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Menangle Park Flora, Fauna and Aquatic Assessments

Menangle Park Local Environment Study
(Project No. 42-07)

Report prepared for:
Campbelltown City Council and Landcom

March 2009

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1. Executive Summary

Note: Maps and tables in report were updated in 2009 to reflect changes to some polygons and a change to the study area. There was no update to database searches, statutory listings, relevant approval agencies, or background literature at this time.

This report details the results of a flora, fauna and aquatic ecological assessment undertaken for Campbelltown City Council and Landcom as a technical component of a Local Environmental Study. The study area is approximately 890ha in size, and includes the Menangle Park residential area and designated surrounding rural areas. It is intended that part, or all, of the study site be rezoned to permit a major urban release for residential and/or industrial development.

The flora, fauna and aquatic ecology of the site was assessed through fieldwork and the application of Ecological Constraint Analysis techniques developed by Eco Logical Australia Pty Ltd (2003). These are an adaptation of methodology from Ian Perkins Consultancy Services and Aquila Ecological Surveys (2002). Legislation and planning documents and other literature relevant to this project were also reviewed.

Aquatic habitat within the study area is highly degraded due to land clearance, agricultural activities, the loss of riparian vegetation, pollution, erosion and sedimentation. No threatened or regionally significant aquatic species were found within the study area. The riparian zones require significant rehabilitation where restoration of aquatic ecological function is to be an objective.

The majority of the study site has been cleared and converted to grassland for agricultural purposes. Nine (9) noxious and three (3) environmental weed species were recorded within the study site. Four (4) flora species listed as Vulnerable or Endangered under State legislation, and 3 regionally significant flora species were found. A total of 121ha of remnant vegetation, listed as Endangered Ecological Communities, including Cumberland Plain Woodland, River-flat eucalypt forest on coastal floodplains of the NSW North Coast, Sydney Basin and South East Corner bioregions (formerly listed as Sydney Coastal River-flat Forest), and Sydney Freshwater Wetlands, remains on the site.

The terrestrial fauna assemblage is diverse with 197 species observed, or considered likely to occur in the study area. This includes 132 bird, 13 frog, 30 mammal (note that some bat call identifications were tentative), and 22 reptile species. Of these, 18 species are listed as Vulnerable, Endangered, or Migratory under State or Commonwealth legislation, and 30 species are considered to be regionally significant. After giving considertion to the habitat requirements of the Vulnerable, Endangered, and regionally significant species, habitat areas of high, moderate and low fauna constraint were identified.

Fauna movements across the site, and potential corridors to support this movement were also considered. Vegetation along the Nepean River is important for facilitating fauna movements. Habitat within the study site is also likely to be used for this purpose. Maintaining and improving linkages between remnant patches of

habitat will be an important consideration for the long-term use and management of the site.

We conclude that there are significant opportunities for the envisioned residential development of the site. However, whilst the Menangle Park site is generally badly degraded, Endangered Ecological Communities, threatened and regionally significant flora and fauna are present on the study site. There is considerable scope to improve the condition and management of ecological values supported by the Menangle Park study site. Recommendations to achieve this are made in chapter 9, within the context of the area's intended use for a major urban release.

Consultation with the Commonwealth Department of the Environment and Water Resources (DEWR) is recommended to take place early in the master-planning process once the development proposal has been more clearly defined. Residential development is likely to impact on matters of national environmental significance, where referral to and approval from is likely to be required from DEWR.

2. Glossary of Terms

Conservation significance	Conservation significance is a composite measure biodiversity value, measuring the size, connectivity and condition of vegetation remnants.
Ecological constraint	Ecological constraint is a composite measure of ecological values, including measures of: • how rare a vegetation community is, • the structural condition of the vegetation remnants, • type and severity of disturbances, • connectivity between remnants on site and off site, • the size of the vegetation remnant; and • the value of the remnant as threatened species habitat.
Endangered Ecological Community	Vegetation communities as listed under Schedule 1 of the NSW *Threatened Species Conservation Act 1995*. Critically Endangered Communities are those with less than 1000ha extant, and do not have a legal definition, but are used in conservation significance assessment processes by Department of Environment and Conservation (DEC).
Fauna assemblage, fish assemblage	Assemblages are the fauna equivalent of vegetation communities. They are a set of species with similar habitat requirements that are commonly found together.
Patch	A patch is a series of connected stands of remnant vegetation.
Polygon	For the purposes of this report a polygon refers to a mapped stand of remnant vegetation of a single community and condition.
Recovery potential	Recovery potential is the anticipated capacity of an area to recover to a state representative of its condition prior to the most recent disturbance event (Ian Perkins Consultancy Services and Aquila Ecological Surveys 2002). Disturbances include fire, clearing, grazing, soil compaction, weed invasion.
Structural condition	Good structural condition is when a vegetation remnant has all of its structural components – canopy, shrub layers and ground cover. Poor structural condition is usually when the shrub layer has been removed and canopy trees have been thinned.
Threatened Species	As listed under either the NSW *Threatened Species Conservation Act 1995* or the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*.

3. Introduction

3.1 Description of Project

Eco Logical Australia Pty Ltd was contracted by APP Corporation in September 2003 on behalf of Landcom and Campbelltown City Council to undertake flora, fauna and aquatic assessment of the Menangle Park Release Area. A decision to examine rezoning the study region as a major urban release area necessitated the preparation of a Local Environmental Study, of which this report is one technical component.

3.2 Study Area

Menangle Park is within the western Sydney region of New South Wales, between Campbelltown and Camden. The site falls entirely within Campbelltown City Council, and abuts the north eastern boundary of Wollondilly Shire.

Figure 1 illustrates the broad location of the site and surrounding area.

The Nepean River bounds the (approximately) 890 hectare site to the south and the west. The eastern boundary follows the South Western Freeway (Hume Highway) before deviating further east and following Menangle Road. The Southern Freeway bisects the study area. A more detailed view of the study area can be seen in Figure 2.

The site is primarily undulating hills to the north, south and east, flattening out towards the centre. The range in elevation is from 60 metres above sea level along the banks of the Nepean River in the north west of the study area, to about 128 metres in the north eastern portion between Menangle Road and the freeway.

The major landholders are Landcom and Campbelltown City Council, and land use is predominantly rural. A coal washing plant abuts the north western corner of the study area, and Mount Annan Botanical Gardens abut the north eastern boundary.

The dominant soil type of the study area is clay based, originating from Wianamatta Shale. This soil type is associated with Cumberland Plain Woodland. The majority of this community has been cleared, with a few remnant patches of mature trees remaining. There are small pockets of alluvial soil supporting River-flat Eucalypt Forest on Coastal Floodplain. Small areas of Sydney Freshwater Wetlands also occur in the study area. All of these communities are listed as Endangered Ecological Communities under the NSW *Threatened Species Conservation Act 1995*. The site is located within the Hawkesbury Nepean Catchment, and the adjacent portion of the Nepean River has been classified as protected (class 'P' waters) under the NSW *Clean Waters Regulation 1972* (see section 5.12).

Figure 1. Study Area.

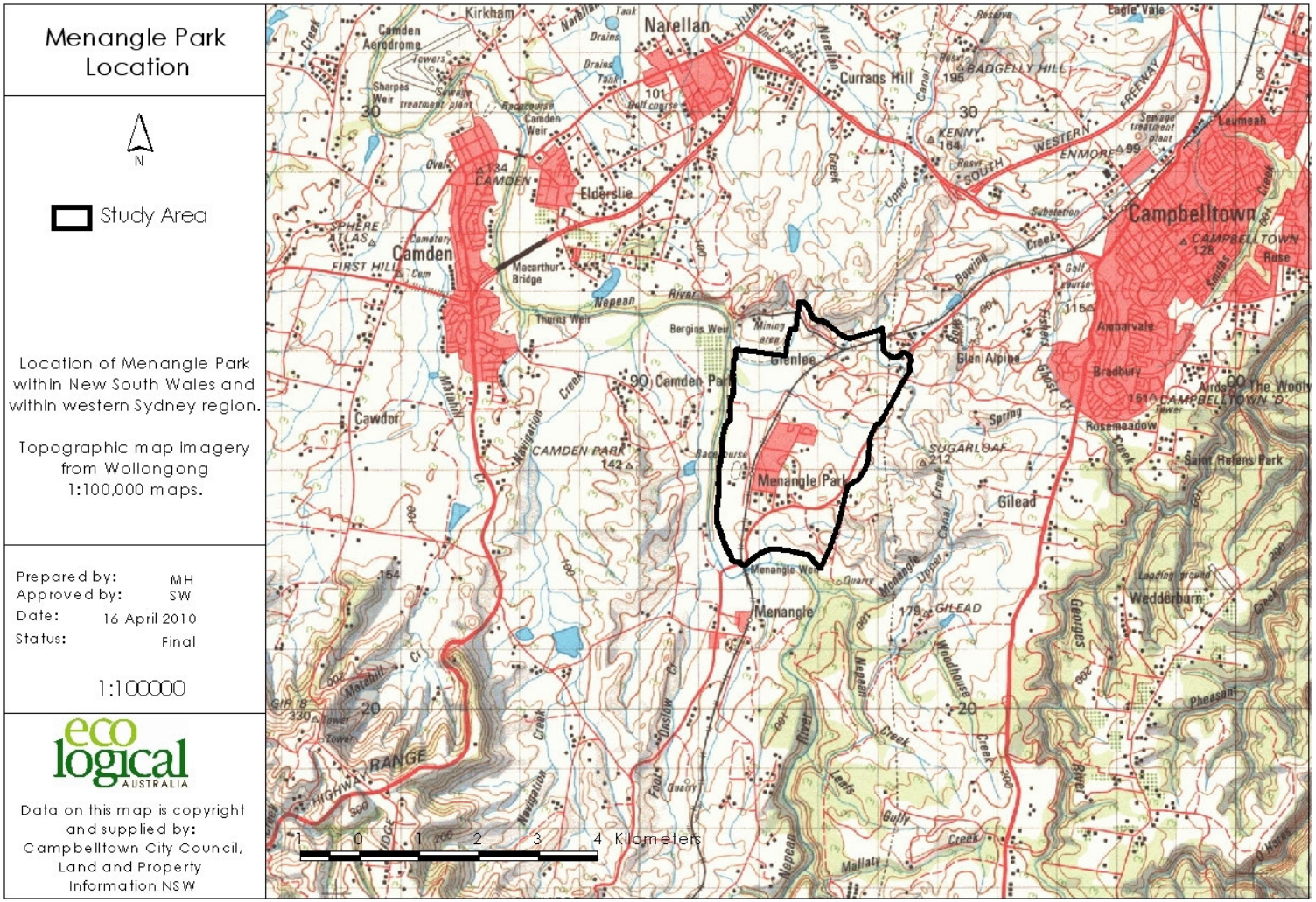
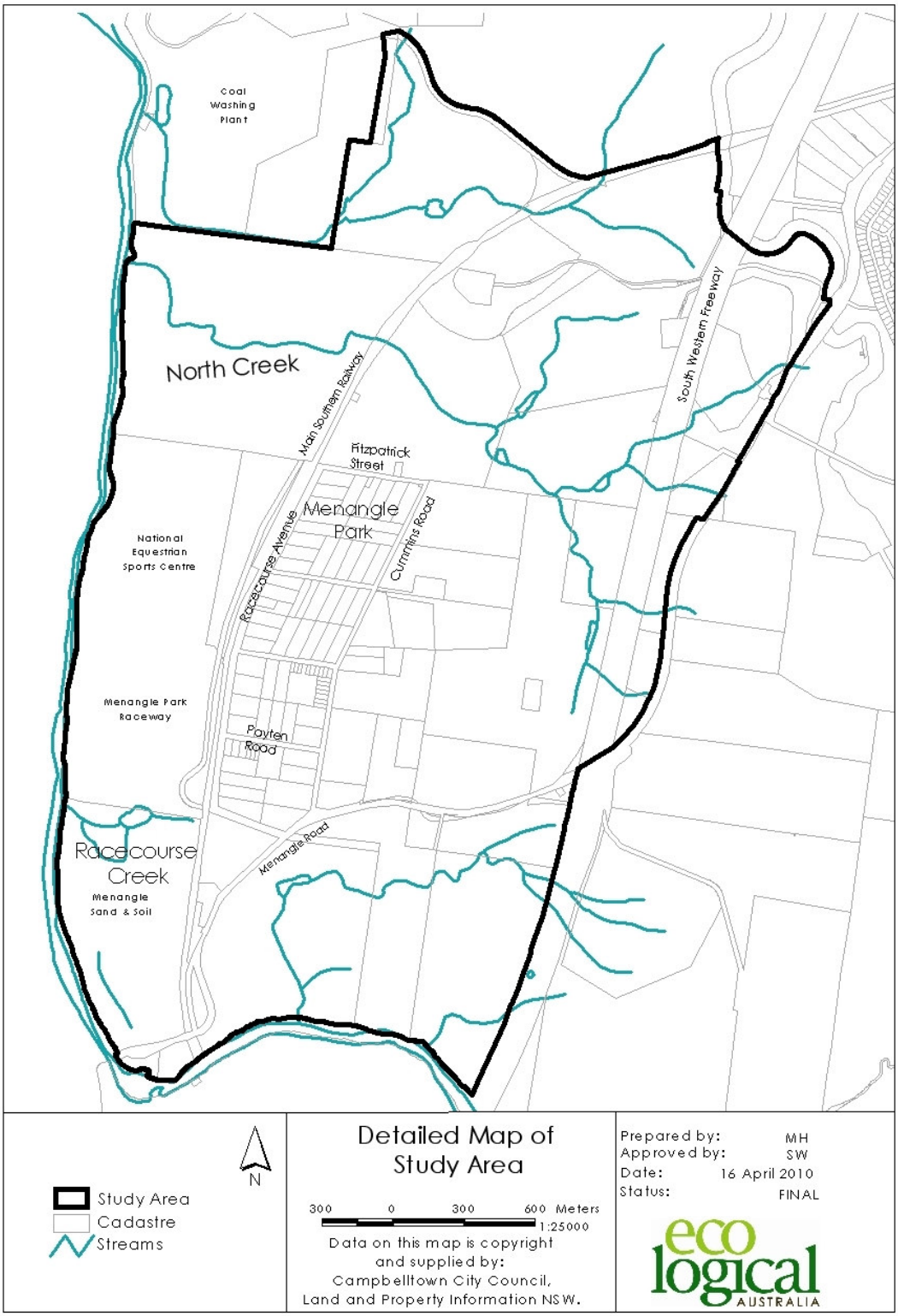


Figure 2. Detailed Study Area.



4. Literature Review

A review of existing literature, maps and databases was undertaken to provide background knowledge of the study area.

4.1 Cumberland Plain Endangered Ecological Communities: Preliminary Draft Recovery Plan

Author: NSW National Parks and Wildlife Service
Date: September 2001

The Cumberland Plain covers much of western Sydney, extending south to Thirlmere, and covers the entire Menangle Park study area. Variations in soil type, landform and drainage have led to a range of plant communities which are recognised as distinct ecological communities. Furthermore, the Cumberland Plain has been heavily impacted by development, and thus many communities are now listed as Endangered Ecological Communities. The plan provides steps for the recovery of Cumberland Plain Endangered Ecological Communities, and aims to "halt the loss and achieve a net gain in the extent and condition of bush in the Cumberland Plain" (NPWS 2001).

To achieve these goals the recovery plan proposes to:

- Control threats such as land clearing, grazing and weed invasion,
- Restore lands to increase intact bushland to 30 percent of its original extent,
- Create a system of protected lands, both public and private, which will fulfil the comprehensive, adequate and representative principles (Commonwealth of Australia 1999).

The identification, mapping and conservation significance of remnant Cumberland Plain vegetation has been a high priority for the recovery plan, and NPWS documents relating to these aspects are reviewed below (section 4.2 – 4.4).

4.2 The Native Vegetation of the Cumberland Plain, Western Sydney: Technical Report

Author: NSW National Parks and Wildlife Service
Date: December 2002

This technical report (NPWS 2002d) was prepared to assist in the field identification of Endangered Ecological Communities and to determine the current extent of native vegetation cover as a basis for the development of Recovery Plans as required by the NSW *Threatened Species Conservation Act 1995*. Maps are included in the report, displaying the approximate distribution of ecological communities.

The scope of the report was to:

- Produce an hierarchical classification of ecological communities using quantitative floristic survey data;
- Provide quantitative descriptions of ecological communities, including the abundance and frequency of occurrence of diagnostic plant species;

- Relate the occurrence of communities to spatial patterns in mapped environmental variables to produce an estimate of pre-European vegetation cover, and;
- Use recent, fine-scale aerial photography to map the current distribution of communities, including a coarse assessment of tree cover and understorey condition.

The report describes the methods of the field survey and gives a comprehensive description of each community.

4.3 The Native Vegetation of the Cumberland Plain, Western Sydney: Interpretative Guidelines

Author: NSW National Parks and Wildlife Service
Date: December 2002

The interpretation guidelines (NPWS 2002b) provide assistance in understanding the objectives, content and uses of the Cumberland Plain vegetation maps (section 4.4).

The reports contain brief summaries of aerial photo interpretation, floristic surveys and vegetation modelling methodologies as well as documenting the specifications of the mapping and limitations of the datasets.

Appendices describe the various communities of the Cumberland Plain and tabular summaries of the extent of each community across the Local Government Areas of western Sydney are presented.

