

Ecological Assessment

Turner Road
Local Environment Study
(Project No. 144-01)

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1. Introduction

1.1 Description of Project

Eco Logical Australia was contracted in November, 2006 to undertake an ecological assessment for land known as Turner Road Precinct. The vision for the Growth Centres - as part of the Metropolitan Strategy for Sydney - was launched by the NSW Government in December 2004. Turner Road is a first stage precinct in the South West Growth Centre. The precinct planning process for this site is well underway and is currently at step 3 of the Precinct Planning Process. The Draft Indicative Layout Plan (ILP) for the site is currently being created for the Growth Centres Commission (GCC) with the aim of an agreed ILP for the precinct. This report is one of a number of technical studies feeding into this process.

1.2 Study Area

The Turner Road study area is located in the Camden LGA, to the east of Camden Valley Way. It is bounded by Camden Valley Way to the West, Turner Road to the South and the heritage listed Upper Canal to the east.

The precinct is made up of the Camden Valley Golf Resort and a number of small land holdings along the southern boundary of the site, however it is predominately owned by the Marist Brothers / Dartwest joint venture and operated as a rural property. Figure 1 shows the broad location of the site.

The Turner Road site is gently undulating, and includes South Creek. The dominant soil type is clay based, originating from Wianamatta Shale. Cumberland Plain Woodland is the associated vegetation type with areas of alluvial soil supporting Alluvial Woodland associated with drainage areas. Both these woodland communities are listed as Endangered Ecological Communities under the NSW *Threatened Species Conservation Act 1995*.

Most of the Turner Road Precinct is currently zoned as rural, whilst the Camden Valley Golf Resort land makes up the northern end of the precinct. The rural areas of the site are managed as farming land. Substantial clearing and long term grazing across the precinct has occurred in most areas with some pockets of native vegetation and large old Eucalypts in relatively good condition.



Figure 1 Study Area

2. Statutory Framework

A substantial array of legislation, policies and guidelines apply to the assessment, planning and management of ecological issues within the study area. This information was reviewed and used to identify priority issues and approaches for the study area. Legislation and policies reviewed include:

2.1 International

- Japan – Australia Migratory Bird Agreement (JAMBA)
- China – Australia Migratory Bird Agreement (CAMBA)

2.2 Commonwealth

- *Environment Protection & Biodiversity Conservation Act 1999* (EPBC Act)
- National Biodiversity Strategy

2.3 State

- *State Environmental Planning Policy (Sydney Region Growth Centres) 2006* (Growth Centres SEPP)
- *Environmental Planning and Assessment Act 1979* (EP&A Act)
- *Threatened Species Conservation Act 1995* (TSC Act)
- *National Parks and Wildlife Act 1974* (NPW Act)
- *Biocertification Amendment of the TSC Act*
- *Fisheries Management Act 1994* (FM Act)
- *Rivers and Foreshores Improvement Act 1948* (RFI Act)
- *Rural Fires Act 1997* (RF Act)
- *Bushfire Environment Assessment Code 2003*
- *Protection of the Environment Operations Act 1997*
- *Catchment Management Act 1989*
- Sydney Regional Environmental Plan No 20 – Hawkesbury-Nepean River (No 2 – 1997)
- *Local Government Act 1993* (LG Act)
- *Local Government Amendment (Ecologically Sustainable Development) Act 1997*
- *Native Vegetation Conservation Act 1998*
- *Noxious Weeds Act 1993*
- *State Environmental Planning Policy No.19 – Bushland in Urban Areas*
- *NSW Biodiversity Strategy 1999*

2.4 Local

- *Camden Council Local Environmental Plan No. 48*(Camden LEP)
- *Camden Natural Assets Policy 2003* (CNAP)

2.5 Planning Context

The Growth Centres SEPP establishes the planning framework for the site. Effectively, rezoning of land is to be achieved through a precinct planning process and modifying the SEPP. In conjunction with the SEPP, a Conservation Plan is being prepared which outline key areas to be protected and purchased to offset impacts occurring within the Growth Centres. Ultimately it is intended that these offset lands will be purchased through a levy placed on development of land within the Growth Centres.

It is intended that the SEPP will be 'biodiversity certified', this will substantially alter the approach to impact assessment at the development application stage, and could exempt developments entirely from assessment under the TSC Act.

Riparian and aquatic planning and assessment is regulated through;

1. Rivers and Foreshores Improvement Act, 1948
2. Native Vegetation Conservation Act, 1998
3. Fisheries Management Act, 1994

This assessment has found that there are no aquatic threatened species issues within the precinct that require further consideration under the FM Act.

In terms of riparian values, a strategic approach to riparian planning has;

1. Identified key riparian lands to be improved and maintained
2. Identified buffer zones around these lands
3. Identified 'Rivers' that will be modified through channelling and piping
4. Identified planning controls for future development/works within riparian zones
5. Identified integrated management strategic for retained riparian zones

Similar to biodiversity certification, it is the intention that an 'order' under the RFI Act will be obtained for the site that exempts or streamlines future development assessment under Part 3A, providing the development is consistent with the strategic framework and planning controls identified through this study.

Referral to the Commonwealth Department of Environment and Heritage (DEH) is required under the EPBC Act if the proposal may have a significant impact on matters of National Environmental Significance (NES matters). Cumberland Plain Woodland is a known NES matter located on the site, which will largely be improved or maintained through this proposal. Threatened and migratory fauna listed under the EPBC Act that are considered likely, or have the potentially, to occur at the site include 3 endangered species, 1 vulnerable species and 6 species listed as migratory under the Act. 1 plant species listed as endangered and 1 plant species listed as vulnerable under the EPBC Act could potentially occur at the site, although they were not found during field survey.

Given the low level of impact, the amount of land to be protected across the precinct and the environmental levy it is unlikely that this proposal will require referral to DEH. However, it is recommended that the GCC undertake consultation with DEH at a policy level to streamline the approach and any required referrals.

2.6 Camden Natural Assets Policy

The aim of the *Camden Natural Assets Policy* (Camden Council, 2003), is to integrate the regulatory requirements of state natural resource management legislation and policies into the local planning framework. The Natural Assets Policy applies to all land within the Camden LGA, particularly ecologically significant and environmentally sensitive land (Camden Council 2003). Ecologically significant land is considered to be bushland remnants in the categories:

- Critically Endangered
- Core habitat – regional
- Core habitat – local
- Support for core
- Other native vegetation

The Natural Assets Policy also contains details of submission requirements for development applications, development guidelines, and principles to be considered for developments (Camden Council 2003). The principles to be considered are:

- No Net Loss
- Precautionary Principle
- Cumulative Impact

'No Net Loss' refers to '*no overall loss in the total extent, quality, ecological integrity and security of the biodiversity values of the Camden local government area*' (Camden Council 2003). The precautionary principle has already been adopted by the NSW government (NPWS 1999), and in essence means that a conservative approach should be used when there is a lack of knowledge or certainty for environmental impacts that could cause serious and irreversible damage. The cumulative impact principle means that the combined effects of a proposal will be considered when it is being assessed.

The CNAP also contains requirements for offsetting to ensure there is a net improvement as a result of development. The principles are;

- Environmental impacts must be avoided first by using cost effective prevention and mitigation measures. Off sets are then only used to address remaining environmental impacts
- All regulatory requirements must still be met
- Offsets are never to reward poor environmental performance
- Offsets will complement other government programs
- Offsets must result in a net environmental improvement.

CNAP outlines two options for the offsetting of unavoidable loss of habitat; *Protection Provision* and *Restoration*. Both offsetting options require the application of multiplier tables as shown below according to the formula

Area to be provided protection or restoration = Area of habitat to be affected X relevant multiplier for the receiving habitat;

Protection Multiplier Table		Class of Protected Habitat	
		Core Regional	Habitat - Local
Class of Affected Habitat	Core Habitat - Regional	6	7
	Core Habitat - Local	5	6
	Support for Core	4	5
	Other Native Vegetation	3	4

Restoration Multiplier Table		Class of Protected Habitat	
		Corridor	Riparian Buffer
Class of Affected Habitat	Support for Core	4	4
	Other Native Vegetation	3	3

The manner in which the CNAP is to be applied to the conservation plan for this precinct and associated development levies will need to be determined by the GCC and the Camden Council.

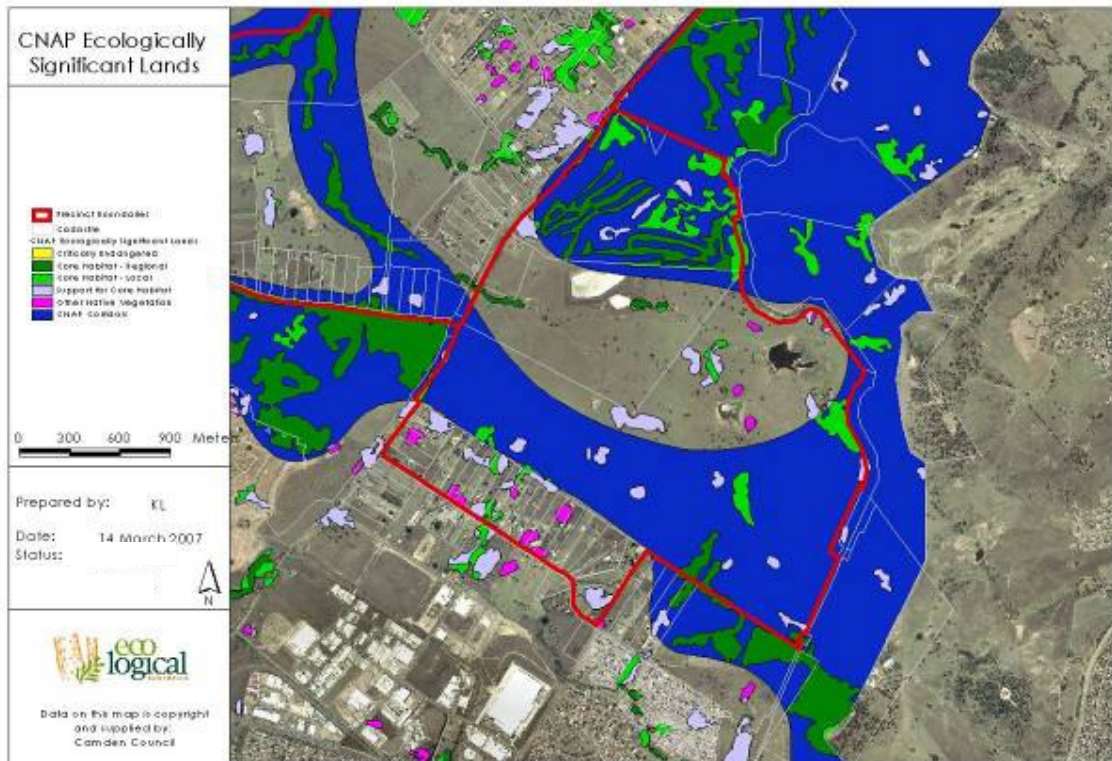


Figure 2 Ecologically Significant and Environmentally Sensitive Lands, as mapped in the CNAP.

3. Terrestrial Biodiversity Assessment

3.1 Methods

3.1.1 Literature Review

In addition to reviewing the legislative requirements relating to the site, a wealth of ecological studies, policies and plans relating to the site and surrounding areas were reviewed to identify known ecological issues, regional context of these issues and current approaches to planning and management. Key documents include:

- Cumberland Plain Endangered Ecological Communities: Preliminary Draft Recovery Plan (NSW NPWS, 2001)
- The Native Vegetation of the Cumberland Plain, Western Sydney: Technical Report (NSW NPWS, 2000)
- Native Vegetation of the Cumberland Plain, Western Sydney Vegetation Community, Condition and Conservation Significance Mapping (NSW NPWS, 2002)
- Harrington Park Stage 2 and Mater Dei Ecological Assessment (Eco Logical Australia, 2004)
- Edmondson Park Ecological Assessment (Eco Logical Australia, 2003)
- Natural Assets Policy (Camden Council, 2003)
- State of the Environment Report (Supplementary) 2001 (Camden Council, 2001)
- Sub-catchments of the Camden LGA (Camden Council, 2003)
- Managing Sydney's Urban Growth: Ecological Assessment South West Study Area (Eco Logical Australia, 2003a)
- Riparian Corridor Management Study, Covering all of the Wollongong Local Government Area and the Calderwood Valley in the Shellharbour Local Government Area (DIPNR 2004).
- Growth Centres Development Code (Growth Centres Commission 2006)

3.1.2 Data Audit

An audit of digital data was undertaken to assist in locating survey sites, targeting threatened species habitat for survey and to develop a GIS database for the study. Key datasets reviewed and compiled through this stage include:

- Atlas of NSW Wildlife (flora and fauna locations)
- Western Sydney Vegetation Mapping (NSW NPWS, 2000)
- Western Sydney Conservation Significance Assessment (NSW NPWS, 2002)
- Digital aerial photography provided by Camden Council
- Site and cadastral boundaries and contours provided by Camden Council
- Riparian buffer zone mapping provided by Department of Natural Resources (DNR)

3.1.3 Field Survey

A total of 20 person hours were spent in the field between the 5th December 2006 and the 5th January 2007. The following was undertaken;

- Validation of vegetation community and condition mapping
- Identification of recovery potential
- Targeted searches for Cumberland Land Snail
- Targeted threatened flora searches

- Threatened fauna habitat assessment
- Anabat recording
- Aquatic habitat condition assessment and targeted searches for threatened aquatic species habitat
- Validation of DNR riparian mapping
- Opportunistic recording of flora and fauna species
- Identification of management issues

