



Nepean River 'Our River'

Riparian Vegetation Management Plan

Prepared for
Penrith City Council

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Project Manager	Ian Dixon 02 4201 2208 Suite 204, Level 2, 62 Moore Street, Austinmer NSW 2515
Prepared by	Ian Dixon, Toni Frecker and Andrew Whitford
Reviewed by	Beth Medway
Approved by	Beth Medway
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Abbreviations and terms

Abbreviation	Description
CEEC	Critically Endangered Ecological Community - ecological community identified as facing an extremely high risk of extinction in the immediate future
EEC	Endangered Ecological Community - ecological community identified as facing a very high risk of extinction
EPBC Act	Commonwealth <i>Environment Protection and Biodiversity Conservation Act 1999</i>
Exotic	Species not native to an area. Also called 'introduced' species.
FM Act	NSW <i>Fisheries Management Act 1994</i>
Native	Species that occurs in an area naturally (also referred to as local provenance)
Noxious weed	Weed species listed under the NSW <i>Noxious Weeds Act 1993</i> for an area
OEH	NSW Office of Environment and Heritage
PoM	Plan of Management
Riparian	Areas along the side of a waterway or river, often considered to be at least 40 m either side from the top of bank.
TSC Act	NSW <i>Threatened Species Conservation Act 1995</i>
VMP	Vegetation Management Plan
Weed	Invasive plant species, usually exotic.
WON	Weed of National Significance – listed by the Federal Government. WONS are priority weeds that pose threats to primary industries, land management, human or animal welfare, biodiversity and conservation values.

Executive summary

The 'Our River' Nepean River Master Plan (Clouston Associates 2013) identified the need for a plan to manage riverside or riparian vegetation along the Nepean River at Penrith. In particular, the Master Plan recognised the following actions are needed to achieve 'Our Healthy River':

- protect and enhance the natural resource of the river
- reinforce effective planting strategies
- create a high diversity habitat corridor.

Penrith City Council engaged Eco Logical Australia to develop a vegetation management plan (VMP) consistent with the 2013 Master Plan and in accordance with best practice principles of river corridor management. The VMP also considers feedback from consultation with Council, the community, and State Government agencies such as the NSW Office of Water, Office of Environment and Heritage (OEH), and Department of Primary Industries (Fisheries). The VMP recognises that there are a range of strong opinions in the community about riparian vegetation and how it should be managed, and the VMP recommends ongoing community education and involvement.

The VMP provides guidance on future management of the Nepean River riparian vegetation and aquatic habitats. It:

- describes the values of riparian vegetation and aquatic habitat, and identifies key threats to their condition
- describes the physical and biological characteristics of the study area, including endangered ecological communities and threatened species habitat
- describes management issues, including prioritised actions, riparian guidelines and recommended plant species for different zones within the corridor
- provides baseline conditions including species lists for selected sites to be used as a reference for future performance monitoring.

To assist the initial implementation, the highest priorities of the VMP are summarised as follows:

- develop and begin to implement the community education and involvement program
- remove rubbish throughout the corridor
- primary weeding in patches to start with canopy weeds
- maintain areas of 'good quality' vegetation communities
- continue to mow designated grassed areas
- selectively prune up to 30% canopy cover in areas of dense vegetation to provide filtered views for residential areas
- assess and prepare detailed design of selected water edge access points

A licence under Section 91 of the NSW *Threatened Species Conservation Act* will be needed from OEH to implement the VMP as it will involve work within an Endangered Ecological Community.

Implementation of this plan will be subject to availability of funds and resources.

This plan will be updated every five years. The next review will be in 2019.

1 Introduction

1.1 Study need

The 'Our River' Nepean River Master Plan (Clouston Associates 2013) provides Penrith City Council and the community with the strategic framework for the future stewardship of the City's river reach. The Master Plan identified the need for further design development, including the preparation of a riparian vegetation management plan (VMP). Council engaged Eco Logical Australia (ELA) to prepare this VMP to complement and expand on the concepts developed in the Master Plan.

1.2 Master Plan principles

The 'Our River' Master Plan (Clouston Associates 2013) provides five key principles that build upon the constraints and opportunities identified through site analysis and community consultation stages:

1. *Our Accessible River* – The river is a significant and important recreational asset in the region, but many people are unaware of its presence and values. Key to the wider awareness of the river and its recreational use and enjoyment is improved access to the parklands along its foreshores and the opportunity to get down to the water's edge and onto the water.
2. *Our Active River* – Once the river is reached what is on offer to the visitor and resident? An active and vibrant river should provide a wide range of recreational opportunities both on and off the water, making the river a place to be enjoyed by all, both for active recreation and for quiet reflection and contact with nature.
3. *Our Cultural River* – The river has a long cultural history, dating back thousands of years. As a spectacular natural and cultural landscape setting, the river provides the opportunity for a series of memorable spaces and places each with their own focus and character, creating a place to celebrate the community's culture and diversity.
4. *Our Healthy River* – As a key cultural and recreational asset, the river's health is vital to the environmental health of its river landscape and the health and wellbeing of those who live beside it or visit it. Enhancing the health of the river vegetation and the quality of water is therefore of key importance to a sustainable local environment and ultimately the health of the local community.
5. *Our Managed River* – Like all rivers systems, the river's catchment extends beyond local government boundaries and its management needs to be considered in this wider perspective. Managing and maintaining the river's natural values, cultural heritage and landscape character provides a sustainable setting for compatible recreation, both on and off the water.

While this VMP aims to address all five principles in the Master Plan, it most closely aligns with the fourth principle of river health. Clouston Associates (2013) sets out the principles of 'Our Healthy River' as:

- protect and enhance the natural resource of the river
 - continue to improve water management in catchments leading into the river
 - promote protection of the rivers upstream from catchments
 - manage any new development to stringently control construction sediment
 - promote water sensitive urban design principles for all new development
- reinforce effective planting strategies
 - extend the habitat corridors of the river beyond the river bank

- select appropriate high canopy, clear-stemmed trees along the riverside that are indigenous to the area, allowing views to the water while maintaining canopy linkages
- retain important river vistas within identified view corridors, when locating trees along the river bank
- work with relevant agencies to develop appropriate plant species lists
- create a high diversity habitat corridor
 - work to reduce weed infestation along the river banks (continuous but prioritise with other projects)
 - provide a coordinated approach for riparian vegetation along the river bank, with consideration of view corridors in the selection of plant species
 - provide wildlife diversity and enhance appropriate habitat
 - protect natural ecosystems.

1.3 Constraints and opportunities

Constraints and opportunities identified by Clouston Associates (2013) that are most relevant to riparian vegetation management are:

- there is much sound native vegetation on the foreshore, but species diversity is limited and weeds extensive
- flooding and bank stability are key constraints in establishing healthy foreshore vegetation and robust stable paths
- there are fine views along the river and to the escarpment, but vegetation growth obscures many river views
- there is not a significant diversity of landscape character along the river foreshore
- aquatic and terrestrial weeds along the river pose problems for native habitat and recreational uses.



Plate 1: Bank erosion, weeds and poor habitat provide opportunities for improvement

1.4 Aims of the VMP

This VMP outlines how to achieve the Master Plan principles whilst addressing key constraints and opportunities. To achieve this, a balance between habitat improvement and public amenity is needed. For example, it is challenging to 'extend the habitat corridors of the river beyond the river bank' when it is also important to 'improve access to the parklands along its foreshores and the opportunity to get down to the water's edge and onto the water'.

The following balanced framework is therefore proposed:

- protect, rehabilitate and recreate riparian habitat in designated areas to offset the proposed loss or reduction of existing habitat
- provide adequate spatial coverage of habitat for native flora and fauna, including longitudinal connectivity, riparian width and habitat complexity
- stabilise banks by retaining or planting deep rooted trees
- enhance the visual experience by creating a more natural environment between key destinations, whilst catering for filtered views of the river
- adopt best practice management strategies and techniques
- stage works to maintain ecosystem functions.

1.5 Community consultation

Consultation undertaken for this VMP was part of a continuum that has included consultation for previous Plans of Management for Tench, Weir and River Road Reserves, and the Our River Master Plan. Council values community input to the planning process and is committed to ongoing consultation during the implementation phase. As outlined in this plan, Council is keen to increase community involvement in management of the riparian corridor.



Plate 2: Community volunteer involved in bush regeneration

As described in the report by People, Place and Partnership (2014), the community was invited to provide input to the draft VMP via online comments and workshop participation. A wide range of views were expressed and this VMP aims to address the issues raised, noting that it is not possible or desirable to satisfy all views.

2 What is a healthy river?

A river is an ecological system intimately linked with the surrounding landscape. It is not just a channel that conveys water. River ecosystems include the flora and fauna and their habitats, linkages between the river and its catchment, the dynamics of water flow, and the transport and transformation of nutrients. A river system is healthy when its character, biodiversity and functions are sustained over time. A healthy river is resilient in the face of environmental changes (Murray-Darling Basin Commission 2012).

River ecosystems can be broadly distinguished by two habitat types: the riparian zone and aquatic habitat. **Figure 1** shows features of a typical healthy river corridor.

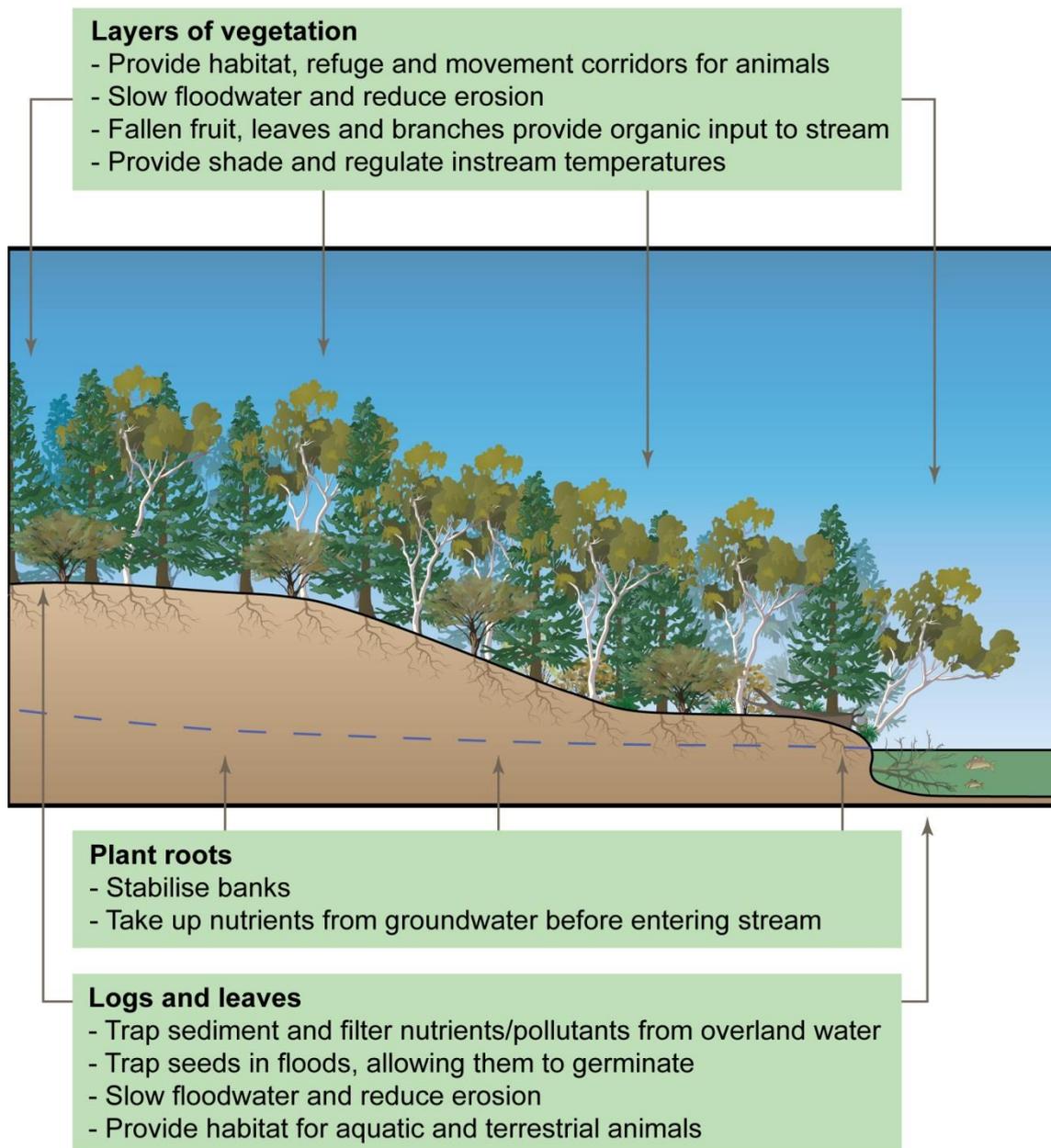


Figure 1: Schematic of river habitat features and functions

2.1 Riparian zone

The riparian zone comprises the banks and floodplains of creeks and rivers. It is defined as the area that can be influenced by a river, and be an influence to the river (Naiman et al. 2005). It is recognised as the vegetated area between aquatic habitat and terrestrial habitat. The importance of the riparian zone is often underestimated, but is widely proven to be a primary driver of river and catchment health.

The riparian zone performs many functions, as illustrated in **Figure 1**. These functions are beneficial to a variety of flora and fauna, and to the overall catchment ecology. Functions include providing shade to the water, trapping sediment, filtering nutrients, and cleaning water before it flows to downstream reaches, estuaries and the ocean.



Plate 3: Overhanging branches provide aquatic habitat

To provide these functions, a number of features of the riparian zone must be present and maintained:

- trees
 - width of vegetated riparian zone (from the water edge to terrestrial habitat)
 - longitudinal continuity of canopy (no significant gaps between tree canopies; a gap is defined at >5 m and spans the entire length of the riparian corridor)
 - connectedness (linkages between the riparian vegetation and other areas of native vegetation)
- native plants
 - few weeds, garden varieties or non-native/exotic species in each strata (canopy, midstorey and understorey)
 - no high-impact species
- cover
 - all strata present (canopy, midstorey and understorey)
 - each stratum covers its full extent
- regeneration
 - variety of tree ages (juvenile, sub-adult, adult)
 - presence of large old and standing dead trees
- debris
 - abundance of fallen logs
 - leaf litter cover on ground.

2.2 Aquatic habitat

Aquatic habitat is comprised of the wetted channel and in-stream structure (rocks, logs, undercut banks, etc). The channel provides habitat to a variety of aquatic fauna (fish, yabbies, macroinvertebrates), semi-aquatic fauna (frogs, turtles, water monitors) and is a drinking and foraging source for an abundance of other animals (bats, wading birds, wetland birds, reptiles, small mammals). The habitat types available can vary dramatically with position in the catchment, geology, upstream land use and riparian condition.

NSW DPI (Fisheries) has mapped the Nepean River as a *Key Fish Habitat* (KFH) because of its importance in the catchment and broader aquatic ecosystem. Here, the term 'fish' refers to all fin fish, crustaceans, molluscs, worms, insects and other invertebrates that spend all or part of their life cycle in aquatic habitats. Habitats identified throughout the length of a river include pools, riffles, snags, gravel beds, undercut banks, wetlands and riparian vegetation, as well as microhabitats within these zones. The NSW DPI 2013 *Policy and Guidelines for Fish Habitat Conservation and Management* describe the following KFH characteristics that are relevant to the Nepean River at Penrith: riparian vegetation, in-stream vegetation, snags, channels and substrates.

2.2.1 Riparian vegetation for KFH

See **section 2.1** above for a general discussion on riparian zones. Further to this, riparian vegetation is specifically important to maintaining KFH through bank stabilisation, filtering of pollutants and contributing organic material to the river.

Riparian vegetation provides localised stability to a dynamic channel (i.e. it naturally moves). The roots of trees bind and stabilise the soil, and together with snags help to maintain the general channel shape, including essential habitat features such as pools, riffles and backwaters. This erosion control prevents siltation of the in-stream habitat.