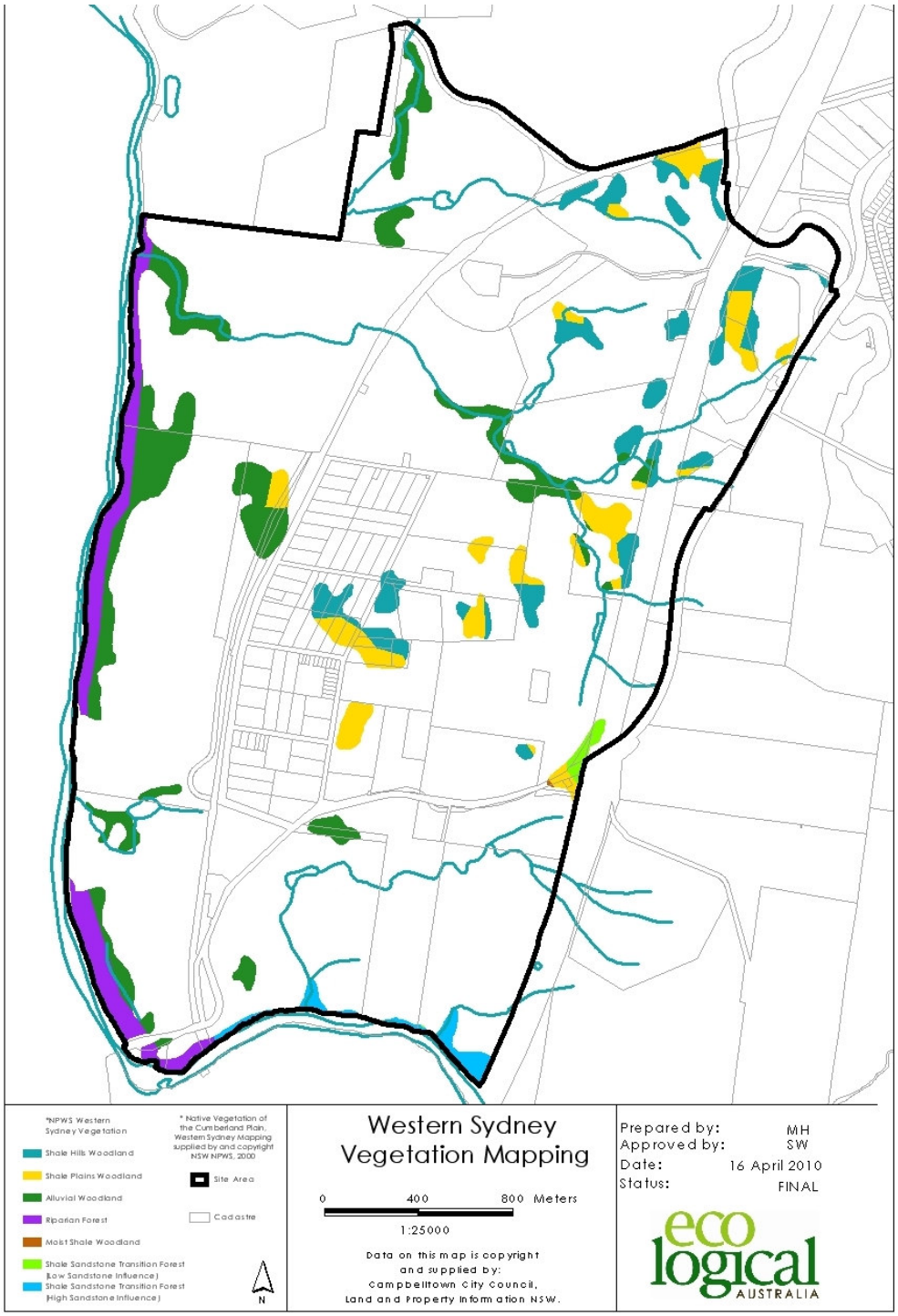
4.4 Native Vegetation of the Cumberland Plain, Western Sydney Vegetation Community, Condition and Conservation Significance Mapping

Author: NSW National Parks and Wildlife Service
Date: December 2002

Digital maps were supplied (NPWS 2002c). The first set of maps showed vegetation communities across the site. The results of this mapping for the Menangle Park study area can be seen in the second set of maps showed the draft conservation significance assessment of the site. The rules for this assessment are shown in Table 3 of this report.

This mapping was undertaken to give a regional view of the extent, condition and location of remnant native vegetation across the Cumberland Plain. This mapping forms the baseline for the Cumberland Plain Recovery Plan.

Figure 3. NPWS Western Sydney Vegetation Mapping



4.5 Harrington Park Stage 2 Ecological Assessment

Author: Ian Perkins Consultancy Services and Aquila Ecological Surveys
Date: June 2002

This report discusses the assessment of NPWS Cumberland Plain Vegetation Mapping (CPVM) for the Harrington Park site and its adaptation to create a site-specific vegetation map. A modified version of the methodology used for Harrington Park was adopted for the Edmondson Park ecological assessment (Eco Logical Australia 2003). This modified methodology has been used for the ecological assessment of Menangle Park.

Stage 1 of the process recognises that the NPWS CPVM is for regional purposes and is not applicable to the assessment of a single site. It seeks to verify the accuracy of the mapping for Harrington Park site, using fine scale aerial photography to define the extent of vegetation and check it against the NPWS mapping.

Stage 2 uses field survey to check the accuracy of the community information and condition assessment. This data is incorporated into the high resolution vegetation mapping, resulting in a detailed map showing vegetation extent, community, condition and some indication of resilience.

4.6 Edmondson Park Ecological Assessment

Author: Eco Logical Australia Pty Ltd
Date: August 2003

This report, together with its technical appendices, documents an assessment of the environmental values and constraints of the Edmondson Park Urban Release area. The methodology used in the Menangle Park project is derived from that used in the Edmondson Park project.

The study involved literature reviews, survey work and analyses, the data from which was then incorporated into a bushfire assessment and conservation management plan.

A detailed vegetation survey and mapping exercise was completed for the study area, recording information on vegetation communities and condition as well as disturbances. Data collected from this survey was used to determine recovery potential (using an adaptation of the approach adopted in the Harrington Park assessment by Ian Perkins Consultancy Services and Aquila Ecological Surveys 2002) and conservation significance (according to the decision rules applied in the Native Vegetation of the Cumberland Plain, Western Sydney Vegetation Community, Condition and Conservation Significance Mapping).

A literature review was conducted to determine any threatened fauna species that were known or likely to occur in the area. Field surveys targeted specific species and provided further habitat information. Survey for threatened flora species in the study area was included as part of the detailed vegetation field assessment. An appraisal

of fish habitat and assemblages was conducted, including a search for threatened or endangered fish species.

Threatened species habitat information determined from both literature reviews and field assessment was combined with maps from the vegetation assessment to determine ecological constraint.

4.7 Priority Sewerage Program Environmental Impact Statement: Menangle and Menangle Park (Volume 1 and 2)

Author: CH2M Hill for Sydney Water
Date: October 1999

The Menangle and Menangle Park areas were identified as one of seven high priority areas under the NSW Government's Priority Sewerage Scheme, which aims to reduce environmental problems associated with unsewered areas within the Sydney and Illawarra regions (CH2M Hill 1999a). This Environmental Impact Statement (EIS) considers the environmental impacts of both providing sewerage to the Menangle and Menangle Park areas, and constructing the necessary pipelines for transportation to the West Camden Sewerage Treatment Plant (STP).

Following a search of relevant NPWS and Australian Museum databases, a short list of species and vegetation communities listed under the *Threatened Species Conservation Act 1995* was prepared upon which to focus the flora and fauna component of the EIS (CH2M Hill 1999b):

- 5 flora species
    - Bent pomoderris (*Pomaderris sericea*) Note: there was one database record of this species, which was considered to be unreliable,
    - Camden White Gum (*Eucalyptus benthamii*),
    - *Pomaderris brunnei,*
    - Rice flower (*Pimelea spicata*),
    - White Cyanchum (*Cyanchum elegans*),
- 12 fauna species
    - Blue-billed Duck (*Oxyura australis*),
    - Bush stone-curlew (*Burhinus grallarius*),
    - Cumberland Land Snail (*Meridolum corneovirens*),
    - Glossy Black Cockatoo (*Calyptorhynchus lathami*),
    - Greater Broad-nosed Bat (*Scoteanex rueppellii*).
    - Green and Golden Bell Frog (*Litoria aurea*),
    - Koala (*Phascolarctos cinereus*),
    - Large-eared Pied Bat (*Chalinolobus dwyeri*),
    - Large-footed Myotis (*Myotis adversus*),
    - Powerful Owl (*Ninox strenua*),
    - Spotted-tailed Quoll (*Dasyurus maculatus*),
    - Squirrel Glider (*Petaurus norfolcensis*),
- 2 Endangered Ecological Communities
    - Cumberland Plain Woodland,

- Sydney Coastal River-flat Forest (now listed as River-flat eucalypt forest on coastal floodplains of the NSW North Coast, Sydney Basin and South East Corner bioregions).

Both *Endangered Ecological Communities* were found to be present with in the study area, and whilst none of the listed flora or fauna species were detected during the surveys, potential habitat for some species was detected (CH2M Hill 1999b).

To minimise impacts on flora and fauna, the EIS recommended the following measures:

- Aligning the pipeline as closely as possible to Camden Park Road,
- Silt fencing,
- Weed control and,
- Feral animal control (if necessary)
- Sewerage pumping stations be located outside of the 100 year flood extent,
- Access covers for pipes in flood affected areas designed to be watertight to prevent inflow, thus minimising the risk of sewage leakage.

The site locations from the EIS which are relevant to this study are the residential area of Menangle Park, and along the proposed main sewer pipeline, which ran south along Menangle Road towards Menangle (CH2M Hill 1999b). Hence, whilst this EIS did not detect any listed species, this result cannot be taken to imply that these species could not occur within the region investigated in this study.

4.8 Draft Menangle Park Release Area Water Cycle Management Options Report

Author: Ecological Engineering Pty Ltd
Date: August 2002

This report investigated management options for the Menangle Park release area that would allow the water quality and river flow objectives for the Nepean River, as Protected Waters (Class P) under the Clean Waters Regulation, to be met.

They recommended:

- The mandatory installation of AAA rated fittings and appliances to reduce the demand for potable water,
- Stormwater management through streetscape bioretention systems on terrain flatter than 10%, and flood retarding basins with bioretention and wetland systems for areas with greater slopes,
- A local Sewage Treatment Plant (note: it is now proposed to pump sewage to the Camden Sewage Treatment Plant),
- A reticulated reclaimed water system for toilet and garden use,
- Prevention of direct discharge of sewer overflows by constructing detention and treatment storage in the "sand mining" area west of the railway line.

This report did not consider all potential environmental impacts in its review of the various options, but did recommend the conservation and restoration of riparian corridors to 20m from the centreline on either side of waterways. It is noted the NSW *Rivers and Foreshores Improvement Act 1948* aims to protect, as a minimum, 40m

from the top of the banks for rivers, estuaries and lakes. Furthermore, the potential impacts of the proposed options upon flora and fauna within or downstream from the study site are unclear.

4.9 Menangle Park Preliminary Water Cycle Assessment: Final Report

Author: GHD for Landcom and Campbelltown City Council
Date: December 2002

This report investigated water cycle strategies for a 400ha area within Menangle Park, and for two "opportunity areas". The region covered by the GHD report did not, however, cover all of the study area for the Flora, Fauna and Aquatic Assessment (this report). The water cycle assessment reviewed background information, (soils, geology, climate, rainfall), included advice from government agencies, and then considered constraints and water cycle options. The assessment recommended a preferred strategy, and also included policies and matters that would need to be reviewed.

The constraints identified by the water cycle assessment were the potential for acid sulfate soils, which were considered unlikely, but "cannot be entirely discounted", dispersive erosion, and salinity (GHD 2002). The assessment identified saline seeps/ scalds, damage to infrastructure, and the presence of salt tolerant plants, all of which are an indication of saline conditions in that region. The risk of salinity problems was broadly rated against soil profiles from 1:100,000 mapping. Landform was utilised to model the possible mechanism for these salinity problems, although the relationship between the risk rating for soils and the landform model is not made clear. The landform model suggests that saline seep areas may be expected at the break in slope, or at the base of the soil profile (regolith), thus much of the site has the potential to be affected by salinity-related issues. Further survey to define the salinity and dispersive soil models for the site was recommended.

The water cycle assessment report was thorough in its consideration of background information, and the advice of government agencies. However, whilst salinity is clearly a significant issue, the sites where salinity was noted were restricted to an area southwest of the Glenlee yards. Based on the soil risk rating and landform modelling it appears that salinity is likely to occur elsewhere within the study site, but it is unclear where these areas could be. Further, whilst consideration is given to salinity effects on infrastructure, no comments are made as to the possible effects on aquatic or land habitats, which could potentially be severe. The risk of sewer overflows, which was reviewed in Ecological Engineering Pty Ltd (2002), was not discussed in the water cycle assessment report. It is unknown if this equates to zero risk.

4.10 Statement of Joint Intent for the Hawkesbury Nepean River System

Author: NSW Government
Date: 13 August 2002

The Statement of Joint Intent (SOJI) records the commitments of State agencies and relevant Councils, including Campbelltown City Council, for the implementation of

the endorsed recommendations from the NSW Healthy Rivers Commission. Whilst the SOJI is still in the process of being implemented, a number of the recommendations made by the Commission are relevant to the proposed Menangle Park development. These include:

- Reducing phosphorus inputs to the river should remain the priority strategy for algal control in freshwater sections,
- To manage eutrophication, nutrient reductions should be considered together with other options such as flow management, and weed management,
- That there should be an increased focus on preventing adverse impacts on water quality from inadequate management of local sewage,
- Standards for the management of *Cryptosporidium* and *Giardia*, parasites which can cause sickness in both humans and animals, are required,
- Responsibility for stormwater management and planning should be clearly vested with Local Government,
- Councils and developers, when considering stormwater management, should give attention to water quality and ecological integrity, as well as flood mitigation and drainage (ie. water quality and ecological values should not be considered to be secondary to drainage issues),
- Approval for new urban development should only be granted when it can be demonstrated that both the land and neighbouring aquatic systems are capable of coping, both individually and collectively, with the proposed development,
- Councils should discourage, or evaluate with caution, proposal for new on-site sewerage disposal at sites where known or potential sewage problems exist, or where reticulated water supply has been provided,
- All levels of the decision-making processes governing urban development should explicitly address the need for protection of riverine corridors.

These recommendations should be considered during the planning and assessment of the Menangle Park development.

4.11 Hawkesbury Lower Nepean Catchment Blueprint

Author: Local Government Advisory Group
Date: February 2003

Whilst the Hawkesbury Lower Nepean Catchment Blueprint has no legislative enforcement power, it provides strategic direction for natural resource management for the next ten years within the Hawkesbury and Lower Nepean catchments. The blueprint identifies three themes; land use, river health, and biodiversity. The blueprint also identified partnerships with a wide variety of stake-holders in all three themes as being important, including the community, institutional managers and government agencies. A total of 21 management targets and prioritised management actions to meet these targets are also detailed.

5. Statutory Framework

A brief description of the main relevant environmental legislation and policies are provided below.

5.1 Environment Protection & Biodiversity Conservation Act 1999

The Commonwealth *Environment Protection & Biodiversity Conservation Act 1999* (EPBC Act) stipulates that approval from the Commonwealth Environment Minister is required if a development is likely to have a significant impact on matters considered to be of national environmental significance. Cumberland Plain Woodland is listed as a matter of national environmental significance. Additionally, threatened and migratory species listed under this act are found on the study site.

The Commonwealth Department of the Environment and Water Resources (DEWR) advised Eco Logical Australia in 2004 that whilst comment by this agency is not technically required during the master plan stage, that the species, vegetation communities, and the size of the project warrant advice being sought from DEWR on the referral and approval process. DEWR also recommended the submission of a draft referral to allow any comments by DEWR to be taken into consideration before the finalisation of the master plans.

Since the initial advice the Commonwealth and NSW have entered into a bilateral agreement in relation to assessments made under Part 3A, Part 4 and 5 of the EPBC Act. The changes relate only to assessment, and for controlled actions referrals and approvals are still required. For this process DEWR will examine and review the environmental assessment prepared under NSW law. As before, consent is not required from DEWR at the masterplan stage.

5.2 Environmental Planning and Assessment Act 1979

The NSW *Environmental Planning and Assessment Act 1979* (EP&A Act) is the principal planning legislation for the state, providing a framework for the overall environmental planning and assessment of development proposals. Various legislation and instruments, such as the NSW *Threatened Species Conservation Act 1995* (TSC Act), are integrated with EP&A Act and have been reviewed separately.

In determining a development application, the consent authority is required to take into consideration the matters listed under Section 79C of the EP&A Act that are relevant to the application. Key considerations include:

- Any environmental planning instrument, including drafts
- The likely impacts of the development
- The suitability of the site for the development
- Any submissions made in accordance with the EP&A Act or regulations
- The public interest

5.3 Threatened Species Conservation Act 1995

The TSC Act aims to protect and encourage the recovery of threatened species, populations and communities listed under the Act. The TSC Act is integrated with the EP&A Act and requires consideration of whether a development (Part 4 of the EP&A Act 1974) or an activity (Part 5 of the EP&A Act) is likely to significantly affect threatened species, populations and ecological communities or their habitat. Various threatened species and three Endangered Ecological Communities (Cumberland Plain Woodland, River-flat eucalypt forest on coastal floodplains of the NSW North Coast, Sydney Basin and South East Corner bioregions, Sydney Coastal River Flat Forest, and Sydney Freshwater Wetlands) have been recorded within and adjacent to the site.

5.4 National Parks and Wildlife Act 1974

The NSW *National Parks and Wildlife Act 1974* provides for the establishment, management and protection of National Parks and other conservation reserves, landscapes and landforms of significance, the conservation of objects, places or features of cultural value, and the protection of native flora and fauna.

5.5 Fisheries Management Act 1994

The *Fisheries Management Act 1994* (FM Act) aims to conserve, develop and share the fishery resources of NSW for the benefit of present and future generations. The FM Act defines 'fish' as any marine, estuarine or freshwater fish or other aquatic animal life at any stage of their life history. This includes insects, molluscs (eg. oysters), crustaceans, echinoderms, and aquatic polychaetes (eg. beachworms), but does not include whales, mammals, reptiles, birds, amphibians or species specifically excluded (eg. some dragonflies are protected under the TSC Act instead of the FM Act). A permit is required if an activity will block fish passage.

5.6 Rivers and Foreshores Improvement Act 1948

The NSW *Rivers and Foreshores Improvement Act 1948* (RFI Act) aims to provide effective controls on activities that could harm sensitive waterway and foreshore environments. The Act has provisions that require a permit for excavations, fill and other works within 40m of the top of the bank for rivers, estuaries and lakes as it is recognised that they can have significant detrimental environmental impacts on habitat, water quality, flooding and erosion. This Act exempts 'local authorities' from the need to obtain a permit.

There are creek lines present in the site that are subject to this Act (a "river" as defined under the Act generally applies to those waterways that show up on 1:25,000 topographic mapping). A part 3a permit would be required under the RFI Act for such works. The RFI Act is soon to be repealed and replaced by the *Water Management Act* but the provisions under this act are likely to be similar to the RFI Act. A notable exception, however, is that 'local authorities' will no longer be exempt from the need to obtain a permit.

5.7 Rural Fires Act 1997

The objectives of the NSW *Rural Fires Act 1997* (RF Act) are to provide for:

- The prevention, mitigation and suppression of fires
- Coordination of bushfire fighting and prevention
- Protection of people and property from fires
- Protection of the environment

Section 100B of the RF Act provides for the Commissioner to issue a bushfire safety authority for subdivision of bushfire prone land that could lawfully be used for residential or rural residential purposes or for development of bushfire prone land for a special fire protection purpose.