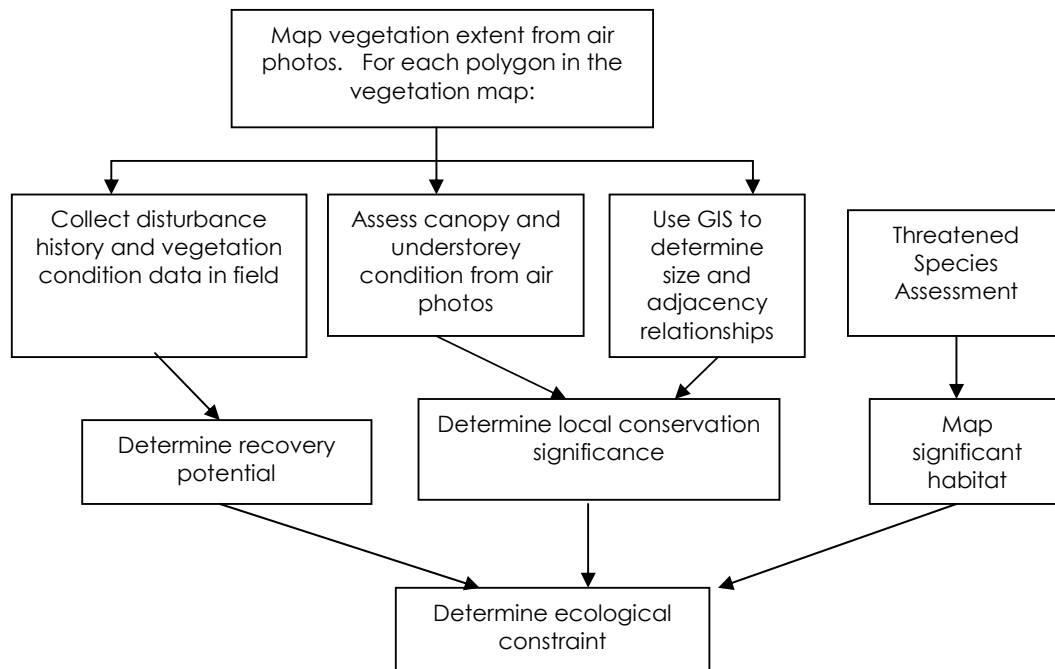
3.1.4 *Ecological Constraints Analysis*

Ecological Constraints Analysis based on that used for Edmondson Park (Eco Logical Australia 2003) is a stepped analysis of the environmental values of an area. It provides a combined measure of ecological values, and is increasingly used as a basis for negotiations over locations, types and densities of land development. It includes measurement of:

- how rare a vegetation community is
- the structural condition of vegetation remnants
- type and severity of disturbance
- connectivity between remnants on and off site
- the size of the vegetation remnant
- the value of the remnant as threatened species habitat

The steps involved in this type of ecological constraints analysis are illustrated in the flowchart in Figure 3 below. Vegetation mapping is combined with field survey work, threatened species assessment and the NPWS (2002) conservation significance assessment methodology to determine the relative level of ecological value or constraint across a site.

Figure 3. Ecological constraints flowchart



Appendix 1 contains the detailed methodology used at each of the steps illustrated in Figure 3 including determination of recovery potential, conservation significance assessment criteria and threatened species significant habitat mapping.

3.2 Results

3.2.1 General

The current state of vegetation (CPW and Alluvial Woodland) communities is typically isolated and degraded; existing as patches of young trees or remnant canopy trees over grazed pasture. Small patches of good quality woodland vegetation occur in the south of the site within small landholder lands. Vegetation here is structurally and floristically diverse and as such would be a priority for conservation.

3.2.2 Vegetation Communities

Four vegetation communities were identified across the site. The bulk of the site has been historically cleared; consequently most of the vegetation on site is regrowth. Age of regrowth varies across the precinct, based on similarities with Harrington Grove, the oldest trees are pre 1947, with most regrowth occurring since the late 1970's and 1980's.

- Shale Plains Woodland (EEC)

- Shale Hills Woodland (EEC)
- Alluvial Woodland (EEC)
- Pasture/cleared (exotic dominant)

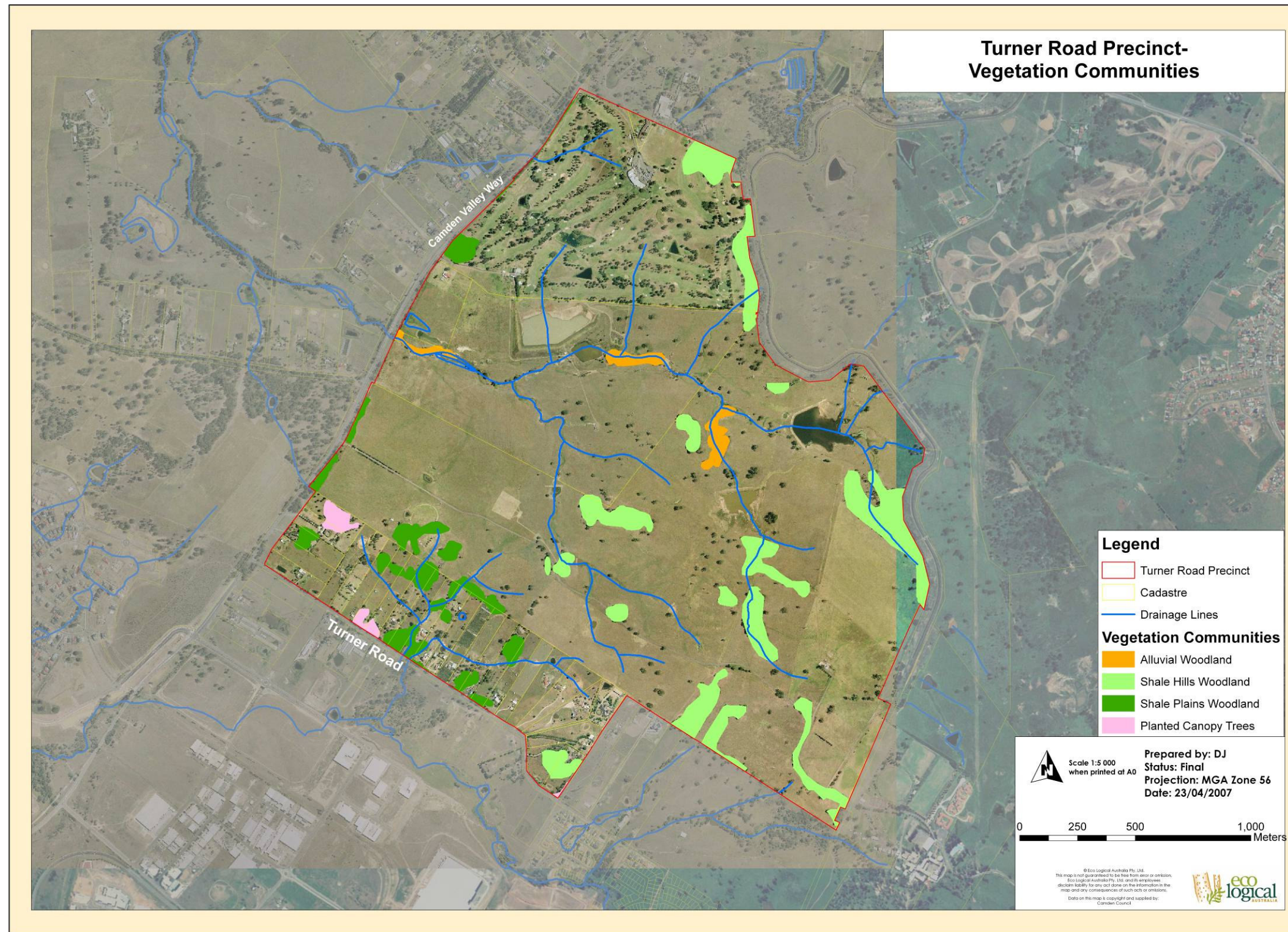


Figure 4. Vegetation and Threatened Species Locations

Table 5. Indicative Aerial Calculations

Vegetation Type and Condition	Community	Hectares	% of site
Alluvial Woodland/ABC	Sydney Coastal River-flat Forest	4.1	0.8%
Shale Hills Woodland/ABC	Cumberland Plain Woodland	12.9	2.5%
Shale Hills Woodland/TX/TXR/TXU	Cumberland Plain Woodland	19.3	3.7%
Shale Plains Woodland/ABC	Cumberland Plain Woodland	1.5	0.3%
Shale Plains Woodland/TX/TXR/TXU	Cumberland Plain Woodland	11.4	2.2%
Planted Canopy Trees/TX/TXR/TXU		2.1	0.4%
Cleared/Pasture		475.5	90.3%
Total		526.7	100.0%

3.2.3 Fauna

Field survey identified 25 fauna species at the site. Birds were the most common faunal group observed (24 species) and 1 mammal, a rabbit, was also recorded. No threatened species or regionally significant species were recorded on site (Appendix 2 and Appendix 4).

The Western Sydney Growth Centres Conservation Plan identified 22 threatened species that have the potential to be impacted upon by the development of the Growth Centres. A 10km radius search using the BioNet database identified a further 22 threatened species required for consideration. Appendix 2 lists all 44 species together with an assessment of their likelihood of occurrence within the site.

Fauna habitat was limited across the majority of the site. Much of the site is exotic grassland/pasture which offers little habitat value for native flora and fauna. Small areas of shale plains woodland in the south of the site contained structurally diverse, native dominated vegetation and as such may provide important habitat for native fauna. Large (DBH > 100cm), hollow bearing eucalypts are scattered throughout the site. Such trees may provide important roosting and breeding habitat for bats and birds.

Habitat observed at the site includes:

- Woody debris
- Small and medium hollows
- Forest Redgum (Cumberland land snail)
- Grassland
- Leaf litter
- Emergent aquatic vegetation
- Fringing aquatic vegetation
- Creek banks

- Rock
- Stags

3.2.4 Flora

Field survey identified 40 flora species at the site. 18 were exotic species and 2 of those; African boxthorn (*Lycium ferocissimum*) and small-leaf privet (*Ligustrum sinense*) are Class 4 declared noxious weeds within the Camden LGA.

Forest Redgum (*Eucalyptus tereticornis*) and Grey Box (*Eucalyptus molucanna*) were the most commonly encountered tree species across the site while African Boxthorn (*Lycium ferocissimum*) and African Olive (*Olea europaea ssp Africana*) were the most frequently observed shrubs. Kangaroo grass (*Themeda australis*) and *Aristida* spp. often occurred in the groundcover however weeds such as paddy's lucerne (*Sida rhombifolia*), kikuyu (*Pennisetum clandestinum*) and paspalum (*Paspalum sp.*) typically dominated the groundlayer at the site.

Systematic vegetation surveys were not conducted during the current study, rather field survey focused on recording dominant species within each vegetation stratum at polygons across the site. As such it is likely that the total number of plant species present at the site exceeds the 40 species reported above.

The Western Sydney Growth Centres Conservation Plan identified 17 threatened plant species that have the potential to be impacted upon by the development of the Growth Centres. Database searches identified a further 11 threatened species. Appendix 2 lists these species and their likelihood of occurrence within the study site.

No threatened species or regionally significant species were observed during field survey.

3.2.5 Recovery Potential

The results of the field based assessment of recovery potential are displayed in figure 5. The majority of native vegetation remaining on site was ranked as having either a moderate or high recovery potential. Areas of high recovery potential along the eastern boundary of the site and within the mall landholdings to the south, reflect the areas of vegetation that have had grazing and clearing excluded for some time, allowing the native understorey to remain or regenerate.

3.2.6 Conservation Significance Mapping

The results of the conservation significance mapping for the Turner Road precinct are displayed in Figure 6.

Of the remaining native vegetation on site, the majority was classed as other native vegetation, this was a reflection of the fragmented and small patch size of the vegetation communities remaining within the Turner Road precinct. Patches of native vegetation which were in good condition, and larger than 10ha or adjacent to such a patch was classed as core, these occurred along the south western boundary of the site illustrating the connectivity of the vegetation to the communities surrounding the site. The retention of large patch size is an important factor in determining the viability of the community and its quality as fauna habitat.

3.2.7 Significant Habitat Mapping

The results of the threatened species significant habitat analysis can be seen in Figure 7.

Approximately half of the validated vegetation polygons were considered to have a likely chance of supporting threatened species as primary habitat, resulting in moderate habitat significance. The remainder of the vegetation was considered to be of low habitat significance, predominantly due to the dominance of the occurrence of long term grazing in combination with the very dry nature of the soil across the Turner Road precinct.

