is not exclusion fencing for the corridors. Koala numbers would still decline as dog and car threats are still in place without exclusion fencing within the developments.
- **Pathway 3** - habitat is protected, there are connectivity structures for Appin Road and exclusion fencing protects the corridors. The Panel believes this would maintain koala numbers at approximately current levels.
- **Pathway 4** - includes the interventions for 3, but also includes active management within the fenced koala habitat area, including removing any dogs that enter the fenced area, monitoring and managing disease, identifying and addressing specific stressors in the area from light and noise. The Panel believes that this approach above all would lead to growing koala numbers in the region.

Each of the pathways has certain risks that rise or fall as you move down the figure with increasing efforts. Risks include the cost of fencing installation and upkeep; risks to koalas from dogs and cars; risks that certain pathways across Appin Road cannot be secured. These issues are discussed more in Section 2.1.2 and a high-level adaptive management approach to the implementation of these mitigation choices is set out in Section 2.1.3, with adaptive management of the ongoing operations described in 2.1.4.

The location of the Campbelltown koala population in the GMGA, including within the existing national park and protected areas, the habitat in the proposed Mount Gilead development, biobank sites such as Beulah, habitat in the CPCP area, are all connected. In managing this region, these locations and the movement of koalas needs to be thought of holistically – a koala moving from the Georges River corridor could end up in either the Mount Gilead or CPCP domains, illustrating that in respect of the koala population the areas can be seen as one.

Such holistic management requires planning for connectivity, monitoring that occurs in one area being comparable with that in the other areas, and adaptive management approaches designed and implemented with consideration of the region as a whole.

Understanding the function that corridors, ‘stepping-stone habitat’¹³ and patches have in enabling koalas to move through the landscape is important. Biolink (2018) undertook an analysis for Campbelltown City Council, using a least-cost modelling approach, to model likelihoods of how koalas would move between the Georges and Nepean Rivers. The use of the modelling assists with planning and management decisions and can be further enhanced when it is underpinned by koala monitoring data.

¹³ Discontinuous areas of habitat such as paddock trees, wetlands and roadside vegetation (DIPNR, 2004)

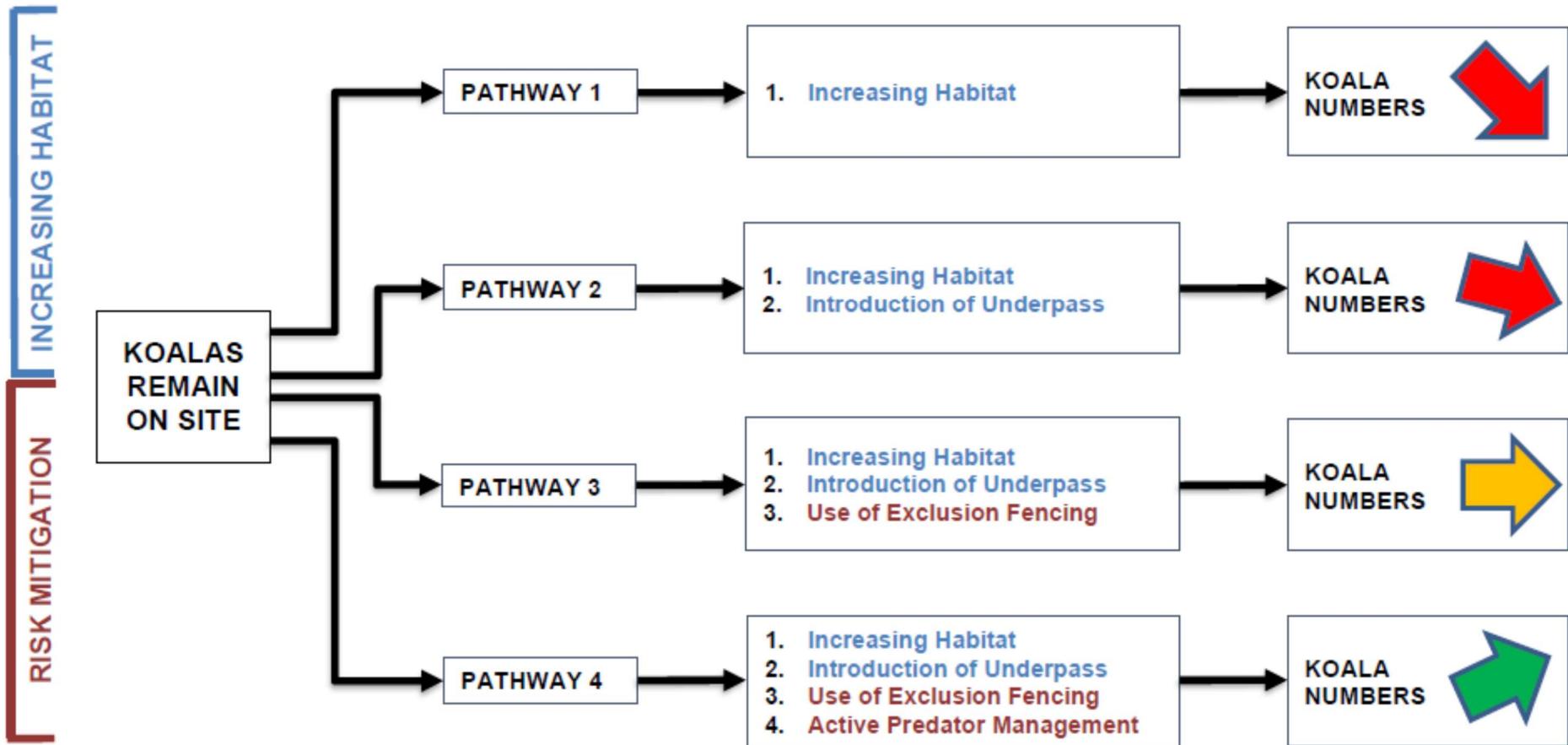


Figure 6: Mitigation options and impact on koala population

2.1.1.2 Preventing the northern end of the Nepean River Corridor from being a population sink

In preserving koala habitat, being mindful of the potential risks of some landscape structures is important in decision making. Ensuring, as far as possible that habitat is connected to other habitat in multiple directions, and that the presence of koalas in the habitat does not expose them to risks. A negative outcome would be for habitat to be preserved as a dead-end, and the dead-end habitat to be open to threats such as accessible roads or predatory dogs; this scenario creates a population sink where koalas continue to move into the habitat, only to be killed by threats, creating a koala vacancy and therefore enticing more koalas to move in.

This illustrates the importance of maintaining the koala corridors through the Mount Gilead site. The Nepean River north-south corridor has been identified in the CPCP as a 'primary corridor' through the landscape, running from the south near Wilton, along the Nepean River in the GMGA, and functionally ending adjacent to or in the Mount Gilead site. Maintaining a functional corridor through Mount Gilead to the Nepean means that koalas moving north along the Nepean River do not reach a dead-end, which can present risks of a population sink, or a lack of escape routes should fire move along the Nepean corridor. Mount Gilead offers an easterly escape route, but also an efficient route to maintaining genetic connectivity with the other members of the Campbelltown koala population near the Georges River corridor (including in the proposed Georges River Koala Reserve).

2.1.2 Planning for the long term, and dealing with uncertainty

The whole program of works and development in the region is scheduled to occur out to 2056, and with cycles of planning of urban facilities, development and construction, habitation and repeating those cycles for different locations and infrastructure. The approach of undertaking regional planning upfront and on the broad scale through the CPCP and for Mount Gilead is beneficial in that it allows restrictions and requirements to be established now in planning policies and approval conditions that can help improve outcomes for natural assets and environmental values across a wide area of land.

However, nothing is guaranteed, and both chronic and acute threats can emerge in a landscape to deteriorate the situation for koalas. There will be uncertainty about what hurdles will emerge in implementing a proposed pathway forward, and unforeseen events are also possible; these uncertainties will present challenges to decision makers and land managers.

Therefore, the Panel recommends using principles of adaptive management for koalas (and other species) in the GMGA, with a program of monitoring (including baseline) of koalas, threats and habitat put in place. Monitoring indicators can serve functions of tracking long-term conditions of the koalas in the landscape (health, demographics, presence/absence) and monitoring leading indicators such as immediate threats that need to be responded to.

The long term and ongoing program of urban development, out to 2056, will result in future unknown events and risks, and possibly opportunities, so scenario planning and mitigation options should be a core component of adaptive planning for preparedness and resilience.

The Panel has been provided with some early conceptual layouts and designs for the proposed development in MGS1 (approved) and MGS2 which is a focus of this report. This includes information such as MGS2 documents, calculations of carrying capacity and illustrations of a koala connectivity structures (Figure 7). The Panel has also been provided with draft CPCP documentation, including the overarching plan, koala subplan, monitoring subplan, etc.