A Bushfire Safety Authority permits development to the extent that it complies with bushfire protection standards. Application for a Bushfire Safety Authority must be lodged as part of the development application process and must demonstrate compliance with the Planning for Bushfire Protection Guidelines (RFS 2001).

The RF Act also outlines the responsibilities of land owners to manage their land for bushfire protection and provides a mechanism for the approval of hazard reduction works, through the issue of a bushfire hazard reduction certificate.

5.8 Rural Fires and Environmental Assessment Legislation Amendment Act 2002

The NSW *Rural Fires and Environmental Assessment Legislation Amendment Act 2002* amends the RF Act and the EP&A Act with respect to bushfire prone lands, bushfire hazards and bushfire emergencies.

5.9 Planning for Bushfire Protection: a Guide for Councils, Planners, Fire Authorities, Developers and Home Owners 2006

This guide (NSW Rural Fire Service 2006) is the key bushfire planning document for the state. The document identifies requirements and strategies for new developments to help protect from bushfire hazards. It details the location and depth of asset protection zones, fire trails and perimeter roads, water supply and building standards in bushfire risk areas. This document is given legal force through the *Rural Fires and Environmental Assessment Legislation Amendment Act 2002* (section 5.8).

5.10 Bushfire Environment Assessment Code 2003

The code provides a streamlined process for assessing and approving bushfire hazard reduction works, particularly for authorities managing public land. It is intended to apply to asset protection zones and strategic fire advantage zones identified in Bushfire Risk Management Plans.

5.11 Protection of the Environment Operations Act 1997

The NSW *Protection of the Environment Operations Act 1997* (POEO Act) aims to protect environment quality within New South Wales, particularly in relation to reducing or mitigating pollution, whilst having regard to the need to maintain ecologically sustainable development. The POEO Act allows for explicit environmental protection policies (see section 5.12).

5.12 Clean Waters Regulations 1972

The *Clean Waters Regulations 1972* is given legal force through the POEO Act. Schedule 5 Section 6(2) of the POEO Act states that the standards applicable to classified waters are those standards prescribed by the Clean Waters Regulations. The Nepean River in the vicinity of the Menangle Park study site are classified as class 'P' waters, whilst waters downstream in the Camden region are classified as class 'C' waters. For both class 'C' and 'P' waters discharges must be by sewer, and sewerage system overflows are not permitted.

5.13 Catchment Management Act 1989

Through a network of Catchment Management Committees, the NSW *Catchment Management Act 1989* aims to co-ordinate identification of land degradation, programs for rehabilitation and community awareness and to promote stable and productive environmental conditions. The Warragamba Catchment Blueprint, which commenced in 2002/03 provides strategic direction for Natural Resource Management across the catchment over the next ten years. The Catchment Blueprint identifies and sets targets with prioritised management actions and includes issues relating to natural resource and environmental management.

5.14 Sydney Regional Environmental Plan No 20 – Hawkesbury-Nepean River (No 2 – 1997)

The aims of the *Sydney Regional Environmental Plan No 20 – Hawkesbury-Nepean River (No 2 – 1997)* are to protect the environment of the Hawkesbury-Nepean River system by ensuring that impacts from future land uses are considered in a regional context. The Menangle Park site is in within the area covered by this plan, and hence the requirements of this document are relevant. Issues that need to be considered under the regional environmental plan includes referring proposals to downstream councils likely to suffer a significant adverse environmental impacts, and to consider the cumulative impact of development proposals on the catchment.

5.15 Local Government Act 1993

The NSW *Local Government Act 1993* provides for management of land within a Local Government Area. Under the Act plans of management must be prepared for 'community land'. The plans should address a variety of factors including biodiversity conservation and management. Councils must adopt a specific plan of management for community land affected by a recovery plan, threat abatement plan or containing critical habitat identified under the TSC Act.

5.16 Local Government Amendment (Ecologically Sustainable Development) Act 1997

The NSW *Local Government Amendment (Ecologically Sustainable Development) Act 1997* requires that councils consider principles of Ecologically Sustainable Development and prepare an annual State of the Environment report. The principles of ESD, as defined in the Act are the precautionary principle, inter-generational equity, conservation of biological diversity, incorporation of environmental factors in valuations and pursuit of environmental goals in a cost-effective fashion.

5.17 Noxious Weeds Act 1993

The objectives of the NSW *Noxious Weeds Act 1993* are to identify which noxious weeds require control measures, identify control measures suitable to those species and to specify the responsibilities of both public and private landholders for noxious weed control. Nine noxious weed species were observed on the study site (section 7.1.1).

5.18 State Environmental Planning Policy No.19 – Bushland In Urban Areas

This NSW State Environmental Planning Policy (SEPP) aims to protect and preserve bushland within selected local government areas, including the Campbelltown local government area. The policy recognises the recreational, educational and scientific significance of such bushland and aims to protect the flora, fauna, significant geological features, landforms and archaeological relics in such areas. It encourages management to protect and enhance the quality of the bushland and facilitate public enjoyment, compatible with its conservation. The policy states that a person shall not disturb bushland zoned or reserved for public open space purposes without the consent of the council.

5.19 State Environmental Planning Policy No. 44 – Koala Habitat Protection

This SEPP encourages the conservation and management of natural vegetation areas that provide habitat for Koalas and to ensure permanent free-living populations will be maintained over their present range. It provides a stepped process of habitat assessment, requires the preparation of Plans of Management for development applications in core Koala habitat and supports the inclusion of areas of core Koala habitat in environment protection zones. Koalas have been recorded in the vicinity of the study area. For some vegetation on the site more than 15% of koala feed trees listed on the schedules to the policy were observed, which indicates 'potential koala habitat'. The presence of potential koala habitat triggers an assessment under SEPP44 for any proposed development in the area.

5.20 NSW Biodiversity Strategy 1999

The NSW Biodiversity Strategy has been adopted by the New South Wales Government and aims to protect the native biological diversity of NSW and maintain ecological processes and systems through a collaborative framework of government and community efforts. It aims to achieve a variety of biodiversity outcomes, including the preparation of Local Biodiversity Action Plans. The strategy includes the application of the precautionary principle so that lack of full knowledge of impacts is not be used as an excuse for postponing action.

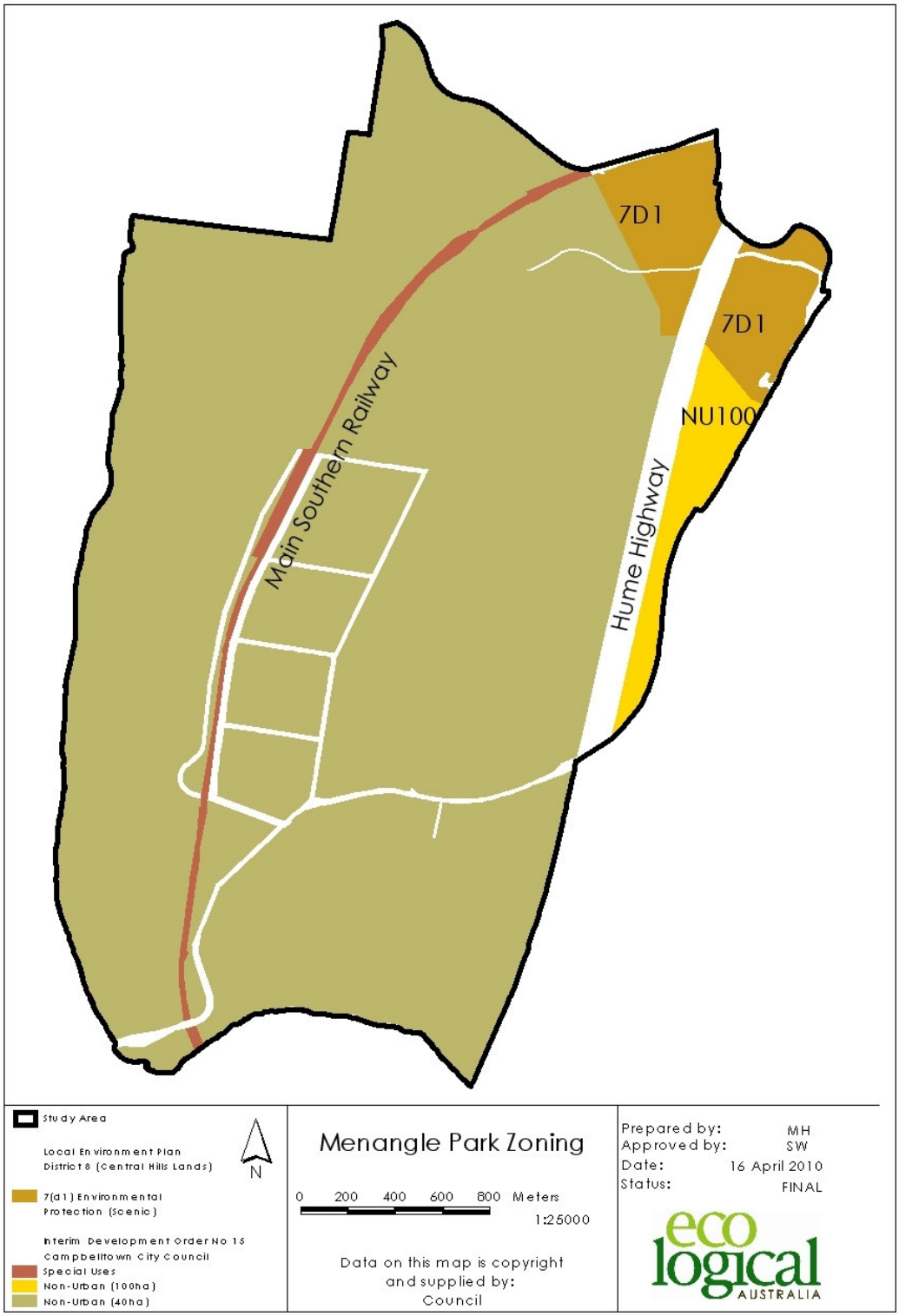
5.21 Interim Development Order No. 15 – City of Campbelltown

This interim development order applies to part of the Campbelltown Local Government Area. Most the study site is covered by this regulation, with the majority of the site being zoned as 1 Non-Urban, and the portion for the railway is zoned as Special Uses (**Figure 4**). The zone 1 Non-Urban, prohibits the erection of dwellings unless the parcel of land is either 40ha or more, or 100ha or more. Thus zone 1 Non-Urban is split into two sub-regions, which are shown in **Figure 4**.

5.22 Campbelltown Local Environmental Plan - District 8 (Central Hills Lands)

This Local Environment Plan (LEP) aims to ensure that the land that it covers retains its urban character. A small part of the northeastern corner of the Menangle Park study area (Figure 4) is zoned as 7(d1) Environmental Scenic Protection under this LEP. This zoning aims to set aside land to maintain its rural and scenic character, to preserve farming activities, and to provide a stock of and suitable for large area recreation establishments. This zoning aims to set aside land to maintain its rural and scenic character, to preserve farming activities, and to provide a stock of land suitable for large area recreation establishments. A range of activities are prohibited under this zoning, and consent is required from Council for subdivision, but subdivision to produce allotments of less than 100ha is not permitted.

Figure 4. Zoning Map for the Menangle Park Study Area.



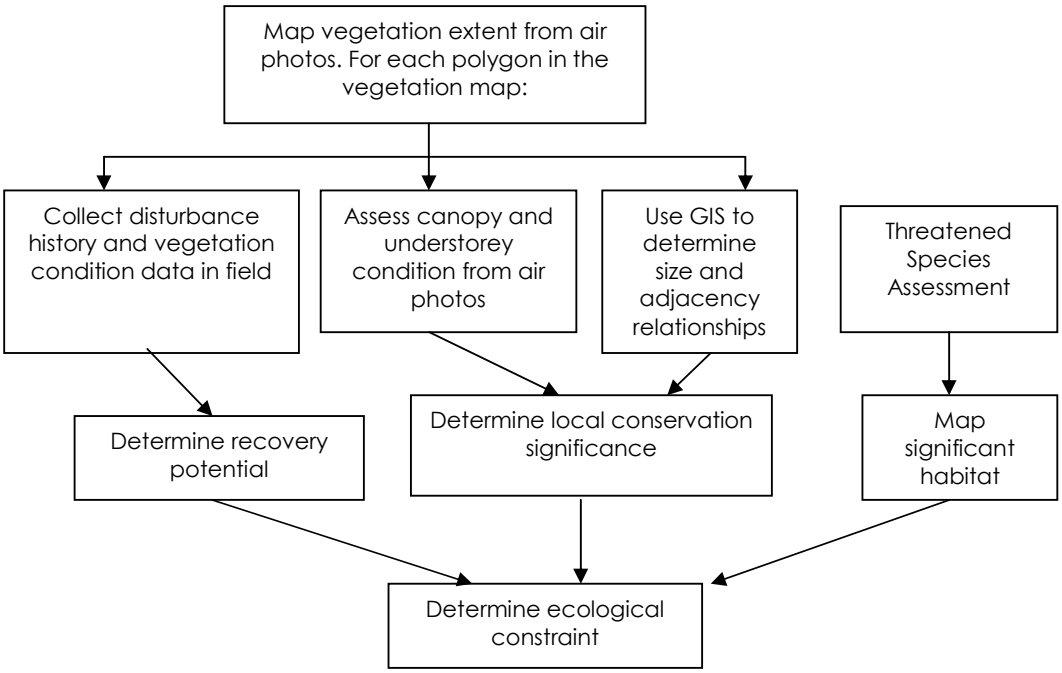
6. Methods

Ecological Constraint Analysis 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 the vegetation remnants
- type and severity of disturbances
- connectivity between remnants on and off site
- the size of the vegetation remnant, and
- the value of the remnant as threatened species habitat

The steps involved in this type of ecological constraint analysis are illustrated in the flowchart in Figure 5 below. Field survey work is combined with threatened species assessment and the NPWS conservation significance assessment maps to determine the relative level of ecological value or constraint across a site.

Figure 5. Ecological Constraint Flowchart



6.1 Flora Survey

6.1.1 Aerial Photo Interpretation

Eco Logical Australia Pty Ltd mapped extant native vegetation, at a scale of 1:4,000, from high resolution digital aerial photographs provided by Campbelltown City Council. ArcView GIS software was used for this and all other GIS analysis throughout the course of the project.

Using a combination of the NPWS Cumberland Plain mapping and aerial photograph interpretation, vegetation community information, canopy density and understorey condition were assigned to each polygon. Field surveys were carried out to assess the accuracy of the mapped boundaries and attributed information. Table 1 below outlines the classification rules used to determine canopy and understorey condition. This table is a modification of Table 4 in the Interpretation Guidelines for the Native Vegetation Maps of the Cumberland Plain, Western Sydney (NPWS 2002b).

Table 1. Canopy and Condition Codes.

Code	Canopy Density	Description
A	>10%	Canopy and understorey in good condition
B	5-10%	Canopy thinner, some understorey
C	>10%	Good canopy cover, extensive weed presence in understorey
TX	<10%	Scattered tree overstorey over agriculture
TXr	<10%	Scattered tree overstorey over rural residential
TXu	<10%	Scattered trees over urban development.

6.1.2 Field Survey

Gingra Ecological Surveys, with assistance from Eco Logical Australia Pty Ltd staff, conducted field survey of the study area over 3 days in early October 2003. Each vegetation patch identified in the NPWS Cumberland Plain Vegetation Mapping Project, as well as any additional patches detected from the aerial photography, was visited to verify the mapping. Figure 6 maps these sites.

Characteristics of each vegetation polygon in fair to good condition were recorded on a pro-forma developed specifically to assess vegetation composition and condition for vegetation remnants on the Cumberland Plain. A copy of this pro-forma has been attached as an appendix on page 70. Characteristics of smaller or highly disturbed remnants were noted, but not recorded in as much detail.

The following parameters were recorded at each of the sampling sites:

- vegetation structure
- disturbance history
- indications of recovery potential
- soil condition (including compaction and presence of fill)
- location
- aspect
- slope
- floristics

Figure 6. Vegetation Survey Sites

6.2 Fauna Survey

6.2.1 Data Audit

Literature and databases relevant to the general area were reviewed to assist in determining which threatened species were likely to occur along the route. Literature reviewed included:

- Western Sydney Urban Bushland Biodiversity Survey (NPWS *et al.* 1997)
- Other ecological assessments conducted in similar environments in the south-western Sydney area (Aquila Ecological Surveys 2002, URS 2002, Ian Perkins Consultancy Services and Aquila Ecological Surveys 2002).
- National Parks and Wildlife Service's Atlas of New South Wales Wildlife.

6.2.2 Field Survey

A survey of the study area was carried out by Aquila Ecological Surveys environmental consultancy in conjunction with staff from Eco Logical Australia Pty Ltd on the October 12, 13 and 14 2003.

The techniques employed to identify the diversity of native and introduced species present within, and adjacent to, the study area were:

- Habitat assessment;
- Direct observation of fauna species;
- Hand searches within, and under, litter and ground debris for reptiles, frogs and the Cumberland Land Snail (*Meridolum corneovirens*);
- Bird watching;
- Call identification (birds, frogs and mammals);
- The identification of indirect evidence, such as tracks, scratching and scats;
- Spotlighting for nocturnal mammals and birds; and
- Ultrasonic detection targeting microchiropterans (insectivorous bats).

While undertaking the field survey, efforts were made to document the structure and value of the habitats present within, and adjacent to, the study area for any species previously recorded, or expected to occur, in the region. This targeted:

a) species protected under the *National Parks and Wildlife Act 1974*
b) threatened species in the Schedules to the *TSC Act*
c) species listed in the Schedules to the *EPBC Act* and
d) regionally significant species listed in NPWS *et al.* (1997)

Efforts were made to identify habitat features important to the life cycle of likely threatened animals. Such feature included mature trees with hollows, connectivity with other woodland areas, suitable aquatic environments, caves or cave substitutes.

By the completion of the field investigations, approximately 35 person hours of active searches had been accumulated, active searches being defined as the time spent actively searching for observations or evidence of fauna species.

6.3 Aquatic Survey

Field surveys within the study area were undertaken by BioAnalysis at 10 sites from 27 September 2003 to 12 October 2003 to identify and assess aquatic habitat (Figure 13).

No creeks within the study area were named on 1:25 000 topographic maps, so for clarity these creeks have been given unofficial working names for use within this document: Racecourse Creek (sites 1 and 2), and North Creek (sites 3 – 10).

All stretches of permanent water were sampled; it should be noted that whilst other watercourses are shown on topographic maps of the study area to the east of railway and southeast of Menangle Road, these were not sampled. Surrounding vegetation for these watercourses had been cleared, and flows appeared to be ephemeral in nature, which made aquatic sampling problematic. Furthermore, due to substantial disturbance these watercourses were considered to have extremely low ecological values and hence were not considered in detail.