Streams with well-developed riparian vegetation generally have a higher biological productivity than those without trees along their banks. Material falling from trees provides food for crustaceans and aquatic insects, which in turn provide food for fish. More than half of the diet of predatory fish may come from insects falling into the stream from the riparian zone. Overhanging trees provide shade, which regulates water temperature (often critical for fish survival) and can create a dappling effect to camouflage fish from predators (NSW DPI 2013). In a study of fish and riparian vegetation, Freshwater Mullet were 70% less abundant near grassed banks than beside well-vegetated banks (Growth et al. 2003).

Non-native riparian plants can lead to many problems including the rapid spreading and choking of the channel, out-competing native trees, and shading of understorey native shrubs, reeds and grasses. Feeding opportunities for fish may also be reduced. The deciduous leaf fall of weed species, such as Willow (*Salix* spp.) is added seasonally and broken down in water over a relative short timeframe, whereas the harder leaves of Eucalypts and other native trees are gradually shed into the water year-round and take much longer to decompose. Feeding trials in Australia have indicated that some aquatic invertebrates prefer native gum leaves to willow leaves (Schulze and Walker 1997).

Most species of willow are Weeds of National Significance. They are among the worst weeds in Australia because of their invasiveness, potential for spread, and economic and environmental impacts.

Weeds of National Significance
Weed Management Guide



Plate 4: Willows and erosion adjacent River Road in 1978 (Photo courtesy: Penrith City Council)

2.2.2 In-stream vegetation for KFH

In-stream vegetation is very important to fish. Many fish lay (deposit) eggs around in-stream aquatic vegetation (NSW DPI 2013). In-stream vegetation may include trees, sedges, rushes, macrophytes and algae. Some trees such as *Melaleuca* and *Casuarina* can grow within channels and provide fish habitat by creating bars, islands and pools along the bed of the stream. The tree roots stabilise sediments and the exposed vegetation increases channel roughness (thus slowing flows). Some sedges such as *Baumea* and *Lomandra longifolia* grow directly along the lower part of banks and provide excellent slope protection and capture nutrients.

Macrophytes are aquatic plants that live either fully submerged, partially emerged from water, or float on the surface. They act as a nutrient sink and source, stabilise sediments, and provide feeding opportunities and shelter for fish and other aquatic organisms. Typical submerged plants in the Nepean River include *Vallisneria australis* (Ribbonweed), which may function as migration corridors for diadromous fish (species that migrate between saltwater and freshwater throughout their lifecycle), and are therefore critical to the recruitment success of some fish species such as *Macquaria novemaculeata* (Australian Bass) (NSW DPI 2013).

2.2.3 Snags for KFH

'Snags' is a term used to describe large woody debris from trees and shrubs, including whole fallen trees, broken branches and exposed roots that have fallen or washed into a waterway and are now

wholly or partially submerged by water. For KFH, snags also include submerged large rocks. Snags tend to accumulate in freshwater and upper estuarine areas and form one of the most important habitat components for fish within streams. NSW DPI (2013) describe the functions of snags as:

- providing flow refuges for fish (i.e. places to rest out of the main current flow)
- providing cover for fish (i.e. sites to hide from predators, interact with competitors, or avoid direct sunlight)
- providing 'markers' to designate territorial boundaries for species that move or migrate within the river system
- providing breeding sites for species which lay adhesive eggs onto hard substrates
- providing substrate for algal, biofilm, fungal, bacterial, benthic plants, macroinvertebrates and vertebrate communities to colonise
- providing organic enrichment by capturing detritus and contributing to secondary production as the debris degrades
- stabilising sediments and armouring the stream bed and banks, thereby preventing stream erosion, and providing structure in alluvial systems
- increasing the physical habitat complexity of the stream.

2.2.4 Stream channels and substrates for key fish habitat

In many rivers, deep pools provide important fish habitat and refuge areas. As the flow in rivers decreases in drought, fish retreat to pools to wait for the return of higher flows. Even after prolonged droughts, fish will rapidly recolonise a river provided these refuge areas are available. Other channel habitats such as undercut banks, rock ledges, snags, reed beds, backwaters and riffles offer a variety of habitats for fish (NSW DPI 2013).

The biodiversity of streams is also dependent on substrata complexity. The bed of the river may be comprised of bedrock, gravel, snags, sand or mud, and may provide breeding grounds for different fish species. Gravel habitats are generally much more productive than equivalent areas of sand or mud. The spaces between the stones are inhabited by invertebrates, and provide small fish with refuge from predators and strong currents. Gravel also provides a surface for algae to grow, which is eaten by many invertebrates and some fish. Gravel beds are used as spawning habitat for a variety of freshwater fish (NSW DPI 2013).

3 Legislative requirements

Riparian and aquatic ecosystems of the Nepean River at Penrith are protected under several laws:

- NSW *Environmental Planning and Assessment Act 1979* (EP&A Act) provides for the protection of native vegetation.
- NSW *Threatened Species Conservation Act 1995* (TSC Act) establishes mechanisms for the management and protection of listed threatened species of native flora and fauna (excluding fish and marine vegetation which are managed under the *Fisheries Management Act 1994*), including the listing of threatened species or key threatening processes. A licence under Section 91 of the TSC Act will be needed from OEH to implement the VMP as it will involve work within an Endangered Ecological Community.
- NSW *Fisheries Management Act 1994* (FM Act) deals with the protection of aquatic habitats, including threatened fish, woody debris, snags, rocks or freshwater native aquatic vegetation.
- NSW *Water Management Act 2000* (WM Act) requires 'controlled activity approval' for private landowners to carry out activities on waterfront land, which includes the bed and a distance of 40 m from any river, lake or estuary, measured from the top of bank.
- NSW *Noxious Weeds Act 1993* lists and categorises weed species that Council and other landowners must control.
- Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) establishes mechanisms for the management and protection of Matters of National Environmental Significance, such as threatened ecological communities, flora and fauna species, and migratory species.

A threatening process is something that threatens, or could potentially threaten, the survival or evolutionary development of a species, population or ecological community. Key threatening processes related to riparian vegetation and aquatic habitats have been identified by three pieces of legislation (FM Act, TSC Act and EPBC Act). Examples relevant to the Nepean River include:

- *degradation of native riparian vegetation along New South Wales water courses* (FM Act)
- *removal of large woody debris from New South Wales rivers and streams* (FM Act)
- *clearing of native vegetation* (TSC Act) identifies riparian zone degradation, such as bank erosion leading to sedimentation that affects aquatic communities
- *loss and degradation of native plant and animal habitat by invasion of escaped garden plants, including aquatic plants* (TSC Act and EPBC Act)
- *removal of dead wood and dead trees* (TSC Act).

Council will work with other agencies such as OEH and DPI Fisheries to ensure all legislative obligations are met when undertaking activities in the riparian corridor. The regulatory agencies were consulted during development of this plan.

4 Study area

The Nepean River is a large tributary of the Hawkesbury River catchment. Its headwaters include a mix of residential, rural and natural land uses, including Sydney's drinking water catchment impounded by Warragamba Dam. Penrith Weir has created a narrow lake through the township (approximately 150 m wide by 6 km long).

The VMP study area extends from Penrith Weir to approximately 4.8 km upstream near Lapstone Place, Leonay (**Figure 2**). It captures the Council managed land on the river's foreshore, but excludes privately owned or managed foreshore properties. This land is comprised of three foreshore reserves:

- Weir Reserve (east bank of river from near the Great Western Highway to Penrith Weir, and eastwards to Peach Tree Creek)
- Tench Reserve (east bank of river from the Nepean Belle Paddlewheeler slipway, Regentville to private residences on Nepean Ave, Penrith)
- River Road Reserve (west bank of river from near Lapstone Place, Leonay to the Great Western Highway).

A photograph and brief description of each of the main areas of riparian vegetation along the Nepean River foreshore are provided in **Appendix A**.

4.1 History

The lowland catchment of the Nepean River has a long history of land clearing since European settlement. Historic photographs and illustrations of the Penrith region show a heavily cleared landscape with partially vegetated steep banks. The original form of the river at Penrith has been permanently lost since the construction of Penrith Weir in 1909. Numerous floods and progressive development have periodically modified the riparian vegetation. Today's form is a mix of planted native and introduced trees, remnant vegetation patches, bank slumps and dense weedy undergrowth.

Watkin Tench's description of the Nepean River near Penrith in 1789:

'At daylight we renewed our peregrination: and in an hour after we found ourselves on the banks of a river...We proceeded upwards, by a slow pace, through reeds, thickets, and a thousand other obstacles'

Benson & Howell 1990

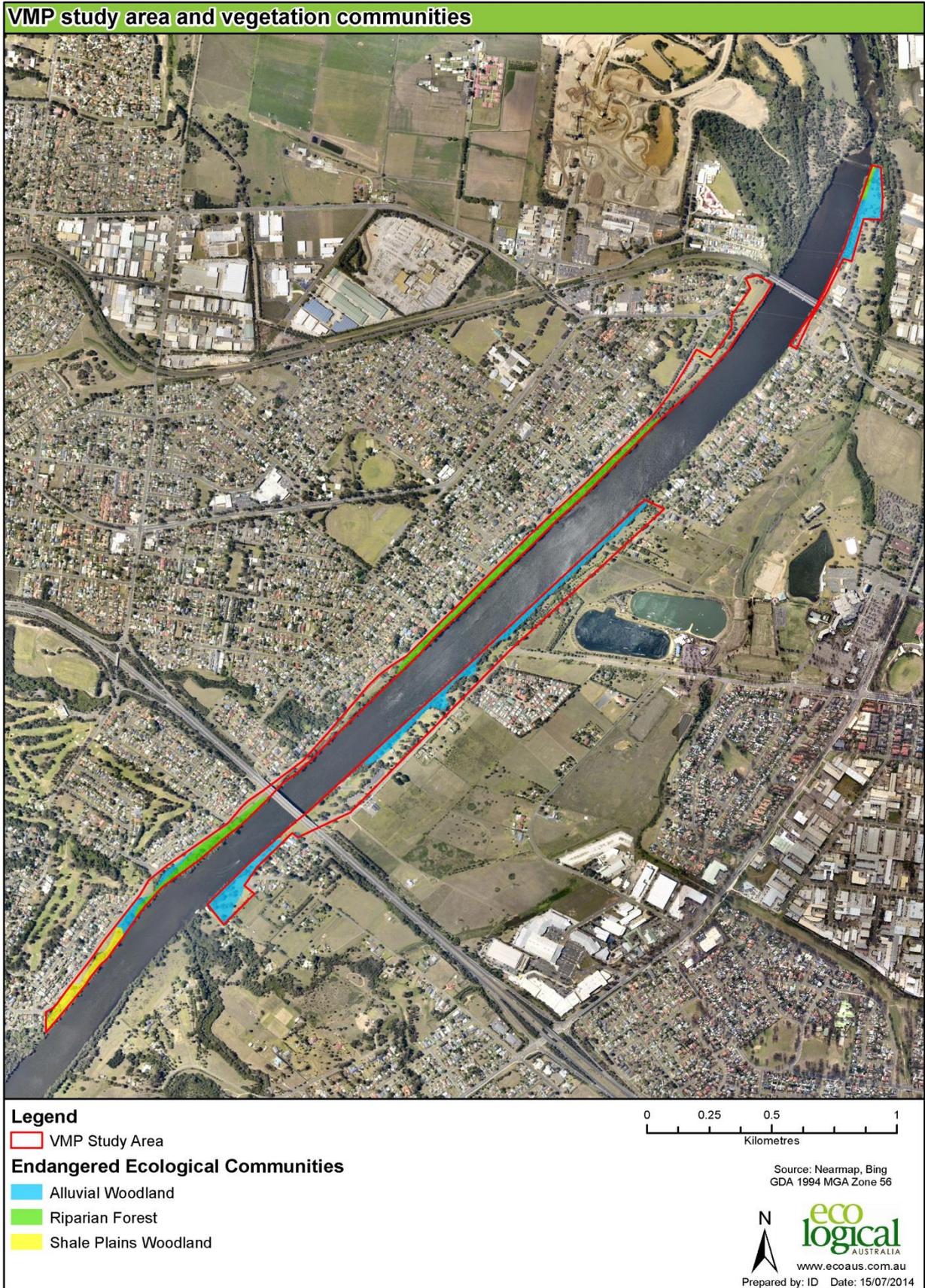


Figure 2: VMP study area and endangered ecological communities

4.2 Land use

The riparian area is used mainly as public space, providing a mix of parkland, footpaths, playgrounds, picnic areas, watercraft access and vegetated streamside areas. Other uses include infrastructure (bridges, power lines, stormwater), tourism (paddleboat and nature), cultural (family/group gatherings) and sport (rowing, water skiing, boating, fishing).

Land adjacent to the riparian study area is largely residential houses and roads, with small pockets of semi-rural properties, industrial buildings and several cultural heritage sites (e.g. Penrith Gallery, The Lewers Bequest, Madang Park Farm House).



Plate 5: View from River Road in 1958 (Photo courtesy: Robin McKay)

4.3 Topography and hydrology

Penrith LGA lies on the western edge of the Sydney Basin, and is relatively flat compared to the adjacent mountainous area. The Nepean River in the study area is wide (average 150 m) and slow moving due to Penrith Weir downstream. The river banks are mostly steep, with narrow benches and some modified terrain to allow for public space (footpaths and parkland).

Three main tributaries flow into the study area: Mulgoa Creek (with Schoolhouse Creek), Jamison Creek and Peach Tree Creek. The largest of these, Mulgoa Creek, has an extensive rural catchment originating as far south as Luddenham suburb. Although large flows and floods are partially regulated by upstream dams (Warragamba, Cataract, Avon and Cordeaux dams), clearing of vegetation for urban and rural use has modified the overland flows and downstream hydrology. Flooding of the Nepean foreshore is common, with major floods recorded nearly every decade since European settlement. The most recent significant flood occurred in August 1990.

4.4 Soils and geology

The study area is mostly located on Quaternary Alluvium soil type and geology, with a small section of the southern area on Tertiary Alluvium soil type. This geology is characterised by floodplains, valley flats, drainage depressions and fertile soils.

4.5 Ecological communities

An ecological community is an assemblage of species which can include flora, fauna and other living organisms that occur together in a particular area. They are generally recognised by the trees, shrubs and groundcover plants that live there. An Endangered Ecological Community (EEC) is an ecological community identified as facing a very high risk of extinction. A Critically Endangered Ecological Community (CEEC) is facing an extremely high risk of extinction in the immediate future.

The River-flat Forests occupied the most fertile agricultural soil in the Sydney area, land first farmed in the 1790s.

'The greater part of the alluvial lands upon the Hawkesbury and Nepean have been cleared, and are under cultivation,' reported James Atkinson in 1826.

Previous mapping of vegetation (Tozer 2003) within the study area was validated by ELA during the field survey. Three vegetation communities are identified along the foreshore, although highly modified in parts: Alluvial Woodland, Riparian Forest and Shale Plains Woodland. These communities are sub-communities of the following:

- River-flat Eucalypt Forest is listed under the TSC Act as an EEC. The condition varies from poor to moderate in the study area due to dense understorey weeds and lack of native recruitment. Within the study area, this EEC is characterised by a native canopy dominated by *Casuarina cunninghamiana*, *Eucalyptus amplifolia*, *E. tereticornis*, *Melia azedarach* and *Melaleuca styphelioides*. Weeds vary from scattered to abundant in all strata.
- Cumberland Plain Woodland is listed as a CEEC under the TSC Act and EPBC Act. The condition is poor in the study area due to dense understorey weeds and lack of large trees and native recruitment. Although attempts have been made to regenerate some areas, the native vegetation is patchy with weeds dominating much of this CEEC.

4.5.1 River-flat Eucalypt Forest

In the vegetation mapping of the Cumberland Plain, two main forms of River-flat Eucalypt Forest have been identified: 'Riparian Forest' and parts of the 'Alluvial Woodland' that are dominated by eucalypts. Within the study area along the Nepean River, 6.1 ha of vegetation is mapped as Riparian Forest and 8.6 ha as Alluvial Woodland (**Figure 2**).