There are a number of definitive findings and recommendations that the Panel has made, and also a set of options that could be considered, depending on the success of a range of proposed approaches. These options are set out in the following Section 2.1.3 for both the

MGS2 and CPCP areas. The section has been developed to inform adaptive management decisions during the planning and implementation phase of the urban developments in the GMGA, including the proposed MGS2. A key factor in which scenario emerges will be whether and where functional connectivity can be secured across Appin Road, and whether exclusion fencing can be widely rolled out to separate koalas from threats in the east west corridors.

Key to minimising interaction of koalas and threats will be the installation of barriers between koalas and the risks from cars and dogs, which can be achieved by using koala exclusion fencing. Connectivity will be ensuring the long-term stability of the koala population and providing for safe crossing structures above or below Appin Road is key to this.

Table 2 sets out a summary of the proposed protections for both the MGS2 development and the CPCP at the early planning and development phase. The Panel is aware that there are constraints (financial, geographic etc.) that are being considered, and these are reflected to some extent by the scenarios presented by the Panel. As described above, minimising the exposure of koalas to direct and indirect threats is a key issue and this will be most effectively enabled through koala exclusion fencing. However, the Panel does note that the installation and ongoing maintenance and replacement of koala fencing is not a trivial expense, with rough estimates by the Panel of \$400,000 per kilometre (net present value) for installation and maintenance (Santika et al., 2015; Horsfall, 2017)

2.1.2.1 Adaptive management approaches for the development & construction phase at Mount Gilead

Documents for the proposed MGS2 (Biodiversity certification report and supplementary material) and the draft CPCP present approaches for implementing habitat protection and managing risks. These are summarised in Table 2. A full description of the corridors, protection measures and panel comments are at Table 5. These include protection and improvement of habitat in the local area, deployment of some exclusion fencing for corridors and roads as part of the CPCP, post and rail fencing with buffering for MGS2, and two Appin Road crossings for MGS2, and at least one Appin Road crossing for CPCP.

In relation to the establishment of crossings for Appin Road, preferred methods and locations for crossings have been identified, however the Panel notes:

- there is uncertainty for MGS2 as to whether the koala crossing ridge to Noorumba will be used by koalas, or whether alternative crossing structures at Noorumba can be implemented that koalas may be more likely to use (see Section 2.3)
- for MGS2, further certainty is required about the planned crossing adjacent to Beulah across Appin Road. This is a very important component of the east-west corridor and ensuring there is no sink at the top of the Nepean corridor.

Table 2: Summary of mitigation and protection measures

Corridor	Biodiversity certification area	Current proposals
Georges River Corridor	CPCP	Fencing Appin (East, West), establishment of Georges River Koala Reserve, pre-clearance fauna protocol developed and monitoring of performance measures
Nepean River Corridor	CPCP	Fencing, strategic conservation area, Nepean and Medhurst offset site, pre-clearance fauna protocol developed and monitoring of performance measures
Corridor A Menangle Creek to Noorumba	MGS2	Protected by biodiversity offsets; tree-top bridge across Appin; post fence, two creek crossings, possible third across transport corridor, elevated bridge with over 10m clearance, pre-clearance fauna protocol developed and monitoring of performance measures, Noorumba Biobank Site (part of corridor)
Corridor B Woodhouse Creek to Beulah	MGS2	Protected by biodiversity offsets; koala underpass under Appin road; post fence east side and west side; multi-use buffer east side, revegetation programs, Woodhouse creek biobank site, pre-clearance fauna protocol developed and monitoring of performance measures, Beulah Biobank Site
Corridor C Nepean Creek to Beulah	MGS2/ CPCP	Habitat conserved, fenced on the south side
Corridor D Mallaty Creek to Georges River	CPCP	Habitat conserved, fenced to keep out koalas
Corridor E Ousedale	CPCP	Habitat conserved; koala fencing for threats; revegetation in some areas, cross Appin Road to be considered, land purchases considered to complete corridor
Corridor F Elladale Creek and Simpsons Creek to the colliery	CPCP	Habitat conserved, koala fencing for threats; revegetation in some areas,

2.1.2.2 Panel suggestions

MGS2 Scenarios

MGS2 Scenario 1 is the preferred approach of the Panel.

MGS2 Scenario 1 assumes connectivity structures across Appin Road (facilitating access to habitat) are achievable and are used by koalas (proposed tree-top bridge at Corridor A and the proposed Corridor B underpass as shown in Figure 7 is constructed) and there are no constraints on the ability to deploy and upkeep koala fencing:

- **Georges River Corridor** - koala fencing installed and maintained along both sides of Appin Road, connectivity structure within the corridor (at the bridge over the Georges River on Appin Road)
- **Nepean River Corridor** - koala fencing installed and maintained between Nepean corridor and development to the East; Picnic area with koala fencing
- **Corridor A** – protected habitat; tree-top bridge across Appin Road is feasible and is utilised; koala fencing both sides of the corridor’s full length, in particular where adjacent to dwellings

- **Corridor B**- protected and restored habitat; koala underpass under Appin Rd adjacent to Beulah proceeds and is successfully used by koalas; Corridor B should be wider, there should be a 30 m buffer both sides of Woodhouse Creek, and exclusion fencing at the edge of the buffer with the use of grids and gates within fencing to allow people to enter; using koala feed tree planting close to koala exclusion fence with care taken that falling limbs do not damage the fence. The APZ should not be in the habitat buffer, but should be on the development side of the exclusion fence and in the development footprint; Traffic speed limit 50 km/h.

Panel suggestions in Scenario 1 above may not be feasible, if the koala bridge approach across Appin Road at Corridor A is not utilised (there is no evidence that koalas use tree-top bridges), if no other Appin Road crossing at the Noorumba Reserve can be executed, if there are issues with developing a crossing at Beulah Biobank, and also if the CPCP crossing at Corridor E cannot be realised. Scenario 2 presents a potential way forward in response to these challenges.

MGS2 Scenario 2 assumes fencing is unrestricted and can be used where needed, but Appin Road connectivity is not achieved in the north of the Mount Gilead site near the Noorumba Reserve. Connectivity is assumed across Appin Road at Beulah Biobank – although the MGS2 BCAR indicates that this fauna underpass is subject to on-going consultation with the Department and TfNSW, the Panel sees it as vital to maintain an east-west corridor at the northern end of the Nepean Corridor.

- **Corridor A** habitat protected; tree-top bridge across Appin is not utilised by koalas, then the development of an underpass or culvert under Appin Road, or a gantry bridge above Appin Road (see Mona Vale example) should be explored, and these supported by other devices such as grids in the road to stop the movement of koalas around fencing. If a crossing is still not achievable over Appin Road, then the koala population in Noorumba Reserve would be functionally isolated in fragmented habitat, so koala fencing both sides of Corridor A should be installed as far along the corridor as possible, within which the koala population should be actively managed including breeding or relocation of koalas to manage genetic diversity.
- **Corridor B** habitat protected; koala underpass under Appin Rd adjacent to Beulah and koala fencing both sides of corridor B is deployed; koala buffer both sides of corridor: buffer width = 30 m additional to the corridor, with koala feed trees planting in the buffer zone close to the exclusion fence, with care taken that falling limbs do not damage the fence. APZ in the development area. If there are locations along the corridor that cannot be protected with exclusion fencing because of steep terrain, then a wider buffer should be deployed (~60 m) using non feed trees, and with Traffic speed limited to 40 km/h in that area. Extra planting required to the exclusion fencing, including koala buffer would contribute to the additional koala habitat credits required by the proponents (See Section 2.2). If connectivity between the north end of Corridor B and Nepean Corridor (at Menangle Creek) is temporarily closed to koalas or not utilised by koalas in the term, the Corridor C should be considered for connection to Nepean.
- The habitat between Noorumba Reserve and Nepean River is no longer assumed to be useful koala habitat, so the picnic area adjacent to the Nepean would be replanted with koala feed trees to help address this habitat reduction.
- While the BCAR indicates Beulah underpass is being considered, this is such an important crossing that the Panel believes it needs to go ahead for this to be an effective corridor. Otherwise there would need to be a largescale long-term active management protocol for the area.

CPCP Scenarios

Key points

- for the CPCP area, there is uncertainty as to whether an Appin Road crossing is achievable in the vicinity of Appin village (linking corridor E);
- for CPCP, can an alternative location be secured such as corridor D, where there appears to be better access to the roadway;
- further consideration on work to ensure koalas can cross under Appin Road further south within the Georges River Koala Reserve (at bridge over Georges River).

CPCP Scenario 1 assumes Crossing at Appin road as underpass at Corridor E.

- **Georges River Reserve** - Koala fencing installed and maintained along both sides of Appin road; Connectivity structure developed within the corridor at Georges River (Kings Falls Bridge) east of Appin township.
- **Nepean River corridor** - Koala fencing installed and maintained between Nepean corridor and development to the East;
- **Corridor C** - habitat conserved; fence along both sides to keep out threats.
- **Corridor D** - Habitat protected until and unless Corridor E underpass is secured, and linkage is constructed and vegetated and used; koala fencing along Appin road and Nepean keeps koalas out of corridor;
- **Corridor E** - Habitat protected; koala fencing for threats; crossing under Appin Road secured and utilised;
- **Corridor F** protected; koala fencing for threats; replanting undertaken.
- Exclusion fencing both sides of Corridors E and F with koala buffer both sides of corridor use of grids and gates within fencing; buffer width = 30 m each side (total 60m) using koala feed tree planting up to koala exclusion fence, with care taken that falling limbs do not damage the fence. APZ extends from exclusion fence additional into the development footprint. Traffic speed limit 50 km/h.