Within both Racecourse and North Creeks qualitative information concerning the condition, quality and geomorphology was collected at a number of sites. Details of the habitat and any anthropogenic disturbances were also collected, and an assessment of the relative abundance of aquatic macrophytes was made. Three replicate samples of the assemblages of fish were also collected at each site using a Smith-Root 15C Electrofisher backpack unit.

6.3.1 Analysis

The SIGNAL biotic index (Chessman 1995, Chessman *et al.* 1997, Chessman 2003) was used to assign average pollution sensitivity grades to each of the sites. An average SIGNAL value was calculated for each site by summing the sensitivity grades assigned to each macro invertebrate family and dividing by the number of families at each site. The SIGNAL values range from 1 (most tolerant to pollution) to 10 (most sensitive to pollution). Average SIGNAL values greater than 6 indicate clean water, whilst between 5 and 6 the water quality is doubtful or mildly polluted. SIGNAL values between 4 and 5 indicate moderate pollution, whilst a value less than 4 indicates severe pollution (Chessman *et al.* 1997).

The aquatic habitat within the study area was given one of three 'health' classifications based on water quality, sedimentation and erosion, exotic species and diversity and abundance of macro invertebrates and fish. A map showing the classification of aquatic habitat in the study area was produced based on the data collected in the field (Figure 13).

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.

6.4 Ecological Constraint Analysis

Analysis of ecological constraint at Menangle Park was undertaken using the methodology from the Edmondson Park Ecological Assessment (Eco Logical Australia 2003) as a guide. These methods were themselves an adaptation of those developed collaboratively by Ian Perkins Consultancy Services and the NSW National Parks and Wildlife Service for the Harrington Park Ecological Assessment (Ian Perkins Consultancy Services and Aquila Ecological Surveys 2002).

6.4.1 Recovery Potential

Using information collected in the field a site's 'recovery potential' is determined. 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"* (Ian Perkins Consultancy Services and Aquila Ecological Surveys 2002). Table 2 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.

6.4.2 Conservation Significance

As part of the recovery planning process for Cumberland Plain vegetation communities, NPWS 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 3.

Threatened species information is 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.

6.4.3 Ecological Constraint

Information derived from the recovery potential, conservation significance and threatened species calculations are combined to give separate indications of 'Vegetation Constraint' and 'Fauna Constraint'. The results from these analyses are combined and where the ranked value of a polygon differs between them, the higher of the two rankings is chosen for the overall ecological constraint.

Table 4 and Table 5 show the decision rules used to combine these three maps.

6.5 Study Limitations

This study was prepared to a high standard based on a project brief defined in consultation with the client. The scope of the study was also defined by time and budgetary constraints imposed by the client, and the availability of reports and other data on Menangle Park. This study meets the objectives of these services, but it should be noted that there were limitations to this study. These limitations include:

- An amendment to this report occurred in March 2009 to reflect further consideration of the vegetation type, and conservation significance assessment, at three locations within the site (polygons 8, 38, 39, 57, 58, 66, and 76). No other updates occurred at this time, except in relation to these polygons, and changes were limited to sections 6.5, 7.4.1, 7.4.2, and 9.1.6, and Figures 15 and 16.
- A further amendment to this report occurred, limited to updating figures and tables to reflect a reduction in the study area.
- Changes to available information, legislation and schedules are made on an ongoing basis and readers should obtain up to date information. This report was updated during March and April 2007 to reflect changes to legislation, and changes to threatened communities, species, and populations listings.
- Aerial photograph interpretation, which was used in the preparation of vegetation maps, is a subjective process. Potential variation in this study was minimised by one person conducting all interpretation work.
- Both animals and plants can be cryptic in their habits (ie. hard to detect), and can colonise new areas. Databases and other surveys were reviewed, and the availability of potential habitat were utilised for such species. They could, however, potentially be detected in the future.
- No trapping for fauna species was conducted.
- Assessment was based on broadscale techniques and focused on the larger areas of remnant habitat, with some smaller patches not targeted.
- Access for field survey was not possible for some areas. In these instances, in the case of vegetation survey, an assessment using binoculars was made.
- Conservation significance assessment does not include any consideration of edge-to-area ratio for remnant habitat, which can affect the long term viability and management of habitat.

Table 2. 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 *Bursaria* thickets in grassland	Recently cleared (<2 years)	Unmodified or largely natural. Uncultivated.	Native dominated	High
			Exotic dominated	Moderate
		Modified. Heavily cultivated and/or pasture improved. Imported material.	Either	Low
	Historically cleared (>2 years) and consistently managed as cleared.	Unmodified or largely natural. Uncultivated.	Native dominated	Moderate
			Exotic dominated	Low
		Modified. Heavily cultivated and/or pasture improved. Imported material.	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
			Exotic dominated	*Low*
		Moderately modified by long term grazing or mowing.	*Native dominated*	*Low*
		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
	Understorey patchily intact	*Disturbed*	*Native dominated*	*Moderate*
			Exotic dominated	*Low*
	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 3. 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 CEC	C2	Core
			Adjacent to S1	S2	Support for core
			None	O	Other remnant vegetation
	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 4. Ecological Constraint Matrix Step 1.
Source: Eco Logical Australia (2003). This step combines the recovery potential and conservation significance maps.

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

Table 5. Ecological Constraint Matrix Step 2.
Source: Eco Logical Australia (2003). This step combines results from Table 10 with the threatened species layer to determine ecological constraint.

	Combined Recovery Potential and Conservation Significance (result of Table 4 above)				
Threatened Species Assessment		**High**	**Moderate**	**Low**	**Very Low**
	Known (High)	High	High	High	High
	Likely (Moderate)	High	Moderate	Moderate	Moderate
	Nil (Low)	High	Moderate	Low	Very Low

7. Results

7.1 Flora

Following a search of the Atlas of NSW Wildlife if was determined that four threatened plant species have been reliably recorded in the vicinity (within 5 kilometres) of the study area in the recent past (Table 6). This list is consistent with the flora species targeted in the sewerage scheme EIS (section 4.7, CH2M Hill 1999b).

Table 6. Threatened Flora Species Likely to Occur in the Study Area

Species	Risk Code*	Location	Habitat
Cynanchum elegans	TSC-E1 3ECi	Razorback Range	Sheltered slopes in dry rainforest. Suitable habitat not present in study area.
Eucalyptus benthamii	TSC-V 2VCi	Nepean River, Camden	Riparian Forest along Nepean River on sandy alluvial flats
Pimelea spicata	TSC-E1 3ECi	Mt Annan; Narellan	Cumberland Plain Woodland on clay soils
Pomaderris brunnea	TSC-V 2VCi	Nepean River, Camden Park	Alluvial flats along Nepean River

***** Risk Codes

TSC	Threatened Species Conservation Act
E1	Endangered - species at risk of extinction within 20 years
V	Vulnerable - species at risk of extinction in 20 to 50 years
2	Species with a restricted distribution in Australia (range < 100km)
3	Species with a range of greater than 100km but occurring in small populations and specific habitats
C	Species represented in at least one conservation reserve
a	Species with over 1000 plants in conservation reserves
i	Species with a known population of less than 1000 in conservation reserves

None of the above species were detected within the study area during the course of survey work for the current project.

7.1.1 Field Survey and Vegetation Mapping

A complete species list from this survey is contained within Appendix 1: Flora Survey and Assessment. No species listed under the Threatened Species Conservation Act were found. The following species of regional significance were encountered during the course of the field survey.

Table 7. Regionally Significant Flora Species
(Recorded during survey work for the current project.)

Common name	Species Name	Significance Reasoning
	Maireanna microphylla	Known from only 3 sites in western Sydney, including Leacock Regional Park and Menangle Park
Western Boobialla	*Myoporum montanum*	Known from only 4 locations in western Sydney (James, McDougall & Benson 1999), in the Camden and Blacktown local government areas.
Narrawa Burr	*Solanum cinereum*	Known from only 5 locations within western Sydney, including dry rainforest at Fairfield City Farm, Campbelltown, Camden and Holroyd (James, McDougall & Benson 1999) and the study area at Menangle Park

Weed species were observed, a total of nine species declared as noxious weeds in the Campbelltown area (Table 8) and three environmental weed species (Table 9). These lists are unlikely to be comprehensive however, as the field survey targeted native flora rather than weeds.

Table 8. Noxious Weed Species.
(Recorded during survey work for the current project).

Common name	Species Name	Noxious Weed Category*
African boxthorn	*Lycium ferocissimum*	W2
Balloon vine	*Cardiospermum grandiflorum*	W4c
Blackberry	*Rubus fruticosus (agg. spp.)*	W2
Bridal Creeper	*Myrsiphyllum asparagoides*	W4c
Paterson's curse, Vipers Italian bugloss	*Echium spp.*	W3
Prickly Pear	*Opuntia stricta*	W4f
Green Cestrum	*Cestrum parqui*	W3
Privet - broadleaf	*Ligustrum lucidum*	W4b
Privet - narrowleaf	*Ligustrum sinense*	W4b

***** Risk Codes

W2	The weed must be fully and continuously suppressed and destroyed.
W3	The weed must be prevented from spreading and its numbers and distribution reduced.
W4b	The weed must not be sold, propagated or knowingly distributed and any existing weed must be prevented from flowering and fruiting.
W4c	The weed must not be sold, propagated or knowingly distributed and the weed must be prevented from spreading to an adjoining property.
W4f	The weed must not be sold, propagated or knowingly distributed. Any biological control or other control program directed by the local control authority must be implemented.

Table 9. Environmental Weed Species.
(Recorded on the Menangle Park study site).

Common name	Species Name
African Lovegrass	*Eragrostis curvula*
African Olive	*Olea europaea*
Fireweed	*Senecio madagascariensis*

Six native plant communities were found in the study area (see appendix 1 for detailed descriptions of the communities).

The majority of the north eastern section of the study area is Shale Plains Woodland, graduating into Shale Hills Woodland towards the southern portion of the region. A strip of wetlands occurs in a low-lying area adjacent to a creek in the centre of the site, with Riparian Woodlands following the creekline.

The study area is bounded to the west and south by a broad band of Riparian Forest along the banks of the Nepean River.

North of Menangle Park Paceway there is a stand of Alluvial Woodland in good condition apart from evidence of frequent fires. In this stand the understorey is grassy with only scattered shrubs.

Community and patch condition information from the Eco Logical Australia Pty Ltd vegetation mapping are presented graphically in Figure 7.

Figure 8 displays areas of potential habitat for the threatened species listed in Table 6, as well as the remnant patches where the regionally significant species listed in Table 7 were located. The data recorded in the field survey is presented in the tables in Appendix 6 and 7.

The vegetation types described above are all communities which fall within the definition of 'endangered ecological communities' listed under the Threatened Species Conservation Act.

Table 11 lists the vegetation types within the study area and their corresponding endangered ecological community.

Table 10 below contains the area calculations for this mapping and analysis.

Table 10. Areal calculations for ecological maps

Vegetation Cover	**Hectares**	**%**
Native Vegetation	115.06	13%
Non-native vegetation	10.75	1%
Other (i.e. Unvegetated)	761.99	86%
TOTAL	887.80	100%
Vegetation Communities	**Hectares**	**%**
Alluvial Woodland	11.80	10%
Freshwater Wetland	9.81	9%
Riparian Forest	36.56	32%
Riparian Woodland	6.64	6%
Shale Hills Woodland	14.95	13%
Shale Plains Woodland	35.30	30%
TOTAL	115.06	100%
Recovery Potential	**Hectares**	**% of vegetated area**
High	40.72	35%
Moderate	60.76	53%
Low	2.31	2%
Very Low	11.27	10%
TOTAL	115.06	100%
Ecological Constraint	**Hectares**	**% of vegetated area**
High	88.73	77%
Moderate	25.14	22%
Low	1.19	1%
TOTAL	115.06	100%

Table 11. Endangered Ecological Communities of the Menangle Park Study Area

VEGETATION TYPE	COMMUNITY *	Ha	%
Riparian Forest	River-flat eucalypt forest on coastal floodplains of the NSW North Coast, Sydney Basin and South East Corner bioregions	55.00	6%
Alluvial Woodland	River-flat eucalypt forest on coastal floodplains of the NSW North Coast, Sydney Basin and South East Corner bioregions		
Riparian Woodland	River-flat eucalypt forest on coastal floodplains of the NSW North Coast, Sydney Basin and South East Corner bioregions		
Shale Plains Woodland	Cumberland Plain Woodland	50.25	6%
Shale Hills Woodland	Cumberland Plain Woodland		
Freshwater Wetland	Sydney Freshwater Wetlands	9.81	1%
	TOTAL	115.06	13%

* River-Flat Eucalypt Forest on Coastal Floodplains of the NSW North Coast, Sydney Basin and South East Corner bioregions includes and replaces the previous listing of this vegetation as 'Sydney Coastal River-Flat Forest' Endangered Ecological Community.

None of these endangered ecological communities is considered to be a "Critically Endangered Community", where less than 1000ha of that community type remains in the state (NPWS 2002a).

Figure 7. Vegetation Community and Condition

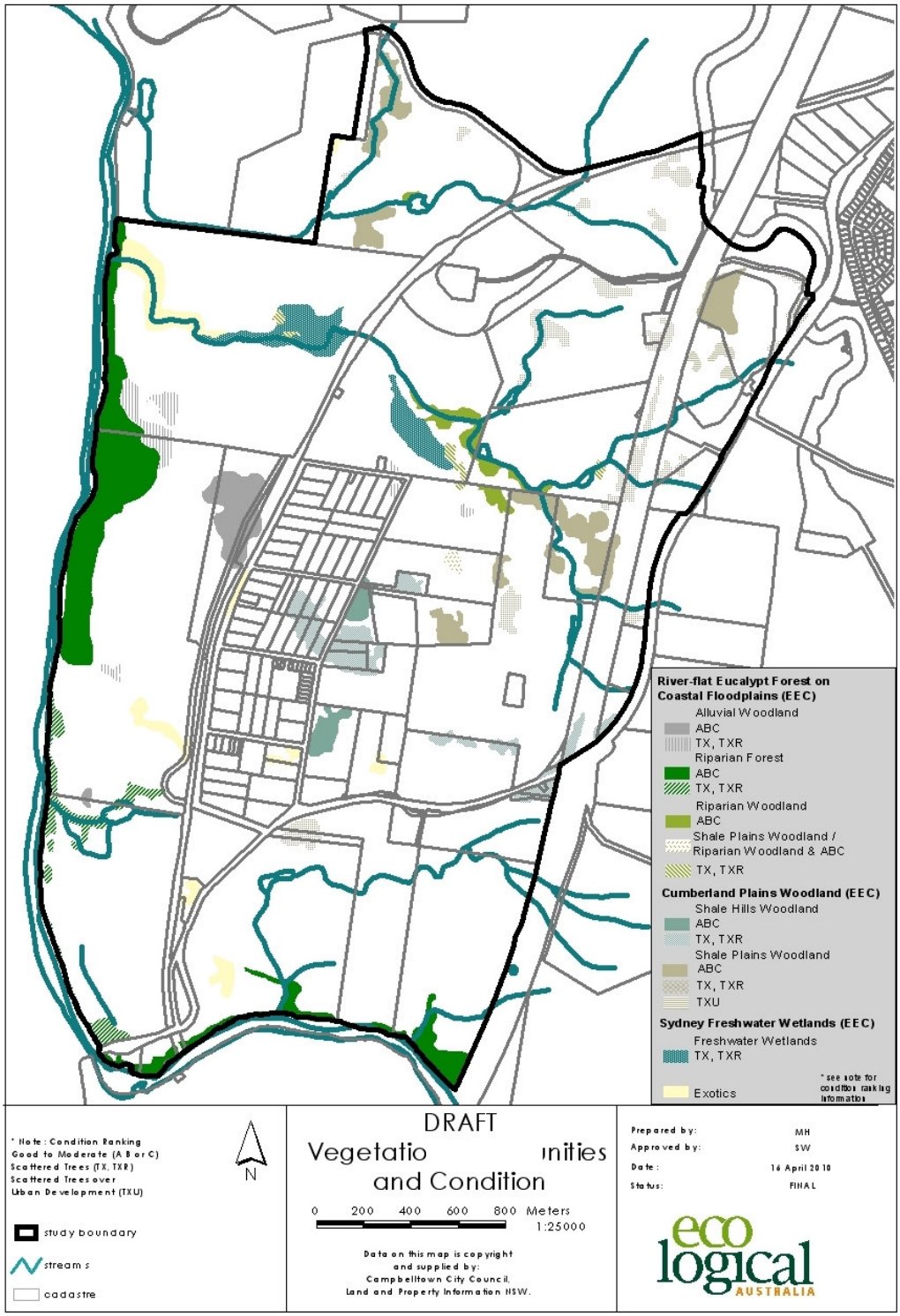
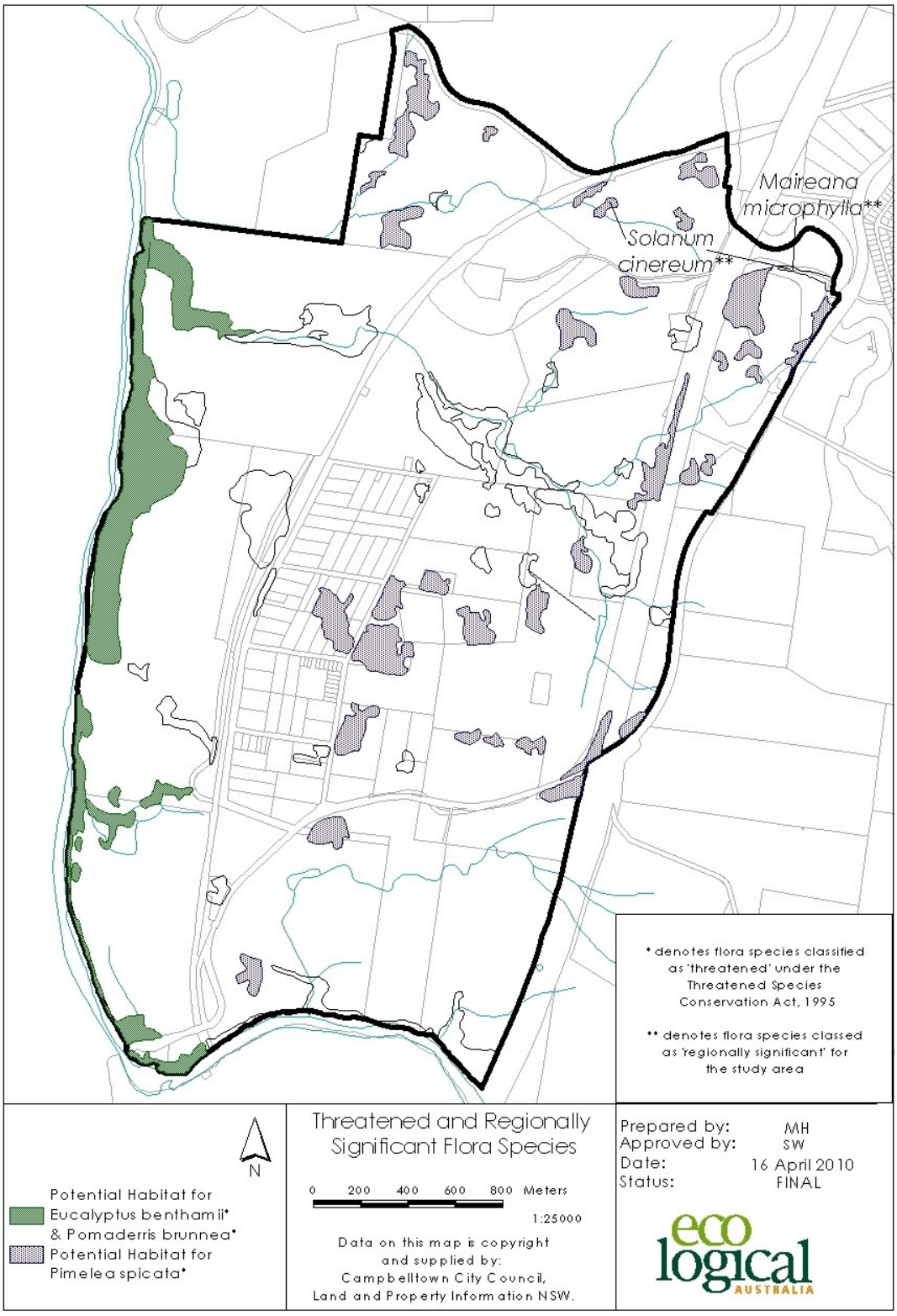


Figure 8. Flora Habitat Value Figure



7.1.2 Recovery Potential

The decision rules developed by Ian Perkins Consultancy Services and Aquila Ecological Surveys (2002, see Table 2) require consideration as to whether the understorey is native dominated or exotic dominated. Field survey and analysis indicated that an additional category should be applied in relation to the study area. A number of sites supported vegetation where the cover of native understorey plants was between 10% and 50% of total understorey plant cover. This means that native species do not technically dominate the study area, but nevertheless constitute a significant component of the understorey, indicating a somewhat higher recovery potential than sites with less than 10% cover of native understorey species.