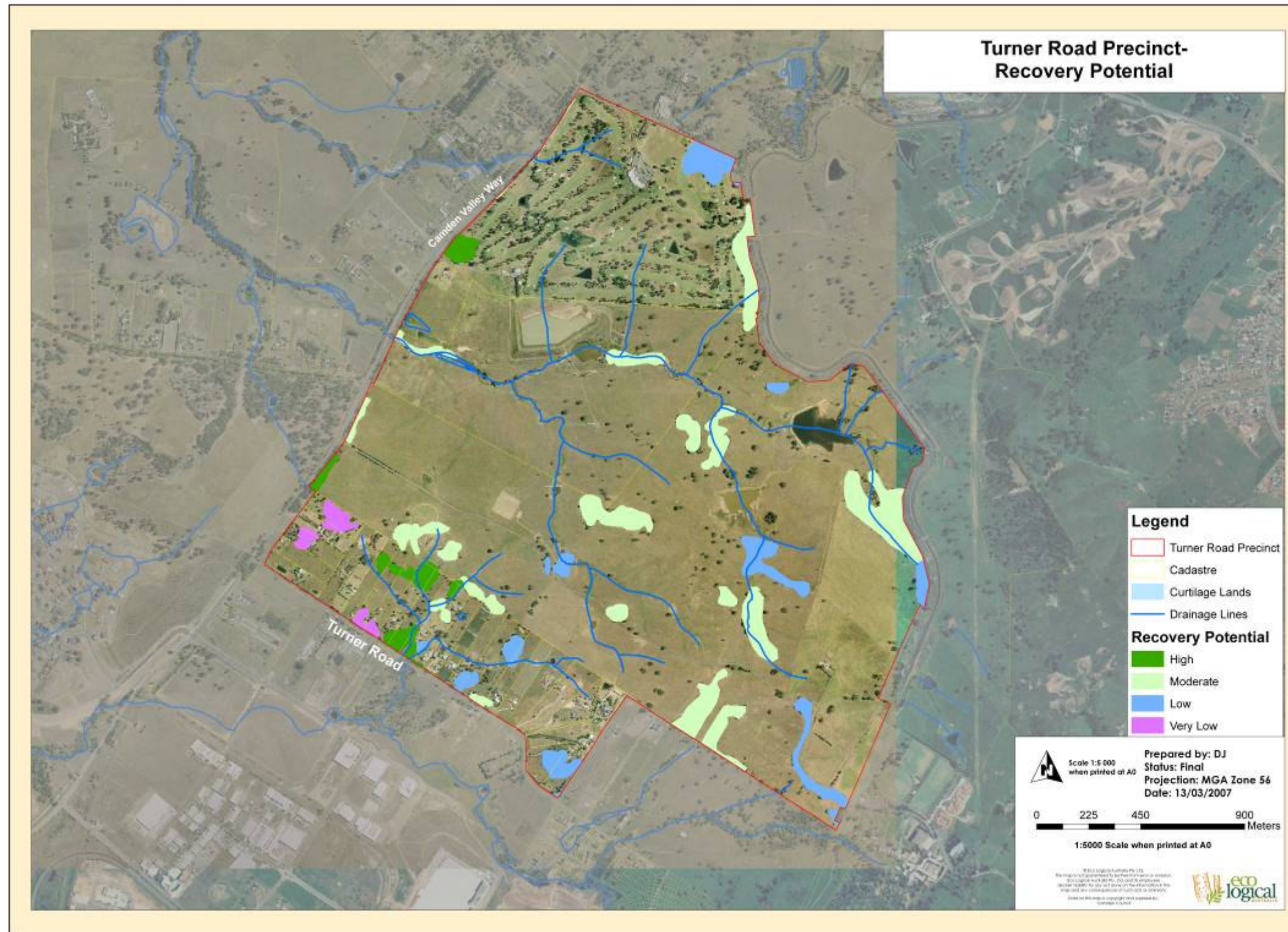


Figure 5. Recovery Potential

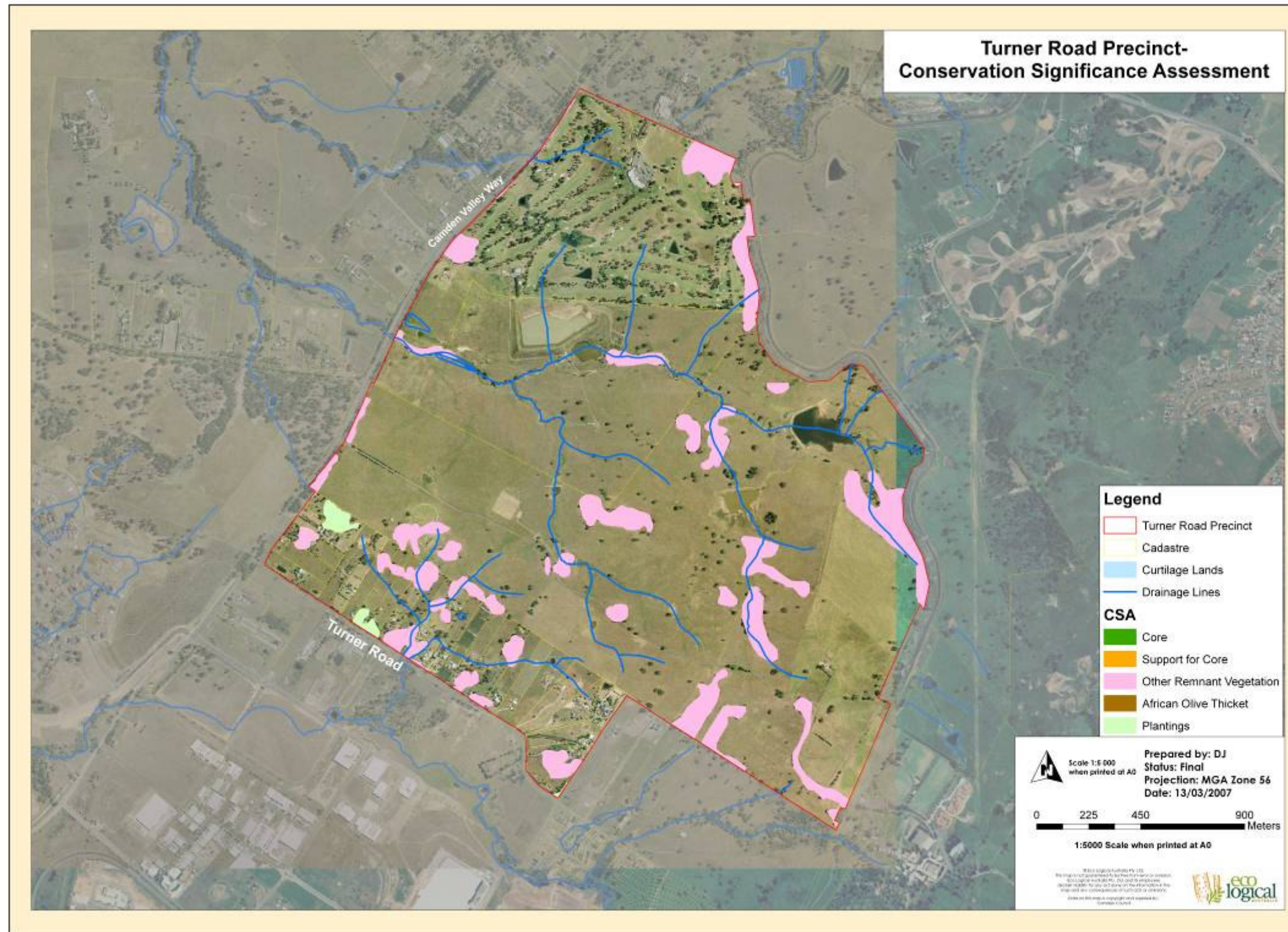


Figure 6. Conservation Significance

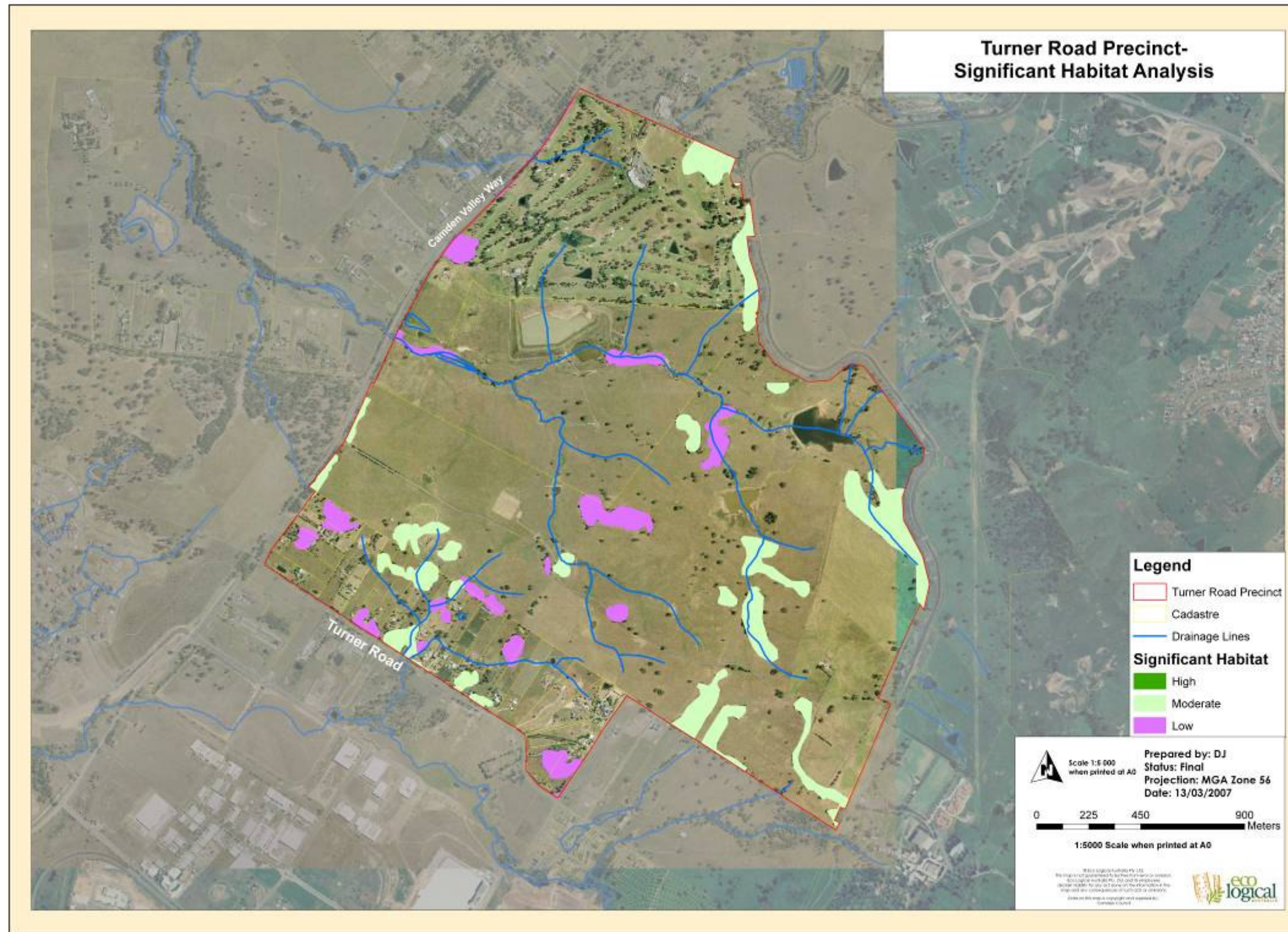


Figure 7. Threatened Species Significant Habitat

3.2.8 Ecological Constraints Mapping

An ecological constraint ranking was derived applying the amended methodology used in the Edmondson Park Ecological Assessment (see Appendix 1 of this report). The results of this analysis can be seen in Figure 8. Broadly the rankings are as follows:

- High constraint = woodland and riparian forest, as these vegetation communities have the potential to be utilised by a wide range of species including some that could be threatened or regionally significant
- Moderate constraint = areas that have some habitat value for a narrower range of species but are generally dominated by edge species and have a moderate to poor recovery potential (Gingra Ecological Surveys 2003)
- Low constraint = all other native vegetated areas, generally isolated and small in size, with a very low recovery potential.
- Olive = vegetated areas that are entirely thickets African Olive or have dense African Olive as the understorey thus reducing the recovery potential to practically nil.
- Plantings = artificially planted patches of existing vegetation.

Areas of moderate constraint have some habitat value for a narrower range of species but are generally dominated by edge species and have a moderate or poor recovery potential. These habitats may, however, have a corridor function across the site.