Characteristics

Riparian Forest is a tall open forest community on alluvial soils adjacent to main river channels, with emergent trees, such as Broad Leaf Apple (*Angophora subvelutina*), Cabbage Gum (*Eucalyptus amplifolia*), Bangalay (*E. botryoides*) and River Peppermint (*E. elata*). The small tree layer often includes wattles, such as White Sally (*Acacia floribunda*) and Coast Myall (*A. binervia*). Originally, the understorey would have had occasional dense pockets of low rainforest vegetation, such as Grey Myrtle (*Backhousia myrtifolia*) and a grassy shrub layer with Blackthorn (*Bursaria spinosa*).

Alluvial Woodland occurs along minor watercourses and on terraces adjacent to Riparian Forest and commonly includes trees such as Cabbage Gum (*E. amplifolia*), Forest Red Gum (*E. tereticornis*) and dense stands of Swamp Oak (*Casuarina glauca*).

Threats

Recognised threats to the River-flat Eucalypt Forest community are:

- activation of acid sulfate soils
- removal of dead wood
- rubbish dumping
- frequent burning which reduces the diversity of woody plant species
- further clearing for urban and rural development, and the subsequent impacts from fragmentation
- flood mitigation and drainage works
- landfilling and earthworks associated with urban and industrial development
- grazing and trampling by stock and feral animals (particularly pigs)
- changes in water quality, particularly increased nutrients and sedimentation
- weed invasion
- climate change.

4.5.2 Cumberland Plain Woodland

In the vegetation mapping of the Cumberland Plain, two forms of Cumberland Plain Woodland have been identified, including 'Shale Plains Woodland' which occupies 1.7 ha of the study area along the Nepean River (**Figure 2**).

Characteristics

Shale Plains Woodland is the most widely distributed form of Cumberland Plain Woodland. *Bursaria spinosa* is the dominant shrub species and there are canopy trees such as grey box (*E. moluccana*), forest red gum (*E. tereticornis*), spotted gum (*Corymbia maculata*) and thin leaved stringybark (*E. eugenoides*). The diverse understorey layer is similar for both forms of Cumberland Plain Woodland. It is common to find grasses, such as Kangaroo Grass (*Themeda australis*), Weeping Meadow Grass (*Microlaena stipoides* var *stipoides*) and herbs, such as Kidney Weed (*Dichondra repens*), Blue Trumpet (*Brunoniella australis*) and *Desmodium varians*.

Threats

The main threat is further clearing for urban or rural development, and the subsequent impacts from fragmentation. Other threats include: grazing and mowing (which stops regrowth of the community); inappropriate water run-off entering the site (which leads to increased nutrients and sedimentation); weed invasion (which out-competes native vegetation); and inappropriate fire regimes (which have altered the appropriate floristic and structural diversity).

4.5.3 Recovery plan

The Cumberland Plain Recovery Plan (DECCW 2011) constitutes the formal NSW recovery plan for 20 threatened species, populations and ecological communities including River-flat Eucalypt Forest and Cumberland Plain Woodland. It provides the foundation for biodiversity protection in western Sydney based on the following principles:

- The protection and management of large intact remnants is more effective and efficient than for smaller, fragment remnants.
- Recovery efforts need to aim to ensure that a representative sample of all target threatened species, populations and communities is conserved.

The NSW Office of Environment and Heritage (OEH) is developing more targeted approaches for managing River-flat Eucalypt Forest and Cumberland Plain Woodland. In the interim, action statements have been prepared that list management actions¹, which aim to maximise the extent of occurrence and condition of the River-flat Eucalypt Forest and Cumberland Plain Woodland. Of particular relevance to this VMP, is OEH's action to 'support and promote the adoption of best practice standards for bushland management and restoration'.

4.6 Flora species

Dominant riparian flora species recorded in the study area are listed in **Appendix B**. Additional species are listed in the previous plans of management for Council's reserves (Berzins & Rose Deco 2008, LandArc 2006, LandArc 2004). No threatened flora species listed under the EPBC or TSC Acts were observed by ELA within the study area. Of the 80 dominant species ELA recorded, more than half of those are exotic species, including one declared noxious weed in the Penrith LGA and four classed as Weeds of National Significance (**Table 1**).

Table 1: Noxious weeds recorded within the study area

Scientific Name	Common Name	Noxious class	WONS
<i>Anredera cordifolia</i>	Madeira Vine		Y
<i>Lantana camara</i>	Lantana		Y
<i>Rubus fruticosus</i> agg. spp.	Blackberry	4	Y
<i>Salix nigra</i>	Black Willow		Y

¹ <http://www.environment.nsw.gov.au/savingourspeciesapp/>



Plate 6: Weeds smothering native riparian vegetation

4.7 Fauna species and habitat

Table 2 below summarises threatened fauna species listed under the TSC and EPBC Acts which are predicted or are likely to occur within the study area, or in adjacent bushland. This includes species that may live, forage, breed or opportunistically use the riparian and aquatic zones. Fish species known to occur are listed in **Table 3**, as reported by NSW Fisheries in 2007. Habitat features recorded within the study area provide a mix of benefits for a range of fauna (**Table 4**).

Table 2: Threatened fauna with potential to be found on or adjacent to the VMP study area

Common name	Scientific name	NSW status	Commonwealth status
Broad-headed Snake	<i>Hoplocephalus bungaroides</i>	E1,P,2	V
Cattle Egret	<i>Ardea ibis</i>	P	C,J
Fork-tailed Swift	<i>Apus pacificus</i>	P	C,J,K
Giant Burrowing Frog	<i>Heleioporus australiacus</i>	V,P	V
Glossy Ibis	<i>Plegadis falcinellus</i>	P	C
Green and Golden Bell Frog	<i>Litoria aurea</i>	E,P	V
Grey-headed Flying-fox	<i>Pteropus poliocephalus</i>	V,P	V
Large-eared Pied Bat	<i>Chalinolobus dwyeri</i>	V,P	V
Rainbow Bee-eater	<i>Merops ornatus</i>	P	J
Regent Honeyeater	<i>Anthochaera Phrygia</i>	E4A,P	E
Swift Parrot	<i>Lathamus discolor</i>	E,P,3	E
White-bellied Sea-Eagle	<i>Haliaeetus leucogaster</i>	P	C
White-throated Needletail	<i>Hirundapus caudacutus</i>	P	C,J,K
Wood Sandpiper	<i>Tringa glareola</i>	P	C,J,K

Status: EA4 = Critically Endangered; E = Endangered; V = Vulnerable; P = Protected; 3 = Sensitivity Class 3; C = China Australia Migratory Bird Agreement; J = Japan Australia Migratory Bird Agreement; K = Republic of Korea Australia Migratory Bird Agreement.

Table 3: Fish species recorded in Penrith Weirpool

Common name	Scientific name
Australian Bass	<i>Macquaria novemaculeata</i>
Australian Smelt	<i>Retropinna semoni</i>
Bullrout	<i>Notesthes robusta</i>
Bully Mullet	<i>Mugil cephalus</i>
Catfish	<i>Tandanus tandanus</i>
European Carp*	<i>Cyprinus carpio</i>
Firetail Gudgeon	<i>Hypseleotris galii</i>
Flathead Gudgeon	<i>Philypnodon grandiceps</i>
Freshwater Herring	<i>Potamalosa richmondia</i>
Freshwater Mullet	<i>Myxus petard</i>
Goldfish*	<i>Carassius auratus</i>
Long-finned eel	<i>Anguilla reinhardtii</i>
Striped Gudgeon	<i>Gobiomorphus australis</i>

* introduced species

Source: *Fish communities of the Nepean River in the vicinity of Pheasants Nest Weir* (Baumgartner & Reynoldson 2007).

Table 4: Habitat features present in the riparian corridor

Habitat feature	Fauna group using feature
Stag (dead trees)	Birds, including birds of prey
Tree hollows	Arboreal mammals and birds
Intact canopy	Arboreal mammals and birds
Flowering trees and shrubs	Foraging resources for birds, arboreal mammals and bats
Mistletoe	Foraging resources for birds, arboreal mammals and bats
Fallen timber	Small mammals, reptiles, and insects
Leaf litter	Invertebrates, amphibians, reptiles, ground-dwelling mammals
Decorticating bark	Microchiropteran bats, reptiles
Riparian vegetation	Amphibians, birds, reptiles, microchiropteran bats
Dense native shrubs	Small birds and birds common to urban environments, ground-dwelling mammals.
Dense exotic shrub	Small birds and birds common to urban environments.
Watercourse	Amphibians and wading birds
Exotic grassland	Wading birds and predatory birds

4.8 River health

Penrith Council has been monitoring river health in the LGA since 2004. Monitoring has focused on indicators of health, such as macroinvertebrate communities, water quality and channel/riparian habitat quality.

A well-balanced and functioning biological community is one of the best indicators of a healthy river. Benthic macroinvertebrates (bottom-dwelling organisms including aquatic insects, crayfish, clams, snails and worms) are used to help determine river health because of their high numbers, known pollution tolerances, limited mobility, wide range of feeding habits, varied life spans, and dependence on the land environment around the waterway. Chemical grab samples provide a snapshot of the water

quality at the time of sampling, but the macroinvertebrates are living there all the time and are an indicator of historic disturbance. Their composition will be affected by either periodic episodes of poor water quality or continuous poor water quality. Healthy rivers generally have greater diversity of macroinvertebrates. Macroinvertebrates are indicators of pollution because some types are highly sensitive to it, while others tolerate it.

Recent results within the VMP study area (Nepean River at Tench Reserve) report good habitat availability (in-stream habitat and riparian structure), but poor macroinvertebrate assemblage (i.e. pollution-sensitive taxa were missing). Watershed Ecology (2013) makes the observation that lower than expected biological ratings for this site may be more indicative of the uniqueness of the habitat than poor ecosystem health.

5 Management

5.1 Treatment zones

Seven broad vegetation treatment zones are recommended for the study area. The seven zones are named to closely match terminology used in the Master Plan:

- Treatment Zone 1 - reinforce native vegetation
- Treatment Zone 2 - filtered views (residential areas)
- Treatment Zone 3 - filtered views (parkland)
- Treatment Zone 4 - filtered views (remote footpaths)
- Treatment Zone 5 - water edge access point
- Treatment Zone 6 - key destinations
- Treatment Zone 7 - infrastructure.

These are defined by adjacent land use (e.g. residential), Master Plan concepts (e.g. new arrival space) and existing features (e.g. power lines). The Master Plan is the primary driver of these management zones as it identifies locations of future key destinations, access to water edge and filtered views. Where the Master Plan does not describe an area, the VMP prioritises native revegetation as the recommended treatment.

Each zone is conceptually depicted in the following guidelines with a brief description of issues, priority actions and sub-zone management. The illustrations provided for each zone are indicative only and are only a guide to placement of appropriate vegetation types. Features should be tailored to the specific site of future works to accommodate subtle differences and risk to bank stability. For example, bank steepness may vary within a zone, so selection of shrub species and their placement should match the desired outcome for that area. This is most relevant for shrubs that could block views.

The zones are mapped in **Figure 3**, but may overlap or intertwine in parts. Zones may also change over time with new development or modifications to the existing reserves. An adaptive approach is recommended to apply the most appropriate treatment zone to any given area at the time of implementation.

5.2 Management principles

Best practice bush regeneration techniques should be applied to vegetation management in the corridor. This will include:

- Weed control and revegetation should be conducted by a team of professional bush regenerators.
- Weed removal and revegetation/regeneration should be done progressively in patches to maintain habitat and bank stability.
- Pruning trees needs to be done by a qualified arborist to maintain tree health, public safety and amenity. Up to 30% of the canopy (<10cm diameter branches and trunk) can be pruned. Consideration will be given to maximising views when selecting the branches to be pruned.
- The root bole should be retained in the soil for bank stability if trees are removed.
- If native trees (e.g. *Casuarinas*) are to be removed to improve views, the loss of these will need to be offset by planting elsewhere first (allow minimum two year establishment period) and ensuring bank stability is maintained.
- Priority should be given to removing exotic trees rather than natives if it is to improve views.

- No exotics should be planted in the corridor because of the risk of them becoming invasive (i.e. weeds).
- Local provenance species should be used for revegetation.
- Where possible, trees and branches that are removed should be reused as woody ground habitat within the Treatment Zone 1 areas and other zones as suitable.

Vegetation management must be complemented by removal of rubbish from the area. This will require an ongoing commitment from Council and was recognised as high priority by the community. Rubbish bins with lids to prevent fauna entering also need to be placed at convenient locations along the corridor and regularly serviced.

Where possible, structures in the corridor (e.g. retaining walls) should use natural materials such as rock boulders and wood to provide habitat as well as being functional and attractive.

5.3 Funds and resources

Implementation of this VMP will be subject to availability of funds and resources. Additional funds and resources are required to implement this plan successfully. This needs to cover ongoing maintenance as well as primary works, including:

- bush regenerators to schedule and perform on-ground works and supervise Bushcare volunteers
- contractor and Council bush regenerators to schedule and perform on-ground work
- arborists to periodically prune or remove selected trees
- detailed design and construction of engineered works such as tracks, boardwalks, terraces, retaining walls, gabions etc – to be done in consultation with Council's Bushland Management Officer
- disbursements such as plants, mulch, tools, herbicide etc
- staff and materials to support community education and involvement.

5.4 Costing

The cost of implementing this VMP will need to be calculated on a case-by-case basis for specific sites. As a guide, the following describes how to calculate costs for weed control revegetation and monitoring/reporting. Costs may vary significantly over consecutive years of management according to the response of the treatment zones to the weed control and revegetation techniques. On-going maintenance costs (labour and materials) may also increase over time with inflation. Rates and costs are based on estimates of current standard commercial rates and there is potential for variation across the sector. These costs should be used as a guide only as factors such as GST and CPI have not been included. No allowance has been made for any 'construction' works relating to the management zones including excavation, grading, topsoil, etc.

5.4.1 Weed control costs

Bush regeneration contractors may be required to implement weed control in the management areas. These works are estimated to cost \$2,000 per day for a team of four bush regenerators, including a supervisor. The cost of bush regeneration works includes the costs of herbicide, vehicles and equipment which are required to implement weed control. Costs will vary depending on the type of weeds present and access. At a per square metre basis, costs can be estimated for primary weed control (up to \$3/m²), secondary weed control (up to \$4/m²) and maintenance weed control (up to \$4/m²).

5.4.2 Revegetation costs

Bush regeneration contractors may be required to implement revegetation in the management areas. These costs are estimated at \$4.00 per plant including planting, tree guards, water crystals and initial watering for tree/shrub species, and an estimated \$2.50 per plant including planting, water crystals and initial watering for understorey species. The number of plants required per square metre is described in **Sections 5.7 to 5.13**. A 10% mortality rate should be included in calculating total plants required and costed towards the first year of maintenance. Other costs will vary depending on the treatment type, location and access, and may include preparation work (\$2/m²), jute matting or mulch and installation (\$5.50/m²), and monitoring and reporting (\$2/m²).

5.5 Community education and involvement

Opportunities to raise community awareness about the importance of native vegetation for a healthy river and stimulate greater community involvement in riparian vegetation management are considered a high priority and include:

- 'graffiti-proofed' information boards at key locations along the river corridor to present heritage and environmental information
- information on Council's website including links to relevant sites
- regular volunteer Bushcare activities to conduct on-ground works
- community Bushcare forum (e.g. every six months) with guest speakers
- Bushcare newsletter
- brochures to summarise information about weed species, preferred species for planting, fauna inhabiting the river corridor.

Bushcare is a growing community movement with volunteers of all ages involved in bush regeneration, weed removal, tree planting, habitat restoration, wildlife monitoring and water quality monitoring. In addition to the environmental benefits of community involvement, the social benefits to Bushcare volunteers include:

- learning new skills
- meeting new people
- getting to know the neighbours
- giving something back to the community
- being active and getting outdoors.