Understorey was scored according to the following three categories:

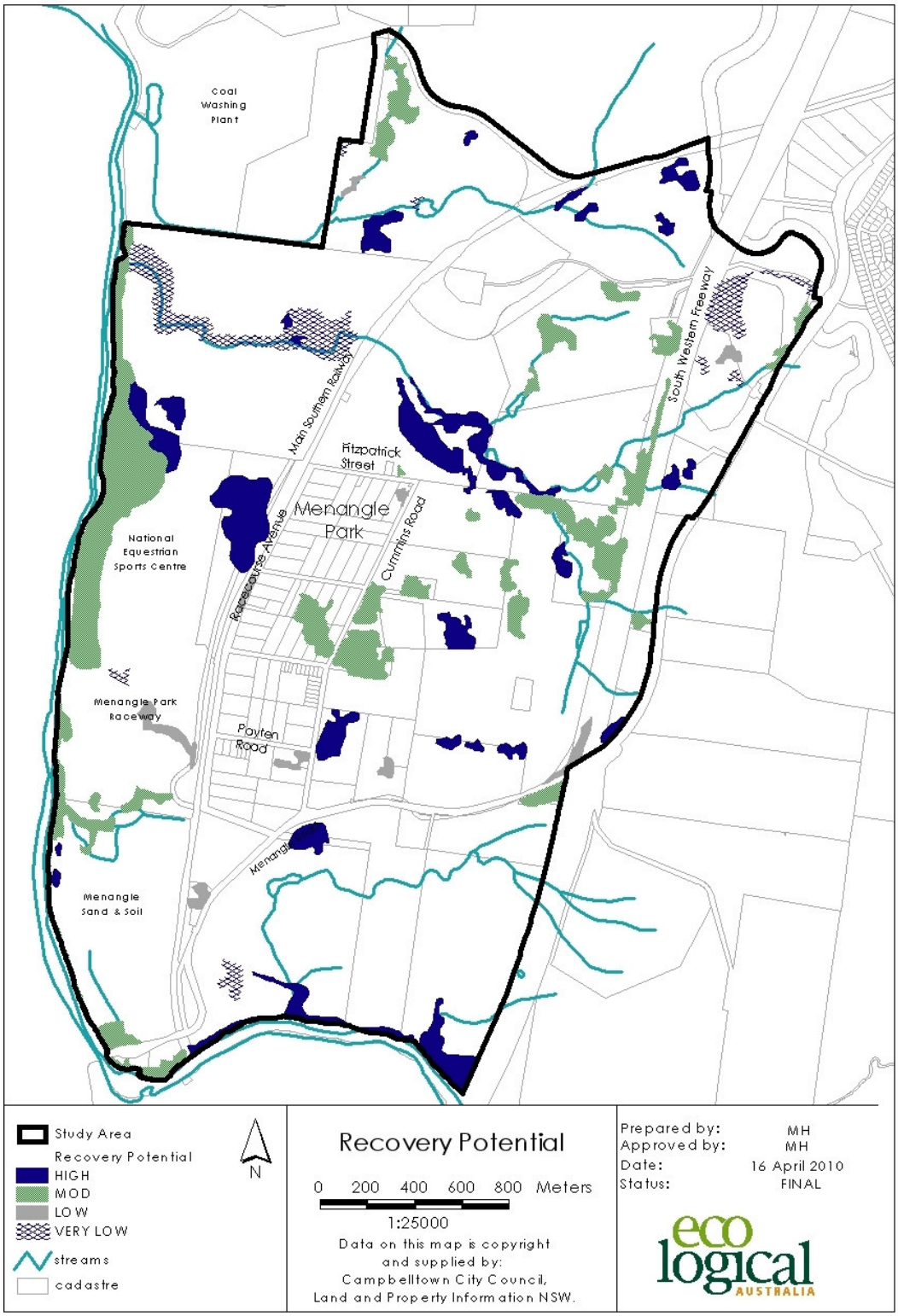
- Y Greater than 50% native plant cover. Understorey dominated by natives
- M 10-50% native plant cover.
- N Less than 10% native plant cover.

As the survey was directed to the assessment of vegetation polygons identified in the NPWS Cumberland Plain vegetation mapping and there has been little in the way of land use change in the study area since that mapping was completed, most of the polygons fell into the "Wooded/Native Canopy Present or Regenerating" arm of the recovery potential decision tree.

Figure 9 displays the results of this analysis. For the majority of polygons, recovery potential was ranking as either HIGH or MODERATE depending on the degree to which native understorey plants were present. For sites where weed invasion was at a high level and soil profiles were intact a MODERATE ranking was generally given unless soil disturbance was evident in which case a LOW ranking was assigned.

For small isolated remnants which would require high management costs recovery potential was downgraded from HIGH to MODERATE.

Figure 9. Recovery Potential

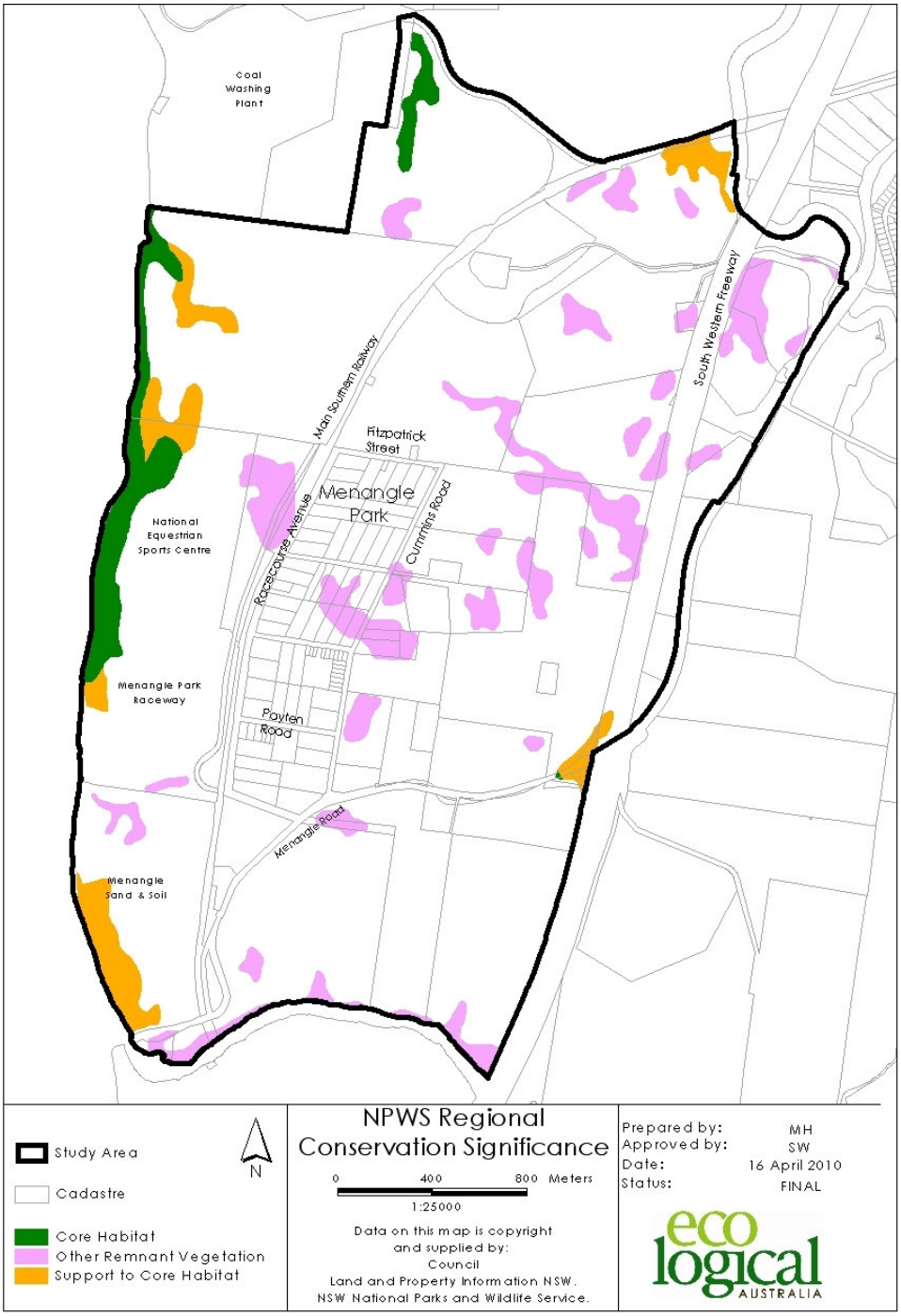


7.1.3 Conservation Significance Mapping

The results of the NPWS conservation significance mapping for the Menangle Park study area are displayed below.

Figure 10. NPWS Conservation Significance

Source: NPWS (2002c)



7.2 Fauna

Five habitat types for fauna were recognised in the study area. Their distribution in the study area is illustrated in Figure 11 and brief descriptions are provided in appendix 2.

A total of 29 species listed under the TSC Act or EPBC Act were considered, which included all 12 fauna species considered in the sewerage scheme EIS (section 4.7, CH2M Hill 1999b). Four species of listed insectivorous bats were tentatively identified through call recordings: eastern false pipistrelle (*Falsistrellus tasmaniensis*), eastern freetail-bat (*Mormopterus norfolkensis*), greater broad-nosed bat (*Scoteanax rueppellii*), and large-footed myotis (*Myotis adversus*). The powerful owl (*Ninox strenua*) has been observed in riparian forest in the study area (local resident pers. comm.). No other listed species were observed during the study period. Based on habitat availability, a further 8 listed species of fauna were considered to be likely to occur in the Menangle Park study area, with 16 listed species considered to be unlikely to occur (Table 12 and Table 13, Aquila Ecological Surveys 2003). The reasons for each species why it was considered unlikely to occur are detailed in Appendix 2.

Of the species known or likely to occur, four are listed under the EPBC Act: green and golden bell frog (*Litoria aurea*), grey-headed flying-fox (*Pteropus poliocephalus*), regent honeyeater (*Xanthomyza phrygia*), and the swift parrot (*Lathamus discolor*, Table 12). Migratory species are also listed under the EPBC Act, with two migratory species, Latham's snipe (*Gallinago megala*) and the leaden flycatcher (*Myiagra ruficollis*), observed in the Menangle Park study area, and five species considered to be likely to occur (Table 14). One of these migratory species, the regent honeyeater, is also listed as endangered under the EPBC Act and TSC Act (Table 12).

A total of ten regionally significant species, or signs of these species, were observed (Aquila Ecological Surveys 2003). A further 20 regionally significant species were considered to be likely to occur in the Menangle Park study area based on habitat availability (Table 15).

Table 12. Threatened Fauna Species Which are Likely to Occur.
A list of threatened fauna species known to occur, or likely to occur based on habitat type, within the Menangle Park study site. The listing of the species under the *Threatened Species Conservation Act 1995* (TSC Act) and *Environment Protection & Biodiversity Conservation Act 1999* (EPBC Act) is indicated by: E = Endangered, V = Vulnerable.

Common Name	Species Name	TSC Act	EPBC Act
Common Bentwing-bat	*Miniopterus schreibersii*	V	-
Cumberland land snail	*Meridolum corneovirens*	E	-
Eastern False Pipistrelle	*Falsistrellus tasmaniensis*	V	-
Eastern Freetail-bat	*Mormopterus norfolkensis*	V	-
Greater Broad-nosed Bat	*Scoteanax rueppellii*	V	-
Green and Golden Bell Frog	*Litoria aurea*	E	V
Grey-headed Flying-fox	*Pteropus poliocephalus*	V	V
Koala	*Phascolarctos cinereus*	V	-
Large-eared Pied Bat	*Chalinolobus dwyeri*	V	-
Large-footed Myotis	*Myotis adversus*	V	-
Powerful Owl	*Ninox strenua*	V	-
Regent Honeyeater	*Xanthomyza phrygia*	E	E
Swift Parrot	*Lathamus discolor*	E	E

Table 13. Threatened Fauna Species Which are Unlikely to Occur.
A list of threatened fauna species recorded within the vicinity of Menangle Park study site, but which are considered unlikely to occur based on habitat availability (see appendix 2 for full details). The listing of the species under the *Threatened Species Conservation Act 1995* (TSC Act) and *Environment Protection & Biodiversity Conservation Act 1999* (EPBC Act) is indicated by: E = Endangered, V = Vulnerable.

Common Name	Species Name	TSC Act	EPBC Act
Black-chinned Honeyeater	*Melithreptus gularis gularis*	V	-
Blue-billed Duck	*Oxyura australis*	V	-
Broad-headed Snake	*Hoplocephalus bungaroides*	E	E
Brown Treecreeper	*Climacteris picumnus*	V	-
Bush Stone-curlew	*Burhinus grallarius*	E	-
Eastern Pygmy-possum	*Cercartetus nanus*	V	-
Freckled Duck	*Stictonetta naevosa*	V	-
Giant Burrowing Frog	*Heleioporus australiacus*	V	V
Glossy Black-Cockatoo	*Calyptorhynchus lathami*	V	-
Hooded Robin	*Melanodryas cucullata*	V	-
Red-crowned Toadlet	*Pseudophryne australis*	V	-
Rosenberg's Goanna	*Varanus rosenbergi*	V	-
Speckled Warbler	*Pyrrholaemus sagittatus*	V	-
Spotted-tailed Quoll	*Dasyurus maculatus*	V	V
Squirrel Glider	*Petaurus norfolcensis*	V	-
Yellow-bellied Glider	*Petaurus australis*	V	-

Table 14. Migratory Species Which are Likely to Occur.
A list of migratory fauna species known to occur, or likely to occur, within the Menangle Park study site. A migratory species is considered to be those species listed under the EPBC Act, which includes JAMBA, CAMBA, and Bonn Convention listed species.

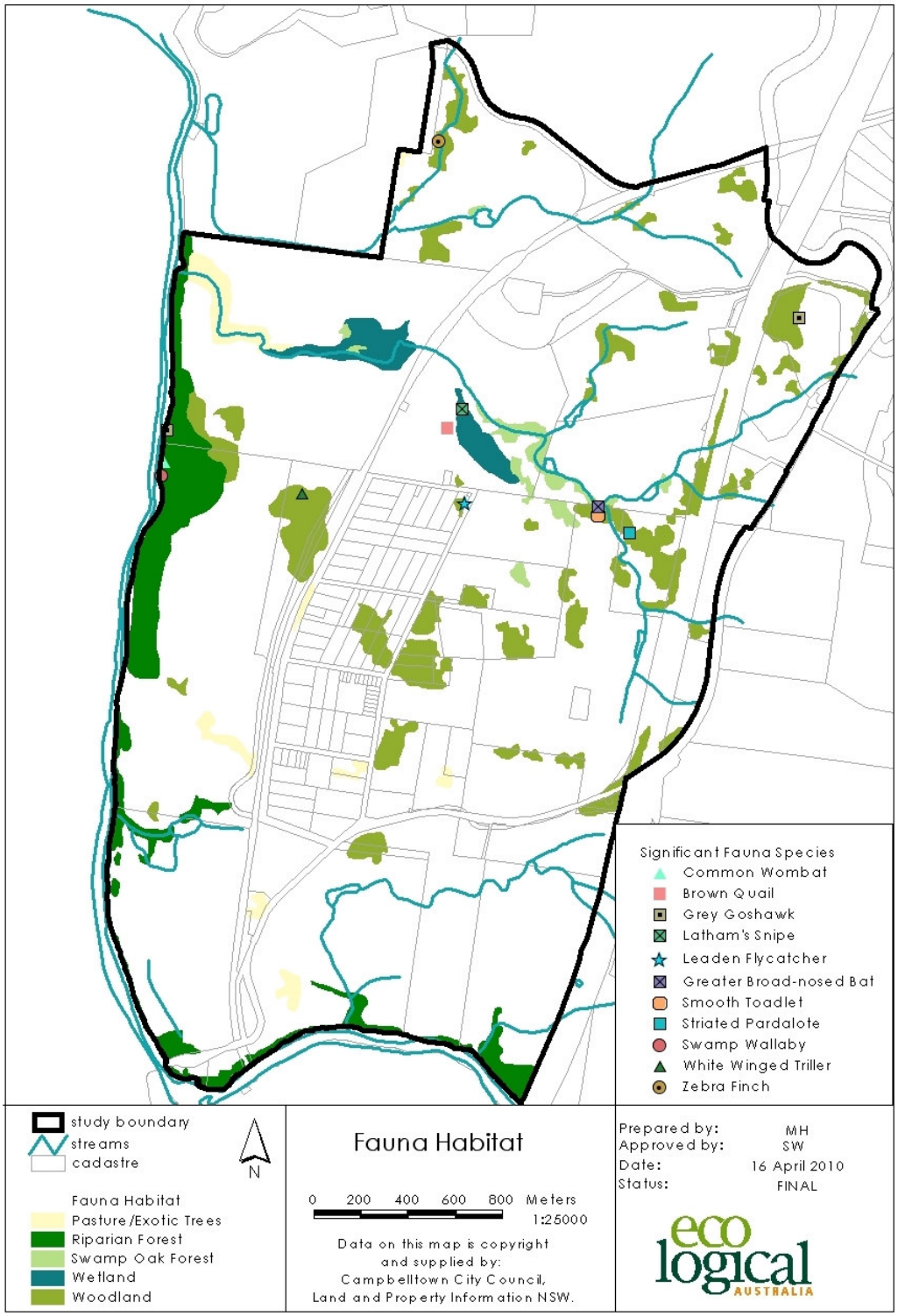
Common Name	Species Name
Cattle egret	*Ardea ibis*
Latham's snipe	*Gallinago megala*
Leaden flycatcher	*Myiagra ruficollis*
Regent honeyeater	*Xanthomyza phrygia*
Rufous fantail	*Rhipidura rufifrons*
White-bellied sea-eagle	*Haliaeetus leucogaster*
White-throated needletail	*Hirundapus caudacutus*

Table 15. Regionally Significant Fauna Species Which are Likely to Occur.
A list of regionally significant fauna species known to occur, or likely to occur, within the Menangle Park study site. Species considered to be regionally significant are those listed as regionally significant in the Urban Bushland Biodiversity Survey (NPWS *et al.* 1997).