The Scenario 1 particularly differs from the proposed approaches by the MGS2 proponents and the CPCP drafters including:

- use of exclusion fencing (not post and rail) between development and koala habitat in Mount Gilead;
- differentiation of the concept of APZ (to protect houses from fire), and habitat buffer (to protect habitat and koalas from stressors and threats from development), with the APZ starting at the exclusion fence and in the development footprint;
- monitoring and adaptive management strategy (including the assessment of whether or not installed mitigations are functioning as required)
- in the CPCP Area, Corridor D to be protected until and unless a connection structure across Appin Road for Corridor E can be developed and is used by koalas.

CPCP Scenario 2 assumes Appin Road crossing occurs at Corridor D, and is not feasible in the south near Appin for Corridor E. As with all scenarios, it is assumed that Georges River Koala Reserve north-south Corridor has exclusion fencing installed and maintained along both sides of Appin Road including at Kings Falls Bridge, and there is koala fencing installed and maintained along the Nepean corridor facing development to the East.

Corridors in the CPCP have an equivalent approach to buffers and APZ as occurs in the MGS2, where koala buffer is 30 m wide additional to the corridor reaching to the exclusion fence, and the APZ is distinct to the buffer on the road/development side of the exclusion fence. If there are locations along the corridor that cannot be protected with exclusion

fencing because of steep terrain, then a wider buffer should be deployed (~60m) using non feed trees, and with traffic speed limited to 40 km/h in that area.

- **Corridor C** protects as much habitat connected to Beulah as possible. Corridor C should be re-examined for maintaining connections to Nepean Corridor if the MGS2 connectivity at the Menangle Creek and Nepean River confluence is compromised with road infrastructure.
- **Corridor D** is designated as the main east-west connection in the CPCP and an underpass linkage is constructed and vegetated and used by koalas; fence along both sides of Corridor D to keep out threats.
- **Corridor E** protected habitat; koala fencing for threats; managed population to ensure healthy genetics of the koalas and ongoing exclusion of threats.
- **Corridor F** protected habitat; koala fencing for threats; managed population to ensure healthy genetics of the koalas and ongoing exclusion of threats.

CPCP Scenario 3, where crossings under Appin Road are not feasible; assumes Georges River koala fencing installed and maintained along both sides of Appin Road, and the Nepean Corridor. Koala fencing installed and maintained along the Nepean corridor facing development to the East.

- **Corridor C** protects as much habitat connected to Beulah as possible.
- **Corridor D, E and F** where underpass crossings at corridor D and E are both not feasible (or ineffective if bridge crossings are deployed but not used). In this case the populations in Corridors E and F need to be actively managed for breeding, genetics and population growth using translocation from the Georges River Koala Reserve, and active management to ensure habitat availability and exclusion of threats.

2.1.2.3 Further infrastructure development and property construction

It is understood that over the coming decades, further development of the region is envisaged to deliver housing, town centres, utilities and services to the community, this includes development of roads and transport corridors that may run parallel to corridors, or may cut through corridors (Figure 1).

In the case that lineal infrastructure is planned that runs parallel but outside a corridor, then consideration should be given in the planning, construction and operational phases to increased influence of light and noise. Relevant mitigations should be put in place with suitable time prior to construction along corridors, and monitoring put in place to measure the intensity of the stressor and the impact on the local koala population. The approach to managing koalas during construction will also depend on whether it happens in a graduated way in stages or all at once.

It is noted that the MGS2 proponents are planning the use of best practice guidelines for construction. A construction management plan and a Koala management Plan would be developed and approved through a Commonwealth process

For infrastructure that cuts across corridors temporarily, this should be taken into account in the planning, and mitigations put in place, such as through the building phase. Prior to the construction phase, koalas may be required to be nudged out of the area, or temporarily relocated to another location potentially a sanctuary.

Infrastructure that will cut across a designated corridor should include underpass or overpass structures to enable the movement of koalas along the corridor, with suitable fencing, light and noise barriers put in place early enough through the process so that it is at scale by the time the infrastructure is constructed.

2.1.3 Adaptive management approaches for the operational phase

On-going monitoring of leading and training indicators will be required to understand the success of mitigations, and the response to the koalas of these efforts. Trailing indicators such as koala presence/absence, and koala health (genetics and disease) will monitor the impact of development on the local koala population.

Some leading indicators can be set up as triggers to inform when further mitigations need to be considered – additional fencing, noise or light barriers, communication to residents, road furniture, or more than consideration should be given to translocating koalas to a dedicated managed location or alternative site.

Performance indicators and triggers can be used to inform when additional mitigations are needed, and expert advice should be sought. Further scenario planning should also occur.

Mitigations such as active management are feasible (described in Section 2.1.4), and potentially lend themselves to the development of a local koala or wildlife sanctuary, which could bring additional tourism and/or research benefits. Translocation of koalas out of the area could also be a long-term option, if the population does not thrive and that becomes the preferred approach. Further discussion of adaptive management approaches in Section 2.1.4.

2.1.4 Active koala management - if koalas are to remain in fragmented patches

A significant threat to isolated or near-isolated populations of koalas could include unforeseen problems of over-browsing (associated with reduced habitat and low dispersal rates) and low genetic diversity leading to inbreeding depression. There may therefore be a greater need for a strategic approach to the management of these potentially isolated koala populations, or those that are at greater risk of becoming isolated due to urban sprawl and development. The active management of koalas in such scenarios may afford for the opportunity to manage populations to ensure genetic diversity and resilience.

An active management approach may involve the monitoring of disease, checking the genetic health of the population, possible relocation of koalas for breeding and the captive management of sanctuaries to provide a long-term insurance population. Here, in this captive management scenario, the koalas would not be able to roam freely and there would be on-ground action for the maintenance and restoration of their enclosed habitat, with breeding by arrangement and informed by genetics. The NSW Koala Strategy is consistent with this approach and suggests the relocation of koalas to unoccupied koala habitat, which may include habitat sectioned as conservation sanctuaries (NSW Government, 2018).

The Mulligans Flat is an example of a strategic active management approach to wildlife conservation. The Mulligans Flat and Goorooyanoo Nature Reserve are two adjacent nature reserves located on the outskirts of Canberra. These reserves are a part of a national effort to conserve endangered woodlands and were set up by the ACT Government to protect box-gum woodlands around Canberra. Together, they total 1,623 ha of land and contain 1,146 ha of Yellow Box – Blackely's Red Gum Grassy Woodland, which represents some the largest protected areas of Yellow Box – Blackely's Red Gum Grassy Woodland in the ACT (Woodlands and Wetlands Trust, 2020).

In 1994, Mulligans Flat was established as nature reserve in a bid by the ACT government to protect the area in response to increasing residential development. In 2002, the Mulligans Flat – Goorooyarroo Woodland experiment arose in direct response to the Woodlands for Wildlife ACT. The Lowland Woodland Conservation Strategy Action Plan was announced that ensured the active recovery and protection for the Yellow Box-Red Gum Grassy Woodland (endangered ecological community) present in the nature reserves (Shorthouse et al., 2012).

The two reserves required restoration interventions to ensure their long-term ecological function and protection of this critically endangered ecological community. The Mulligans Flat – Goorooyaroo experimental restoration project was established as a collaboration between ACT government researchers, ACT government land managers and university researchers. The project was designed to integrate a restoration project with research in a highly accessible way (Shorthouse et al., 2012). The key aim of the project is to restore critically endangered grassy box-gum woodland that has degraded over time. The area has a strong previous history (over 150 years) of livestock grazing, patch cropping, pasture improvement and removal of timber for fencing, firewood and reducing rabbit harbour, which has altered soil condition, contributed to species decline, changed the vegetation structure, introduced weeds and eroded water courses. Furthermore, native plant recovery has been hindered due to grazing pressure by increased eastern grey kangaroo presence in response to urban development within the region. These combined and accumulated effects have led to a declining wildlife population within the nature reserves, and in some cases, local extinctions(Shorthouse et al., 2012).

The research component of the project also provides an opportunity for gaining insight into the efficacy of the range of restoration techniques used in the project and answering some theoretical questions posed. In 2010, baseline data was recorded, and initial treatments implemented. The experiment involved systematic trialling of a range of treatments that could provide insights into the complexities of rehabilitation. By doing so, an adaptive style approach could be taken whereby refinement of management approaches could occur based on the experimental outcomes. In brief, the experimental design involved the identification of 24 areas of vegetation, within which four 1 ha ‘sites’ were established. These 96 sites were subjected to a range of management treatments and contain ‘plots’ where the monitoring is undertaken. The treatments included; exclusion of kangaroo grazing, addition of deadwood, prescribed burning, varied tree and shrub densities and the exclusion of bettong digging in Mulligans Flat (Shorthouse et al., 2012).