A detailed community education and involvement plan and materials are needed to support management of the riparian corridor at Penrith and the catchment more broadly. Council will lead preparation and implementation of the plan. There are many resources available at minimal cost to assist Council community education and involvement program. For example, the Sydney Weeds Committee for Sydney West – Blue Mountains website (<http://sydneyweeds.org.au>) has links to books, posters, brochures and on-line information.

Bushcare is a national movement which started in the suburbs of Sydney in the 1980s. This environmental volunteer work (sometimes called Urban Landcare) occurs mostly on public land managed by local councils or NSW government agencies.

5.6 Assessing performance

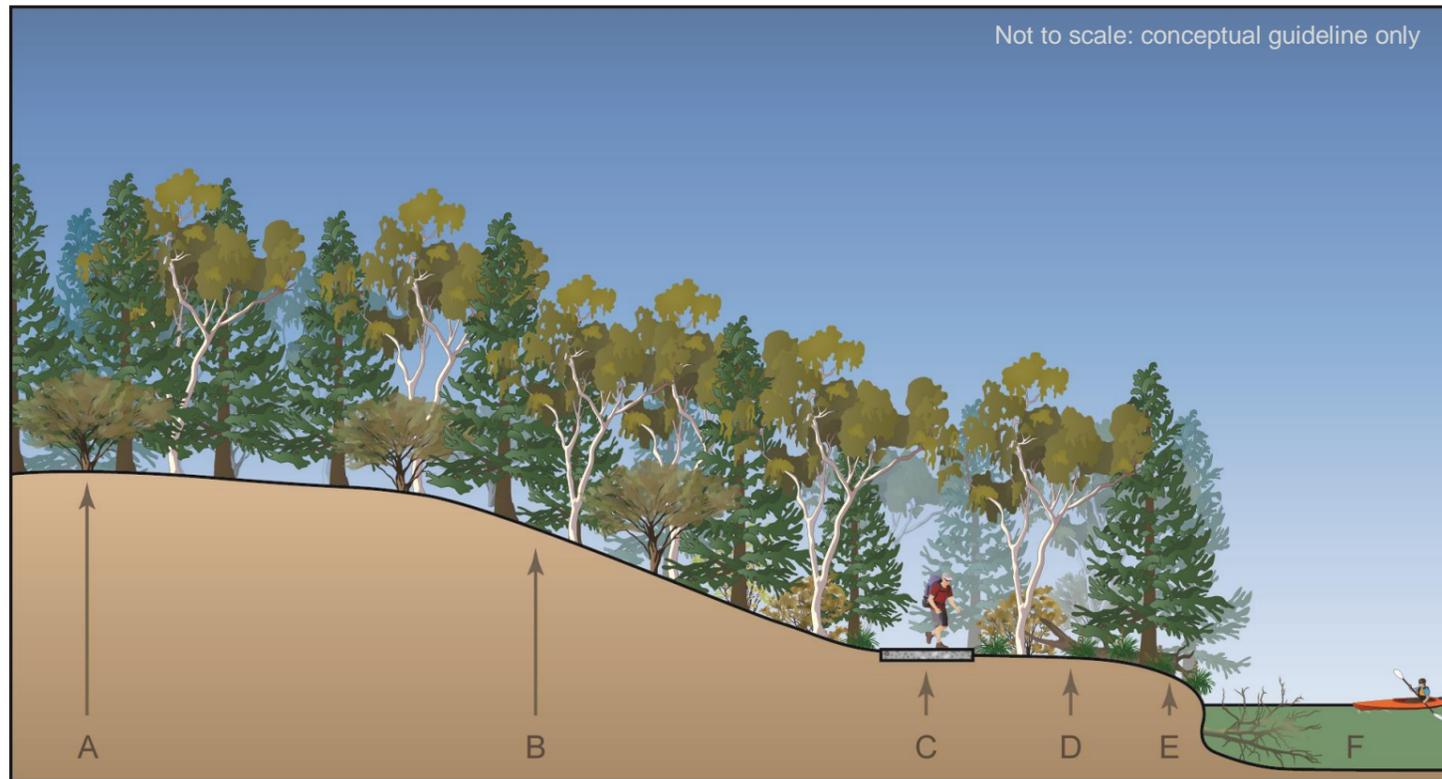
Implementation of the VMP will be regarded as successful if conditions in the corridor progressively change from the baseline to the zone types illustrated in **Sections 5.7 to 5.13**. If results indicate that conditions are trending in a different direction (e.g. more weeds and exotics, increasing bank instability), then the reasons why this is occurring should be examined and adaptive management action taken.

To help determine if vegetation is changing as desired in response to management, baseline conditions have been assessed at four locations along the river corridor. The baseline survey has been performed using transects in accordance with the *Biodiversity Fund Ecological Monitoring Guide* (DSEWPC 2013). The methods and results are presented in **Appendix D**. Vegetation condition in these transects needs to be monitored every five years when the VMP is reviewed and updated.



Figure 3: Broad treatment zones within the VMP study area (zones may intermix in parts)

5.7 Treatment Zone 1 - Reinforce native vegetation



Key management issues

- Exotic trees, shrubs and groundcovers are well established along the banks in some locations.
- Banks are very steep in places and are at risk of erosion, especially where vegetation trees are lacking.
- Additional good quality habitat is required to offset losses elsewhere along foreshore.

Prioritised actions

Priority	Action
High	<ul style="list-style-type: none"> • Designate special areas as dedicated rehabilitation sites. This may require fencing and signage to deter unsuitable use. • Conduct primary weed control as required, leaving roots and fallen trunks intact. • Plant riparian width to its full extent using native trees, shrubs and groundcovers.
Medium	<ul style="list-style-type: none"> • Continue weed control of exotic trees, shrubs and groundcovers to allow successful establishment of native plantings.
Low	<ul style="list-style-type: none"> • Upgrade paths to include interpretive signage explaining the value of riparian features.

Legend (proposed vegetation management)

- A. Maximise vegetated riparian width.
- B. Fully plant banks with a minimum of three layers: canopy, midstorey and understorey.
- C. Cater for low impact pedestrian access, but without filtered views or access to water edge. Use low growing species and scattered shrubs near paths for safe visibility.
- D. Retain or introduce large logs and debris to create woody ground habitat.
- E. Toe of bank with dense groundcovers for erosion control and fringing habitat.
- F. Retain or add in-stream large woody debris for edge protection and habitat.

Recommended species and planting density (see Appendix C for additional species)

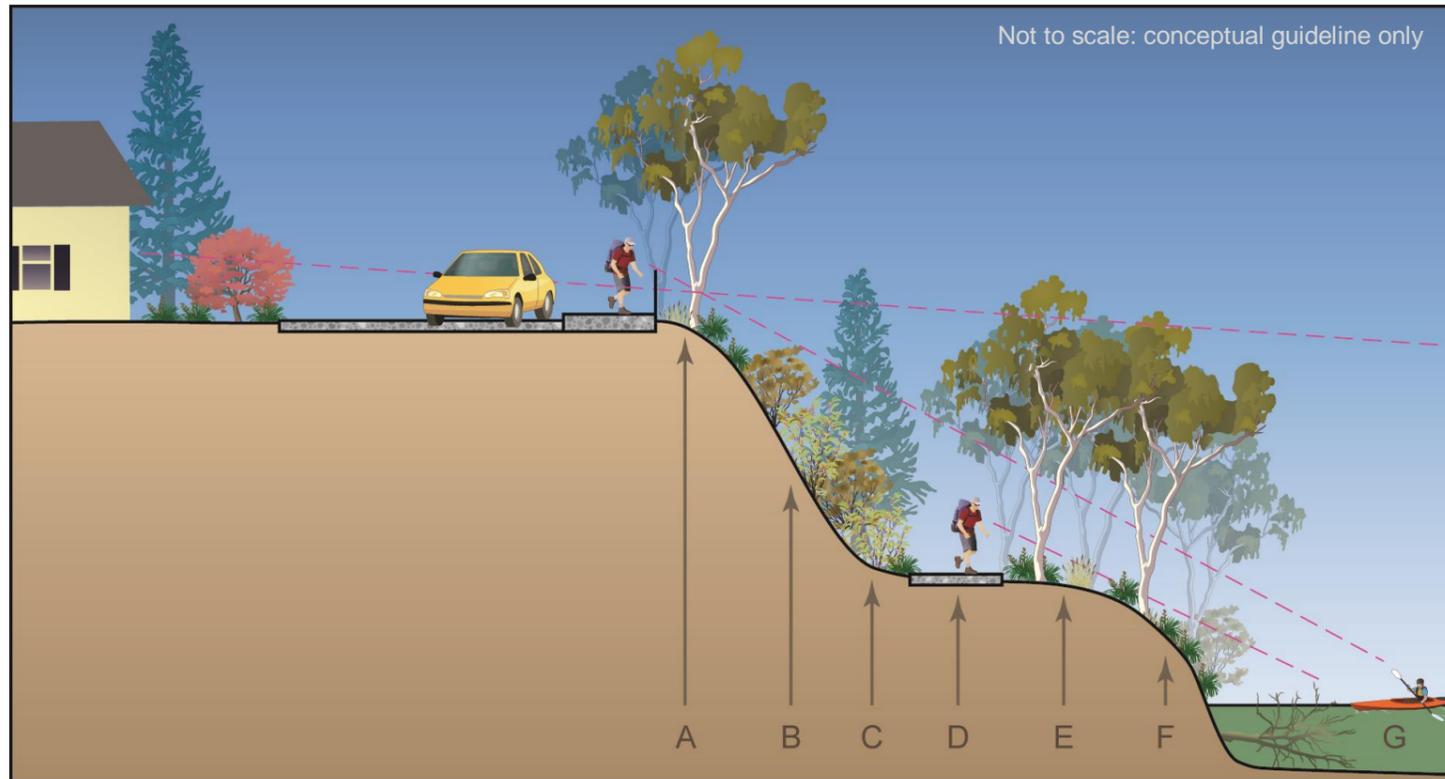
Scientific name	Type	A	B	C	D	E
<i>Acacia binervia</i>	Small tree	X	X		X	
<i>Acacia implexa</i>	Small tree	X	X			
<i>Acacia parramattensis</i>	Small tree	X	X			
<i>Adiantum aethiopicum</i>	Groundcover	X	X		X	X
<i>Alternanthera denticulata</i>	Groundcover			X	X	X
<i>Angophora subvelutina</i> ^{1,2}	Tall tree	X	X		X	
<i>Breynia oblongifolia</i>	Shrub	X	X	X	X	
<i>Bursaria spinosa</i>	Shrub	X	X		X	
<i>Carex appresa</i>	Groundcover					X
<i>Casuarina cunninghamiana</i> ^{1,2}	Tall tree	X	X		X	
<i>Clerodendrum tomentosum</i>	Tall shrub	X	X		X	
<i>Commelina cyanea</i>	Groundcover	X	X	X	X	X
<i>Eucalyptus agglomerate</i> ¹	Tall tree	X	X			
<i>Eucalyptus amplifolia subsp. amplifolia</i> ^{1,2}	Tall tree	X	X			
<i>Eucalyptus deanei</i> ¹	Tall tree	X	X		X	
<i>Eucalyptus saligna</i> ¹	Tall tree	X	X			
<i>Eucalyptus tereticornis</i> ²	Tall tree	X	X			
<i>Ficus coronata</i>	Small tree	X	X	X	X	
<i>Glochidion ferdinandi var. ferdinandi</i>	Small tree	X	X	X	X	
<i>Hibiscus heterophyllus var. heterophyllus</i>	Shrub	X	X		X	
<i>Juncus usitatus</i>	Groundcover					X
<i>Lachnagrostis filiformis</i>	Groundcover	X	X	X	X	X
<i>Lomandra longifolia</i>	Groundcover			X	X	X
<i>Microlaena stipoides var. stipoides</i>	Groundcover	X	X	X	X	X
<i>Phyllanthus gasstroemii</i>	Small shrub	X	X		X	
<i>Phyllanthus gunnii</i>	Small shrub	X	X		X	
<i>Pittosporum revolutum</i>	Shrub	X	X	X	X	
<i>Rubus parvifolius</i>	Shrub	X	X		X	
<i>Trema aspera</i>	Shrub	X	X		X	

1) Dominant trees selected for Alluvial Woodland and Riparian Forest

2) Dominant trees selected for Shale Plains Woodland

Suggested planting density: tall tree 1/50 m²; small tree 1/25 m²; tall shrub 1/25 m²; shrub 1/10 m²; groundcover 2-4/m² or as required.

5.8 Treatment Zone 2 - Filtered views (residential areas)



Key management issues

- Exotic trees, shrubs and groundcovers are well established along the banks in some locations.
- Banks are very steep at risk of erosion where there are few trees for stability.
- Dense exotic trees and native *Casuarina cunninghamiana* are blocking views of the river.

Prioritised actions

Priority	Action
High	<ul style="list-style-type: none"> • Implement weed control in the best quality habitats to protect endangered communities from further degradation. • Selectively prune some tree branches (<30% canopy) to improve filtered views. • Staged removal of exotic trees, leaving root ball in ground for continued bank stability. This will enhance views in the immediate future.
Medium	<ul style="list-style-type: none"> • Plant native trees along bank to replace exotic trees. • Plant native shrubs and groundcovers to stabilise steepest banks. • Continue weed control of exotic trees, shrubs and groundcovers to allow successful establishment of native plantings.
Low	<ul style="list-style-type: none"> • Selectively remove some dense Casuarinas to improve filtered river views, but only once native plantings are well established.

Legend (proposed vegetation management)

- A. Highest bank with groundcovers and clear-stemmed trees for stability and enhanced views.
- B. Steep bank with dense groundcovers and shrubs for stability. Shrub height should allow for views.
- C. Middle bank (background) with small pockets of trees/shrubs where bank grade allows.
- D. Pathway with low groundcovers for pedestrian safety.
- E. Lowest bank with groundcovers and clear-stemmed trees for stability and enhanced views. Scattered pockets of shrubs for habitat.
- F. Toe of bank with dense groundcovers for erosion control and fringing habitat. Species will vary with slope and soil moisture.
- G. Retain or add in-stream large woody debris for edge protection and habitat.