Table 6 – Summary of Areas based on manual assessment of likely clearing

Recovery Potential	Hectares	% of site
High	5.6	1.1%
Moderate	29.7	5.6%
Low	13.2	2.5%
Very Low	2.6	0.5%
Cleared/Pasture	475.5	90.3%
Total	526.7	100.0%
Conservation Significance	Hectares	% of site
Other Remnant Vegetation	49.1	9.3%
Plantings	2.1	0.4%
Cleared/Pasture	475.5	90.3%
Total	526.7	100.0%
Significant Habitat	Hectares	% of Precinct
Medium	35.2	6.7%
Low	16.0	3.0%
Cleared/Pasture	475.5	90.3%
Total	526.7	100.0%
Ecological Constraint	Hectares	% of site
Moderate	45.7	8.7%
Low	3.4	0.6%
Plantings	2.1	0.4%
Cleared/Pasture	475.5	90.3%
Total	526.7	100.0%

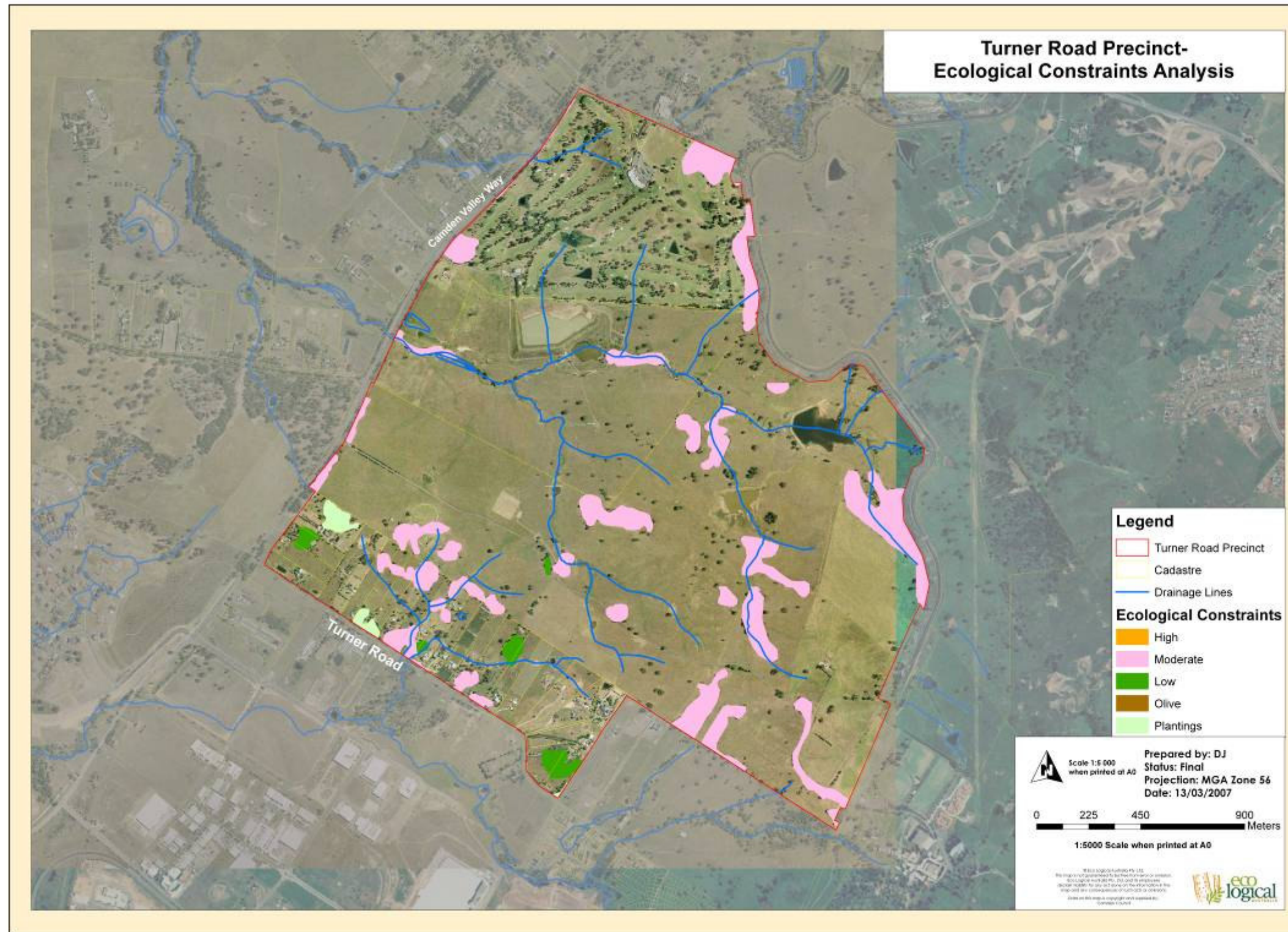


Figure 8. Ecological Constraint

3.3 Impact Assessment

The Department of Planning will be seeking to obtain "biodiversity certification" for the Growth Centres SEPP, in part, through the preparation of a Conservation Plan. The granting of certification to the SEPP may remove the need to assess impacts of development on threatened species within the identified development precincts.

Should biodiversity certification of the Growth Centres SEPP not be forthcoming, impacts of development, as outlined by the ILP, will need to be assessed for all state and federally listed threatened species, populations and ecological communities through application of the 7-part test.

3.3.1 *Endangered Ecological Communities*

Two TSC Act listed endangered ecological communities occur at the study site; Cumberland Plain Woodland (CPW) and River-Flat Eucalypt Forest on Coastal Floodplains of the NSW North Coast, Sydney Basin and South East Corner bioregions (Alluvial Woodland). Cumberland Plain Woodland is also listed as an endangered ecological community under the EPBC Act.

Due to the isolated and degraded nature of the majority of vegetation on site and the small area of vegetation to be removed, the proposal is unlikely to impact significantly on the EECS at the site. The retention and conservation of the larger and better quality areas of vegetation on site within a system of parks and reserves, as shown in the draft ILP, will help to minimise biodiversity losses at the site.

The total area of land contained within category 1 and 2 riparian corridors that will be vegetated across the precinct is approximately 45.2ha, with additional patches of vegetation to be preserved within pocket parks. Dependant on final ILP's, the revegetation of the riparian corridors is likely to compensate for the loss of vegetation that will occur. The vegetation lost across the precinct under the current ILP is of moderate or low ecological constraint. The revegetation of riparian corridors will see an overall increase in the quality of vegetation within the precinct compared to the present status.

3.3.2 *Threatened Species*

15 threatened fauna, 4 threatened plants, 1 endangered population and 2 endangered ecological communities could potentially be directly or indirectly affected by development of the Oran Park Precinct and may require assessment under the EP&A assessment of significance.

Threatened and migratory fauna listed under the EPBC Act that are considered likely, or have the potential, to occur at the site include 3 endangered species, 1 vulnerable species and 6 species listed as migratory under the Act. 1 plant species listed as endangered and 1 plant species listed as vulnerable under the EPBC Act could potentially occur at the site although these were not found during field survey. Cumberland Plain Woodland is listed as an endangered ecological community under the EPBC Act and occurs at the site (refer to figure 4).

Habitat for the majority of threatened species known or with the potential to occur at the site is marginal and its removal under the current proposal is unlikely to lead to significant adverse impacts for threatened species populations in the study area.

Wherever possible, large, hollow bearing trees should be retained on site so as to minimise adverse impacts on hollow dependant threatened bats in the study area. The retention of hollow bearing trees will also help to minimise adverse impacts on hollow dependant birds such as owls and parrots.

3.4 Planning Controls for Terrestrial Biodiversity

Objectives

- Improve or maintain biodiversity values within the precinct
- improve or maintain as much existing vegetation as practicable within the precinct
- Reduce impacts of runoff from roads and impervious areas on within adjacent lands.

Controls

- Parks and open spaces are to be located and designed to best retain existing vegetation to provide amenity and protection of biodiversity.
- Ensure that development adjoining protected areas is sympathetic and compatible with adequate controls to minimise impact
- Use of local provenance native species in landscaping and street scaping.
- Retention of existing large hollow bearing trees.
- Minimal infrastructure to be located within this zoning and only where it can be demonstrated not to compromise the integrity of the community.
- Recreational activities to be passive
- Rehabilitate/establish local provenance native vegetation
- Vegetation communities with high ecological value (as shown in figure 11) to be zoned within environmental conservation and recreation zoning as outlined in the GCC SEPP. Vegetation located adjacent to riparian corridors can be incorporated into the same zoning of environmental conservation. Isolated

patches can be zoned for public recreation with the requirement that the natural values of the land be enhanced restored and protected.

4. Groundwater Dependent Ecosystems Assessment

Groundwater dependant ecosystems are ecosystems which have their species composition and their natural ecological processes determined by ground water (ARMCANZ & ANZECC, 1996). A wide variety of flora and fauna depend directly or indirectly upon groundwater. Groundwater dependant ecosystems are recognised as falling into 1 of 4 types;

- Terrestrial vegetation
- Base flows in streams
- Aquifer and cave ecosystems
- Wetlands

Field investigation found that it is unlikely that the ecosystems existing within the precinct could be classified as groundwater dependant. There is potential for some of the large old established Eucalypts to utilise groundwater in times of low rainfall, however the degraded and dry nature of the site indicated that the vegetation of other strata where not utilising groundwater, and therefore the species composition and ecological processes where not being shaped by groundwater.

The base flow of streams across the site may be fed to some degree by groundwater, however the majority of the waterways across the precinct did not contain water at all, and no streams contained any visible flow. The small sections of south creek which contained water were stagnant and polluted, therefore this would not be a suitable habitat for in-stream or near-stream ecosystems.

There are no known aquifer or cave systems within the precinct.

No natural wetlands or swamps were encountered within or adjacent to the precinct. A number of farm dams providing an artificial form of wetland habitat were encountered, however the quality of this habitat is generally considered to be marginal. A number of new wetlands will be established across the precinct as part of water quality and flood controls.

5. Riparian Assessment

5.1 Riparian Corridor Mapping

5.1.1 Methods

Initial desktop riparian objective setting for the streams throughout the site was carried out by Department of Natural Resources (DNR). Most of the streams throughout the study area were tagged and assigned a value from 1 to 3 that reflects their relative riparian importance within the catchment. The three riparian categories are;

- Category 1 – key environmental corridor
- Category 2 – terrestrial and aquatic habitat
- Category 3 – bed and bank stability/water quality

Table 4 outlines the buffer specifications for each riparian category.

Table 4. DNR Riparian Categories and buffer specifications

Riparian Category	Minimum Riparian Width (measured from top of bank along either side of the watercourse)
Category 1	40m CRZ + 10 m buffer Revegetate; any structures to be located outside CRZ
Category 2	20m CRZ + 10m buffer Revegetate, any structures to be located outside CRZ
Category 3	10m CRZ (no buffer) Revegetate, any structures to be located outside CRZ

As part of the next stage of identifying riparian outcomes from the initial mapping, a field survey of the site was carried out with the DNR and Department of Environment and Conservation (DEC) representatives on December 20 2006. The objective of the day was to discuss the current riparian classification of streams/rivers, associated buffers, the draft ILP's, and uses within the riparian zones. The outcomes of the day were documented by ELA and agreed principles as well as specifically discussed decisions on particular watercourses were integrated into the riparian zone mapping and recommendations developed by ELA. Further consultation between specialist consultants was undertaken to produce a refined riparian zone mapping product which demonstrated the recommended extents and respective treatment of each watercourse across the precinct. In addition, overland habitat linkages between catchments (stepping stone corridors) have been identified as part of the overall strategy.

It is worth noting that whilst the initial riparian categorisation was based upon a desktop assessment, the final riparian classification is considered to be a negotiated strategic planning outcome that considers not only the current form of each riparian area but its future form in a highly urbanised environment. It is therefore the context of each stream in the overall strategy that is considered to be of greatest importance.

5.1.2 Results

Figure 9 holds the results of continued amendments to the existing DNR mapped rivers and associated riparian buffer zone categorisations. The mapping across both sites was reviewed by DNR on site and then further refined through a number of meetings with working group, and government agencies resulting in a map reflecting the proposed treatments of each stream reach to enable the assessment of impacts and recommendation of planning controls for the ILPs.

A number of changes were made to the original DNR mapping and categorisation, including the alteration of a number of category 3 streams to "engineered drainage". These engineered drainage lines will become piped underground or artificially channelled as part of the new urban landscape. It is considered that it is appropriate for these reaches to become engineered drainage, as they are the upper reaches of their respective waterways and currently perform drainage functions only and hold little habitat value for flora or fauna.

The main objective for riparian areas across the precinct is to ensure category 1 and 2 CRZ's containing significant riparian habitat are retained, and with appropriate restoration efforts will provide for biodiversity linkages throughout the precinct and with the surrounding areas. South Creek is the major category 1 stream within the precinct, this will result in a 40m CRZ and 10m additional buffer area to be retained either side of South Creek along its length (figure 9). A number of category 2 streams also traverse the precinct (Figure 9), these are to be buffered by a 20m CRZ with an additional 10m to be incorporated into the urban development of the precinct.

Three options have been proposed for the stream through the proposed employment/industrial zone (Figure 9) to allow for the assessment of the variety of requirements for this area, including development, flood detention, stormwater treatment and waterway integrity.

Two overland 'stepping-stone' habitat linkages have been proposed for the precinct. One in the south, connecting the two catchments and another in the north-east to be established through native landscaped open space areas and an existing power easement (figure 9).

Whilst not yet finally determined, it is envisaged that components of category 2 and 3 streams will be realigned as part of the final outcome, as such the mapping should be considered as indicative only in terms of the final location of each reach.

Due to the location of large farm dams, the power line easement and existing modifications to the upper reaches of South Creek it is likely that realignment of areas of South Creek will also be proposed. Final riparian buffer locations particularly for South Creek will need further negotiation with government agencies to ensure that a category 1 outcome can be achieved for South Creek in locations where the power line easement intersects the natural creek line. Riparian corridors have been buffered from the mapped centreline of the stream, the identification of 'top of bank' will require survey by a registered surveyor.