The project is ongoing and has made considerable progress to date. There has been a positive response from invertebrates (Barton et al., 2011) and reptiles (Manning et al., 2011). Ground layer vegetation also showed signs of recovery as well as the effective eradication of foxes, cats and rabbits. The successful reintroduction of the first Eastern Bettongs seen in a wild situation on the mainland for over 80 years was undertaken as well as the reintroduction of the New Holland Mouse. Along with the active management of the nature reserves, evidence from the ecological research will continue to inform and exert some influence on the ACT Parks and Conservation Service’s land management policies and programmes (Shorthouse et al., 2012).

2.2 OFFSETS AND PROTECTED HABITAT

Offsets are designed to provide a compensatory mechanism for the negative environmental or biodiversity impacts of development at one site, which cannot be avoided or minimised further, to be offset by positive activities at another site. Offsets otherwise known as biobank sites (TSC Act) or biodiversity stewardship sites (BC Act) are a last resort mechanism to protect, in this case koala habitat, in perpetuity. Based on the area and type of impact an assessment method is used to determine the level of offsetting required. When acquiring species or ecosystem credits under this system, they can be obtained state-wide, and do not need to fall within the locality of the development.

Table 3 provides an overview of the proposed offsetting measures in MGS2 and the draft CPCP and provides panel commentary on those measures.

Table 3: Proposed offset measures in MGS2 and CPCP

Plan	Proposed Measures	Panel comment
Mount Gilead Stage 2 Development	<p>The BCAR states that there would be direct impact to 332.17 ha of the assessment area. 201.81 ha of habitat will be permanently protected and managed for conservation. Of this, 197.46 ha would generate ecosystem credits and the remaining 4.3 ha would be red flag vegetation conservation area buffers. These would be conserved through the five registered Biobank sites on site (Browns Bush, Mount Gilead Homestead, Woodhouse Creek, Nepean and Medhurst sites).</p> <p>1,901 species credit for the koala are required, the five Biobank sites generate 1,202 credits. This leaves a deficit of 699 koala credits. This would be met by the purchase of additional credits from registered biobank sites in the region or via the Biodiversity Conservation Trust.</p>	<p>Preference for local offsets to ensure protection of koala habitat for the Campbelltown population. However, given the 2019/20 bushfires protection of koala habitat in areas to recover koala populations is also of key importance.</p>
Cumberland Plain Conservation Plan	<p>Establishment the Georges River Koala Reserve. The Office of Strategic Lands owns 60% of the land and is establishing BSAs over some of its holdings.</p> <p>The Office of Strategic Lands will manage the voluntary land acquisition program under the plan and once all land is acquired, will establish BSAs to generate biodiversity credits that will be used to cover costs associated with future management of the reserve. Ownership and management of the reserve will be transferred to the NSW National Parks and Wildlife Service.</p> <p>Around 6,000 ha of important koala movement corridors and habitat have been identified within the strategic conservation area that are candidates for reservation or BSAs.</p>	<p>The strategic certification under the CPCP has no requirement for 'like for like' and provides a flexible offsetting arrangement whereby the proponent can propose an alternative conservation measure, that the Minister agrees <i>adequately</i> addresses impacts on biodiversity values.</p> <p>The Panel notes that adequate should meet the objective of the NSW Koala Strategy.</p>

2.3 CORRIDORS, CONNECTIVITY AND MINIMISING EDGE EFFECTS

A wildlife corridor is a stretch of habitat that joins two or more areas of similar habitats. They can be in the form of a sequence of stepping stones across the landscape or as a continual lineal strip of vegetation and habitat (DIPNR, 2004). As habitats are increasingly cut off from each other due to various contributing factors including urban development, corridors play an important role in partially compensating for habitat loss and fragmentation by linking habitats and helping to maintain ecosystem health

It is critical to ensure connectivity between important patches of koala habitat. Large connected areas linking various koala habitats sustain populations by facilitating dispersal of populations, supporting breeding, providing resources for feeding and protecting against localised extinctions (NSW Government, 2020c). Ensuring as far as possible that the habitat has multiple connections can help to prevent the formation of dead ends and population sinks and ensure that koalas (and other species) have routes to escape threats such as bushfires.

Vehicle strike is a major cause of death for koalas in Campbelltown, with hotspots identified on Picton Road between Cordeaux Dam and Wilton, Macarthur Drive, Easter end of Wilton Road, Appin Road between Appin and Campbelltown and the Hume Highway at the Bargo

exit (DPIE, 2019c): These identified hotspots occur where a major road intersects a primary koala corridor, typically at the headwaters of a watercourse.

Factors that make koalas so susceptible to vehicles strikes include their inability to recognise roads and traffic as a potential threat, making them likely to crossroads, even in dangerous environments. Furthermore, koalas are a highly mobile species prone to dispersal, increasing the likelihood of them crossing barrier in search of areas of new habitat and because they are largely nocturnal, their visibility to motorists whilst crossing roads is low (Biosis & Open Lines Environmental Consulting, 2020). The highest proportion of vehicle strikes have been found to be juvenile koalas, with a strong male-bias, indicating their vulnerability from dispersal.

Exclusion fencing and the establishment of underpasses (e.g. Figure 7) or overpasses (e.g. land bridges) are required to protect wildlife and ensures connectivity between habitats and reduces interaction with busy highways. In Australia, the Pacific Highway upgrade in Ballina¹⁴ and the Compton Road widening project in Brisbane¹⁵ are examples where connectivity structures have been utilised to protect koalas and other species of mammals and reptiles. The movement of koalas can also be impeded by other man-made infrastructure (e.g. the Upper Canal, easements along the gas supply line and transport corridors). Although exclusion fences and under passes require ongoing maintenance, they are considered the most effective roadkill mitigation measure on major roads.

¹⁴ The Woolgoolga to Ballina Pacific Highway upgrade includes a Koala Management Plan with commitments from Transport for NSW towards no koala road-kills occurring as a result of the upgrade. The three main mitigation measures resulted in koala-proof fencing along the length of the upgrade, twelve culverts under the upgrade, and koala food tree plantings. Monitoring programs in 2018 and early 2019 indicated that apart from koalas, several species were also using these culverts (Sandpiper Ecological Surveys, 2019)

¹⁵ In 2004, Compton Road that traverses through large bushlands in Brisbane was upgraded from two lanes to four. In order to mitigate the impacts to local fauna, Brisbane City Council constructed infrastructure which included glider poles, rope ladders, fauna-friendly culverts, escape poles and exclusion fencing (Brisbane City Council, 2020). The fences were designed in such a way that it acts as a funnel directing wildlife towards these crossing structures. 18 species of mammals including koalas, kangaroos, wallabies, bandicoots, birds, echidnas, frogs, skinks, snakes, lizards etc. were recorded as having used the connectivity infrastructure (Griffith University, 2020)

GILEAD STAGE 2



Figure 7: Proposed bridge at Noorumba Reserve (top right) and underpass (40 m wide) at Beulah Reserve (bottom right) at Appin Road

Source: Lendlease

Note: The bridge has not been proven effective for koala crossing.

The Division of Environment, Energy and Science, within the Department identified the most important connections of koala habitat in the Campbelltown and Wollondilly region and defined these as primary, secondary or tertiary corridors (Table 4 and Figure 4). The process to identify the corridors and further information on them is in the *Conserving koalas in the Wollondilly and Campbelltown Local Government Areas* report (DPIE, 2019c).

Table 4: Types of corridors defined by the Department

Source: DPIE (2019c)

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

Biolink calculated the optimal average corridor width for koalas in Campbelltown to be 425 m. This is based on the home range size requirements for female koalas and the region's low carrying capacity (Phillips, 2018).

Eco Logical notes that studies indicate that the 425 m width is an overestimate of the width required for female koalas, and that Biolink has undertaken its calculations based on female koalas having a home range that is circular in shape. Eco Logical notes a study by (Lunney et al., 2010) that identified various home range shapes of koalas in the region including long narrow home ranges. Additionally, with regards to the 425 m corridor width, Eco Logical also notes the Biolink statement that it is *“evident from available studies in CCC LGA that koalas will use areas with a narrower width than this”* (Biolink, 2018).

There are two primary corridors that have been identified, the Georges River and Nepean River corridors. There are six secondary corridors identified in the GMGA that have the potential to provide east-west connectivity between the Nepean and Georges rivers. These corridors are shown in and described in Table 5. Corridors A and B and part of Corridor C are within the proposed Mount Gilead development and Corridors C to F are part of the draft CPCP.

The assessment criteria for these potential movement corridors are (DPIE, 2020d):

- proximity of corridor to current and future infrastructure, and planned urban areas
- threat from other animals including domestic dogs
- corridor’s topography and vegetation
- extent of land unattractive or dangerous for wildlife to cross
- minimum width of corridor after setting aside land marked for development
- potential for wildlife crossing to be built across Appin Road.