Common Name	*Species Name*
Azure kingfisher	*Alcedo azurea*
Brown cuckoo-dove	*Macropygia amboinensis*
Common wombat	*Vombatus ursinus*
Brown quail	*Coturnix ypsilophora*
Buff-rumped thornbill	*Acanthiza reguloides*
Eastern shrike-tit	*Falcunculus frontatus*
Fuscous honeyeater	*Lichenostomus flavescens*
Golden-headed cisticola	*Cisticola exilis*
Grey goshawk	*Accipiter novaehollandiae*
Green tree frog	*Litoria caerulea*
Lace Monitor	*Varanus varius*
Little eagle	*Hieraaetus morphnoides*
Latham's snipe	*Gallinago megala*
Marsh snake	*Hemiaspis signata*
Pacific baza	*Aviceda subcristata*
Peaceful dove	*Geopelia placida*
Peregrine falcon	*Falco peregrinus*
Restless flycatcher	*Myiagra inquieta*
Short-beaked echidna	*Tachyglossus aculeatus*
Smooth toadlet	*Uperoleia laevigata*
Striated pardalote	*Pardalotus striatus*
Superb fairywren	*Malurus cyaneus*
Swamp wallaby	*Wallabia bicolor*
Wedge-tailed eagle	*Aquila audax*
White-bellied sea-eagle	*Haliaeetus leucogaster*
White-throated needletail	*Hirundapus caudacutus*
White-winged chough	*Corcorax melanorhamphus*
White-winged triller	*Lalage tricolor*
Yellow-rumped thornbill	*Acanthiza chrysorrhoa*
Zebra finch	*Taeniopygia guttata*

Figure 11. Fauna Habitat Types.*

* Locations of the Eastern False Pipistrelle and East Coast Freetail Bat are not shown as these were only 'possible' records, identified tentatively through call recordings.



7.3 Aquatic

The aquatic habitats within the study area are generally quite degraded (Figure 13); land clearing and agricultural activities being the most likely causes. Invasion by riparian and aquatic weeds and alterations to natural stream flows have all exacerbated the problem. Blooms of filamentous algae were evident in many places, probably as a result of excessive nutrients. There were also many artificial barriers to fish migration in the form of road crossings and culverts.

Brief descriptions of the aquatic habitats are below, and site locations are shown in Figure 13. Further details are provided within appendix 3.

7.3.1 Racecourse Creek (Sites 1 & 2)

The upstream section of Racecourse Creek at the first two sites was highly degraded, with two introduced species *Ranunculus sceleratus* and *Rumex crispus* amongst the dominant plant species. The former of these species is tolerant of high nutrient levels (Sainty and Jacobs 1994), indicating the likelihood of nutrient runoff from adjacent properties.

Major barriers to upstream migration of aquatic organisms exist, especially under the railway line. Degradation of aquatic habitat continues downstream, with many weed species and evidence of heavy sedimentation. Closer to the Nepean River, however, the streambank of Racecourse Creek has a modest cover of native vegetation and was given a moderate aquatic habitat classification (Figure 13).

7.3.2 North Creek - National Equestrian Sports Centre Section (Sites 3, 4, 5 & 6)

The downstream section of the North Creek close to the Nepean River was given a moderate aquatic habitat classification (Figure 13). The quality of the water at sites 3 and 4 was good and there were no artificial barriers to fish passage.

North Creek is in very poor condition upstream of site 5 all the way to the railway line. A small wooden bridge constitutes the first of numerous artificial barriers to upstream migration of aquatic organisms, there is evidence of significant sedimentation on the creek bed, and excessive growth of filamentous algae, aquatic and riparian weeds such as blackberry is also common.

7.3.3 North Creek - Horse Riding Farm Section (Sites 7, 8, 9 & 10)

East of the railway along this creekline the aquatic habitat generally improves with distance upstream, coinciding with an increase in native riparian vegetation. There is evidence of erosion and deposition from further upstream, and blackberry infestation of the riparian zone, but species of aquatic macrophytes are also commonly occurring.

Along this creek from site 9 through 10 and up to the Hume Highway there is a heavily vegetated riparian zone with abundant native *Casuarina spp.* as well as many terrestrial (blackberry) and semi-aquatic weeds (*Rumex crispus*). The water quality within this section of the creek appeared to be reasonable however there was evidence of streambank erosion and damage from grazing animals.

The creeks between the Hume Highway and Menangle Road are heavily impacted and generally represent very poor aquatic habitat, with emergent aquatic species such as *Typha orientalis* and *Phragmites australis* prevalent. (Figure 13).

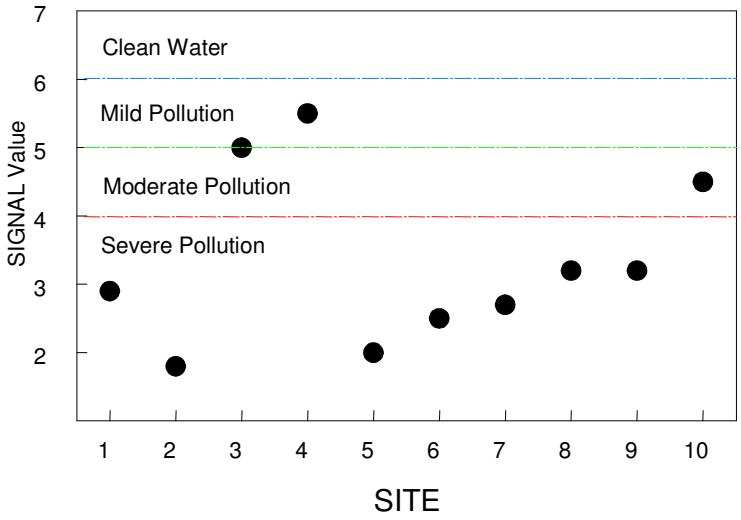
There was evidence of mild water pollution at sites 3 and 4, with all other sites having moderate levels (appendix 3).

7.3.4 Assemblages of Macroinvertebrates

A total of 444 macroinvertebrates from 35 families were collected from the 10 sites sampled in Menangle Park. Sites 8, 9 and 10 had the greatest richness and abundance of macroinvertebrates, but there was large within-site variability, and no significant differences in the richness or abundance of macroinvertebrates between sites (appendix 3).

The macroinvertebrate SIGNAL analysis suggests that the water quality at sites 3 and 4 is mildly polluted, with all other sites having moderate to severe water pollution (Figure 12).

Figure 12. Average Macroinvertebrate SIGNAL Values for each Aquatic Site.



7.3.5 Assemblages of Fish

A total of 101 individual fish and crustaceans were collected. Introduced fish species (mosquito fish and oriental weatherloach) dominated, with native fish species representing only 10% of the total fish abundance (appendix 3). A total of 47 individuals of the freshwater shrimp *Paratya australiensis* was found from sites 3, 4, 8, 9 and 10.

There were significant differences between sites in the richness and abundance of fishes, with site 1 having the greatest richness, whilst there were no fish caught at sites 2, 5 and 6.

Table 16. Fish Species Recorded in the Menangle Park Study Site.
None of the fish species are listed as being Vulnerable or Endangered under the *Fisheries Management Act 1994* (FMA Act).

Common Name	Species Name
Firetail gudgeon	*Hypseleotris galii*
Mosquito fish *	*Gambusia holbrooki*
Striped gudgeon	*Gobiomorphus australis*
Cox's gudgeon	*Gobiomorphus coxii*
Oriental weatherloach *	*Misgurnus anguillicaudatus*

* = introduced species

7.3.6 Threatened and Regionally Significant Aquatic Species

Two fish species listed under the FM Act could potentially occur in the study area: the Macquarie Perch (*Macquaria australasica*) and the Australian Grayling (*Prototroctes maraena*). Macquarie Perch have been recorded in the Nepean River system (Llewellyn and MacDonald 1980) and the Australian Grayling has been recorded in the Hawkesbury-Nepean River system (Pollard and Growns 1993).

Given the degraded nature of the aquatic habitats, the occurrence of mosquito fish and the barriers to fish passage, no threatened or endangered species or regionally significant species were found within the study area and are not considered likely to be found there in the future.

7.3.7 Classification of Aquatic Habitats

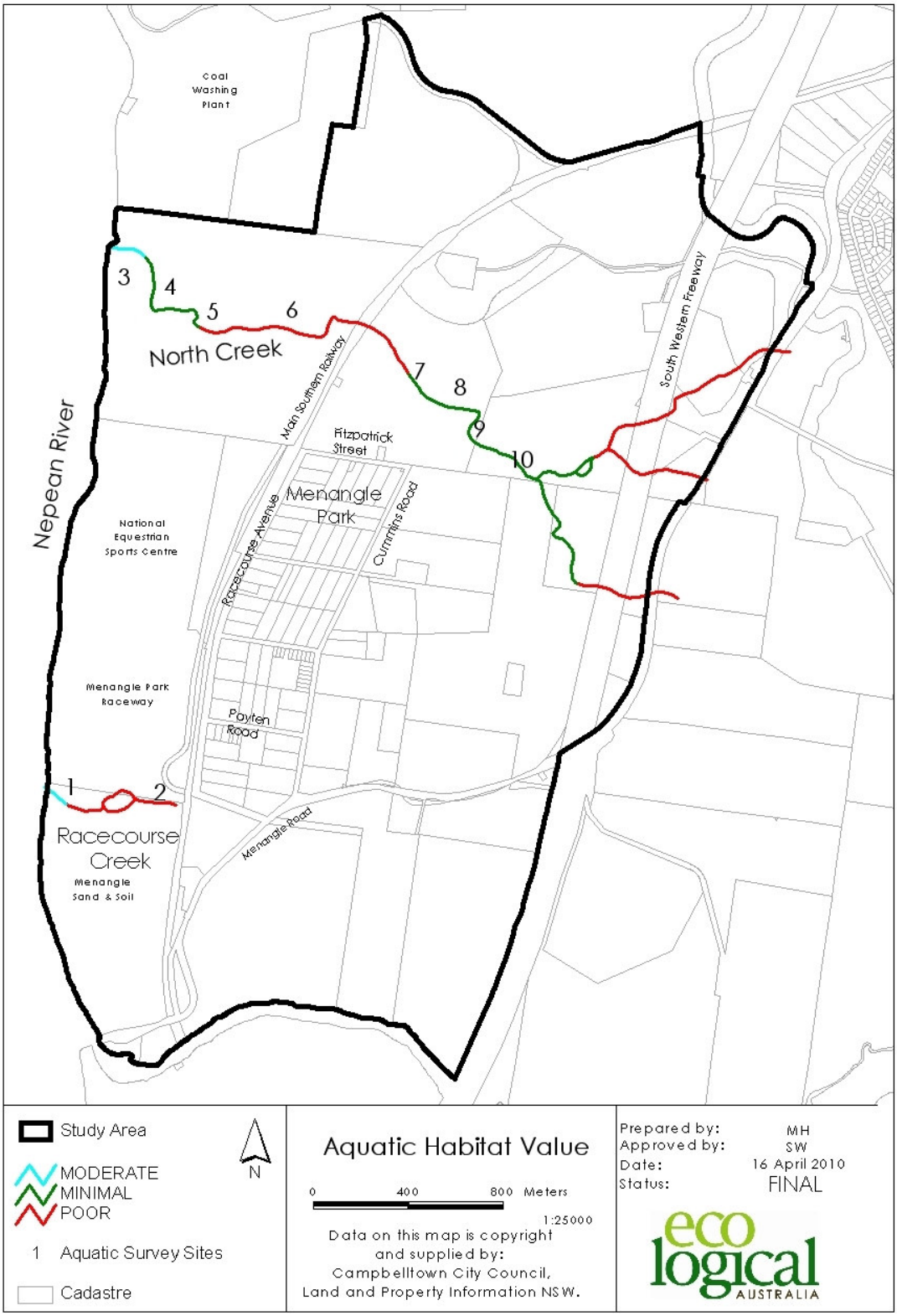
Aquatic habitat on the study site was generally low, with moderate quality habitat being recorded at sites 1, 3 and 4 only (Figure 13).

Table 17. Summary Aquatic Data for Menangle Park Study Area.
The table below is a summary of data on aquatic health, ecological values, and ecological constraints to conservation/restoration and future development within the study area. The 'Aquatic Habitat' is the assessment of the current value (ecologically), and 'Ecological Values' is an assessment of the potential value after rehabilitation (recovery).

Section	Site	Aquatic Habitat	Ecological Values	Ecological Justification[1]	Comments[2]
Racecourse Creek	1	Moderate	Moderate	• Introduced fish/weeds • Sedimentation • Mine haul road	• None
	2	Poor	Low	• Artificial barriers • Eutrophication • Aquatic weeds • No riparian	• Downstream effects on Moderate aquatic habitat below site 1.
North Creek - Equestrian Sports Centre	3	Moderate	High	• Riparian weeds • Cattle access	• Low pollution
	4	Moderate	High	• Riparian weeds • Cattle access	• Low pollution
	5	Poor	Low	• Artificial barriers • Eutrophication • Aquatic/riparian weeds • Water pollution • Cattle access	• Downstream effects on moderate aquatic habitat at sites 3 and 4.
	6	Poor	Low	• Artificial barriers • Eutrophication • Aquatic/riparian weeds • Water pollution • Cattle access	• Downstream effects on moderate aquatic habitat at sites 3 and 4.
North Creek - Horse Riding Farm	7	Minimal	Moderate	• Artificial barriers • Eutrophication • Aquatic/riparian weeds	None
	8	Minimal	Moderate	• Artificial barriers • Eutrophication • Aquatic/riparian weeds	• None
	9	Minimal	Moderate	• Artificial barriers • Eutrophication • Aquatic/riparian weeds	• None
	10	Minimal	Moderate	• Artificial barriers • Eutrophication • Aquatic/riparian weeds	None
East of Railway		Minimal	Low	• Artificial barriers • Aquatic/riparian weeds • Cleared	• None
South-east of Menangle Road		Minimal	Low	• Stream modification • Cattle grazing • Cleared	• None

[1] Negative attributes of a location, which reduce its ecological value.
[2] Attributes, in addition to the current and potential values, that must be considered in terms of future development.

Figure 13. Aquatic Habitat Condition and Survey Sites.



7.4 Ecological Constraints Analysis

7.4.1 Vegetation Constraint

A vegetation constraint ranking was derived applying the amended methodology used in the Edmondson Park Ecological Assessment (see Table 4 and Table 5 of this report and Eco Logical Australia 2002). The results of this analysis can be seen in Figure 14.

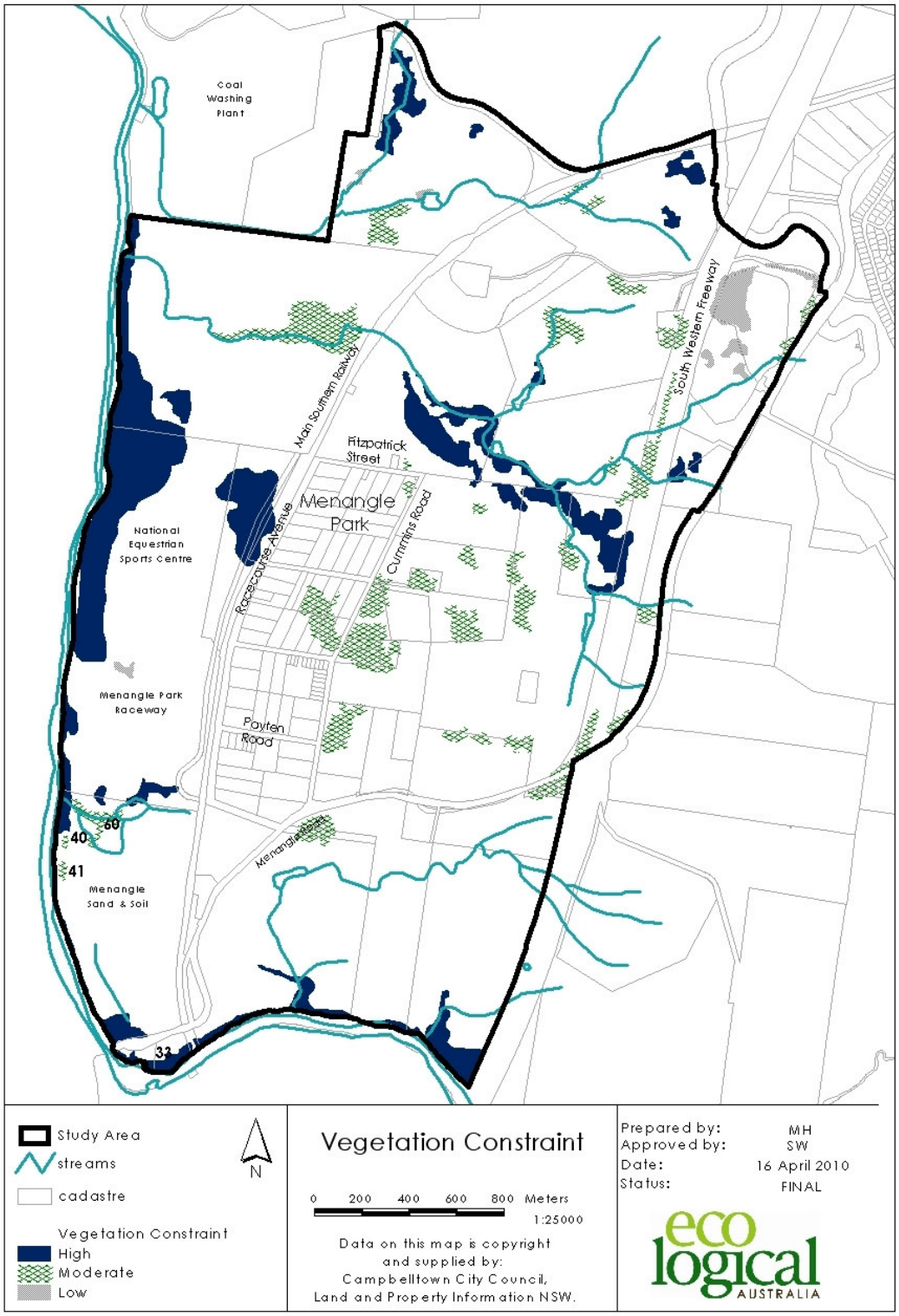
Stands of remnant vegetation supporting mature trees with hollows and having HIGH recovery potential were assigned a HIGH ranking for vegetation constraint.