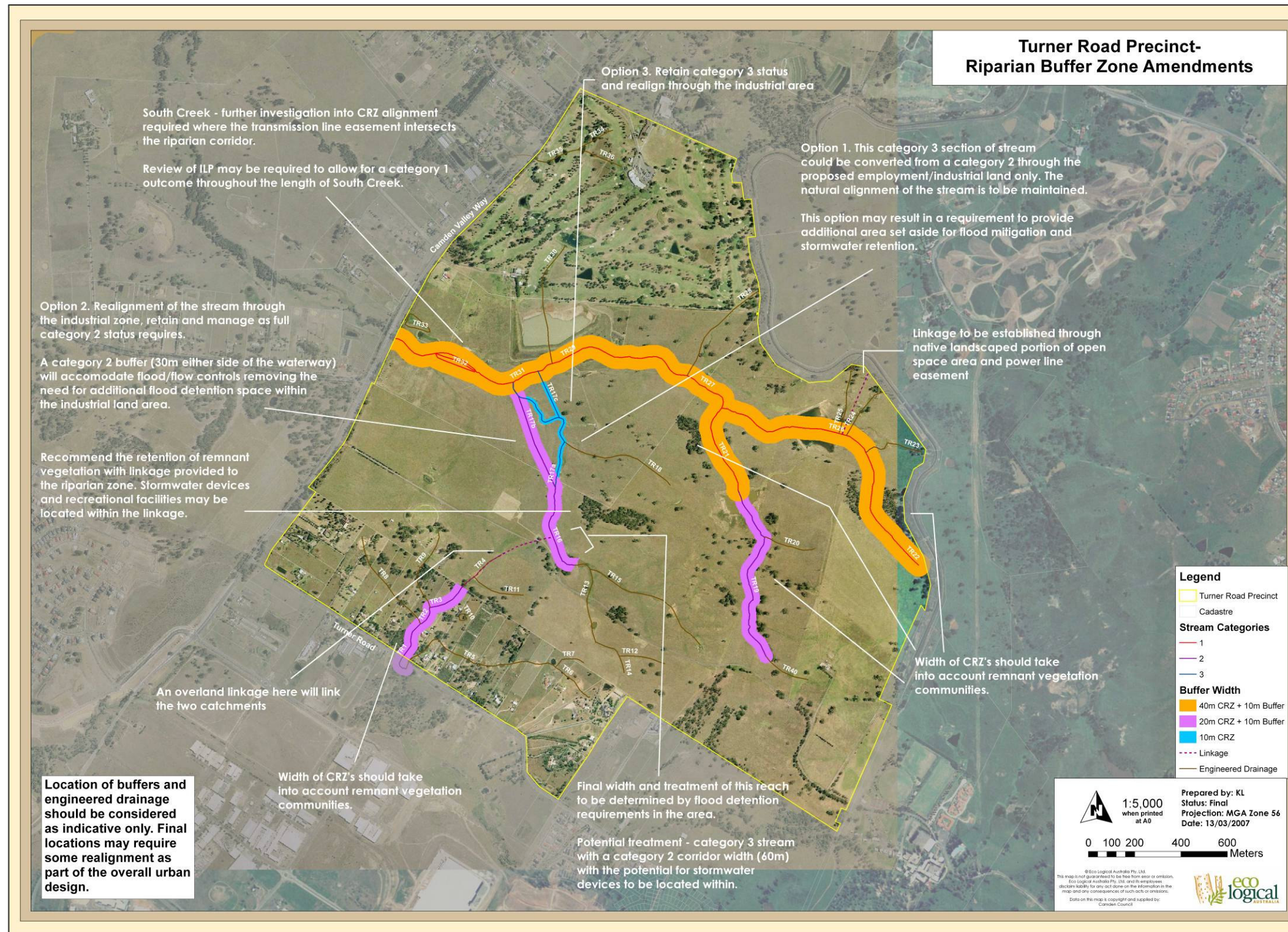


Figure 9 Riparian Corridors

5.2 Riparian Land Management

Refer to planning controls

5.3 Riparian Vegetation Management Strategy

This chapter outlines a suite of objectives and implementation strategies relating to the management of riparian corridors. These have been kept at a level of detail considered to be appropriate for the precinct plan. Further detail regarding on ground actions including management costs and performance criteria are to be determined at a later stage of the planning process.

5.3.1 Objectives

- Conserve Maintain and improve the riparian zone (CRZ and vegetated buffer)
- Establish continuous and fully vegetated native tree, shrub and groundcover in the riparian zones
- Prevent degradation resulting from weed invasion and recreational use.
- Implement low fuel regime through limiting growth of mid storey and having separation between canopy trees

5.3.2 Implementation Table

Task	Who	When	Performance criteria	Restrictions
Sourcing plant stock Seed collection and propagation Plant recovery Log recovery Brush-mat recovery	Bush Regeneration contractor and/or Civil Contractor	Prior to civil works	Collection of sufficient seed to propagate required plants, or identification of appropriate source	Must use local provenance stock
Site Preparation Sediment fencing Stock fencing Construction fencing Tree protection fencing	Civil Contractor	Prior to civil works	Fencing installed	
Creepline Stabilisation Lay heavy duty erosion control matting Create log jams and bank armouring with woody debris Install rock rip-wrap structures	Bush Regeneration contractor	Within 6 months	Structures installed and operating efficiently	Emphasis must be placed on retaining natural form and function of channels
Planting Mulching (100mm depth) or jute mat Plant tubestock Install growbags Use brush-mat	Bush Regeneration contractor	Within 6 months	80% survival rate or replacement planting occurring when survival drops below 80%	To be undertaken when planting conditions are favourable during spring

				and autumn
Maintenance Bush Regeneration Weed control Watering Replacement planting	Bush Regeneration contractor	Immediately upon completion of planting and then for a further 5 years. If during the 5 year maintenance period the plants are destroyed / damaged the maintenance period will be extended to ensure plants are established	Weed species cover and abundance less than 5% by the end of the maintenance period Greater than 75% surface area of native groundcovers by the end of the maintenance period	To be undertaken on a regular basis throughout the year and in response to peak weed growth periods
Reporting	Bush Regeneration contractor	Monthly for first 12 months, and then quarterly for next 4 years	Reports submitted on time	Reports to include works undertaken, progress in relation to performance criteria, problems encountered and how they were overcome
Monitoring	Ecologist	Once every 6 months for 5 years	Establish photo-monitoring points, vegetation quadrats and fauna survey program	Surveys to require no more than 3 days

5.3.3 Species lists and planting densities

Where revegetation occurs, it is recommended that the species identified below are planted.

Cumberland Plains Woodland

Species	Densities
Canopy	
<i>Angophora floribunda</i>	1 plant per 5m ²
<i>Eucalyptus moluccana</i>	1 plant per 5m ²
<i>Eucalyptus tereticornis</i>	1 plant per 5m ²
<i>Eucalyptus eugenioides</i>	1 plant per 5m ²
Midstorey and climbers	
<i>Acacia decurrens</i>	1 plant per 1.5m ²
<i>Acacia parramattensis</i>	1 plant per 1.5m ²

<i>Bursaria spinosa</i>	1 plant per 1.5m ²
<i>Daviesia ulicifolia</i>	1 plant per 1.5m ²
<i>Dillwynia juniperina</i>	1 plant per 1.5m ²
<i>Dodonaea viscosa ssp cuneata</i>	1 plant per 1.5m ²
<i>Ozothamnus diosmifolius</i>	1 plant per 1.5m ²
Ground layer	
<i>Hardenbergia violacea</i>	4 plants per 1m ²
<i>Aristida sp.</i>	4 plants per 1m ²
<i>Austrodanthonia fulva</i>	4 plants per 1m ²
<i>Dianella longifolia</i>	4 plants per 1m ²
<i>Dichondra repens</i>	4 plants per 1m ²
<i>Echinopogon caespitosus</i>	4 plants per 1m ²
<i>Eragrostis brownii</i>	4 plants per 1m ²
<i>Microlaena stipoides</i>	4 plants per 1m ²
<i>Themeda australis</i>	4 plants per 1m ²
<i>Poa labillardieri</i>	4 plants per 1m ²

Alluvial Woodland

Species	Densities
Canopy	
<i>Angophora floribunda</i>	1 plant per 5m ²
<i>Angophora subvelutina</i>	1 plant per 5m ²
<i>Casuarina glauca</i>	1 plant per 5m ²
<i>Eucalyptus amplifolia</i>	1 plant per 5m ²
<i>Eucalyptus tereticornis</i>	1 plant per 5m ²
Midstorey and climbers	
<i>Acacia parramattensis</i>	1 plant per 1.5m ²
<i>Bursaria spinosa</i>	1 plant per 1.5m ²
<i>Melaleuca linariifolia</i>	1 plant per 1.5m ²
Ground layer	
<i>Commelina cyanea</i>	4 plants per 1m ²
<i>Dichondra repens</i>	4 plants per 1m ²
<i>Lomadra longifolia</i>	4 plants per 1m ²
<i>Microlaena stipoides</i>	4 plants per 1m ²
<i>Oplismenus aemulus</i>	4 plants per 1m ²
<i>Pratia purperescens</i>	4 plants per 1m ²

<i>Themeda australis</i>	4 plants per 1m ²
<i>Wahlenbergia gracilis</i>	4 plants per 1m ²

Ephemeral

Species	Densities
<i>Baumea articulata</i>	4 plants per 1m ²
<i>Bolboschoenus caldwellii</i>	4 plants per 1m ²
<i>Bolboschoenus fluviatilis</i>	4 plants per 1m ²
<i>Carex appressa</i>	4 plants per 1m ²
<i>Carex inversa</i>	4 plants per 1m ²
<i>Casuarina glauca</i>	4 plants per 1m ²
<i>Cyperus exaltus</i>	4 plants per 1m ²
<i>Eleocharis acuta</i>	4 plants per 1m ²
<i>Eleocharis sphacelata</i>	4 plants per 1m ²
<i>Fimbristylis dichotoma</i>	4 plants per 1m ²
<i>Imperata cylindrica</i>	4 plants per 1m ²
<i>Juncus usitatus</i>	4 plants per 1m ²
<i>Lepidosperma laterale</i>	4 plants per 1m ²
<i>Lomdandra longifolia</i>	4 plants per 1m ²
<i>Ludwigia peploides</i>	4 plants per 1m ²
<i>Melaleuca linariifolia</i>	4 plants per 1m ²
<i>Paspalum distichum</i>	4 plants per 1m ²
<i>Potamogeton tricarinatus</i>	4 plants per 1m ²
<i>Schoenoplectus mucronatus</i>	4 plants per 1m ²
<i>Schoenoplectus validus</i>	4 plants per 1m ²
<i>Triglochin procera</i>	4 plants per 1m ²
<i>Triglochin procerum</i>	4 plants per 1m ²
<i>Typha orientalis</i>	4 plants per 1m ²

5.4 Planning Controls for Riparian Lands

Riparian Corridors

Objectives for and the additional controls associated with each category of stream as mapped in figure 9 and 11 are summarised below

General objectives/key issues for riparian zones

- Provide bed and bank stability
- Protect water quality
- Provide continuity and connectivity
- Integration with floodplain processes
- Manage edge effects at riparian/urban interface
- Protection of natural values within channels, CRZ and vegetated buffer
- Appropriate zoning of each stream category into environmental conservation and recreation zoning as outlined in the GCC SEPP.

Critical controls for all stream categories

- Provide a minimum 'core' riparian zone (CRZ) as shown on figure 10 and 11
- Additional vegetation width of 10m to counter edge effects with urban interface as shown on figure 10 and 11
- Streams to be zoned as Environmental Conservation, to enable the protection and restoration of these areas to preserve biological integrity and native vegetation corridors.
- Rehabilitate/establish local provenance native vegetation
- Locate services (power, water, sewerage, and water quality treatment ponds) outside of the CRZ. (Encroachment into the non core riparian area may be possible if the impact on riparian functions is minimal and integrity maintained)
- Locate flood compatible activities (playing fields) outside of the CRZ. (Encroachment into the riparian area may be possible if the impact on riparian functions is minimal and integrity maintained)
- Locate stormwater infrastructure outside CRZ (and treat before discharge)
- Suitable zoning that recognises the environmental significance of riparian corridors to be provided where necessary
- The location of access ways to the waterway is not to compromise the ecological integrity of the existing and final riparian vegetation or streambed and bank stability
- Minimise the impact of walkways, cycleways and general access points by using ecologically informed design principles
- Provide a suitable interface between the riparian area and urban development (roads, playing fields, open space) to minimise edge effects
- Manage urban development to avoid increasing the impact of salinity on the landscape and watercourse.
- Asset protection zones not to be located within the CRZ's

Category 1 specific objectives

- Provide a continuous vegetated riparian corridor for the movement of flora and fauna species through the catchment and beyond the catchment
- Provide extensive habitat and connectivity between habitat nodes for both terrestrial and aquatic fauna
- Maintain viability of native riparian vegetation

Category 1 specific controls

- Provide a continuous riparian corridor that:
 - provides linkages to stands of remnant vegetation where applicable, and
 - a "core riparian zone" (CRZ) with a minimum width of 40 m from the top of the bank, and a 10 metre wide vegetated buffer either side of the CRZ
 - sufficient (additional) riparian corridor width based on geomorphological and environmental considerations
- Provide a suitable environmental protection zoning to the riparian land (CRZ and buffer) that recognises its environmental significance.
- Restoring/rehabilitating the riparian zone (CRZ and buffer) with local provenance native vegetation
- Ensure vegetation in the CRZ and vegetated buffer is at a density that would occur naturally
- Minimising the number of road crossings
- Maintain riparian connectivity by using piered crossings in preference to pipes or culverts
- Ensure lateral connectivity for instream function.

Category 2 specific objectives

- To maintain and restore the natural functions of a stream and its aquatic and terrestrial qualities
- To maintain the viability of native riparian vegetation
- To provide suitable habitat for local and terrestrial aquatic fauna

Category 2 specific controls

- CRZ with a minimum width of 20m from top of bank and a 10 metre wide vegetated buffer either side of the CRZ.
- Provide where possible sufficient additional riparian corridor width based on geomorphological and environmental considerations
- Provide a suitable environmental protection zoning to the riparian land (CRZ and buffer) that recognises its environmental significance.
- Restoring/rehabilitating the riparian zone with local provenance native vegetation
- Ensure vegetation in the CRZ and vegetated is at a density that would occur naturally
- Minimising the number of road crossings and ensure they maintain riparian connectivity
- Provide lateral connectivity for instream function.

Category 3 specific objectives

- To retain, maintain and restore where possible the natural functions of a stream, including bed and bank stability to protect local water quality.