It is noted in the draft CPCP that regardless of whether potential secondary east–west koala movement corridors are protected for koalas over the long term, native vegetation will be secured and enhanced under the CPCP, benefitting other threatened species and ecological communities. This also supports the possibility of securing and enhancing potential corridors such as Ousedale Creek to Appin North for koalas in the long term.

Urban development in proximity to fauna habitat has increased the potential ‘edge effects’ that species such as koalas experience. In this context, ‘edge effects’ has been described as the interaction as a result of a transition between two different ecosystems where the threats to fauna is most pronounced, such as that experienced in the Campbelltown region where clearing of native fauna habitat has created an ‘edge’ (also often referred to as the habitat perimeter) with, and interaction between, the anthropogenic land uses (such as agriculture and, increasingly, urban development) (Benitez-Malvido & Arroyo-Rodríguez, 2008).

Edge effects can include both direct (i.e. vehicle strike and dog attacks) and indirect (i.e. light and noise pollution, urban storm runoff) impacts on fauna and flora, and can result in altered behaviour (for example, changes in home ranges or in how species disperse throughout a landscape) that can have longer term repercussions. The magnitude of edge effects and how it impacts fauna residing within the habitat is primarily a factor of the remaining habitat area, and includes factors such as the smoothness of the border (i.e. jagged habitat borders can result in an increased edge:area ratio), the length of the ‘edge’ and the narrowness of the remaining habitat.

There are a number of strategies and methods that can mitigate the impact on koalas, particularly at the interface of urban and native environments. This includes, but it is not limited to, vegetated buffer zones and managed habitat areas, koala exclusion fencing (includes fencing at the interface to roads, but also around pools and yards), predator and pest management (including weeding programs), vehicle-strike mitigation measures (under- and overpasses, road grids, traffic calming devices and road design, signage, speed limits, etc.), and community awareness programs.

Panel comments

- Specific Panel comments on each of the corridors and proposed koala protection measures is at Table 5.
- With primary corridors along Georges and Nepean rivers, it is important to provide koala populations with the ability to move freely and safely along the east-west corridors to ensure genetic diversity and population dispersal.
- There is only a buffer on one side of the corridor in the MGS2 BCAR (Figure 9). The Panel views this is insufficient as koalas will need to have protection from threats on both sides of the corridor. Buffers, exclusion fences and APZ should be located on both sides of Woodhouse Creek, as the current proposed buffer zone in MGS2 is for the northern side of the Woodhouse Creek corridor only.
- The buffers in the proposed MGS2 development serve the dual purpose as a buffer for the Woodhouse Creek (and other) koala habitat corridor and as an APZ for the development, with infrastructure such as byroads and walking trails including in the outer buffer zone (Figure 10). The Panel sees the design as suboptimal as it permits threatening activities in close proximity to koalas with no barrier to interaction between the koala and the hazard. There is also the inclusion of stormwater retention ponds within the buffer zone.
- Buffer zones provide a mechanism to minimise edge effects – they reduce interactions between koalas and the urban environment. The Panel notes that buffer zones should:
 - provide separation between the built environment and other associated infrastructure (including roads)
 - be wider when it is not feasible to have an exclusion fence at the edge of the buffer
 - not include APZs (as per the SEPP Guidelines), particularly when subject to revegetation
 - not include roads, playgrounds and picnic areas
 - facilitate the complete avoidance of direct impacts (i.e. road strike)
 - mitigate the impact of indirect impacts, such as attenuating noise and light pollution from the urban development, for native species within the environment
 - prevent koalas moving into urban areas and prevent threat such as dog attacks
 - give consideration to the long-term maintenance of the koala habitat and any proposed mitigation strategies (such as fence maintenance in perpetuity)
- If there are not adequate measures to prevent koalas entering the urban environment, revegetation should discourage koalas utilising these buffer zones, this could be achieved by revegetating the buffer with native vegetation that include no koala preferential feed trees. In some locations such as steep terrain, exclusion fencing may not be feasible, and in these cases wider buffers would be required (~60 m), that don't include koala feed trees, and monitor for predators.
- The Panel also recommends that if the preferred method of koala exclusion fencing is used, the buffer zone should be revegetated with preferred koala feed and shelter tree species, with thought given to how far back from the fence line revegetation occurs to ensure that the fence is still effective and that treefall does not pose a risk to its integrity.
- There is also the opportunity to explore dog-free trails and double-gated entry points into the corridor.

Table 5: Primary and secondary corridors

Corridor	Name	Description	Proposed measures	Panel comments
Primary CPCP	Georges River Koala Reserve	<ul style="list-style-type: none"> allow koalas to move north-south, from Appin in the South to Kentlyn in the North. intended to protect and manage approximately 1,800 ha of koala habitat, out of which 800 ha of publicly owned land along the south-eastern edge of the Cumberland Plain has been announced as part of the future reserve. 	<p>CPCP</p> <ul style="list-style-type: none"> The program aims to deliver an additional 1,050 ha as part of the reserve and restore 250 ha as important koala habitat (NSW Government, 2020c). The high fertility shale and shale-influenced soils in the region will enable the restoration project to focus on plant community types such as grey box, grey gum, narrow-leaved ironbark trees that are preferred by the Southern Sydney Koala population (NSW Government, 2020c). Proposed measures to discourage koalas from crossing Appin Road is the instalment of koala exclusion fencing on both sides of the road in identified movement corridors with the aim of reducing fauna mortality. Measures described in Table 3 	<ul style="list-style-type: none"> Support fencing both sides of Appin Road to prevent vehicle strike Connectivity and threats should be considered within this corridor. Fencing should be placed on Appin Road and a connectivity structure be developed with the Kings Falls Bridge over the Georges River. Support the establishment of the Georges River Koala Reserve is extremely important to safeguard the vital koala population along the Georges River.
Primary CPCP	Nepean	<ul style="list-style-type: none"> Contains the remaining areas of Shale Sandstone transition forest along the Nepean River and its major tributaries provide the only other core habitat for koalas in these areas. This habitat is more limited in extent and linear in configuration. Supports significant numbers of resident koalas and is therefore vital to the persistence of the regional koala population (NSW Government, 2020c) 	<p>CPCP</p> <ul style="list-style-type: none"> Identified to be protected as a strategic conservation area 	<ul style="list-style-type: none"> The corridor should be protected, and connectivity to the east needs to be ensured to stop the development of dead ends/sinks
Secondary A Mount Gilead development	Menangle Creek to Noorumba	<ul style="list-style-type: none"> Connects northernmost point of the Nepean riparian vegetation, before passing under motorway and heading west to Razorback Creek is fourth order below aqueduct, and requires 40 m riparian buffer on each side Fauna crossing structure on Appin Road will need wide run- 	<p>Mount Gilead Development</p> <ul style="list-style-type: none"> Tree-top bridge across Appin Road to provide connectivity for koalas Noorumba Biobank Site (part of corridor) 	<ul style="list-style-type: none"> This corridor will provide little protection for koalas into the future if it is not fenced as it is very narrow with limited capacity to revegetate the buffer zone The proposed tree-top bridge is not likely to be adequate and would not be used by koalas. The feasibility of a pedestrian style bridge should be

		<ul style="list-style-type: none"> up, and will impinge on biobanked land on western side Menangle Creek main channel (northern stream) is third order below aqueduct and steep on the sides near southern tunnel entrance of the aqueduct Areas of vegetation are dominated by species other than Eucalypt (instream is <i>Casuarina</i>) After development, vegetated areas at higher elevations likely to be too narrow Middle section is crossed by two adjacent high-voltage powerlines and a gas main Addition of busway near gas main route will increase width of hostile land without trees 		<ul style="list-style-type: none"> considered to allow koalas and other fauna to cross Appin Road. If the crossing is not feasible, the koala habitat at Noorumba Reserve will be isolated and not function as connected koala habitat, therefore should be fenced off at Appin Road. In this case, the koalas within this fragmented area should be actively managed.
<p>Secondary B</p> <p>Mount Gilead development</p>	Woodhouse Creek to Beulah	<ul style="list-style-type: none"> Meets Menangle Creek at its western end (Corridor A) to become third order stream Third order section (north-south) is only 750 m; both streams above this confluence (Nepean and Woodhouse Creeks) are only second order, which means that riparian corridor is 40 m Remaining east-then-south connection to Beulah is a first order stream and requires only 20 m total width A gas main, power line and Upper Canal aqueduct cross the stream in close proximity The future busway may be located nearby leading to a wide hostile area in the crossing The total width of the riparian zone may be further narrowed by development 	<p>Mount Gilead development</p> <ul style="list-style-type: none"> buffers to mitigate negative indirect impacts on protected 'red flag' areas from development, including koala habitat and corridors. This buffer zone is broken down into a 15 m outer buffer zone (includes local road, residential dwellings, collector road, managed open space and landscaped stormwater detention basins) and a 15 m inner buffer zone (actively managed vegetated areas for conservation, as part of registered Biobank Agreement sites. The buffer zones will also serve as bushfire APZ and will include infrastructure such as stormwater retention basins and walking/cycling paths. a fauna underpass on Appin Road at Beulah Reserve. This is intended to reduce significant roadkill in the region. See Figure 7 two creek crossings (Woodhouse and Nepean Creek) and a possible third across a transport corridor, with each of these crossings having an elevated bridge with over 10 m clearance to ensure connectivity and movement (Eco Logical Australia, 2017). 	<ul style="list-style-type: none"> Corridor B has been identified as a priority koala corridor within MGS2, linking the primary koala corridor to the east of Appin Road to Nepean River corridor in the west, through Woodhouse Creek, Beulah Biobank site and Menangle Creek. Corridor B is a continuous corridor that has a mean width of 316 m, a minimum width of 100 m and no part of the corridor separated by more than 220 m (minimum distance between stepping stone habitat areas (Figure 8)). It is noted that previous studies identified a minimum width of 200 m, opportunities to widen this corridor should be explored With appropriate koala exclusion fencing and buffer zones (30 m each side of the corridor) this corridor should provide appropriate east-west movement for koalas at the northern