The following issues worth noting arose from the vegetation constraints analysis:

- Polygon 3, in the central eastern portion of the study area, has been mapped as MODERATE. The authors feel that it should be assigned a HIGH ranking due to its proximity to a large remnant with HIGH ecological constraint.
- Polygon 25, a small, linear remnant stretching along Glenlee Rd between Menangle Rd and the Hume Highway in the north east of the study area, received a LOW ranking and is mapped as such. Whilst the presence of two regionally significant flora species was recorded in the patch, there would be a high management input required to maintain the remnant for conservation.
- Polygons 57, 58 and 76, along North Creek to the west of the railway line, were initially rated as a high fauna and combined ecological constraint. On review, the authors felt that there was sufficient justification to identify these polygons separately with regards to fauna constraint due to the degraded nature of this area. The impacts in this area include past filling of the wetland area, the loss of the majority of native flora, and abundant weeds. Consequently the fauna constraint was amended to "moderate", which resulted in a revised overall ecological constraint of "Moderate" for this area.
- Polygons 38, 39, 66, and potentially others within the site, if kept, would likely require a high level of management intervention over the long term to retain their biodiversity values, due to their relatively small size and isolation. The ecological constraints identified in this report are based on the identified methodology, and the status at the time of survey, and do not account for potential future changes in condition and ecological value.

Figure 14. Vegetation Constraint

(derived from Figure 8, Figure 9 and Figure 10, refer to Table 4 and Table 5 for methodology)



7.4.2 Terrestrial Fauna Constraint

Using the methods defined in Section 6.4, areas of constraint for fauna on the Menangle Park study site were defined as below:

- High constraint = Woodland, riparian forest and wetlands (with the exception of polygons 57, 58 and 76 where the fauna constraint was amended in March 2009 to 'Moderate'), as these vegetation communities were utilised by a wide range of species including some that are threatened or regionally significant.
- Medium constraint = Areas that have some habitat value for a narrower range of species but are generally dominated by edge species and have moderate or poor recovery potential (Gingra Ecological Surveys 2003)
- Low constraint = all other areas, generally isolated and small in size, with a very low recovery potential

Note that as introduced pastures are well represented in the vicinity, those regionally significant species using exotic grassland are excluded from consideration in the compilation of areas of high constraint.

Some things to note from the fauna constraints analysis include:

- There are a range of species that use the large remnant patches of woodland, riparian forest and wetlands
- Some of the small isolated patches are excluded from the analysis as they were not considered to provide adequate fauna habitat
- Areas with high fauna constraint generally relate to the areas with high recovery potential
- Areas of moderate constraint have some habitat value for a narrower range of species but are generally dominated by edge species and have moderate or poor recovery potential. These habitats may, however, have a corridor function across the site.

The results of this faunal constraint analysis can be seen in Figure 15.

Figure 15. Fauna Constraints Map.

(derived from Figure 8, Figure 9, Figure 10 and Figure 11, refer to Table 4 and Table 5 for methodology)

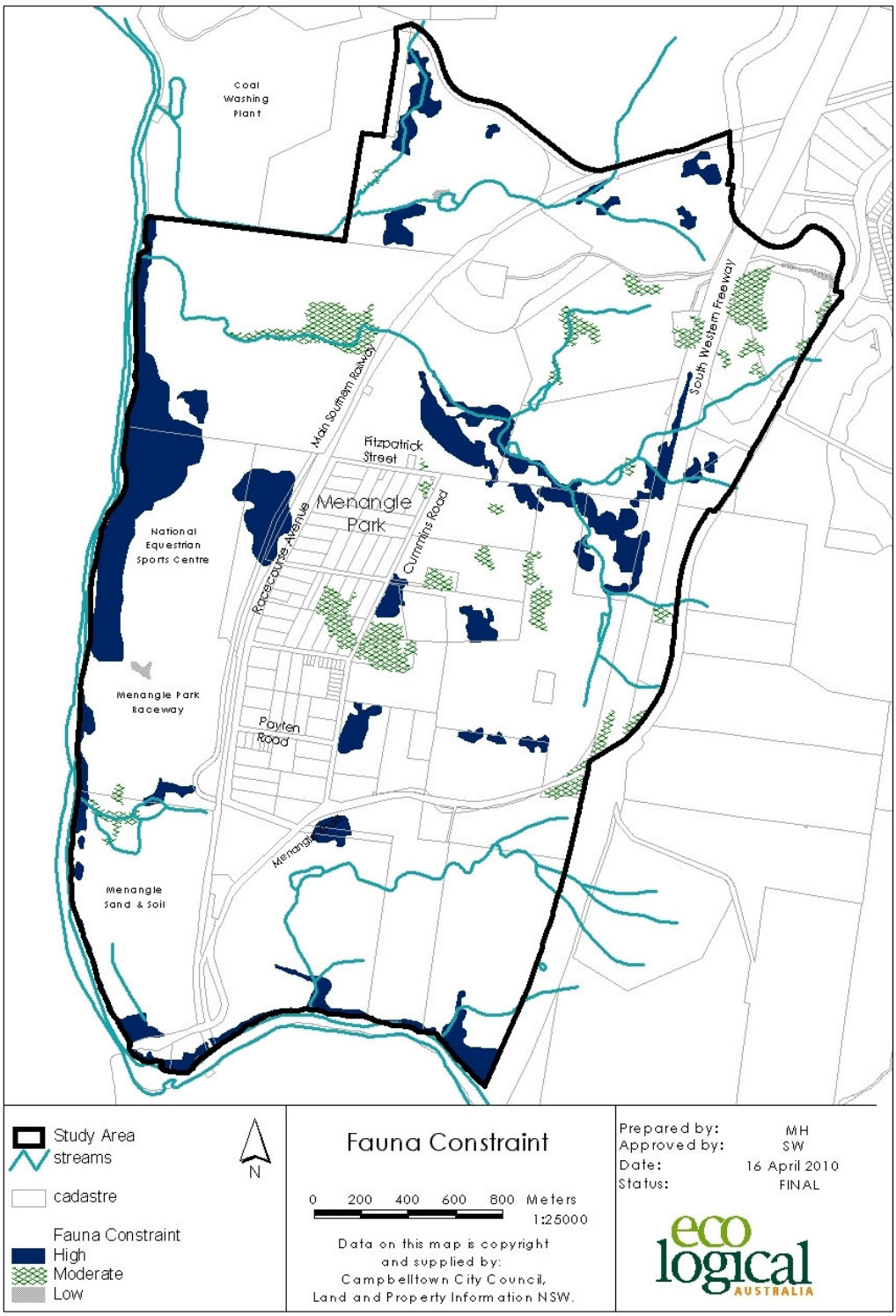
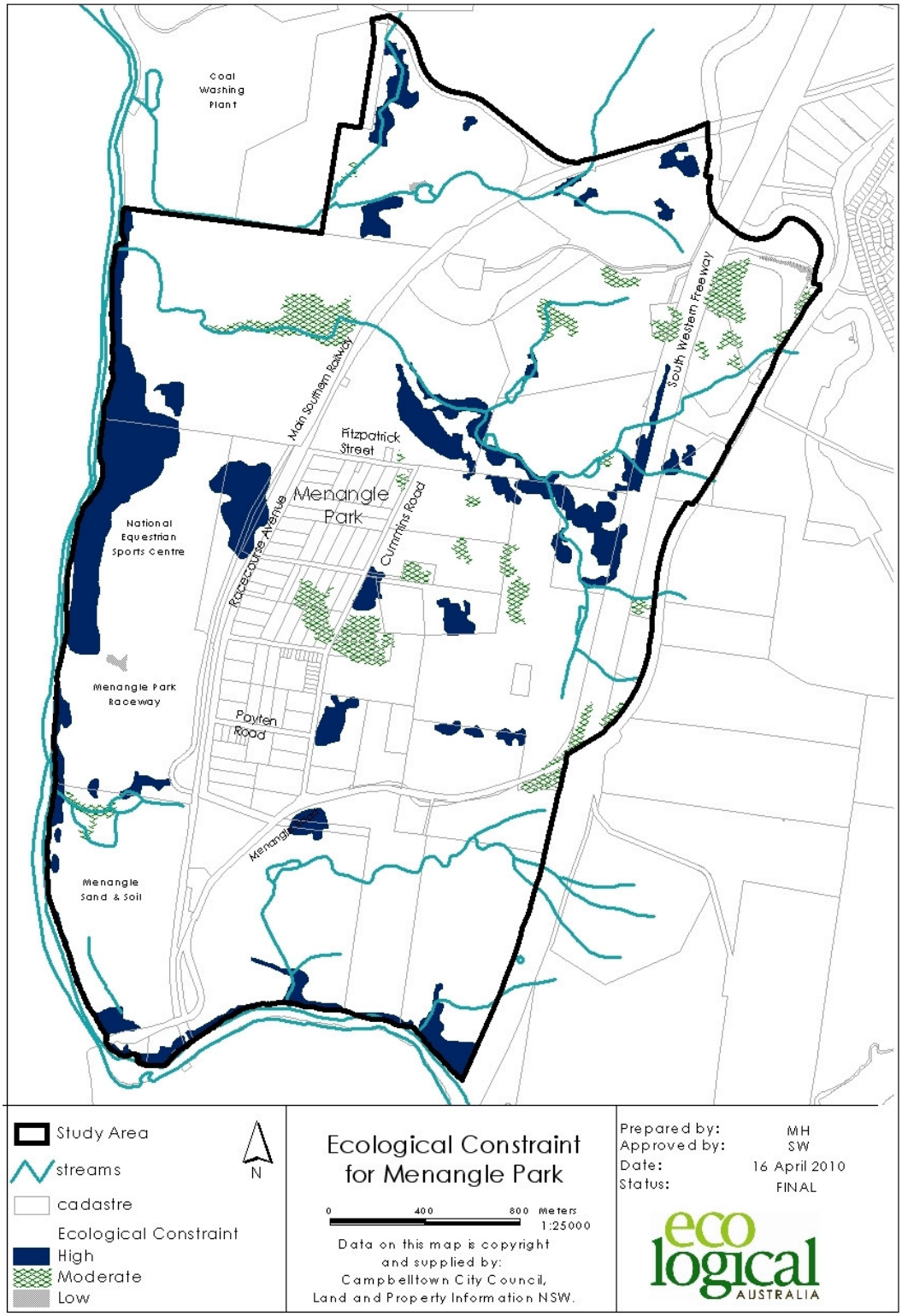


Figure 16. Combined Ecological Constraint

(derived from Figure 14 and Figure 15)



8. Discussion

8.1 Flora

Six different vegetation types were identified during field survey of the Menangle Park study area. Each of these falls within communities listed under the *Threatened Species Conservation Act, 1995*. Under this legislation an assessment is required, prior to development, to determine the likely level of resultant impact. The initial phase of this process is a 7-part test. Species impact statements follow if significant impact is deemed likely.

Two of the vegetation communities (Shale Hills Woodland and Shale Plains Woodland) form part of the Cumberland Plain Woodland community, protected nationally under the *Environment Protection & Biodiversity Conservation Act 1999*. Under this legislation any clearing of these vegetation types requires federal approval.

No flora species listed as threatened under the TSC Act or EPBC Act (Endangered, Vulnerable) were found during field survey, however there is potential for 3 such listed species to occur in remnant patches throughout the study site. 3 regionally significant species were recorded during survey.

8.2 Terrestrial Fauna

A total of 18 species listed under the TSC Act or EPBC Act (Endangered, Vulnerable, and migratory) are known to occur, or are likely to occur, in the Menangle Park study area. Assessment of impacts would be required for these species for any development proposals. A further 30 regionally significant species are also known to occur, or are likely to occur on the study site.

The study area was assessed for those areas which provide habitat for threatened and regionally significant species. Grassland habitats (dominated by introduced species) were excluded from the fauna significance assessment, however, because these are well represented in the region. It is noted that a number of species may still utilise this habitat.

Areas of high constraint included riparian forest, woodland or wetland habitats. These areas provide habitat for a wide range of fauna species. Areas of moderate constraint have habitat value for a narrower range of fauna species, are generally dominated by edge species, and have moderate or poor flora recovery potential.

Of importance is whether remnant habitat could potentially be used as a corridor by fauna for movement to potentially more suitable habitat within and external to, the study area. The riparian forest serves an important function in providing a corridor for movement of fauna along the Nepean River. Remnant habitat close to North Creek and its tributaries, which includes many small patches, may act as stepping-stones for the movement of animals to, or from, other larger areas of habitat, such as Mt Annan Botanic Gardens, to the north of the Menangle Park study area and habitat along the Nepean River to the south.

8.3 Aquatic Habitat

Aquatic habitat within the study area was highly degraded due to land clearance, agricultural activities, loss of riparian vegetation, erosion and sedimentation. No threatened or regionally significant aquatic species were found within the study area.

The data analysis suggested that most aquatic areas in the Menangle Park study area are mildly to severely polluted, with poor species diversity. Further, most aquatic habitat is dominated by weeds and introduced fish, and there are many barriers to fish passage. Thus, for most areas the riparian zones will require some form of rehabilitation to restore aquatic ecological function. These factors result in the ranking of all aquatic habitats on the study site as poor to moderate.

9. Conclusions

Overall, the ecological values of the overall site are highly degraded due to extensive clearing, continuing agricultural and mining activities, weeds, feral animals, fragmentation of habitat, barriers to the movements of both terrestrial and aquatic animals, erosion and poor water quality.

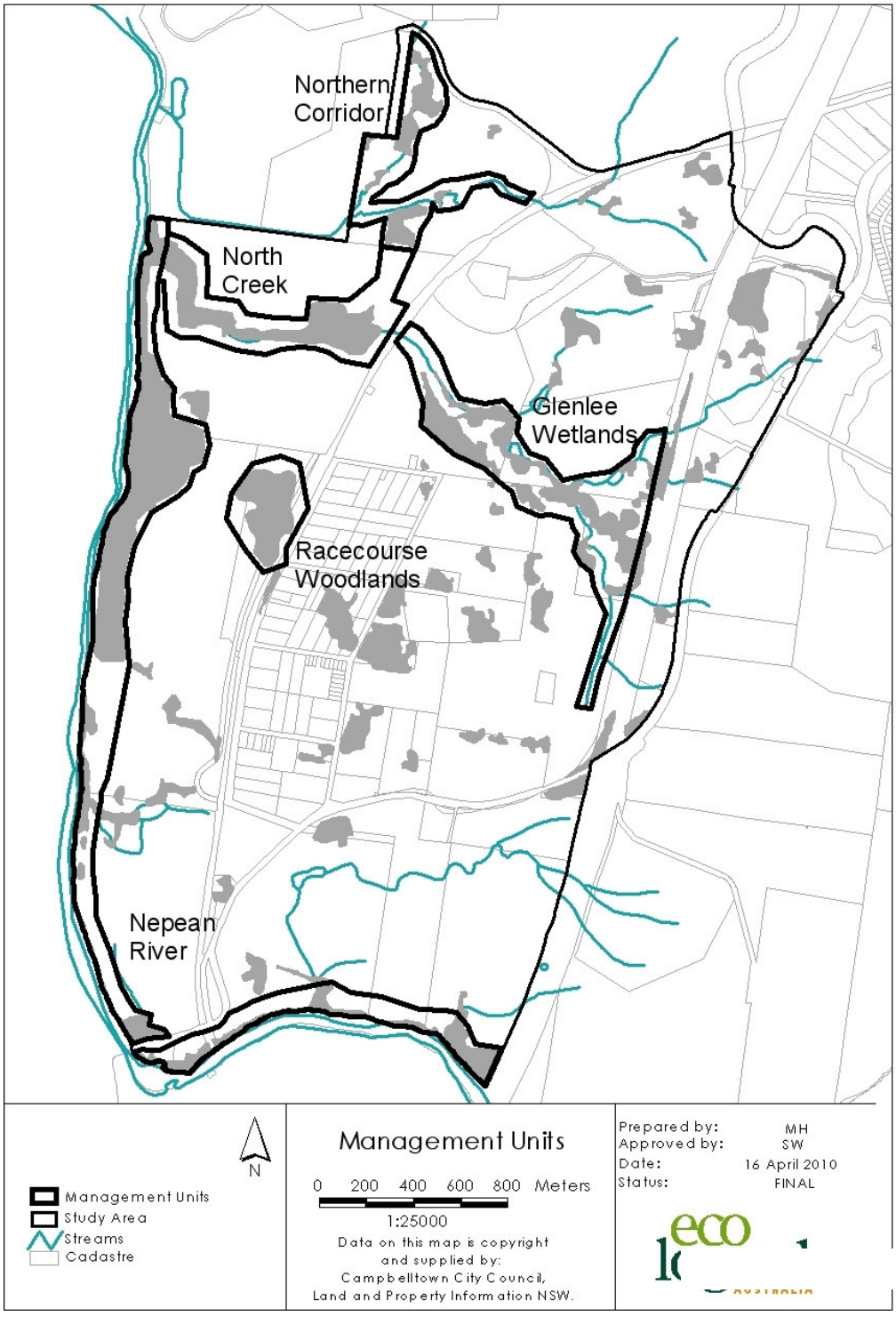
Despite these numerous impacts, the site does contain remnant Cumberland Plain vegetation. This community has been extensively cleared and the majority of remnants from Western Sydney are under increasing pressure for development. The site contains Endangered Ecological Communities, and habitat for flora and fauna species listed under the TSC Act and EPBC Act. Furthermore, 3 regionally significant flora species and 30 fauna species are known to occur, or likely to occur on the site.