Category 3 specific controls

- Provide CRZ with a minimum width of 10m
- A naturally functioning stream to be emulated or preserved wherever possible
- Filling is to be avoided in order to retain the natural stream bed and bank profile
- Engineered drainage solutions to be used as a last resort within CRZ's with the use of appropriate WSUD approaches to be used within sensitive areas

6. Aquatic Habitat Assessment

6.1 Methods

The presence and condition of aquatic habitat at the site was assessed using aerial photograph interpretation followed by on ground site inspection. The aquatic habitat within the study area was given one of four 'health' classifications based on visual assessment of water quality, sedimentation and erosion and presence and abundance of exotic plant species within the riparian zone. A map showing the classification of aquatic habitat in the study area was produced based on the data collected in the field. The classifications were:

- **Good** – no evidence of erosion or stream bank degradation or excessive sedimentation, water quality excellent, riparian vegetation consists of native species, fish and macro invertebrate habitat excellent, no exotic weeds, macro invertebrates or fish species, no artificial barriers to upstream migration.
- **Moderate** – some evidence of erosion, stream bank degradation and sedimentation, water quality good, riparian vegetation consists of mostly native species, fish and macro invertebrate habitat quality good, very few exotic weeds, macro invertebrates or fish species, no artificial barriers to upstream migration.
- **Minimal** – some evidence of excessive erosion, stream bank degradation and sedimentation, water quality fair, riparian vegetation consists of a mix of natives and weeds, minimal fish and macro invertebrate habitat, many exotic weeds, macro invertebrates or fish species, artificial barriers to upstream migration.
- **Poor** – excessive erosion, stream bank degradation and sedimentation, water quality poor, riparian vegetation consists of weeds, poor fish and macro invertebrate habitat, dominated by exotic weeds, macro invertebrates or fish species, major artificial barriers to upstream migration.

6.2 Results

The results of the aquatic health field assessment are shown in figure 10.

A number of category 3 streams across the precinct had no clear characteristics that could be used to rate the condition of the aquatic habitat e.g. no stream bank or flow, therefore a rating of N/A was given to these streams in recognition that they are not classed as having any aquatic habitat value for the purposes of this study.

The majority of the streams assessed were found to be of minimal and poor aquatic habitat reflecting the ephemeral nature and predominantly cleared and heavily grazed environment within the precinct.

No suitable habitat for aquatic threatened species was observed at the site. Despite this finding it needs to be noted that the natural state of the majority of watercourses across the precinct is ephemeral and that during times of flow these watercourses

provide aquatic habitat and connectivity lining areas for species that are not linked during dry conditions.

Most riparian vegetation where it still exists was found to contain considerable weed growth. The presence of exotic species in the riparian zone (in the absence of local native plant species) can still provide some level of habitat for native fauna (shelter, food resource etc), a water quality function (filter nutrients and provide shade) and bank stability. The importance of weed dominated vegetation does not outweigh the importance of native vegetation, however the values of weed infestations should be managed appropriately when planning/carry out any weed removal/rehabilitation activities e.g. staged weed slashing which allows for fauna utilising the vegetation to move on to other areas.

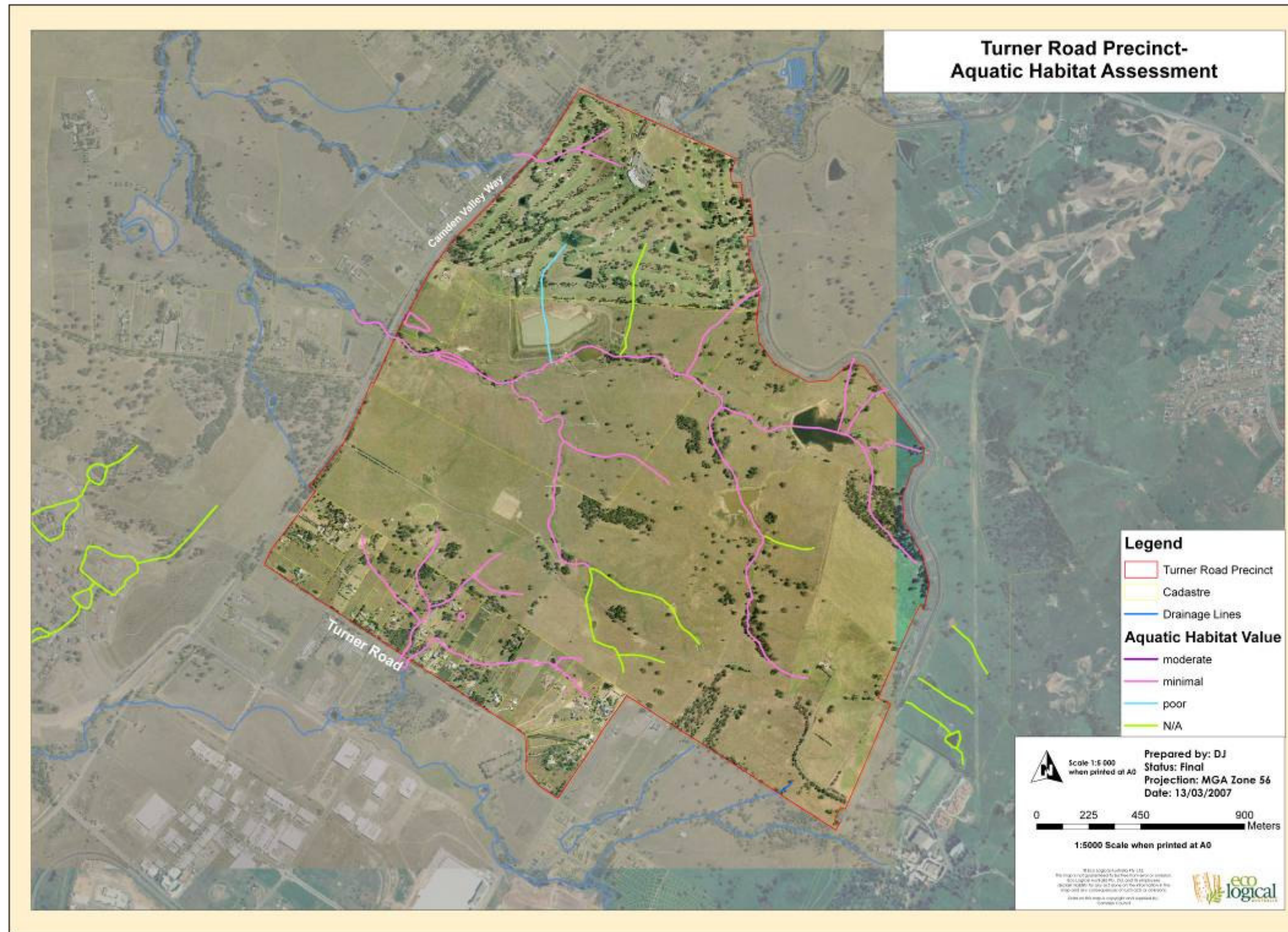


Figure 10 – Aquatic Habitat Condition

7. Conservation and Management Recommendations

7.1 Key Recommendations

- Existing trees be incorporated where possible into the landscape to permit fauna and flora movement through the precinct.
- Retain and restore patches of vegetation (CPW) with high recovery potential remaining within the small landholder properties along Turner Road.
- Retain large hollow bearing paddock trees as they provide roosting and breeding habitat for owls, birds, bats and arboreal mammals.

7.2 Suggested ILP Modifications

Figure 11 shows the priority areas for conservation across the Turner Road Precinct, namely the core riparian zones with additional 10m buffer zones, and areas of important remnant vegetation that remain structurally and floristically diverse. These areas are retained in the draft ILP except for one patch of CPW in the southern most boundary of the precinct, within the small land holder area. This community can be easily incorporated into the category 2 CRZ which runs through the middle of the existing vegetation extent.

Generally, the current ILP will see adequate retention of appropriate riparian CRZ's and additional buffer zones in its first iteration. However, the option for the riparian treatment through the proposed employment/industrial lands has yet to be determined. Flood detention devices are not located within the 40m CRZ of the category 1 CRZ along the extent of South Creek, this will also be the case for the 20m CRZ of the category 2 streams through the centre of the site.

This ILP shows that most of the existing mapped vegetation on the site is planned to be retained, either within riparian corridors or parks. For the remnants that are proposed to be cleared within the golf course and potentially the small land holdings, this is not considered to be a significant environmental impact due to the poor habitat condition. Large hollow bearing Eucalypts remaining as paddock trees in the current landscape should be retained, as they provide potential roosting and breeding habitat for owls, bats, parrots and arboreal mammals. This can be accomplished through tree preservation orders, pocket parks throughout the precinct or incorporating the Eucalypts into the urban landscape as street trees or within large lots.

The ILP will likely see the removal of the dams located across the site; this will cause the loss of frog habitat, marginal habitat for a number of threatened waterbirds and some migrants as well as the loss of foraging habitat for Myotis and water source for other bats in area. This is likely to be mitigated by the provision of constructed wetlands and other stormwater treatment and detention infrastructure within the site and the rehabilitation of South Creek and its' riparian vegetation. It is noted that significant management of open wetland areas is required to prevent/control rubbish dumping and the establishment of nuisance species including ibis and mosquito fish.

Overall the ILP for the Turner Road Precinct, has been designed to retain the key environmental features of the site, namely major riparian corridors and patches of significant remnant vegetation. No major modifications to the current draft of the ILP are required.

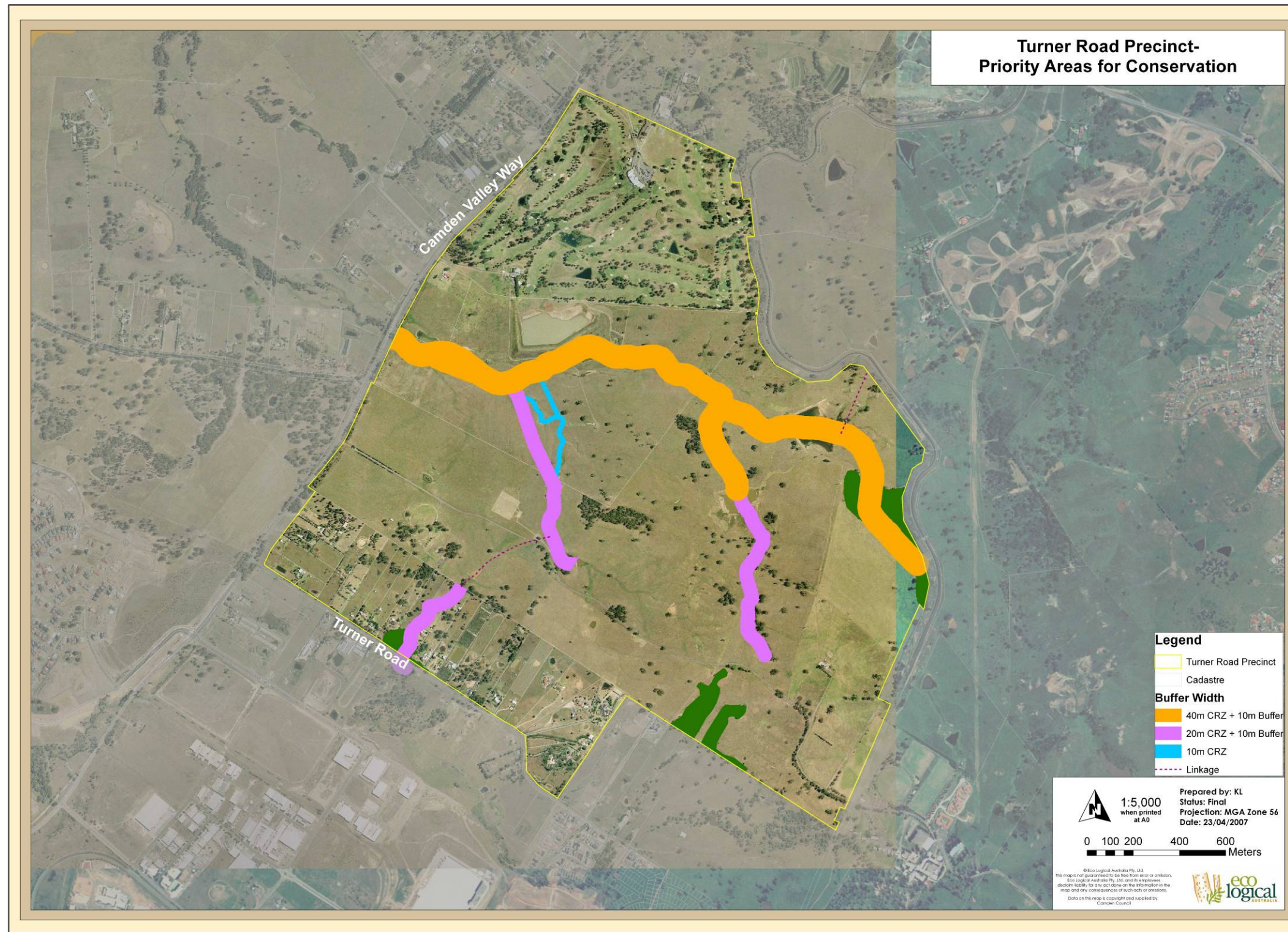


Figure 11. Priority Areas for Conservation

7.3 Tenure and Management Arrangements

The models provided rely on the development process to fund the establishment of reserves through an agreed plan of management and timeframe.