		An overpass is required at Beulah across Appin Road, with a wide run-up on either side	<ul style="list-style-type: none"> Beulah Biobank Site will link to the proposed Browns Bush Biobank site 	<p>end of the Nepean River and Georges River corridors.</p> <ul style="list-style-type: none"> Ongoing monitoring will be essential to the management of this corridor to ensure koalas are still utilising it and not coming into contact with direct and indirect threats. The underpass near Beulah Reserve, as proposed by Lendlease, should be constructed. Particular care needs to be paid to the design and construction of the habitat at the confluence of the Menangle Creek and Nepean River where a number of road bridges are planned, to ensure koalas will use the connection.
Secondary C MGS2/ CPCP	Nepean Creek to Beulah	<ul style="list-style-type: none"> Extends in a south-then-east direction, lower confluence to Menangle Creek Corridor extends southwards and then broad arc in north-east direction (upper end of Woodhouse Creek above Beulah) Flat topography means that development could create narrow corridor Power lines, gas line and proposed busway will create reasonably wide hostile area Very little vegetation over gas main crossing Difficult to create fauna crossing over Appin Road due to terrain 	<p>CPCP</p> <ul style="list-style-type: none"> Habitat is to be conserved Fencing on the south side (CPCP) 	<ul style="list-style-type: none"> This corridor will have a significant edge effect from the urban development surrounding all aspects of it.
Secondary D CPCP (second most)	Mallaty Creek to Georges River	<ul style="list-style-type: none"> Mallaty Creek is third order except for the eastern third where it is second order. At 5 km upstream of the Hume Motorway bridges, the creek meets the Nepean River in a deep gorge section. 	<p>CPCP</p> <ul style="list-style-type: none"> Habitat is to be conserved Fencing at eastern and western edges to prevent koala entry 	<ul style="list-style-type: none"> This corridor is suitable for koala movement and should be protected with exclusion fencing and additional buffer zones The corridor provides the second-preferred route if Corridor E cannot traverse Appin Road

preferred corridor		<ul style="list-style-type: none"> • Wide corridors up to 500 m at several points • Northern side of the creek well vegetated • Power lines, gas line and proposed busway will create reasonably wide hostile area • Very wide overpass structure needed at Belltrees Kennels, where Georges River is nearest to Appin Road • Aqueduct at western end crossing the creek will create a strong pinch-point for animals 		<ul style="list-style-type: none"> • While this section is well vegetated and nutritious, particularly at the north, and the corridor widens to 500 m at various points, higher-nutrient vegetation is limited at other areas. • The area is also traversed by power and gas lines, with a proposed busway bisecting the corridor. The western end where the aqueduct crosses the creek is also expected to be a pinch-point for animals (DPIE, 2020d).
Secondary E CPCP: preferred corridor	Ousedale Creek to Appin North	<ul style="list-style-type: none"> • Fourth order from an upstream confluence with Nepean River; becomes third order upon joining Lily Ponds Creek and therefore 80 m and then 60 m riparian corridor required • Power lines and gas corridors widely spaced, making hostile crossing narrow • Most well-vegetated among all options, with ample vegetation along either side of riparian corridor • Area of corridor considered to be less attractive prospect for development • Designing fauna crossing expected to be easier than other options • Busway is expected to be near the Lilly Ponds-Ousedale creeks confluence, but stream can be bridged easily • Location too far south to be useful for animals moving northwards 	CPCP <ul style="list-style-type: none"> • Habitat conservation and restoration in some areas • Fencing either side • Crossing options across Appin Road are being explored • Land purchases being explored to complete the corridor 	<ul style="list-style-type: none"> • This corridor is suitable for koala habitation and should be protected with exclusion fencing and additional buffer zones as outlined for MGS2. • Suitability as a primary corridor will be contingent on a crossing being secured across Appin Road.

<p>Secondary F CPCP</p>	<p>Elladale Creek and Simpsons Creek to the colliery</p>	<ul style="list-style-type: none"> • Southernmost corridor • Poorly connects west of Appin village to the east through the vicinity of Brooks Point Road • Corridor has a large area of vegetation that is well populated with fauna and has high-nutrient shale soils • Traffic is light on Wilton Road • Area connecting Ousedale Creek and corridor is forecast to have busway transect it, and possibly a future urban centre • Corridor has poor linkage to east • Originates further south along Nepean Gorge, giving it little advantage over existing Cataract Gorge connection between Appin and Wilton 	<p>CPCP</p> <ul style="list-style-type: none"> • Exclusion fencing • Habitat conservation and restoration in some areas 	<ul style="list-style-type: none"> • This corridor is suitable for koala habitat and should be protected with exclusion fencing and additional buffer zones as outlined for MGS2. • Active management efforts will be required, informed by monitoring, if threats such as bushfire and predators are identified to avoid a population sink in this corridor
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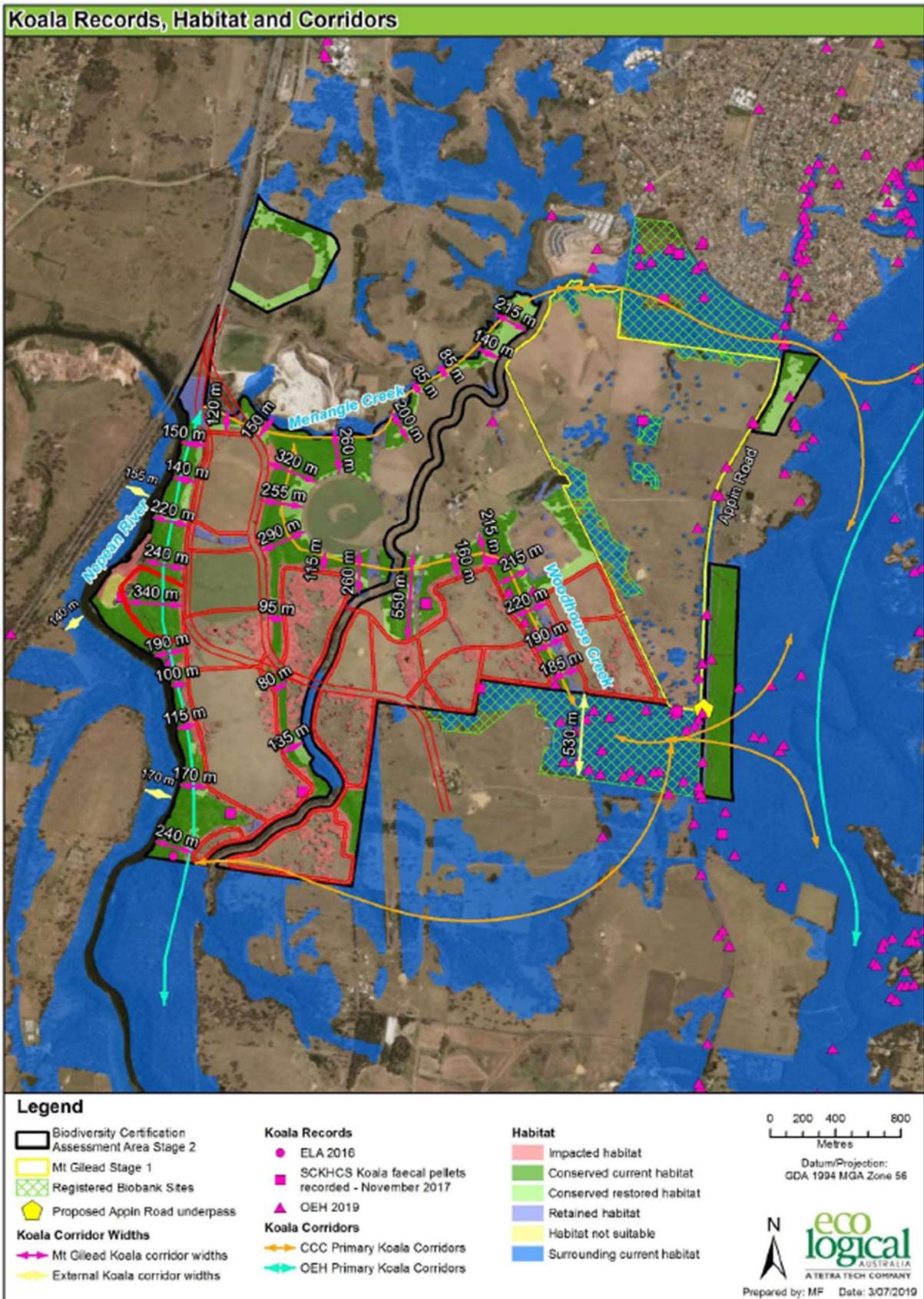