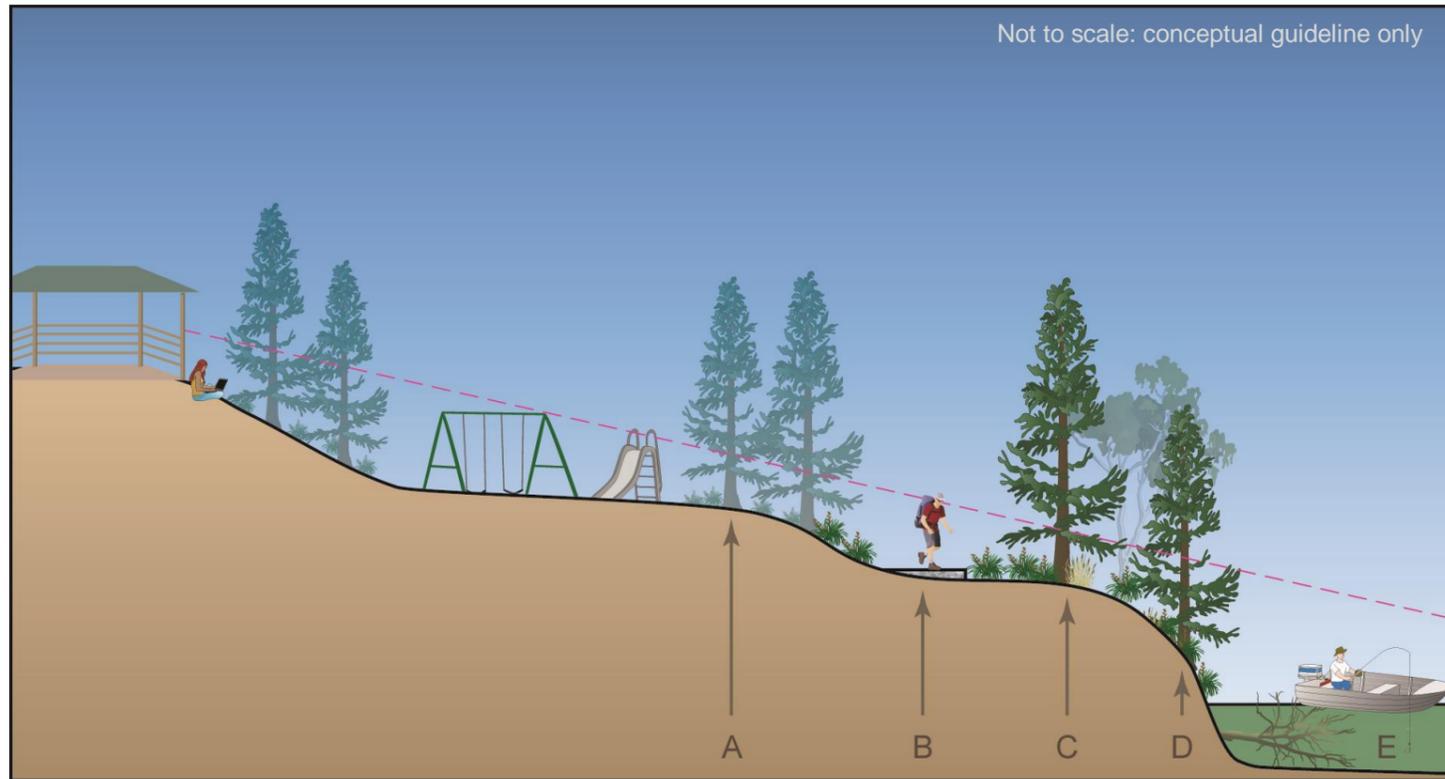
Recommended species and planting density (see Appendix C for additional species)

Scientific name	Type	A	B	C	D	E	F
<i>Acacia binervia</i>	Small tree	X		X			
<i>Adiantum aethiopicum</i>	Groundcover		X			X	X
<i>Alternanthera denticulata</i>	Groundcover					X	X
<i>Angophora subvelutina</i> ^{1,2}	Tall tree			X		X	
<i>Breynia oblongifolia</i>	Shrub		X	X		X	
<i>Bursaria spinosa</i>	Shrub			X			
<i>Carex appresa</i>	Groundcover					X	X
<i>Clerodendrum tomentosum</i>	Tall shrub			X			
<i>Commelina cyanea</i>	Groundcover	X	X		X		
<i>Eucalyptus agglomerate</i> ¹	Tall tree	X		X			
<i>Eucalyptus amplifolia subsp. amplifolia</i> ^{1,2}	Tall tree			X		X	
<i>Eucalyptus deanei</i> ¹	Tall tree			X		X	
<i>Eucalyptus saligna</i> ¹	Tall tree	X		X			
<i>Eucalyptus tereticornis</i> ²	Tall tree	X					
<i>Ficus coronata</i>	Small tree			X			
<i>Glochidion ferdinandi var. ferdinandi</i>	Small tree			X			
<i>Hibiscus heterophyllus var. heterophyllus</i>	Shrub		X				
<i>Juncus usitatus</i>	Groundcover						
<i>Lachnagrostis filiformis</i>	Groundcover		X			X	X
<i>Lomandra longifolia</i>	Groundcover	X			X	X	X
<i>Microlaena stipoides var. stipoides</i>	Groundcover					X	X
<i>Phyllanthus gunnii</i>	Small shrub		X				
<i>Trema aspera</i>	Tall shrub			X		X	

1) Dominant trees selected for Alluvial Woodland and Riparian Forest. Alternative species can include *Casuarina cunninghamiana*.

2) Dominant trees selected for Shale Plains Woodland. Alternative species can include *Casuarina cunninghamiana*. Suggested planting density: tall tree 1/50 m²; small tree 1/25 m²; tall shrub 1/25 m²; shrub 1/10 m²; groundcover 2-4/m² or as required.

5.9 Treatment Zone 3 - Filtered views (parkland)



Not to scale: conceptual guideline only

Legend (proposed vegetation management)

- A. Highest and middle banks with pockets of native tree habitat. Minor limb pruning required to improve views for public safety. Low groundcovers to act as habitat edging and to exclude lawn. Can be formally designed with shaped planting beds and edges (walls).
- B. Pathway with low groundcovers for pedestrian safety.
- C. Lowest bank with groundcovers and minimal shrubs. Existing trees may be selectively pruned for filtered views. New planting areas to use clear-stemmed trees for stability and enhanced views. Promote pockets of shrubs for habitat where paths and park facilities are more distant from river.
- D. Toe of bank with dense groundcovers for erosion control and fringing habitat
- E. Retain or add in-stream large woody debris for edge protection and habitat.

Recommended species and planting density (see Appendix C for additional species)

Scientific name	Type	A	B	C	D
<i>Adiantum aethiopicum</i>	Groundcover	X	X	X	X
<i>Alternanthera denticulata</i>	Groundcover	X	X	X	X
<i>Angophora subvelutina</i> ^{1,2}	Tall tree	X		X	
<i>Breynia oblongifolia</i>	Shrub	X		X	
<i>Bursaria spinosa</i>	Shrub			X	
<i>Carex appresa</i>	Groundcover				X
<i>Clerodendrum tomentosum</i>	Tall shrub				
<i>Commelina cyanea</i>	Groundcover	X	X	X	X
<i>Eucalyptus agglomerate</i> ¹	Tall tree	X			
<i>Eucalyptus amplifolia subsp. amplifolia</i> ^{1,2}	Tall tree	X		X	
<i>Eucalyptus deanei</i> ¹	Tall tree			X	
<i>Eucalyptus saligna</i> ¹	Tall tree	X			
<i>Eucalyptus tereticornis</i> ²	Tall tree	X			
<i>Ficus coronata</i>	Small tree	X		X	
<i>Glochidion ferdinandi var. ferdinandi</i>	Small tree	X		X	
<i>Juncus usitatus</i>	Groundcover				X
<i>Lachnagrostis filiformis</i>	Groundcover		X	X	X
<i>Lomandra longifolia</i>	Groundcover	X	X	X	X
<i>Microlaena stipoides var. stipoides</i>	Groundcover				X
<i>Phyllanthus gunnii</i>	Small shrub			X	
<i>Pittosporum revolutum</i>	Shrub	X		X	

1) Dominant trees selected for Alluvial Woodland and Riparian Forest. Alternative species can include *Casuarina cunninghamiana*.

2) Dominant trees selected for Shale Plains Woodland. Alternative species can include *Casuarina cunninghamiana*. Suggested planting density: tall tree 1/50 m²; small tree 1/25 m²; tall shrub 1/25 m²; shrub 1/10 m²; groundcover 2-4/m² or as required.

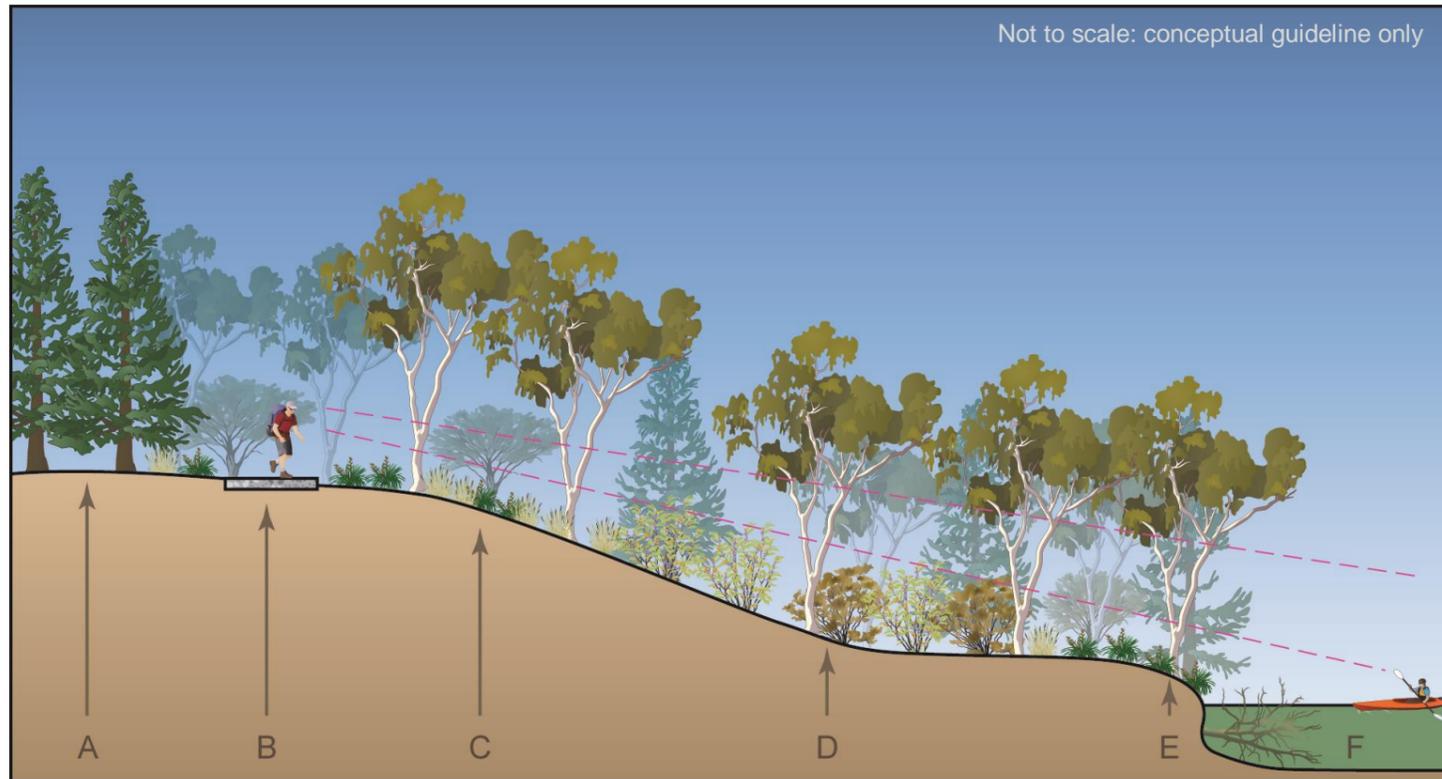
Key management issues

- Large public space parkland requires safety considerations to create a reassuring environment (e.g. snakes, pedestrian/cyclist visibility, crime).
- Exotic groundcovers are well established along the banks and may prevent natural plant recruitment.
- Native trees (e.g. *Casuarina cunninghamiana*) are blocking views of the river in some places, but are important for bank stability and habitat.

Prioritised actions

Priority	Action
High	<ul style="list-style-type: none"> • Staged removal of exotic trees, leaving root ball in ground for continued bank stability. This will enhance views in the immediate future. • Plant native trees along bank to replace exotic trees and create new planting beds away from river, or expand riparian corridor where open space is dysfunctional (e.g. steep grass banks). • Implement weed control to protect endangered communities from further degradation.
Medium	<ul style="list-style-type: none"> • Continue weed control of exotic trees, shrubs and groundcovers to allow successful establishment of native plantings.
Low	<ul style="list-style-type: none"> • Selectively prune branches of existing dense Casuarinas to improve filtered river views, but only once native plantings are well established.

5.10 Treatment Zone 4 - Filtered views (remote footpaths)



Key management issues

- Pathways require a safe environment (e.g. snakes, pedestrian/cyclist visibility, crime).
- Exotic trees, shrubs and groundcovers are well established along the banks.
- Banks are very steep at risk of erosion where there are few trees for stability.
- Dense exotic trees and native *Casuarina cunninghamiana* are blocking views of the river.

Prioritised actions

Priority	Action
High	<ul style="list-style-type: none"> • Staged remove of exotic trees, leaving root ball in ground for continued bank stability. This will enhance views in the immediate future. • Plant clear-stemmed native trees along bank to replace exotic trees and plant out dysfunctional areas to expand riparian habitat. Include dense shrubs where views are not important. • Plant native shrubs and groundcovers to stabilise steepest banks. • Implement weed control in the best quality habitats to protect endangered communities from further degradation.
Medium	<ul style="list-style-type: none"> • Continue weed control of exotic trees, shrubs and groundcovers to allow successful establishment of native plantings.
Low	<ul style="list-style-type: none"> • Selectively prune branches of existing dense Casuarinas to improve filtered river views, but only once additional native plantings are well established and successful.

Legend (proposed vegetation management)

- A. Expand riparian corridor to fill dysfunctional open space or where views are not important.
- B. Pathway with low groundcovers and scattered shrubs for pedestrian safety.
- C. Bank with groundcovers and clear-stemmed trees for stability and enhanced views. Scattered pockets of shrubs for habitat.
- D. Increase shrub plantings in lower areas where views are not impeded.
- E. Toe of bank with dense groundcovers for erosion control and fringing habitat
- F. Retain or add in-stream large woody debris for edge protection and habitat.

Recommended species and planting density (see Appendix C for additional species)

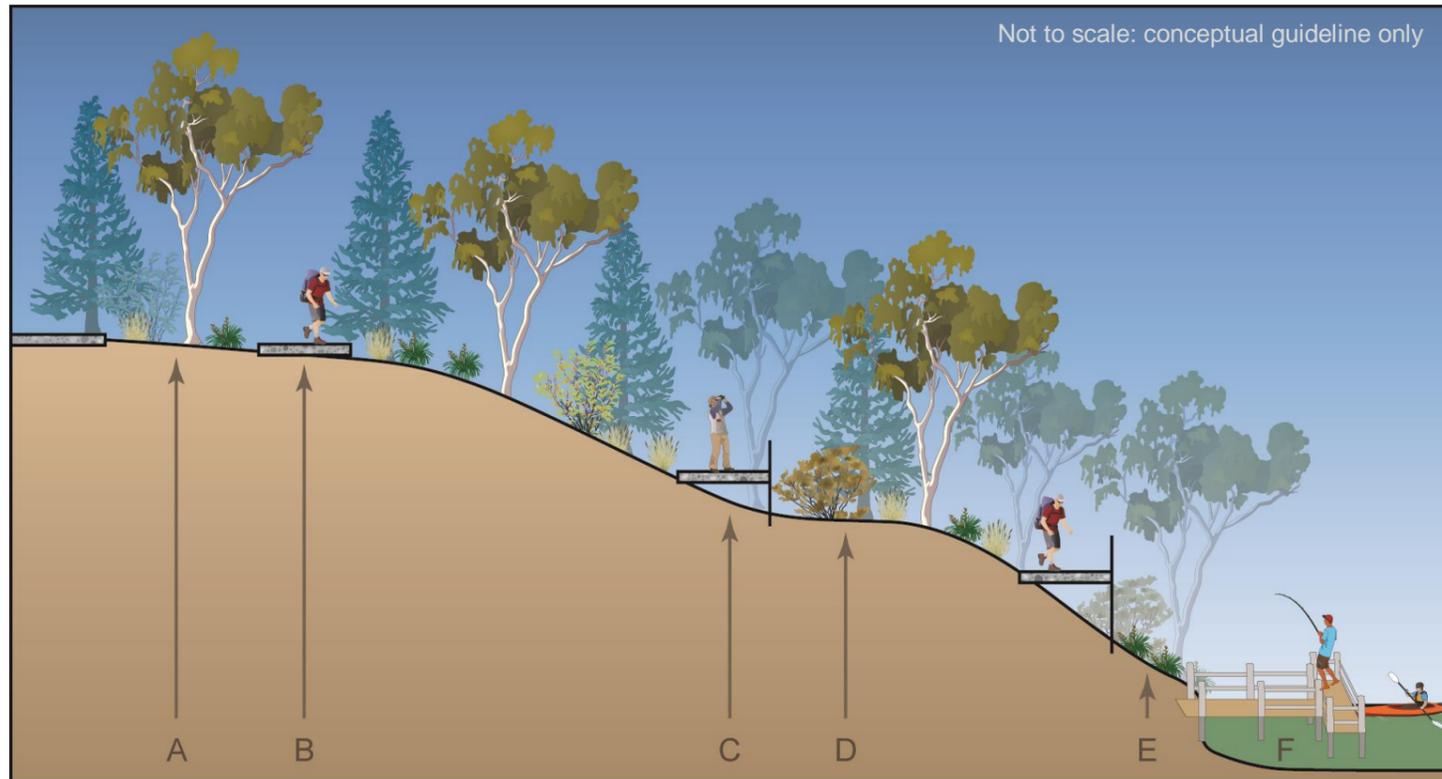
Scientific name	Type	A	B	C	D	E
<i>Acacia binervia</i>	Small tree	X		X		
<i>Acacia implexa</i>	Small tree	X				
<i>Acacia parramattensis</i>	Small tree	X				
<i>Adiantum aethiopicum</i>	Groundcover		X			X
<i>Alternanthera denticulata</i>	Groundcover		X			X
<i>Angophora subvelutina</i> ^{1,2}	Tall tree			X	X	
<i>Breynia oblongifolia</i>	Shrub	X	X	X	X	
<i>Bursaria spinosa</i>	Shrub	X		X	X	
<i>Carex appresa</i>	Groundcover					X
<i>Casuarina cunninghamiana</i> ^{1,2}	Tall tree	X				
<i>Clerodendrum tomentosum</i>	Tall shrub	X		X		
<i>Commelina cyanea</i>	Groundcover	X	X	X	X	X
<i>Eucalyptus agglomerate</i> ¹	Tall tree	X		X	X	
<i>Eucalyptus amplifolia subsp. amplifolia</i> ^{1,2}	Tall tree			X	X	
<i>Eucalyptus deanei</i> ¹	Tall tree				X	
<i>Eucalyptus saligna</i> ¹	Tall tree	X		X		
<i>Eucalyptus tereticornis</i> ²	Tall tree	X		X		
<i>Ficus coronata</i>	Small tree	X	X	X		
<i>Glochidion ferdinandi var. ferdinandi</i>	Small tree	X	X	X		
<i>Hibiscus heterophyllus var. heterophyllus</i>	Shrub	X			X	
<i>Juncus usitatus</i>	Groundcover					X
<i>Lachnagrostis filiformis</i>	Groundcover		X			X
<i>Lomandra longifolia</i>	Groundcover		X		X	X
<i>Microlaena stipoides var. stipoides</i>	Groundcover					X
<i>Phyllanthus gunnii</i>	Small shrub	X	X	X	X	
<i>Pittosporum revolutum</i>	Shrub	X		X	X	
<i>Trema aspera</i>	Tall shrub	X				