Organisation	Examples	Funding Options	Benefits	Limitations
State Agency	* Western Sydney Regional Park	* State Government recurrent budget * New tax	* Highest level of long term security * Emphasis on management for biodiversity * Provides a regional resource for the community * Preferred for larger sites of strategic importance	* Will require additional government resourcing * High management costs for riparian corridors (high edge:area ratio) * Will require emphasis on neighbour relations etc * Agency staff may be required to contribute to broader organisational requirements (emergency response etc) * Policing role * Liability
Joint State/Local	* TBA	* State and Local Government recurrent budget (dependant on how joint agreement established) * New tax or levy	* High level of protection and security * Emphasis on management for biodiversity * Regional Parks can be cooperatively managed with Council	* Will require additional government resources * Will require emphasis on neighbour relations etc * Agency staff may be required to contribute to broader organisational requirements (emergency response etc) * Policing role * Liability

Organisation	Examples	Funding Options	Benefits	Limitations
Local Council	* Public reserves	* Council recurrent budgets (rates) * New Levy * Special rate * Grants	* High level of protection (zoning, tenure, SEPP19, PoM) * Local management * Integration with broader open space management * Pooling of Council resources * 'In-kind' grants * Additional emphasis on recreational use and broader amenity to local community	* Funding liability * Councils inadequately resourced
Trust or not for profit organisation	* Bush Heritage Fund * Nature Conservation Trust	* Sinking fund * Donations	* Managed by a dedicated conservation land management organisation	* BHF established to manage high ecological value lands, this type of land may not fit their model * Do not manage lands for recreational purposes * Lack of community ownership
Private Collective eg. Community scheme	* Harrington Grove Community Title	* Levy through community scheme	* Community involvement with managing the environment * Smaller administrative overheads than government * Easier ability to use private contractors to implement works and take on management risk	* Can limit broader community access * By-laws able to be changed * Funding could be inadequate, particularly if a response to a random event is required * Need to provide nexus with the 'association lot'
Private Individual	* Retention of riparian zones in single large lot with dwelling entitlement	* Privately funded	* Management risk born by an individual * Greater potential for development of innovative funding mechanisms	* Potential for poor management * High risk of being inadequately resourced
Private Trust	* Private trust with trustees established	* Sinking fund established by developer or government	* Single management entity * Trust funded by development upfront * Ability to have government trustees	* Need to ensure trustees are appropriate and accountable * Difficult to obtain additional funding * Potential for poor management of trust, particularly financial management

7.4 Indicative Management Costs

Management costs for natural areas can be extensive, depending on the quality of vegetation, the objectives for management and the level of disturbance. Management costs can be a considerable liability to government land managers, the result being a reluctance to accept management responsibility for such lands.

Further detail on management costs will be available at a later stage of the planning process, some indicative costs to assist in discussions to determine long term management responsibilities are provided below.

7.4.1 Establishment Costs

Based on Greening Western Sydney, DEC (2003) has provided the following estimates for Western Sydney Bushland Management. All figures are based on a five person team, which ranges from \$1200 - \$1500/day.

Good condition bush

3 team days/Ha (\$3,600 - \$4,080)

Moderate condition bush

Year 1: 15 team days/Ha (\$18,000 - \$20,400)

Year 2: 10 team days/Ha (\$12,000 - \$13,600)

Year 3: 5 team days/Ha (\$6,000 - \$6,800)

Poor condition bush

Year 1: 30 team days/Ha (\$36,000 - \$40,800)

Year 2: 15 team days/Ha (\$18,000 - \$20,400)

Year 3: 10 team days/Ha (\$12,000 - \$13,600)

Revegetation

Costs for revegetation assume mechanical planting of trees spaced wide enough to allow a vehicle to drive through and do weed spraying. 2003 costs were \$4.20/tree, planting about 1200 trees/Ha (\$5040). Applying a similar increase of 20% - 36% as above, the likely current costs equate to;

Year 1: \$6,048 - \$6,854

Years 2&3: \$3,000 - \$3,400

Years 4&5 \$600 - \$680

If standard DNR planting densities for Vegetation Management Plans (5.25/ m² for sites greater than 1 hectare) were used for revegetation, this would require approximately 52,500 plants/hectare, which at a cost of \$3.50 installed equates to \$183,750/hectare. This figure does not include site costs, seed collection or maintenance.

7.4.2 Recurrent Management

Depending on the nature of a site, management costs can vary considerably. Examples of recurrent management costs include;

Centennial Park	\$11,000/Ha/year
Landcom (public domain)	\$6,500/Ha/year
Councils	\$3,000 - \$4,000/Ha/year
DEC	\$2,000/Ha/year
Sydney Water (trunk drainage lines)	\$500/Ha/year
Greening Western Sydney (mechanical herbicide application)	\$500/Ha/year

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Appendix 1 - Detailed Methodology for Ecological Constraints Analysis

Recovery Potential

Using information collected in the field 'recovery potential' is determined for each area of vegetation. This is defined as "...the anticipated capacity of (an) area to recover to a state representative of its condition prior to the most recent disturbance event" (IPC & AES, 2002).

Table 1 outlines the decision rules used in this step, resulting in a ranking of High, Moderate, Low or Very Low recovery potential for each vegetation remnant.

Conservation Significance

As part of the recovery planning process for Cumberland Plain vegetation communities, NPWS (2001) have classified remnant vegetation across the Plain into significance categories to assist Councils and other land use planners in making decisions about land use. Remnant woodland and forest vegetation has been ranked as one of four categories:

- 'Core Habitat'; defined as "areas that constitute the backbone of a viable conservation network across the landscape; or areas where the endangered ecological communities are at imminent risk of extinction"
- 'Support for Core Habitat'; "areas that provide a range of support values to the Core Habitat, including increasing remnant size, buffering from edge effects, and providing corridor connections"
- 'Other Remnant Vegetation'; "all native vegetation that does not fall within the above significance categories"

These decision criteria are outlined in Table 2.

NPWS (2002) conservation significance attribute information was assigned to the vegetation polygons mapped on Oran Park / Turner Road sites. Where the classification no longer matched, changes were made.

Threatened Species Assessment

Threatened species information and field observations of habitat value were then collated for the study area and used to determine significant threatened species habitat. Each remnant vegetation patch is classed as having either Known, Likely or Nil chance of supporting threatened species.

The following criteria were adopted for categorisation;

- Known/High
 - Known occurrence of threatened flora or fauna
 - Known occurrence of Cumberland Plain Land Snail

- Known breeding habitat for wide ranging threatened species (e.g. bats and birds with large home ranges)
- Likely/Moderate
 - Likely occurrence of threatened flora or fauna
 - Likely occurrence of Cumberland Plain Land Snail
 - Likely breeding habitat for wide ranging threatened species (e.g. bats and birds with large home ranges)
- Nil/Low
 - Foraging habitat only, for wide ranging species (e.g. bats and birds with large home ranges)

Ecological Constraint

Information derived from the recovery potential, conservation significance and threatened species calculations are combined to determine ecological constraint. Table 3 and Table 4 show the process for combining this information.

Table 1. Recovery potential matrix

Source: Eco Logical Australia (2003).

Current condition and land use	Past land use and disturbance	Soil Condition	Vegetation	Recovery Potential
Cleared (no woodland canopy). Includes <i>Bursaria</i> thickets in grassland	Recently cleared (<2 years)	Unmodified or largely natural. Uncultivated.	Native dominated	High
			Exotic dominated	Moderate
	Historically cleared (>2 years) and consistently managed as cleared.	Modified. Heavily cultivated and/or pasture improved. Imported material.	Either	Low
			Native dominated	Moderate
		Unmodified or largely natural. Uncultivated.	Exotic dominated	Low
			Either	Very Low
Wooded/Native Canopy present or regenerating	No recent clearing of understorey	Unmodified or largely natural. Uncultivated.	Native understorey relatively intact or in advanced state of regeneration. Native dominated.	High
			Native understorey significantly structurally modified, absent or largely absent. Includes areas dominated by African Olive.	Moderate
			<i>Exotic dominated</i>	<i>Low</i>
		<i>Moderately modified by long term grazing or mowing.</i>	<i>Native dominated</i>	<i>Low</i>
		Modified. Heavily cultivated and/or pasture improved. Imported material.	Native understorey significantly structurally modified, absent or largely absent. Includes areas dominated by African Olive.	Very Low
			Native understorey present. Heavily weed invaded.	Low
	<i>Understorey patchily intact</i>	<i>Disturbed</i>	<i>Native dominated</i>	<i>Moderate</i>
			<i>Exotic dominated</i>	<i>Low</i>
	Recent clearing of understorey and or native understorey significantly structurally modified due to existing land use (eg. Mowing, grazing)	Unmodified or largely natural. Uncultivated.	Native dominated. If no vegetation present, assume native dominated.	High
			Exotic dominated	Moderate
		Modified. Heavily cultivated and/or pasture improved. Imported material.	Native dominated	Low
			Exotic dominated	Very Low

Table 2. Conservation significance matrix

Source: NSW NPWS (2002)

Community type	Condition Code*	Patch Size	Connectivity	Code	Conservation Significance
Endangered Ecological Community (Critically endangered) ("CEEC")	ABC, TX or Txr	Any	Any	C3	Core
	Txu	Any	Any	URT	Urban remnant trees (critically endangered communities)
Endangered Ecological Community ("EEC")	ABC (with Understorey in good or moderate condition)	> 10 ha	Any	C1	Core
		< 10 ha	Adjacent to C1 or CEEC	C2	Core
			Adjacent to S1	S2	Support for core
	TX or Txr, ABC (with poor Understorey condition)	Any	Adjacent to any Core	S1	Support for core
			None	O	Other remnant vegetation
	Txu	Any	Any	O	Other remnant vegetation

Table 3. Ecological constraint matrix step 1

Source: Eco Logical Australia (2003). This step combines the recovery potential and conservation significance maps.

Conservation Significance	Recovery Potential				
		High	Moderate	Low	Very Low
Core	High	High	High	High	High
Support for core	High	Moderate	Moderate	Moderate	Low
Other	Moderate	Moderate	Low	Low	Low

Table 4. Ecological constraint matrix step 2

Source: Eco Logical Australia (2003). This step combines results from Table 3 with the threatened species layer to determine ecological constraint.

Threatened Species Assessment	Combined Recovery Potential and Conservation Significance (result of Table 3 above)			
		High	Moderate	Low
Known (High)	High	High	High	High
Likely (Moderate)	High	Moderate	Moderate	Moderate
Nil (Low)	High	Moderate	Moderate	Low

Appendix 2 - Threatened fauna recorded within a 10 km radius of the site (NSW Wildlife Atlas) and across the Camden LGA (EPBC Protected Matters Search Tool)

Threatened Fauna

			source		
Common Name	Species Name	Habitat	GCC	turner bionet	Likelihood of occurrence
Australasian Bittern	<i>Botaurus poiciloptilus</i>	Boggy marsh, wetland margins.	yes		No
Blue-billed Duck	<i>Oxyura australis</i>	Well vegetated freshwater swamps, large dams, lakes. In winter more open waters.	yes		Potential
Cumberland Plain Land Snail	<i>Meridolum corneovirens</i>	Primarily inhabits Cumberland Plain Woodland (an endangered ecological community). This community is a grassy, open woodland with occasional dense patches of shrubs.	yes	yes	Likely
Eastern False Pipistrelle	<i>Falsistrellus tasmaniensis</i>	Usually roosts in tree hollows in the higher rainfall forests within its range.	yes		unlikely
Gang-gang Cockatoo	<i>Callocephalon fimbriatum</i>	Occurs within a variety of forest and woodland types.	yes		Unlikely
Greater Broad-nosed Bat	<i>Scoteanax rueppellii</i>	Moist gullies in mature coastal forests or rainforests. Roosts in hollow tree trunks and branches.	yes		likely
Grey-headed Flying-fox	<i>Pteropus poliocephalus</i>	Roosts in large camps in Botanic Gardens.	yes		potential
Large-eared Pied Bat	<i>Chalinolobus dwyeri</i>	Uncommon but observed in wet and dry eucalypt forests.	yes		unlikely
Masked Owl	<i>Tyto novaehollandiae</i>	Occurs in forests, open woodlands, farmlands with large trees.	yes		potential
Speckled Warbler	<i>Pyrrholaemus sagittatus</i>	Lives in a wide range of eucalypt dominated communities that have a grassy understorey, often on rocky ridges or in gullies. Typical habitat would include scattered native tussock grasses, a sparse shrub layer, some eucalypt regrowth and an open canopy.	yes		potential