Figure 8: Corridor widths in the proposed MGS2 development
 Source: Eco Logical Australia (2020)

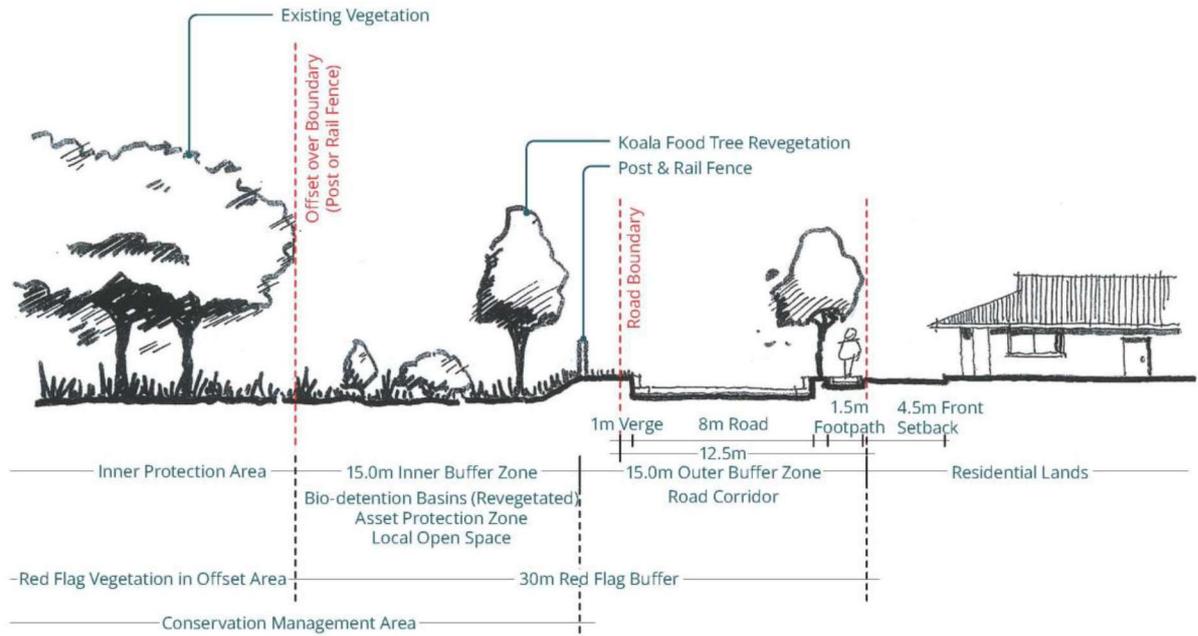


Figure 9: Example of buffer zone at proposed Mount Gilead Stage 2 development
 Source: Eco Logical Australia (2020)



LEGEND

- 01 Shared Path
- 02 Nature Trail
- 03 Fitness Nodes
- 04 Drainage Swale
- 05 Online Detention Basin
- 06 Shelter & Picnic
- 07 Nature Play/ Exploring Trail
- 08 Kick About
- 09 Beulah Biobank Site
- Core Habitat/ Conservation
- Homestead Conservation
- Inner Protection Area – on development side (19m)
- Outer Protection Area – of creek side (10m)
- Existing Tree
- Proposed Tree
- Proposed Koala Habitat Tree

NOTE:

The **Inner Protection Area** prescriptive requirements:

Trees:

- canopy cover should be less than 15% (at maturity)
- trees (at maturity) should not touch or overhang the building
- lower limbs should be removed up to a height of 2m above ground
- canopies should be separated by 2 to 5m
- preference should be given to smooth barked and evergreen trees.

Shrubs:

- create large discontinuities or gaps in the vegetation to slow down or break the progress of fire towards buildings

The **Outer Protection Area** prescriptive requirements:

- shrubs should not be located under trees
- shrubs should not form more than 10% ground cover
- clumps of shrubs should be separated from exposed windows and doors by a distance of at least twice the height of the vegetation.

Grass:

- should be kept mown (as a guide grass should be kept to no more than 100mm in height)
- leaves and vegetation debris should be removed.

The **Outer Protection Area** prescriptive requirements:

Trees:

- tree canopy cover should be less than 30%
- trees should have canopy separation
- canopies should be separated by 2 to 5m

Shrubs:

- shrubs should not form a continuous canopy
- shrubs should form no more than 20% of ground cover

Grass:

- should be kept mown (as a guide grass should be kept to no more than 100mm in height)
- other debris should be mown, slashed or mulched.

Figure 10: Mount Gilead Stage 2 Woodhouse Creek Koala corridor
Source: Eco Logical Australia (2020)

2.3.1 Mitigation of threats within developments

Without mitigation, the risk of vehicle strike to koalas will increase substantially as development proceeds. There is a number of examples of measures that will minimise and mitigate the impacts from roads and transport projects. These include designing fencing to prevent animal entry to roads or transport corridors, avoid locating new roads in environmentally sensitive areas and ensuring that fauna-sensitive road design elements are employed and maintained during and after road construction.

There are a number of measures proposed for the proposed MGS2 development and the draft CPCP to mitigate against threats within the urban region. These are described in Table 6.

Table 6: Proposed measures to protect koala from threats within developments

Plan	Proposed Measures	Panel comment
Mount Gilead Stage 2 Development	<ul style="list-style-type: none"> • Development of a Construction Environmental Management Plan to avoid and mitigate potential construction impacts to offset sites. E.g. include temporary fencing around identified conservation areas, pre-clearance fauna protocols, and dewatering plans for existing dams. Pre-clearance Tree Clearing Protocol to achieve the aim of no death or injury to koalas during the construction phase, movement of tree residue that could provide habitat into the retained offsets, and pathogen and weed control protocols. • Identification and avoidance of conservation areas, with permanent protection and management for Biobank sites • Design measures to mitigate the risk of predation by domestic dogs: dog proof fencing on all residential lots, enforced prohibition of dogs within all Biobank sites, alternative dog-friendly open space areas, and community awareness programs (signage, etc.) • Traffic controls (onsite and road): speed limits (50 km/h) on local roads adjacent to conservation areas, signposted (in accordance with specifications set out by various NSW Government agencies and the Council), traffic calming devices and vegetation clearance adjacent to road • Education and awareness, with programs designed for construction and for the Mount Gilead community (process of managing injured koalas, best practice dog ownership, tree planting days, etc.) 	Areas of koala habitat should have exclusion fencing, where this occurs a 50 km/h speed limit is suitable. However, if koala fencing is not able to be used, a lower speed of 40 km/h should be observed with traffic calming devices and signage.
Cumberland Plain Conservation Plan	<p>The draft CPCP includes a number of commitments aimed at minimising the impacts from adjacent land-uses on conservation areas and to mitigate the impact from increased road development and movements. Specific actions that are highlighted include the preparation of a Koala Management Area Guideline that would incorporate planning, designing and development controls for the management of the impacts identified, the identification of areas where buffers are critical to protect conservation areas, and increase public awareness of the biodiversity values of the conservation sites.</p> <p>These actions will be undertaken in collaboration with the council and local landholders, as land holders in the area, with the CPCP also establishing a working group to provide advice on koala management and mitigation actions. This working group will also be tasked with reviewing mitigation measures within the Koala Management Area Guideline.</p> <p>The CPCP also identifies the need to amend Growth Centre SEPPs to stipulate adherence to the Koala Management Area Guideline for managing impacts within these areas.</p>	Areas of koala habitat should have exclusion fencing, where this occurs a 50 km/h speed limit is suitable. However, if koala fencing is not able to be used, a lower speed of 40 km/h should be observed with traffic calming devices and signage.

2.4 MONITORING AND MANAGEMENT

The uncertainty around how land and population changes and management actions will impact the koala population (either positively or negatively). This uncertainty can be addressed by: understanding the current koala population including how koalas use the landscape and their population attributes; putting in place a monitoring program to track this population over time; and adopting an adaptive management approach that is informed by real-time monitoring so that amendments and improvements can be made to mitigation measures as needed.