Whilst all parts of the site contain some ecological value, five areas (hereafter referred to as 'management units') with higher ecological values have been identified. For ease of reference these management units have been assigned names and the major ecological values associated with each management unit has been listed (Table 18). The approximate extent covered by each management unit is shown in
Figure 17.

Table 18. Management Units and Their Ecological Values.

Name	Ecological Justification
Nepean River Banks	Adjacent to Nepean River, a major waterway Large grouping of high constraint areas Threatened and regionally significant species Connectivity through, and beyond, Menangle Park
Glenlee Wetlands	Large grouping of high constraint areas Wetland Threatened and regionally significant species Headwaters of North Creek
North Creek	Grouping of mixed constraint areas Wetland Threatened and regionally significant species Connectivity of Glenlee Management Unit to Nepean River Banks management unit
Northern Corridor	Grouping of mixed constraint areas (patches) Threatened species habitat Provides potential for connectivity north to Mt Annan Botanic Gardens (ecological corridor will need to be established)
Racecourse Woodlands	Unusual geology and rare vegetation type Large area of high constraint Threatened and regionally significant species Close to Nepean River Banks management unit

Figure 17. Map of Management Units.



Recommendations are made which apply to the entire Menangle Park site, followed by additional specific recommendations for each management unit.

9.1.1 General Menangle Park Recommendations

1. That formal advice be sought from The Commonwealth Department of the Environment and Water Resources (DEWR) on the referral and approval process for this project. DEWR provided preliminary recommendations in 2004 suggesting the submission of a draft referral to allow any comments by DEWR to be taken into consideration before the finalisation of master plans.
2. Protect and manage areas of 'high' ecological constraint.
3. Retain the majority of areas of 'moderate' ecological constraint. The long-term management of smaller areas of 'moderate' constraint should be considered, and if these patches are not be retained their loss should be offset through planting to consolidate remnants and link priority areas (see recommendation 10 below).
4. Provision of a buffer between areas conserved for ecological purposes and areas subject to development. Buffer areas would also assist in bushfire management, both ecologically and by reducing the level of bushfire risk for development.
5. Asset protection zones should not be located in areas set aside for conservation (either retained or planted vegetation).
6. Investigate the possibility of "ecological burns". The aim of these would be to remove weed growth and rejuvenate native shrub growth in woodland and riparian forest habitats. Management post fire would also be required.
7. Undertake best practice soil erosion control during construction, and maintain as required, to prevent sediment flow into watercourses and into 'moderate' and 'high' ecological constraint areas.
8. Stormwater structures to be located outside of conservation areas.
9. The creek to the south of the study site could have a minimum area of riparian vegetation of approximately 5-10m from the top of the bank to facilitate water quality objectives. This can be justified primarily on the grounds of the current poor condition but also because of the considerable riparian zones achieved elsewhere on the site.
10. Develop and implement an Environmental Management Plan, which should include:
    a. Management for existing vegetation,
    b. Revegetation priorities (eg. infill planting in gaps within woodland and riparian forest remnants in conservation areas, connection of fragmented patches of vegetation and a strip along the western side of the motorway) and procedures, such as using local provenance species,
    c. Management of noxious and environmental weeds,
    d. Management of feral animals, and
    e. Plans to formalise access to areas of 'moderate' and 'high' ecological constraint, using fencing, gates, formed walking tracks, etc. as appropriate.

9.1.2 Nepean River Banks Management Unit Recommendations

1. Where remnant vegetation has been reduced to less than 100m from the bank of the Nepean River, revegetate these areas with local provenance riparian species. Where remnant native vegetation adjacent to the Nepean River extends more than 100m from the banks, these areas should be retained.
2. Remove exotic tree and shrub species and other weeds, particularly Gleditsia and Privet.

9.1.3 Glenlee Management Unit Recommendations

1. Vegetation within a corridor of at least 50 metres along either side of North creek should be conserved. Where existing vegetation extends beyond the 50 metre wide strip, the corridor should be extended to include this vegetation.
2. Connections between the Glenlee, North Creek and Northern Corridor management units should be considered (eg. passage under the railway to be improved during upgrade of the line). The NSW Fisheries has recommendations for design to allow fish passage, and see appendix 4 for fauna culvert design principles.

9.1.4 North Creek Management Unit Recommendations

1. It is noted that sand mining is proposed for this region. The sand mining proposal should include provision for revegetation with native species to provide both terrestrial and aquatic habitat, and ecological connectivity.
2. Establish vegetation within a corridor of approximately 50 metres along either side of North Creek to improve water quality, reduce sediment impacts, improve habitat linkages, and to improve the quality of both terrestrial and aquatic habitat.
3. The aquatic survey recorded low water quality at aquatic field sites 5 and 6. Offline structural opportunities exist to improve water quality around this area with subsequent benefit to the aquatic habitat.
4. Barriers to fish passage, where possible, should be removed, or modified to meet criteria provided by NSW Fisheries.

9.1.5 Northern Corridor Management Unit Recommendations

1. Targeted vegetation management and revegetation to support ecological connectivity to Mt Annan Botanic Gardens. This vegetation management to be integrated with the proposed Spring Farm Arterial Road.

9.1.6 Racecourse Woodlands Management Unit Recommendations

1. Conserve this large patch of River-flat eucalypt forest in relatively good condition.

2. Habitat viability would be supported by planting a 50m wide vegetated strip for linkage between this management unit and the Nepean River management unit to the west.

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Appendix 1: Flora Survey and Assessment

Appendix 2: Fauna Survey and Assessment

Appendix 3: Aquatic and Fish Habitat Survey and Assessment

Appendix 4: Fauna Culvert Design Principles.

There is currently no universally accepted design for culverts to facilitate fauna movements. In general, however, the following principles should be considered:

1. Keep planted (or remnant) vegetation as close to culverts as possible. For example, if a species uses woodland then the culvert should be placed close to woodland areas (preferably on both sides of the barrier), or by planting vegetation to lead to the culvert entrances.
2. Use exclusion fencing to funnel fauna towards the culvert and to prevent minimise fauna movement across roads and railways, and thus minimise the potential for vehicle collisions with fauna.
3. Provide a natural base to the culvert which is as similar to the surrounding substrate as possible, as fauna will be more likely to move over natural substrates rather than surfaces which would not normally be encountered, such as concrete.
4. Provide potential cover for fauna from predators (eg. foxes), as they may potentially use the culverts as a hunting ground. Having shelter will help to reduce predation risks and fauna are more likely to use the culvert as they will probably feel less threatened. Shelter could be appropriate vegetation planted within the culvert (if sufficient soil has been provided), or for fauna such as koalas, structures such as vertical and horizontal logs.
5. Allow for water flow (drainage) through the culvert. If the culvert is to be used for drainage in addition to fauna movements then the design will need to incorporate adequate design for drainage, and may need to consider how fish passage will be affected (NSW Fisheries 1999). Consideration should also be given to how water flow will affect soil, vegetation or structure for fauna movement placed within the culvert.
6. Make the culvert as short a distance to travel as possible. The longer a culvert is the less likely a crossing will be successful (ie. the animal could turn back).
7. Make the culvert as wide and high as possible, except if the culvert has been specifically designed for use by a particular species. Note that whilst different fauna species are likely to prefer different sizes of culverts, in general larger culverts will allow use by a larger range of animal species, which will be enhanced by incorporating vegetation and structures.
8. Provide natural lighting within the culvert. This can be achieved by opening up some portions of the culvert to the sky, or by having areas covered by grids or similar structures.
9. For fish passage consider the invert level of the crossing (eg. a gradient or drop off in a culvert), a suitable substrate, and watercourse hydrology and velocity (NSW Fisheries 1999).

References

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Appendix 5: Site Recording Proforma.

Floristic Site Recording Form
Menangle Park Release Area

Date: _____ **Recorder:** _____**Site No:** _____

Film No: _____ **Photo No:** _____(if taken)

Location: _____

Quadrat Size (if not 20 x 20 m): _____

Map Name: _____ **Scale:** _____
AMG Ref: _____E _____N
Lat: _____'S **Long:** _____'E

Landform Pattern: _____
Physiography: (circle)
Crest Upper Slope Mid-slope Lower Slope Flat Open Depression

Altitude: _____metres
Slope: _____degrees
Aspect: _____degrees (magnetic)
Horizontal Elevation: N_____NE_____E_____SE_____S_____SW_____W_____NW_____

Map Geology: _____ **Field Geology:** _____

Soil:
Compaction _____
Intact Profile___ Nutrient enrichment____ Imported fill____

Fire History: Time since fire_____How determined_____

Disturbance:

weed invasion	severity_____	time_____
rubbish dumping	severity_____	time_____
grazing	severity_____	time_____
cultivation	severity_____	time_____
underscrubbing	severity_____	time_____
pasture improvement	severity_____	time_____

Evidence of recovery potential_____
_____
_____

Vegetation Structure: (Walker & Hopkins, 1983)

Stratum	Height (m)	% Cover	Dominant Species

Structural Formation Class: _____
Comments:_____ _
_____

Floristic Composition: **Site No:**

No.	Species	C/A	Data	No.	Species	C/A	Data
1				31			
2				32			
3				33			
4				34			
5				35			
6				36			
7				37			
8				38			
9				39			
10				40			
11				41			
12				42			
13				43			
14				44			
15				45			
16				46			
17				47			
18				48			
19				49			
20				50			
21				51			
22				52			
23				53			
24				54			
25				55			
26				56			
27				57			
28				58			
29				59			
30				60			

C/A: Cover Abundance Scale -Modified Braun Blanquet
Data: to be marked when entered into computer database

Cover Abundance Scale (Modified Braun Blanquet)
1 = cover less than 5% of site and rare
2 = cover less than 5% of site and uncommon
3 = cover less than 5% of site and common
4 = cover of 5 - 20% of site
5 = cover of 20 - 50% of site
6 = cover of 50 - 75% of site
7 = cover of 75 – 100% of site

Appendix 6: Field Survey Data (Part 1).

Site No.	Polygon No.	Easting	Northing	Date	Soil				Fire History		Weed Invasion	
					Compaction	Intact Profile	Nutrient Enrichment	Imported Fill	Time Since	How Determined	Severity	Time
MENA01	48	291679	6223621	2/10/03	None	Y	Y - minor	Y -to East	Long unburnt	No evidence	4	ongoing
MENA02	63	291427	6224151	2/10/03	None	Y	N	N	60 +/- 20	very old scars	4	ongoing
MENA03	8	292096	6224704	2/10/03	None	Y	N	N	3 +/- 1	scorched bark, frequent firing	2	ongoing
MENA04	33	291598	6222468	2/10/03	None	N	N	N	Long unburnt	No evidence	4	ongoing
MENA05	35	292297	6223445	2/10/03	Y - localised	Y	N	N	Long unburnt	No evidence	3	ongoing
MENA06	31	292423	6223769	2/10/03	Y - localised, horse tracks	Y	N	N	Long unburnt	No evidence	4	ongoing
MENA07	30	292496	6224182	2/10/03	moderate - horse paddock	Y	N	N	Long unburnt	No evidence	3	ongoing
MENA08	29	292480	6224188	2/10/03	low	Y	N	N	Long unburnt	No evidence	4	ongoing
MENA09	28	292619	6224455	2/10/03	low	Y	N	N	Long unburnt	No evidence	4	ongoing
MENA10	45	293042	6224877	3/10/03	None	Y	N	N	Long unburnt	No evidence	4	ongoing
MENA11	69	293072	6224792	3/10/03	None	Y	N	N	Long unburnt	No evidence	3	ongoing
MENA12	46	293180	6224839	3/10/03	None	N	N	N	Long unburnt	No evidence	2	ongoing
MENA13	42	293227	6224591	3/10/03	None	Y	N	N	10 +/- 3	scorched bark	4	ongoing
MENA14	27	293041	6224621	3/10/03	None	Y	N	N	20 +/- 10	burnt fence post	3	ongoing
MENA15	4	293305	6224877	3/10/03	Y - localised	Y	N	N	Long unburnt	No evidence	4	ongoing
MENA16	75	293443	6224813	3/10/03	Y - localised	Y	N	N	Long unburnt	No evidence	4	ongoing
MENA17	3	293476	6224562	3/10/03	None	Y	N	N	Long unburnt	No evidence	2	-
MENA18	43	293278	6224456	3/10/03	None	Y	N	N	Long unburnt	No evidence	3	ongoing
MENA19	2	292773	6224940	3/10/03	None	Y	N	N	Long unburnt	No evidence	4	ongoing

Site No.	Polygon No.	Easting	Northing	Date	Soil				Fire History		Weed Invasion	
					Compaction	Intact Profile	Nutrient Enrichment	Imported Fill	Time Since	How Determined	Severity	Time
MENA20	71	292763	6225225	3/10/03	None	Y	N	N	Long unburnt	No evidence	4	ongoing
MENA21	24	294350	6225426	3/10/03	Y - localised	Y	N	N	Long unburnt	No evidence	5	ongoing
MENA22	25	294402	6225549	9/10/03	Y – localized	N	N	N	Long unburnt	No evidence	4	ongoing
MENA23	23	294090	6225567	9/10/03	Heavily compacted	N	N	Y	Long unburnt	No evidence	4	ongoing
MENA24	22	293469	6225902	9/10/03	None	Y	N	N	Long unburnt	No evidence	4	ongoing
MENA25	65	293395	6225921	9/10/03	None	Y	N	N	30 +/- 10	Scorched fence post	4	ongoing
MENA26	21	293801	6226059	9/10/03	Moderate; sheet erosion	Y	N	N	80 +/- 20	Fire scar in tree hollow	2	ongoing
MENA27	18	292968	6226198	9/10/03	Y - localised	Y	N	N	Long unburnt	No evidence	3	ongoing
MENA28	17	292715	6226303	9/10/03	Y - localised	Y	N	N	Long unburnt	No evidence	4	ongoing
MENA29	16	292725	6225902	9/10/03	None away from disturbed areas	N	N	N	Long unburnt	No evidence	3	ongoing
MENA30	15	292668	6225857	9/10/03	Extensive compaction under regrowing trees	Y	N	N	Long unburnt	No evidence	2	ongoing

Appendix 7: Field Survey Data (Part 2).

Polygon No.	Rubbish Dumping		Grazing		Cultivation		Underscrubbing		Pasture Improvement		Evidence of Recovery Potential	Recovery Capacity
	Severity	Time	Severity	Time	Severity	Time	Severity	Time	Severity	Time		
48	2	_	3	ongoing	3	30 +/- 10	-	-	-	-	little evidence, few native shrubs	Mod
63	2	ongoing	2	30 +/- 10	-	-	-	-	-	-	intact canopy, some native u'storey plants	Mod
8	-	-	2	31 +/- 10	-	-	-	-	-	-	intact u'storey & canopy, 10-40 yr regrowth, few mature trees	High
33	3	ongoing	2	ongoing	-	-	-	-	-	-	low. Some native trees and u'storey plants	Mod
35	2	ongoing	3	1 +/- 1	-	-	3	30 +/- 10	-	-	diverse ground layer & tall canopy trees. Ringbarking by horses.	High
31	2	ongoing	2	1 +/- 1	-	-	2	30 +/- 10	-	-	good canopy & substantial native ground cover component	High
30	2	ongoing	4	ongoing	-	-	-	-	-	-	regen tree canopy 30 yrs, some native species in ground layer	Mod
29	1	-	2	ongoing	-	-	3	30 +/- 10	-	-	moderate, intact canopy	Mod
28	2	ongoing	3	ongoing	-	-	3	20 +/- 5	-	-	intact canopy, 30-50% native ground cover	Mod
45	2	20 +/- 10	-	-	-	-	-	-	-	-	canopy plants present, u'storey 10-50% native	High
69	2	10 +/- 5	2	ongoing	-	-	-	-	-	-	scattered canopy trees, few native u'storey plants	Mod
46	2	20 +/- 10	2	ongoing	-	-	-	-	-	-	substantial u'storey component, scattered canopy trees	High
42	-	-	2	ongoing	-	-	-	-	-	-	mature canopy trees, some native u'storey plants	Mod
27	-	-	2	ongoing	-	-	-	-	-	-	intact canopy, some native ground layer plants	Mod
4	2	10 +/- 5	3	ongoing	-	-	-	-	-	-	intact canopy on riparian strip. V low density of native plants in ground layer	High
75	-	-	2	ongoing	-	-	-	-	-	-	extensive regrowth, moderate groun layer diversity	Mod

Polygon No.	Rubbish Dumping		Grazing		Cultivation		Underscrubbing		Pasture Improvement		Evidence of Recovery Potential	Recovery Capacity
	Severity	Time	Severity	Time	Severity	Time	Severity	Time	Severity	Time		
3	-	-	2	ongoing	-	-	-	-	-	-	30 yr regrowth, mostly intact ground layer. Patch connected with 4 would be classed as core	Mod
43	-	-	2	ongoing	-	-	-	-	-	-	scattered trees, occasional native u'storey plants	Mod
2	-	-	2	ongoing	-	-	-	-	-	-	group of canopy trees, v few ground cover plants	Mod
71	-	-	2	ongoing	-	-	-	-	-	-	significant native ground layer component	High
24	3	ongoing	2	40 +/- 10	-	-	-	-	-	-	some mature canopy trees & native grasses nearby	Mod
25	2	ongoing	-	-	-	-	-	-	-	-	regrowth trees, some understorey component	Very Low
23	2	ongoing	2	ongoing	-	-	-	-	-	-	little, if any	Very Low
22	2	ongoing	4	ongoing	-	-	-	-	-	-	scattered canopy trees, significant native u'storey grass component	High
65	2	ongoing	3	ongoing	-	-	-	-	-	-	mature and regrowth trees, significant native understorey component	High
21	2	ongoing	3	ongoing	-	-	-	-	-	-	Canopy trees and high native ground layer cover	High
18	-	-	2	ongoing	-	-	-	-	-	-	Mature canopy species and native ground layer	High
17	-	-	2	ongoing	-	-	-	-	-	-	Regrowing canopy species and native gound cover away from Olea africana	Mod
16	2	ongoing	2	ongoing	-	-	-	-	-	-	Canopy species present but significant soil disturbance	Very Low
15	2	5 +/- 2	2	ongoing	-	-	-	-	-	-	Regenerating trees and mainly native understorey	High