1) Dominant trees selected for Alluvial Woodland and Riparian Forest

2) Dominant trees selected for Shale Plains Woodland

Suggested planting density: tall tree 1/50 m²; small tree 1/25 m²; tall shrub 1/25 m²; shrub 1/10 m²; groundcover 2-4/m² or as required.

5.11 Treatment Zone 5 - Water edge access point



Legend (proposed vegetation management)

- A. All of bank (from highest bank to near water) with groundcovers and scattered clear-stemmed trees for stability and enhanced views.
- B. Pedestrian access may zigzag down the bank between trees. Elevated boardwalk will reduce the need for cut and fill and therefore minimise erosion. Grade and width may need to suit transport of small water craft (e.g. kayaks).
- C. Potential rest points, lookouts or seating opportunities on lower bank.
- D. Dense shrubs where views are not impeded.
- E. Toe of bank with dense groundcovers for erosion control.
- F. Access jetty and fencing to deter pedestrians from walking on adjacent bank.

Recommended species and planting density (see Appendix C for additional species)

Scientific name	Type	A	B	C	D	E
<i>Acacia binervia</i>	Small tree	X				
<i>Adiantum aethiopicum</i>	Groundcover		X	X		X
<i>Alternanthera denticulata</i>	Groundcover					X
<i>Angophora subvelutina</i> ^{1,2}	Tall tree	X			X	X
<i>Breynia oblongifolia</i>	Shrub		X		X	X
<i>Bursaria spinosa</i>	Shrub				X	
<i>Carex appresa</i>	Groundcover					X
<i>Commelina cyanea</i>	Groundcover	X	X	X	X	
<i>Eucalyptus agglomerate</i> ¹	Tall tree	X			X	
<i>Eucalyptus amplifolia</i> subsp. <i>amplifolia</i> ^{1,2}	Tall tree	X			X	X
<i>Eucalyptus deanei</i> ¹	Tall tree				X	X
<i>Eucalyptus saligna</i> ¹	Tall tree	X			X	
<i>Eucalyptus tereticornis</i> ²	Tall tree	X			X	
<i>Ficus coronata</i>	Small tree	X				
<i>Glochidion ferdinandi</i> var. <i>ferdinandi</i>	Small tree	X				
<i>Hibiscus heterophyllus</i> var. <i>heterophyllus</i>	Shrub		X		X	
<i>Juncus usitatus</i>	Groundcover					X
<i>Lachnagrostis filiformis</i>	Groundcover		X	X		X
<i>Lomandra longifolia</i>	Groundcover	X	X	X	X	X
<i>Microlaena stipoides</i> var. <i>stipoides</i>	Groundcover		X			X
<i>Phyllanthus gunnii</i>	Small shrub		X		X	

1) Dominant trees selected for Alluvial Woodland and Riparian Forest. Alternative species can include *Casuarina cunninghamiana*.
 2) Dominant trees selected for Shale Plains Woodland. Alternative species can include *Casuarina cunninghamiana*.
 Suggested planting density: tall tree 1/50 m²; small tree 1/25 m²; tall shrub 1/25 m²; shrub 1/10 m²; groundcover 2-4/m² or as required.

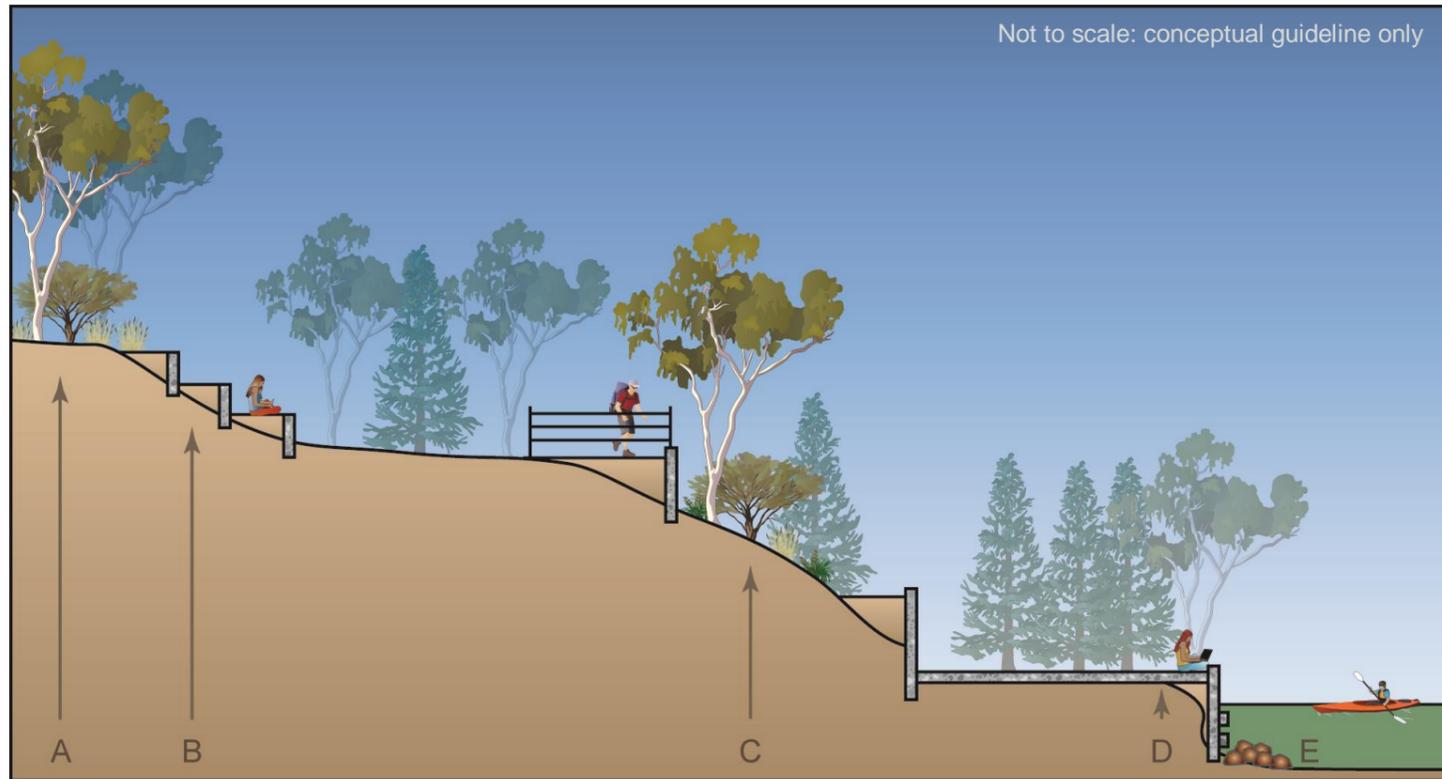
Key management issues

- Provide safe pedestrian access and/or views to water edge.
- Steep banks are at risk of erosion.
- Dense exotic trees and native *Casuarina cunninghamiana* are blocking views or access to the river in some locations.

Prioritised actions

Priority	Action
High	<ul style="list-style-type: none"> • Staged removal of trees and shrubs, leaving root ball in ground for continued bank stability. • Design access paths and jetties with gentle grade using zigzag pattern, elevated boardwalk decking and fencing to exclude pedestrians from vegetated bank.
Medium	<ul style="list-style-type: none"> • Construct paths, boardwalks, jetties etc. • Retain or plant scattered native trees between paths. • Retain or plant native shrubs and groundcovers to stabilise the remainder of bank. Use shrubs where views are not important.
Low	<ul style="list-style-type: none"> • Continue weed control of exotic trees, shrubs and groundcovers to allow successful establishment of native plantings. • Selectively prune branches of existing dense Casuarinas to improve filtered river views from the lower path, but only once native planting are well established and successful.

5.12 Treatment Zone 6 - Key destinations



Key management issues

- Provide key destinations at Weir Reserve, Jamison Rd entry, Tench Reserve and Regatta Park as per the Master Plan.
- Create a safe and expansive open space for mixed events: from small picnic groups to community festivals.
- Provide views and/or seamless connection to river foreshore.
- Banks are very steep at risk of erosion where there are few trees for stability.
- Currently, views from these key locations are partially blocked by native vegetation fringing the channel.

Prioritised actions

Priority	Action
High	<ul style="list-style-type: none"> • Design, assess and obtain approval for construction of facilities (e.g. amphitheatres, car parks, stairs, lookouts etc) for the key destination sites as indicated in the Plan of Management. • Plant offset areas of habitat to compensate for proposed loss of riparian vegetation. • Implement weed control in adjacent habitats to protect endangered communities from further degradation.
Medium	<ul style="list-style-type: none"> • Construct key destination facilities. • Remove vegetation at proposed key destinations once offset areas have been established. • Consider fencing adjacent habitat to deter pedestrian straying from key destinations. • Plant pockets of native vegetation as part of landscaping works at key destinations, with an aim to provide 'stepping-stone' habitat patches along the riparian corridor.

Legend (proposed vegetation management)

- A. Where possible, retain remnant native vegetation and protect from human activities (e.g. small landscape walls to create native garden beds).
- B. Stabilise steep banks with stepped landscaped paths and seating (e.g. grassed amphitheatre).
- C. Provide small pockets of native planting beds with scattered trees to provide habitat nodes. Plant shrubs where views aren't blocked. Use clear-stemmed trees for improved views.
- D. Reinforce toe of bank with walls and paths.
- E. Provide submerged rocky substrate to create aquatic habitat complexity. Vertical walls to have surface roughness to provide micro-habitat for aquatic life.

Recommended species and planting density (see Appendix C for additional species)

Scientific name	Type	A	B	C
<i>Acacia binervia</i>	Small tree	X		
<i>Adiantum aethiopicum</i>	Groundcover		X	
<i>Alternanthera denticulata</i>	Groundcover		X	
<i>Angophora subvelutina</i> ^{1,2}	Tall tree	X		X
<i>Breynia oblongifolia</i>	Shrub	X		
<i>Bursaria spinosa</i>	Shrub	X		
<i>Commelina cyanea</i>	Groundcover		X	
<i>Eucalyptus agglomerate</i> ¹	Tall tree	X		
<i>Eucalyptus amplifolia subsp. amplifolia</i> ^{1,2}	Tall tree	X		X
<i>Eucalyptus deanei</i> ¹	Tall tree			X
<i>Eucalyptus saligna</i> ¹	Tall tree	X		
<i>Eucalyptus tereticornis</i> ²	Tall tree	X		
<i>Ficus coronate</i>	Small tree	X		X
<i>Glochidion ferdinandi var. ferdinandi</i>	Small tree	X		X
<i>Juncus usitatus</i>	Groundcover		X	
<i>Lomandra longifolia</i>	Groundcover	X	X	X
<i>Phyllanthus gunnii</i>	Small shrub	X		X
<i>Pittosporum revolutum</i>	Shrub	X		X

1) Dominant trees selected for Alluvial Woodland and Riparian Forest. Alternative species can include *Casuarina cunninghamiana*.
 2) Dominant trees selected for Shale Plains Woodland. Alternative species can include *Casuarina cunninghamiana*.
 Suggested planting density: tall tree 1/50 m²; small tree 1/25 m²; tall shrub 1/25 m²; shrub 1/10 m²; groundcover 2-4/m² or as required.

5.13 Treatment Zone 7 - Infrastructure



Legend (proposed vegetation management)

- A. Infrastructure (bridges, power lines, culverts etc) to be planted with low growing shrubs and groundcovers to stabilise soil. Species may vary with shade, soil type and access requirements. Rock reinforcing may be required.
- B. Pedestrian access to be stabilised with low growing groundcovers. Paths may zigzag down steep banks to allow access to water edge.
- C. High bank to be densely planted with native shrubs and groundcovers to stabilise banks. No tall growing species as these may impede power lines and bridges.
- D. Lower bank can have greater flexibility in paths (intersections, stairs, lookout platforms, seating, etc) due to lack of trees. Low groundcovers should be used to stabilise edges of paths.
- E. Toe of bank with stabilised material and groundcovers.
- F. Water access possible due to lack of trees and stabilised banks. Placing access points here will reduce the impact to other vegetated banks.

Recommended species and planting density (see Appendix C for additional species)

Scientific name	Type	A	B	C	D	E
<i>Adiantum aethiopicum</i>	Groundcover	X	X	X	X	X
<i>Alternanthera denticulata</i>	Groundcover	X	X	X	X	X
<i>Breynia oblongifolia</i>	Shrub	X	X	X	X	
<i>Bursaria spinosa</i>	Shrub	X	X	X	X	
<i>Carex appresa</i>	Groundcover					X
<i>Clerodendrum tomentosum</i>	Tall shrub			X		
<i>Commelina cyanea</i>	Groundcover	X	X	X	X	X
<i>Ficus coronate</i>	Small tree			X		
<i>Glochidion ferdinandi var. ferdinandi</i>	Small tree			X		
<i>Hibiscus heterophyllus var. heterophyllus</i>	Shrub	X	X	X	X	
<i>Juncus usitatus</i>	Groundcover	X	X		X	X
<i>Lachnagrostis filliformis</i>	Groundcover	X	X	X	X	X
<i>Lomandra longifolia</i>	Groundcover	X	X	X	X	X
<i>Microlaena stipoides var. stipoides</i>	Groundcover	X	X	X	X	X
<i>Phyllanthus gunnii</i>	Small shrub	X	X	X	X	
<i>Pittosporum revolutum</i>	Shrub	X	X	X	X	
<i>Trema aspera</i>	Tall shrub			X		

Suggested planting density: small tree 1/25 m²; tall shrub 1/25 m²; shrub 1/10 m²; groundcover 2-4/m² or as required.