An adaptive management approach informed by monitoring and data capture will help chart a way forward for managing the koala population, at the construction phase as well as through the ongoing management phases. These principles are set out in the SEPP KOALA and in the NSW Koala Strategy. Principle 7 of the draft guidelines released as part of the new Koala SEPP sets out the use of adaptive management of koalas

Adaptive management is an iterative approach that uses ongoing monitoring to adjust or change management actions if they are proving ineffective or, conversely, if one action is having a greater benefit. It allows for the implementation of actions in a structured, yet flexible, manner to achieve a desired outcome. It is, more broadly, a method that ensures risk management is at the forefront on any decisions. It is based on the collection and analysis of data against a set of pre-determined questions/criteria.

An important aspect of adaptive management is the timeframe of actions and the response time to those actions (either positive or negative). For example, there are actions that may take time to be introduced and mature prior to becoming effective. Similarly, the benefits of revegetation on populations potentially would not be seen until several years after.

Linked to this is the need to monitor actions over time and implement strategies to ensure their continual effectiveness. For example, ensuring fence integrity in perpetuity or ensuring that no new predators have entered the habitat.

As part of the NSW Koala Strategy an NSW Koala Monitoring Framework is being developed. This Framework will provide structure to the long-term monitoring of koala populations in NSW, advocating for a consistent, best-practice approach across the functional topics of population dynamics, koala habitat, genetic diversity, disease and reproduction, and threats. At the heart of the Framework is adaptive monitoring, ensuring flexibility in ongoing monitoring that is informed by previous information and sets an overall strategic purpose for monitoring efforts, such as the evaluation of the effectiveness of management actions.

The proposed monitoring in the MGS2 development and in the draft CPCS are at Table 7.

Table 7: Proposed monitoring measures in MGS2 and CPCS

Plan	Proposed Measures
Mount Gilead Stage 2 Development	<ul style="list-style-type: none"> • fauna assessments and modeling of koala populations have been undertaken as part of the biodiversity certification application process, providing a baseline for the koala population in the proposed development footprint • Monitoring associated with approval and compliance
Cumberland Plain Conservation Plan	<ul style="list-style-type: none"> • proposed Cumberland Plain Evaluation Program and the monitoring, evaluation, reporting and adaptive management that will support the implementation of the CPCS (NSW Government, 2020b). • proposed systematic collection and storage of data relevant to the three identified priorities: <ul style="list-style-type: none"> ○ koalas at the interface (especially in response to management actions), ○ the identification of threats, and ○ demographic information (including life history and ecology). <p>This will also be evaluated to identify potential changes as a result of management actions (adverse or positive) and analyse how these management actions could be improved or if</p>

there are alternative actions that could be used. This evaluation will occur in the first 15 years of the Plan's implementation.

- Proposed monitoring to better understand the threat from Chlamydia, in light of their disease-free status, whilst noting that the SoS program will support this monitoring.

Panel comments

- The Campbelltown koala population should be monitored. Baseline data is required to understand the current status of the population. This should be matched by ongoing and regular survey and monitoring efforts, to compare population trends over time and inform adaptive management approaches (including the development and understanding of appropriate triggers and responses, including timeframes). The site should be designated as one of the dedicated monitoring sites under the NSW Koala Strategy. Supporting these efforts should form part of the landholder, developer or proponents' responsibilities.
- Parameters that should be monitored include:
 - population dynamics (including age demographics, fertility and sex ratios, mortality and causation, etc.)
 - the identification, changes and effectiveness of mitigation actions for key threats (predators, vehicles, etc.),
 - tracking how individuals and the koala populations use and disperse throughout the environment (including male movement during mating season, changes in territories, etc.)
 - monitoring for the prevalence of disease, such as Chlamydia and KoRV, which should trigger immediate actions such as vaccination if there is a change in levels detected.
 - monitoring koala generations over time to understand whether offspring are less stressed than their parents and more accustomed to urban edge locations.
- Intrinsically linked to triggers under an adaptive management approach is understanding how monitoring is conducted, and whether there is lag time associated with measurements. For example, trailing indicators such as reduced reproduction may present too late for effective management actions that halt the decline to be implemented. Adaptive management should incorporate leading and lagging indicators appropriately.
- Tissue sampling of joeys, along with tagging of the Campbelltown koala population will allow insight into the functional genetics of this koala population and how it could lead to increased resilience in NSW. For any koala monitored, efforts should be made to contribute samples in the ascribed manner to the Australian Museum, as the dedicated NSW biobank for tissue samples. The resulting genetic data can inform translocation strategies that may be required if active management procedures are needed for fragmented enclosed populations as discussed above in CPCP Scenario 3.
- There is an opportunity to use new techniques and technologies to study this population and inform management efforts. For example,
 - new implantable sensor technologies, similar to proximity tags used in marine environments, could be used to understand koala movements when combined with passive sensor stations, and could be investigated further by NSW initiatives such as the NSW Smart Sensing Network. Proximity tagging will identify whether there are areas of the landscape that koalas do not use, or avoid, which will inform future decisions about habitat protection.

- Drone technology to detect koala presence
- The population has remained relatively free from *Chlamydia* infection. However, there is widespread infection in the Southern Highlands population, and it is believed that this infection could move north into the population due to connectivity between the populations. Animals that are captured and/or handled as part of a monitoring program or those that are rehabilitated and released back into the Campbelltown population should be vaccinated against Chlamydia.

ACRONYMS

Acronym	Full Term
APZ	Asset Protection Zone
BAM	Biodiversity Assessment Method
BC Act	NSW <i>Biodiversity Conservation Act 2016</i>
BCAM	Biodiversity Certification Assessment Methodology
BCAR	Biodiversity Certification Assessment Report
BDAR	Biodiversity Development Assessment Report
BSA	Biodiversity Stewardship Agreement
CKPoM	Comprehensive Koala Plan of Management
CPCP	Cumberland Plain Conservation Plan
DPIE	NSW Department of Planning, Industry and Environment (the Department)
EP&A Act	NSW <i>Environmental Planning and Assessment Act 1979</i>
EPBC Act	Commonwealth <i>Environment Protection and Biodiversity Conservation Act 1999</i>
GMGA	Greater Macarthur Growth Area
LGA	Local Government Area
MGS1	Mount Gilead Stage 1
MGS2	Mount Gilead Stage 2
SEPP	State Environmental Planning Policies
SoS	Saving our Species
TfNSW	Transport for NSW (road authority)
TSC Act	NSW <i>Threatened Species Conservation Act 1995</i>

APPENDIX 1 - TERMS OF REFERENCE

Terms of Reference: Advice regarding the protection of the Campbelltown Koala population

To provide advice to the Minister for Energy and Environment and the Minister for Planning and Public Spaces about:

- The adequacy of the proposed measures for koala conservation proposed by property group Lendlease on land referred to as Mt Gilead Stage 2 (MGS2) and the consistency of these measures with the NSW Koala strategy.
- What, if any, additional conservation measures are considered necessary.
- What, if any, site specific measures for koala species should be incorporated into the Cumberland Plain Conservation Plan for the Greater Macarthur Growth Area to support the long-term viability of the koala population.
- Whether east-west corridors linking the Nepean and Georges Rivers can contribute to the conservation of the Campbelltown koala population; and, if so, which east-west corridors and what measures should be taken to ensure their effectiveness.

In preparing this advice the Chief Scientist & Engineer will review existing science and relevant documentation including;

- NSW Koala Strategy
- Independent Review into the Decline of Koala Populations in Key Areas of NSW, NSW Chief Scientist and Engineer, 2016.
- Conserving Koalas in the Wollondilly and Campbelltown Local Government Areas report, Dept. Planning Industry and Environment, October 2019
- Koala Corridor Project Campbelltown City Council and Wollondilly Local Government Areas: Greater Macarthur Growth Area, Biolink Consultants, October 2018
- South Campbelltown Koala Habitat Connectivity Study prepared for Campbelltown City Council, Biolink Consultants, 2017.
- Fact Sheet CPCP Protecting Koalas on the Cumberland Plain, Dept. Planning, Industry and Environment, September 2019
- Mt Gilead Stage 1 Biodiversity Certification Agreement
- Application for biodiversity certification for Mt Gilead Stage 2, Campbelltown City Council, August 2019
- Biodiversity Certification Assessment Methodology (BCAM). Office of Environment and Heritage, 2011
- Greater Macarthur 2040: An interim Plan for the Greater Macarthur Growth Area, Department of Planning and Environment
- Section 3.25 consultation – Proposed amendments to Growth Centres SEPP to declare Greater Macarthur as Growth Area, Office of Environment and Heritage, March 2019
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- Any other documentation, science and previous reports that are considered relevant.

Reporting timeframe

The advice will be provided in a report by 30 April 2020.

Expert Panel

An Independent Expert Panel, chaired by the Deputy NSW Chief Scientist & Engineer, will be established to provide advice.

Support

Secretariat support will be provided by the Office of the Chief Scientist and Engineer.

The Department of Planning, Industry and Environment will also provide support. The agency contact is Kate Wilson, Executive Director Climate Change and Sustainability, Environment, Energy and Science.

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