Swift Parrot	<i>Lathamus discolor</i>	Breeds in Tasmania, but winters on mainland in diverse timbered habitats, including forests, woodlands, plantations, banksias, street trees and gardens	yes	yes	potential
Black-chinned Honeyeater (eastern subspecies)	<i>Melithreptus gularis gularis</i>	Drier eucalypt forests, woodlands, timber on water courses, often no understorey, scrubs. Favours ironbark woodlands on w. slopes.	yes		potential
Brown Treecreeper	<i>Climacteris picumnus</i>	Drier forests, woodlands, scrubs with fallen branches.	yes		potential
Eastern Bentwing-bat	<i>Miniopterus schreibersii oceanensis</i>	Forages above the canopy and eats mostly moths. Roosts in caves, old mines, road culverts.	yes		potential
Eastern Freetail-bat	<i>Mormopterus norfolkensis</i>	Evidence suggests that the species depends on hollows and tree fissures for roosting sites.	yes		potential
Glossy-Black Cockatoo	<i>Calyptrorhynchus lathamii</i>	She-oaks in forests, woodlands, timbered watercourses.	yes		No
Green and Golden Bell Frog	<i>Litoria aurea</i>	Large permanent freshwater wetlands, with dense stands of reeds.	yes		unlikely
Koala	<i>Phascolarctos cinereus</i>	Swamp Mahogany and Tallowwood are of primary importance to this Koala population. Other local native tree species used by Koalas include Broad-leaved Paperbark, Blackbutt, Red Bloodwood, Flooded Gum and Smooth-barked Apple	yes	yes	unlikely
Large-footed Myotis	<i>Myotis adversus</i>	A range of habitats close to water from lakes, small creeks to large lakes and mangrove lined estuaries.	yes	yes	potential
Powerful Owl	<i>Ninox strenua</i>	Pairs occupy large, probably permanent home ranges in forests to woodlands. Nest in large hollow.	yes		potential
Square-tailed Kite	<i>Lophoictinia isura</i>	Diverse habitats from woodlands to timbered watercourses	yes		unlikely
Yellow-bellied Shearwater-bat	<i>Saccolaimus flaviventris</i>	In almost all habitats from wet and dry sclerophyll forests, open woodland, Acacia shrubland, mallee, grasslands and desert.	yes		potential
Diamond Firetail	<i>Stagonopleura guttata</i>	Found in grassy eucalypt woodlands, including Box-Gum Woodlands and Snow Gum Eucalyptus pauciflora Woodlands. Also occurs in open forest, mallee, Natural Temperate Grassland, and in secondary grassland derived from other communities. Often found in			potential

		riparian areas (rivers and creeks), and sometimes in lightly wooded farmland.			
Hooded Robin	<i>Melanodryas cucullata</i>	Occurs in open woodland often near clearings or open areas from Brisbane to Adelaide throughout much of inland NSW. Requires structurally diverse habitats of eucalypt canopy, some shrub layer and areas of tall grass.			Potential
Macquarie Perch	<i>Macquaria australasica</i>	Found in river and lake habitats primarily within the Murray - Darling Basin but also recorded within the Hawkesbury and Shoalhaven River catchments. Occur in the upper reaches of rivers and their tributaries where they feed on aquatic insects, crustaceans and molluscs.		yes	unlikely
Eastern Quoll	<i>Dasyurus viverrinus</i>	Occurs in a range of habitats including dry sclerophyll forest, scrub, heathland and cultivated land where it forages for insects.		yes	no
Rufous Bettong	<i>Aepyprymnus rufescens</i>	Patchy occurrence from Queensland to north-eastern NSW. Utilises a variety of habitats including tall, moist eucalypt forest to open forest. Tall native grass cover provides important day time shelter. Nocturnal foragers for grasses, herbs, seeds, roots, tubers and occasionally insects.		yes	unlikely

Appendix 3 - Threatened flora recorded within a 10 km radius of the site (NSW Wildlife Atlas) and across the Camden LGA (EPBC Protected Matters Search Tool)

Threatened Flora			Source		
Species Name	Common Name	Habitat	GCC	Turners Rd bionet	Likelihood of occurrence
<i>Acacia bynoeana</i>	Bynoe's Wattle	Grows in sandy clay soils often containing ironstone gravels in open forest and shrubland, usually on ridgetops.	yes	no	No
<i>Cynanchum elegans</i>	White-flowered Wax Plant	Occurs mainly at the ecotone between dry subtropical rainforest and sclerophyll forest/woodland communities. Is a clonal species and suckers in response to disturbance.	yes	no	No
<i>Hibbertia superans</i>		Flowering time is July to December. The species occurs on sandstone ridgetops often near the shale/sandstone boundary. Occurs in both open woodland and heathland, and appears to prefer open disturbed areas, such as tracksides.	yes	no	No
<i>Allocasuarina glauca</i>		Grows in Castlereagh woodland on lateritic soil. Found in open woodland with <i>Eucalyptus parramattensis</i> , <i>Eucalyptus fibrosa</i> , <i>Angophora bakeri</i> , <i>Eucalyptus sclerophylla</i> and <i>Melaleuca decora</i> .	yes	no	No
<i>Epacris purpurascens</i> var <i>purpurascens</i>		Found in a range of habitat types, most of which have a strong shale soil influence. Grows on poorly drained clay soils over sandstone or on shales in eucalypt forest among rocks or along creek banks.	yes	no	Potential

<i>Grevillea juniperina</i> ssp <i>juniperina</i>	Juniper-leaved Grevillea	Grows on reddish clay to sandy soils derived from Wianamatta Shale and Tertiary alluvium (often with shale influence), typically containing lateritic gravels. Recorded from Cumberland Plain Woodland, Castlereagh Ironbark Woodland, Castlereagh Scribbly Gum Woodland and Shale/Gravel Transition Forest.	yes	no	Potential
<i>Marsdenia viridiflora</i> ssp <i>viridiflora</i>		Grows in vine thickets and open shale woodland. Recent records are from Prospect, Bankstown, Smithfield, Cabramatta Creek and St Marys. Previously known north from Razorback Range.	yes	no	unlikely
<i>Persoonia hirsute</i>	Hairy Geebung	The Hairy Geebung is found in sandy soils in dry sclerophyll open forest, woodland and heath on sandstone. It is usually present as isolated individuals or very small populations.	yes	no	no
<i>Pimelea spicata</i>	Spiked Rice-flower	Occurs on undulating topography on substrates derived from Wianamatta Shale in areas of Cumberland Plain Woodland Vegetation Community.	yes	yes	potential
<i>Acacia pubescens</i>	Downy Wattle	Scattered throught the Cumberland plain where it grows on clay and clay-shale soils.	yes	no	potential
<i>Darwinia biflora</i>		Occurs on the edges of weathered shale-capped ridges, where these intergrade with Hawkesbury Sandstone. The vegetation structure is usually woodland, open forest or scrub-heath.	yes	no	no

<i>Leucopogon fletcheri</i>		Occurs in dry eucalypt woodland or in shrubland on clayey lateritic soils, generally on flat to gently sloping terrain along ridges and spurs.	yes	no	unlikely
<i>Dillwynia tenuifolia</i>		In western Sydney, may be locally abundant particularly within scrubby/dry heath areas within Castlereagh Ironbark Forest and Shale Gravel Transition Forest on tertiary alluvium or laterised clays. May also be common in transitional areas where these comm	yes	no	no
<i>Eucalyptus sp 'Cattai'</i>		Occurs in scrub, heath and low woodland on sandy soils, sites being generally flat and on ridge tops. Associated soils are laterised clays overlying sandstone	yes	no	no
<i>Grevillea parviflora ssp parviflora</i>		Grows in sandy or light clay soils usually over thin shales. Occurs in a range of vegetation types from heath and shrubby woodland to open forest. Found over a range of altitudes from flat, low-lying areas to upper slopes and ridge crests. Often occurs in open, slightly disturbed sites such as along tracks.	yes	no	no
<i>Micromyrtus minutiflora</i>		Grows in Castlereagh Scribbly Gum Woodland, Ironbark Forest, Shale/Gravel Transition Forest, open forest on tertiary alluvium and consolidated river sediments.	yes	no	no

<i>Persoonia nutans</i>	Nodding Geebung	Confined to aeolian and alluvial sediments and occurs in a range of sclerophyll forest and woodland vegetation communities, with the majority of individuals occurring within Agnes Banks Woodland or Castlereagh Scribbly Gum Woodland.	yes	no	unlikely
<i>Pultenaea parviflora</i>		May be locally abundant, particularly within scrubby/dry heath areas within Castlereagh Ironbark Forest and Shale Gravel Transition Forest on tertiary alluvium or laterised clays.	yes	no	no
<i>Eucalyptus benthamii</i>	Nepean River Gum	Requires a combination of deep alluvial sands and a flooding regime that permits seedling establishment. Occurs in open forest.	no	no	no
<i>Pomaderris brunnea</i>	Brown Pomaderris	Uncommon in moist forests.	no	yes	unlikely
<i>Epacris sparsa</i>		Sandy clay soils derived from shale lenses between hawkesbury sandstone beds at base of rock faces and platforms in river flood zone	no	yes	no
<i>Bertya ingramii</i>		Grows among rocks or in thin soils close to cliff-edges in dry woodland with she-oaks, wattles and tea-trees.	no	yes	no
<i>Prostanthera askania</i>		Occurs over a very restricted geographic range (of less than 12 km) in the upper reaches of creeks that flow into Tuggerah Lake or Brisbane Water within the Wyong and Gosford local government areas.	no	yes	no
<i>Zieria tuberculata</i>		The Warty Zieria grows in heath amongst rocky outcrops on rain forest edges and in tall forest and shrubland. The flowers appear from late winter to spring.	no	yes	no

Boronia deanei		Occurs in swamp heaths between the Blue Mountains and far south east of NSW. Often occurs at the margins of open forest adjoining swamps or along streams.	no	yes	no
Syzygium paniculatum	Magenta Lilly Pilly	On the south coast the Magenta Lilly Pilly occurs on grey soils over sandstone, restricted mainly to remnant stands of littoral (coastal) rainforest. On the central coast Magenta Lilly Pilly occurs on gravels, sands, silts and clays in riverside gallery rainforests and remnant littoral rainforest communities.	no	yes	no
Homoranthus darwinioides		Grows in in various woodland habitats with shrubby understoreys, usually in gravely sandy soils. Recorded at a range of landforms including ridge tops, slopes and depressions.	no	yes	No
Melaleuca biconvexa	Biconvex Melaleuca	Found in NSW, with scattered and dispersed populations found in the Jervis Bay area in the south and the Gosford-Wyong area in the north. Generally grows in damp places, often near streams or low-lying areas on alluvial soils of low slopes or sheltered aspects.	no	no	No

Appendix 4 - Regionally significant fauna known or with the potential to occur at the study site

Common Name	Scientific Name
Birds	
Azure Kingfisher	<i>Alcedo azurea</i>
Barking Owl	<i>Ninox connivens</i>
Black-chinned Honeyeater	<i>Melithreptus gularis</i>
Black-eared Cuckoo	<i>Chrysococcyx osculans</i>
Brown Cuckoo-dove	<i>Macropygia amboinensis</i>
Brown Quail	<i>Coturnix ypsilophora</i>
Brown Songlark	<i>Cincloramphus cruralis</i>
Brown Treecreeper	<i>Climacteris picumnus</i>
Buff-breasted Sandpiper	<i>Tryngitis subruficollis</i>
Buff-rumped Thornbill	<i>Acanthiza reguloides</i>
Common Bronzewing	<i>Phaps elegans</i>
Common Greenshank	<i>Tringa nebularia</i>
Crested Shrike-tit	<i>Falcunculus frontatus</i>
Double-barred Finch	<i>Taeniopygia bichenovii</i>
Flame Robin	<i>Petroica phoenicea</i>
Fuscous Honeyeater	<i>Lichenostomus flavescens</i>
Golden-headed Cisticola	<i>Cisticola exilis</i>
Great Crested Grebe	<i>Podiceps cristatus</i>
Great Egret	<i>Ardea alba</i>
Grey Goshawk	<i>Accipiter novaehollandiae</i>
Hooded Robin	<i>Melanodryas cucullata</i>
Jacky Winter	<i>Microeca fascinans</i>
Latham's Snipe	<i>Gallinago megala</i>
Little Curlew	<i>Numenius minutus</i>
Little Eagle	<i>Hieraaetus morphnoides</i>
Little Raven	<i>Corvus mellori</i>
Pacific Baza	<i>Aviceda subcristata</i>

Common Name	Scientific Name
Peaceful Dove	<i>Geopelia placida</i>
Peregrine Falcon	<i>Falco peregrinus</i>
Pheasant Coucal	<i>Centropus phasianinus</i>
Red-capped Robin	<i>Petroica goodenovii</i>
Restless Flycatcher	<i>Myiagra inquieta</i>
Rufous Night Heron	<i>Nycticorax caledonicus</i>
Scarlet Robin	<i>Petroica multicolor</i>
Sharp-tailed Sandpiper	<i>Calidris acuminata</i>
Speckled Warbler	<i>Chthonicola sagittata</i>
Striated Pardalote	<i>Pardalotus striatus</i>
Stubble Quail*	<i>Coturnix Pectoralis</i>
Superb Fairywren	<i>Malurus cyaneus</i>
Wedge-tailed Eagle	<i>Aquila audax</i>
Whistling Kite	<i>Haliastur sphenurus</i>
White-bellied Sea-eagle	<i>Haliaeetus leucogaster</i>
White-throated Needletail	<i>Hirundapus caudacutus</i>
White-winged Chough	<i>Corcorax melanorhamphos</i>
White-winged Triller	<i>Lalage tricolor</i>
Wood Sandpiper	<i>Tringa glareola</i>
Yellow-rumped Thornbill	<i>Acanthiza chrysorrhoa</i>
Zebra Finch	<i>Taeniopygia guttata</i>
Diamond Firetail	<i>Stagonopleura guttata</i>
Mammals	
Eastern Grey Kangaroo	<i>Nmacropus giganteus</i>
Short-beaked Echidna	<i>Tachyglossus aculeatus</i>
Common Wombat	<i>Vombatus ursinus</i>
Common Wallaroo	<i>Macropus robustus</i>
Swamp Wallaby	<i>Wallabia bicolor</i>
Amphibians	
Bibron's Toadlet	<i>Pseudophryne bibronii</i>
Green Tree Frog	<i>Litoria caerulea</i>

Common Name	Scientific Name
Haswell's Froglet	<i>Paracrinia haswelli</i>
Smooth Toadlet	<i>Uperoleia laevigata</i>
Reptiles	
Lace Monitor	<i>Varanus varius</i>