Key management issues

- Infrastructure assets (e.g. power lines, bridges, culverts and pipes) require protection and access for maintenance. Banks are very steep and are at risk of erosion where there are few trees for stability; however, trees are not appropriate beneath power lines or close to bridges. Tree roots may also impact pipes and culverts within the bank.
- Exotic trees, shrubs and groundcovers are well established along the banks.

Prioritised actions

Priority	Action
High	<ul style="list-style-type: none"> • Consider locating water access points (e.g. small jetties and steps) in the infrastructure zone, as these areas require tree removal or thinning. • Remove exotic trees, leaving root ball in ground for continued bank stability. • Remove or lop native trees that may impede infrastructure (this is likely to be done by the asset manager and will be an ongoing task). Noting that power lines may have high enough clearance above canopy.
Medium	<ul style="list-style-type: none"> • Plant native shrubs and groundcovers along bank to replace trees, and cover all bare areas.
Low	<ul style="list-style-type: none"> • Continue weed control and management of trees, shrubs and groundcovers to allow successful establishment of suitable native plantings.

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Appendix A: Riparian vegetation profiles

A brief summary of the riparian character along the Nepean River is given in the following pages. Vegetation profiles are grouped into the following regions (see **Figure 4** over page for location of photographs).

Western bank

- Lapstone Place to M4 Western Motorway (**Table 5, Plate 7, Plate 8**)
- M4 Western Motorway to Regatta Park (**Table 6, Plate 9, Plate 10**)
- Regatta Park to Great Western Highway (**Table 7, Plate 11, Plate 12**)

Eastern bank

- Paddlewheeler slipway to Tench Reserve boat ramp (**Table 8, Plate 13, Plate 14**)
- Tench Reserve boat ramp to Jamison Road (**Table 9, Plate 15, Plate 16**)
- Jamison Road to Captains Road (**Table 10, Plate 17, Plate 18**)
- Old Ferry Road to Penrith Weir (**Table 11, Plate 19, Plate 20**)

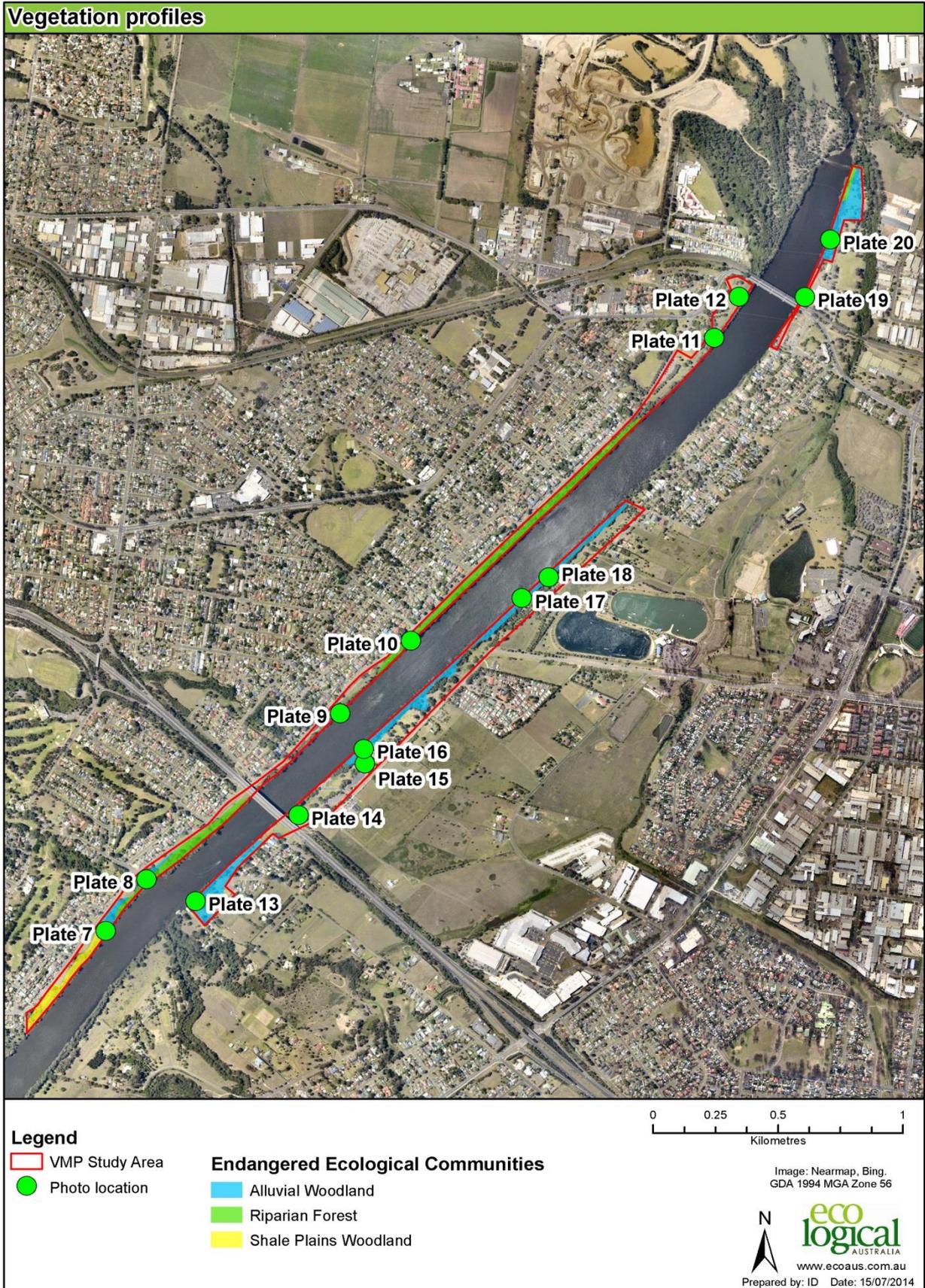


Figure 4: Location of photograph plates

Table 5: Lapstone Place to M4 Western Motorway

Location	Western bank: Lapstone Place to M4 Western Motorway
Description	River Road foreshore upstream of the M4. Upper banks mostly slashed grass. Lower banks steep and inaccessible.
Endangered Ecological Community	Cumberland Plain Woodland (Shale Plains Woodland). River-flat Eucalypt Forest (Riparian Forest and Alluvial Woodland).
Riparian condition	Mostly lacks large native trees, although small patches of old Eucalypts. Very dense weedy understorey, especially on lower banks. Evidence of bush regeneration works and vandalism to planted trees.



Plate 7: Weedy understorey near Parklands Avenue



Plate 8: Small patch of native trees near Buring Avenue

Table 6: M4 Western Motorway to Regatta Park

Location	Western bank: M4 Western Motorway to Regatta Park
Description	River Road foreshore on steep bank downstream of M4. Lower bank mostly dense vegetation. Footpath traverses upper and lower banks.
Endangered Ecological Community	River-flat Eucalypt Forest (Riparian Forest).
Riparian condition	Mix of native and exotic tree species forming sparse-to-dense structure. Occasional shrubs where trees lacking. Groundcover weeds common.



Plate 9 Large woody debris and grassy understorey near Beach Lane

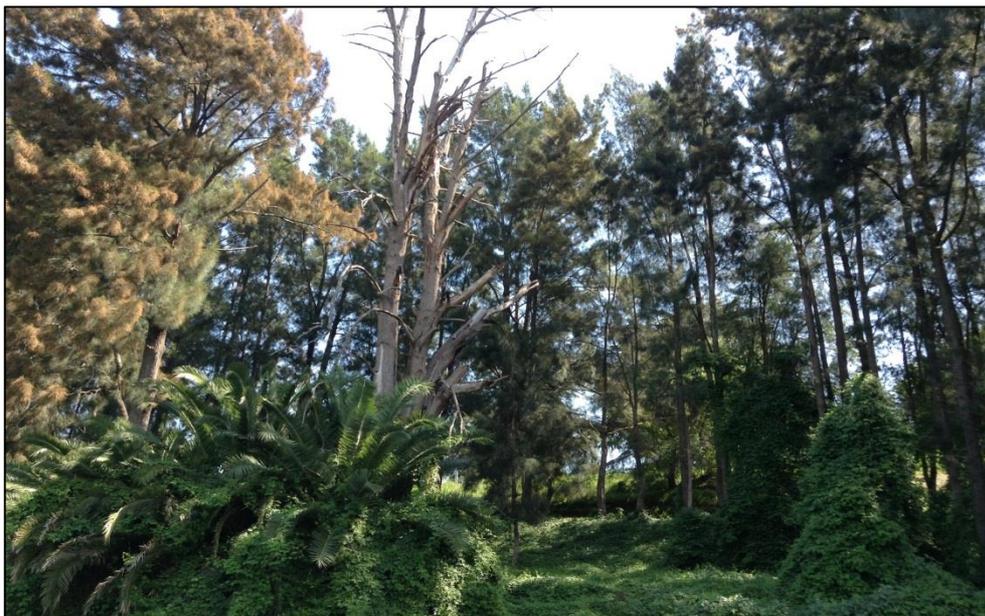


Plate 10: Continuous tree line, with dead habitat tree and weedy understorey near Hunter St

Table 7: Regatta Park to Great Western Highway

Location	Western bank: Regatta Park to Great Western Highway
Description	River Road Reserve upstream of Victoria Bridge.
Endangered Ecological Community	None.
Riparian condition	Narrow band of native trees fringing water's edge. Remainder is mostly slashed grass and planted exotic trees.



Plate 11: Cleared bank with continuous tree line and planted exotic trees near Punt Road



Plate 12: Cleared bank with continuous tree line near Punt Road

Table 8: Paddlewheeler slipway to Tench Reserve boat ramp

Location	Eastern bank: Paddlewheeler slipway to Tench Reserve boat ramp
Description	Includes parkland area at end of Factory Road, foreshore in front of residential area, open lawns around M4 bridge and parkland upstream of Council boat ramp.
Endangered Ecological Community	River-flat Eucalypt Forest (Alluvial Woodland).
Riparian condition	Small patches of native trees fringing water's edge. Evidence of lower bank slumping (likely caused by boat wash) and trampled vegetation from pedestrian access. Groundcover weeds common on steep banks.

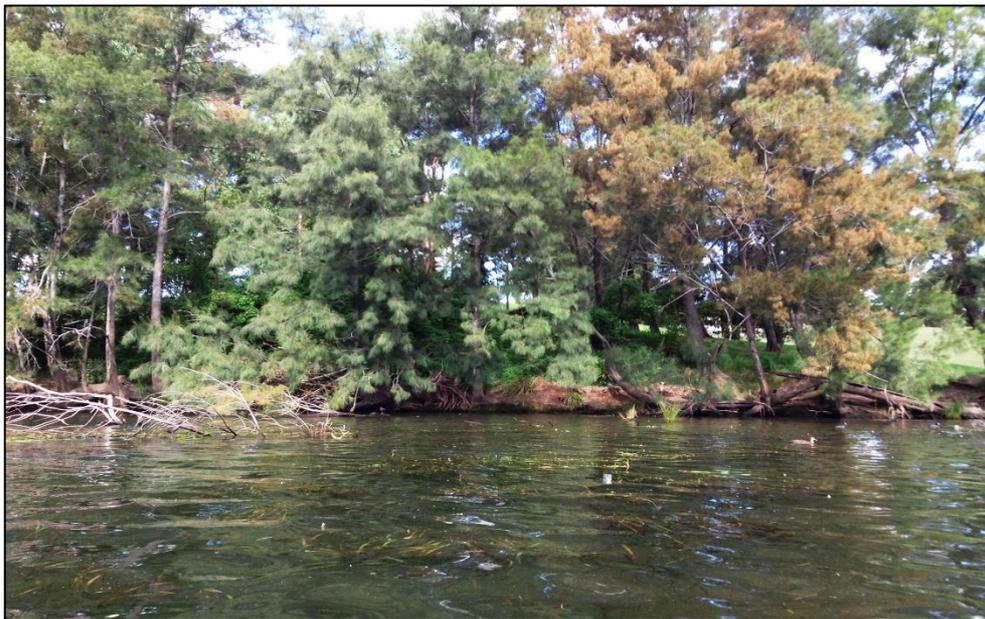


Plate 13: Native foreshore trees near Paddlewheeler slipway



Plate 14: Weedy bank near M4 bridge

Table 9: Tench Reserve boat ramp to Jamison Road

Location	Eastern bank: Tench Reserve boat ramp to Jamison Road
Description	Main area of Tench Reserve with footpaths, BBQs, picnic tables and playgrounds.
Endangered Ecological Community	River-flat Eucalypt Forest (Alluvial Woodland).
Riparian condition	Continuous strip of native trees along lower bank of river, with mix of native and exotic understorey species. Evidence of bush regeneration adjoining lower bank. Mid and upper banks are slashed parkland with patches of native trees.

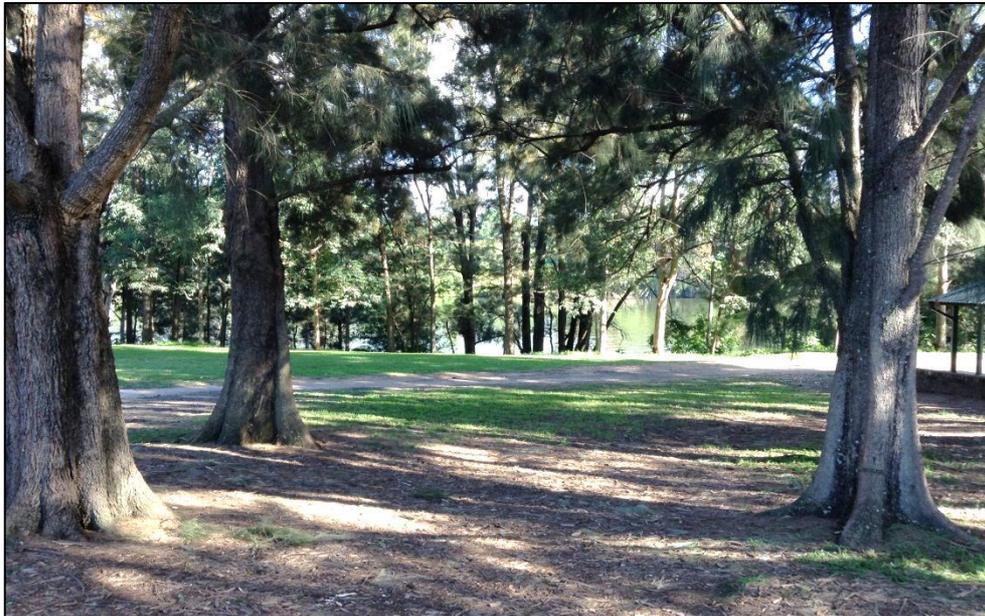


Plate 15: Small patches of native trees in Tench Reserve near car park



Plate 16: Tench Reserve lawns and continuous tree line near main car park

Table 10: Jamison Road to Captains Road

Location	Eastern bank: Jamison Road to Captains Road
Description	Secondary area of Tench Reserve with one footpath.
Endangered Ecological Community	River-flat Eucalypt Forest (Alluvial Woodland).
Riparian condition	Continuous strip of riparian trees and shrubs, with better quality habitat than other parts of the study area. Groundcover weeds common. Bush regeneration evident in patches. Large area of slashed grass on mid and upper bank, with avenue tree planting and small patches of native trees.



Plate 17: Various sized native species near Madang Park Farm House



Plate 18: Dense coverage of native and weed species near Nepean Avenue

Table 11: Old Ferry Road to Penrith Weir

Location	Eastern bank: Old Ferry Road to Penrith Weir
Description	Foreshore land of in front of Log Cabin Motel, Rowing Club and Weir Reserve.
Endangered Ecological Community	River-flat Eucalypt Forest (Riparian Forest and Alluvial Woodland).
Riparian condition	Mixed condition, from completely cleared to scattered native trees with dense weedy understorey. Bush regeneration evident in Weir Reserve. Very dense weeds near confluence with Peach Tree Creek.



Plate 19: Mixed native and weedy shrubs near rowing club

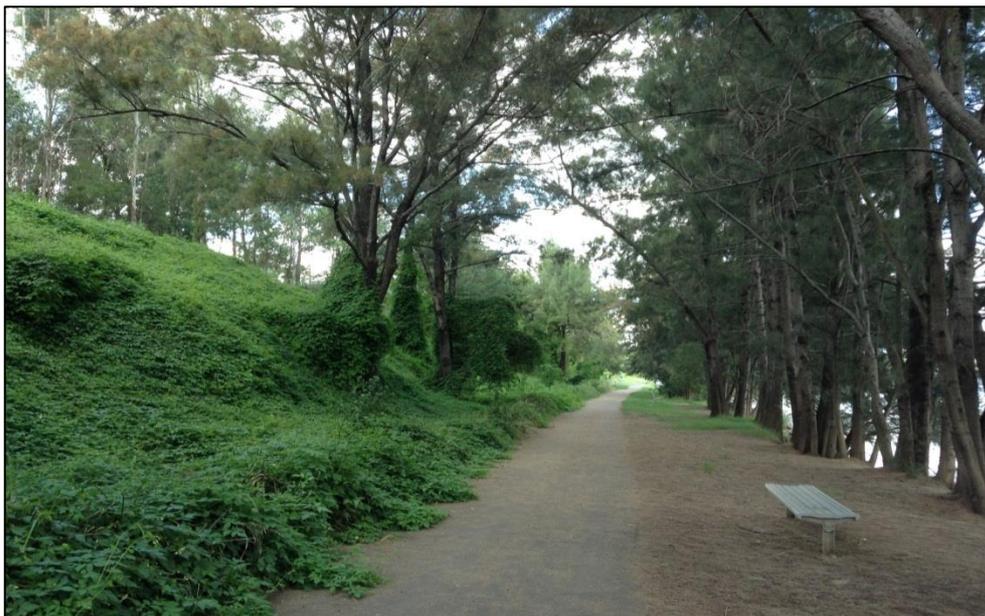


Plate 20: Row of Casuarinas and weedy groundcover in Weir Reserve

Appendix B: Dominant flora recorded in the study area

Scientific Name	Common Name	Native/Exotic	Noxious	WONS	1	2	3	4
<i>Acacia binervia</i>	Coast Myall	N					X	
<i>Acacia floribunda</i>	White Sally Wattle	N			X		X	X
<i>Acacia parramattensis</i>	Parramatta Wattle	N			X			
<i>Acer negundo</i>	Box Elder	E					X	
<i>Acetosa sagittata</i>	Turkey Rhubarb	E				X	X	X
<i>Ageratina adenophera</i>	Crofton weed	E				X		
<i>Ailanthus altissima</i>	Tree of Heaven	E						
<i>Anredera cordifolia</i>	Madeira Vine	E		X	X		X	X
<i>Araujia sericifera</i>	Moth Vine	E			X			
<i>Austrostipa ramosissima</i>	Stout Bamboo Grass	N				X		
<i>Bidens pilosa</i>	Cobblers Pegs	E			X	X		X
<i>Bidens subalternans</i>	Greater Beggars Tick	E					X	
<i>Breynia oblongifolia</i>	Common Breynia	N						
<i>Bursaria spinosa</i>	Blackthorn	N			X			
<i>Callistemon citrinus</i>	Crimson Bottlebrush	N						
<i>Cardiospermum grandiflorum</i>	Balloon vine	E			X	X	X	X
<i>Casuarina cunninghamiana</i>	River Oak	N						X
<i>Celtis sinensis</i>	Hackberry	E			X			X
<i>Cestrum parqui</i>	Green Cestrum	E						
<i>Chloris gayana</i>	Rhodes Grass	E			X		X	
<i>Cinnamomum camphora</i>	Camphor Laurel	E						
<i>Commelina cyanea</i>		N			X			X
<i>Conyza</i> sp.	Fleabane	E					X	
<i>Cortaderia selloana</i>	Pampas Grass	E						
<i>Cynodon dactylon</i>	Couch	E			X	X		
<i>Delairea odorata</i>	Cape Ivy	E					X	
<i>Digitaria ciliaris</i>	Summer Grass	E			X			
<i>Ehrharta erecta</i>	Panic Veldtgrass	E			X	X	X	X
<i>Eragrostis curvula</i>	African Lovegrass	E				X		
<i>Erythrina x sykesii</i>	Coral Tree	E						
<i>Eucalyptus amplifolia</i>	Cabbage Gum	N			X			
<i>Eucalyptus crebra</i>	Narrow leaved Ironbark	N						
<i>Eucalyptus</i> sp.		N				X	X	X
<i>Eucalyptus tereticornis</i>	Forest Red Gum	N			X			
<i>Foeniculum vulgare</i>	Fennel	E						
<i>Gahnia clarkei</i>	Tall Saw-sedge	N						
<i>Gleditsia triacanthos</i>	Honey Locust	E					X	
<i>Hibiscus heterophyllus</i> subsp. <i>heterophyllus</i>	Native Rosella	N					X	
<i>Hydrilla verticillata</i>	Hydrilla	N						
<i>Ipomoea indica</i>	Morning Glory	E						
<i>Jacaranda mimosifolia</i>	Jacaranda	E						X
<i>Juncus usitatis</i>	Common Rush	N						
<i>Lantana camara</i>	Lantana	E		X			X	X
<i>Ligustrum lucidum</i>	Large-leaf Privet	E						X
<i>Ligustrum sinense</i>	Small-leaf Privet	E						X
<i>Lomandra longifolia</i>	Honey Reed	N				X		X
<i>Melaleuca stypheloides</i>	Prickly-leaved Tea Tree	N				X		

Nepean River 'Our River': Riparian Vegetation Management Plan

Scientific Name	Common Name	Native/Exotic	Noxious	WONS	1	2	3	4
<i>Melia azedarach</i>	White Cedar	N			X			
<i>Microlaena stipoides</i>	Weeping Grass	N			X			
<i>Modiola caroliniana</i>	Red-flowered Mallow	E			X			
<i>Oplismenus aemulus</i>	Australian Basket Grass	N			X			
<i>Paspalum dilatatum</i>	Paspalum	E			X		X	X
<i>Pavonia hastata</i>	Pink Pavonia	E				X		
<i>Pennisetum clandestinum</i>	Kikuyu	E			X			
<i>Persicaria decipiens</i>	Slender knotweed	N						
<i>Phoenix canariensis</i>	Canary Island Date Palm	E						
<i>Phragmites australis</i>	Common Reed	N						
<i>Plantago lanceolata</i>	Lamb's Tongue	E						
<i>Populus alba</i>	White Poplar	E						X
<i>Ricinus communis</i>	Castor Oil Plant	E			X		X	
<i>Rubus fruticosus</i> agg. spp.	Blackberry	E	X (4)	X				
<i>Salix nigra</i>	Black Willow	E		X				
<i>Schoenoplectrus validus</i>		N						
<i>Senna pendula</i> var. <i>glabra</i>	Cassia	E						
<i>Setaria</i> sp.	Pigeon Grass	E				X		
<i>Sida rhombifolia</i>	Paddy's Lucerne	E			X	X		X
<i>Sigesbeckia orientalis</i>		N						
<i>Solanum chenopodioides</i>	Whitetip Nightshade	N					X	
<i>Solanum mauritianum</i> .	Wild Tobacco Plant	N					X	
<i>Solanum nigrum</i>	Black-berry Nightshade	E				X		X
<i>Solanum</i> sp.		E					X	
<i>Tagetes minuta</i>	Stinking Roger	E				X	X	
<i>Taraxacum officinale</i>	Dandelion	E						
<i>Toona ciliata</i>	Red Cedar	N						
<i>Tradescantia fluminensis</i>	Trad	E				X		
<i>Trema tomentosa</i>	Native Peach	N			X		X	
<i>Tropaeolum majus</i>	Nasturtium	E						
<i>Typha</i> sp.	Cumbungi	N						
<i>Vallisneria australis</i>	Ribbonweed	N						
<i>Verbena</i> sp.	Purpletop	E						

Noxious Class: 4 – The plant must not be sold, propagated or knowingly distributed

WONS: Weeds of National Significance

Columns titled 1, 2, 3 and 4 refer to survey sites: See **Appendix D**

Appendix C: Recommended riparian species for Nepean River at Penrith

Scientific name	Common name
Trees and tall shrubs (scientific name)	
<i>Acacia binervia</i>	Coast Myall
<i>Acacia floribunda</i>	White Sally
<i>Acacia implexa</i>	Hickory Wattle
<i>Acacia parramattensis</i>	Sydney Green Wattle
<i>Angophora subvelutina</i>	Broad-leaved Apple
<i>Casuarina cunninghamiana</i>	River Oak
<i>Eucalyptus agglomerata</i>	Blue-leaved Stringybark
<i>Eucalyptus amplifolia</i> subsp. <i>amplifolia</i>	Cabbage Gum
<i>Eucalyptus deanei</i>	Mountain Blue Gum
<i>Eucalyptus saligna</i>	Sydney Blue Gum
<i>Eucalyptus punctata</i>	Grey Gum
<i>Eucalyptus tereticornis</i>	Forest Red Gum
<i>Ficus coronata</i>	Creek Sandpaper Fig
<i>Glochidion ferdinandi</i> var. <i>ferdinandi</i>	Cheese Tree
<i>Melia azedarach</i>	White Cedar
Understorey shrubs < 5 metres high (scientific name)	
<i>Breynia oblongifolia</i>	Common Breynia
<i>Bursaria spinosa</i>	Native Blackthorn
<i>Clerodendrum tomentosum</i>	Hairy Clerodendrum
<i>Hibiscus heterophyllus</i> var. <i>heterophyllus</i>	Native Rosella
<i>Phyllanthus gasstroemii</i>	Blunt Spurge
<i>Phyllanthus gunnii</i>	Spurge
<i>Pittosporum revolutum</i>	Yellow Pittosporum
<i>Rubus parvifolius</i>	Native Raspberry
<i>Trema aspera</i>	Native Poison Peach
Shallow water and wetland species (scientific name)	
<i>Alisma plantago-aquatica</i>	Water Plantain
<i>Azolla pinnata</i>	Ferny Azolla
<i>Bolboschoenus fluviatilis</i>	Marsh Club-rush
<i>Centipeda minima</i>	
<i>Cyperus difformis</i>	Variable Flat-sedge
<i>Cyperus exaltatus</i>	Tall-flat Sedge
<i>Cyperus laevis</i>	Flat Sedge
<i>Fimbristylis velata</i>	Fringe-rush
<i>Ludwigia peploides</i> subsp. <i>montevidensis</i>	Water Primrose
<i>Paspalum distichum</i>	Water Couch
<i>Phragmites australis</i>	Common Reed
<i>Potamogeton tricarinatus</i>	Floating Pondweed
<i>Schoenoplectus validus</i>	River Club-rush
<i>Spirodela</i> sp.	Small Duckweed
<i>Typha orientalis</i>	Broad-leaved Cumbungi
Submerged freshwater perennials (scientific name)	
<i>Najas tenuifolia</i>	Water Nymph
<i>Vallisneria gigantea</i>	Eel-weed
Grasses, herbs and ferns (scientific name)	
<i>Adiantum aethiopicum</i>	Maidenhair Fern
<i>Agrostis avenacea</i>	Blown Grass

Scientific name	Common name
<i>Alternanthera denticulata</i>	Lesser Joyweed
<i>Carex appresa</i>	Tall Sedge
<i>Cheilanthes sieberi</i> subsp. <i>sieberi</i>	Poison Rock Fern
<i>Commelina cyanea</i>	Scurvy Weed
<i>Echinopogon caespitosus</i>	Tufted Hedgehog Grass
<i>Elymus scaber</i> var. <i>scaber</i>	
<i>Entolasia stricta</i>	Wiry Panic
<i>Geranium homeanum</i>	
<i>Helichrysum scorpioides</i>	Button Everlasting
<i>Hydrocotyle peduncularis</i>	Pennywort
<i>Imperata cylindrica</i>	Blady Grass
<i>Juncus usitatus</i>	Common Rush
<i>Lomandra longifolia</i>	Spiny-headed Mat-rush
<i>Ludwigia peploides</i> subsp. <i>montevidensis</i>	Water Primrose
<i>Microlaena stipoides</i> var. <i>stipoides</i>	Weeping Grass
<i>Nicotiana suaveolens</i>	
<i>Opercularia aspera</i>	Common Stinkweed
<i>Oplismenus aemulus</i>	Soft-leaved Creeping Grass
<i>Oxalis chnoodes</i>	
<i>Paspalidium distans</i>	
<i>Persicaria decipiens</i>	Slender Knotweed
<i>Persicaria hydropiper</i>	Water Pepper
<i>Persicaria lappathifolia</i>	
<i>Persicaria orientalis</i>	Princes Feather
<i>Poa labillardieri</i>	Tussock Grass
<i>Pratia purpurascens</i>	White Root
<i>Pseudognaphalium luteoalbum</i>	Jersey Cudweed
<i>Pteridium esculentum</i>	Common Bracken
<i>Pteris tremula</i>	Tender Brake
<i>Sigesbeckia orientalis</i>	Indian-weed
<i>Stellaria flaccida</i>	Forest Starwort
<i>Stipa ramosissima</i>	Stout Bamboo Grass
<i>Stipa verticillata</i>	Stout Bamboo Grass
<i>Wahlenbergia communis</i>	Tufted Bluebell
<i>Wahlenbergia gracilis</i>	Australian Bluebell
Climbers and twiners (scientific name)	Common name
<i>Cayratia clematidea</i>	Slender Grape
<i>Cissus antarctica</i>	Native Grape
<i>Convolvulus erubescens</i>	Bindweed
<i>Eustrephus latifolius</i>	Wombat Berry
<i>Geitonoplesium cymosum</i>	Scrambling Lily
<i>Glycine tabacina</i>	
<i>Muehlenbeckia gracillima</i>	
<i>Polymeria calycina</i>	Polymeria
<i>Sarcopetalum harveyanum</i>	Pearl Vine
<i>Smilax australis</i>	Austral Sarsaparilla
<i>Stephania japonica</i> var. <i>discolor</i>	Snake Vine

Appendix D: Results of survey plots

We surveyed two Alluvial Woodland sites (Sites 1 and 2), one Shale Plains Woodland site (Site 3) and one Riparian Forest site (Site 4) in the study area on 19-20th March 2014 (**Table 12, Figure 5**). Survey methods followed those prescribed in the *Biodiversity Fund Ecological Monitoring Guide* (DSEWPC 2013). Each survey area comprised of a 50 m long transect and 20 x 20 m quadrat. Sites were selected in each reserve to be representative of the dominant vegetation community, and positioned in areas away from future development (i.e. away from water access locations identified in the Master Plan). The purpose of this placement is to allow for future monitoring of improved vegetation works, rather than documenting the loss of riparian habitat due to paths, stairs, car parks etc.

The following pages summarise the vegetation characteristics at these sites.

Table 12: Location of survey plots 19-20th March 2014

Site	Vegetation Community	Start easting	Start northing	Start photo	End easting	End northing	End photo
1	Alluvial Woodland	284248	6262347	Plate 21	284281	6262381	Plate 22
2	Alluvial Woodland	285475	6263756	Plate 23	285493	6263807	Plate 24
3	Shale Plains Woodland	282326	6260703	Plate 25	282359	6260744	Plate 26
4	Riparian Forest	284644	6263021	Plate 27	284685	6263053	Plate 28

Coordinate system: GDA 1994 MGA Zone 56

Transect length approximately 50 m

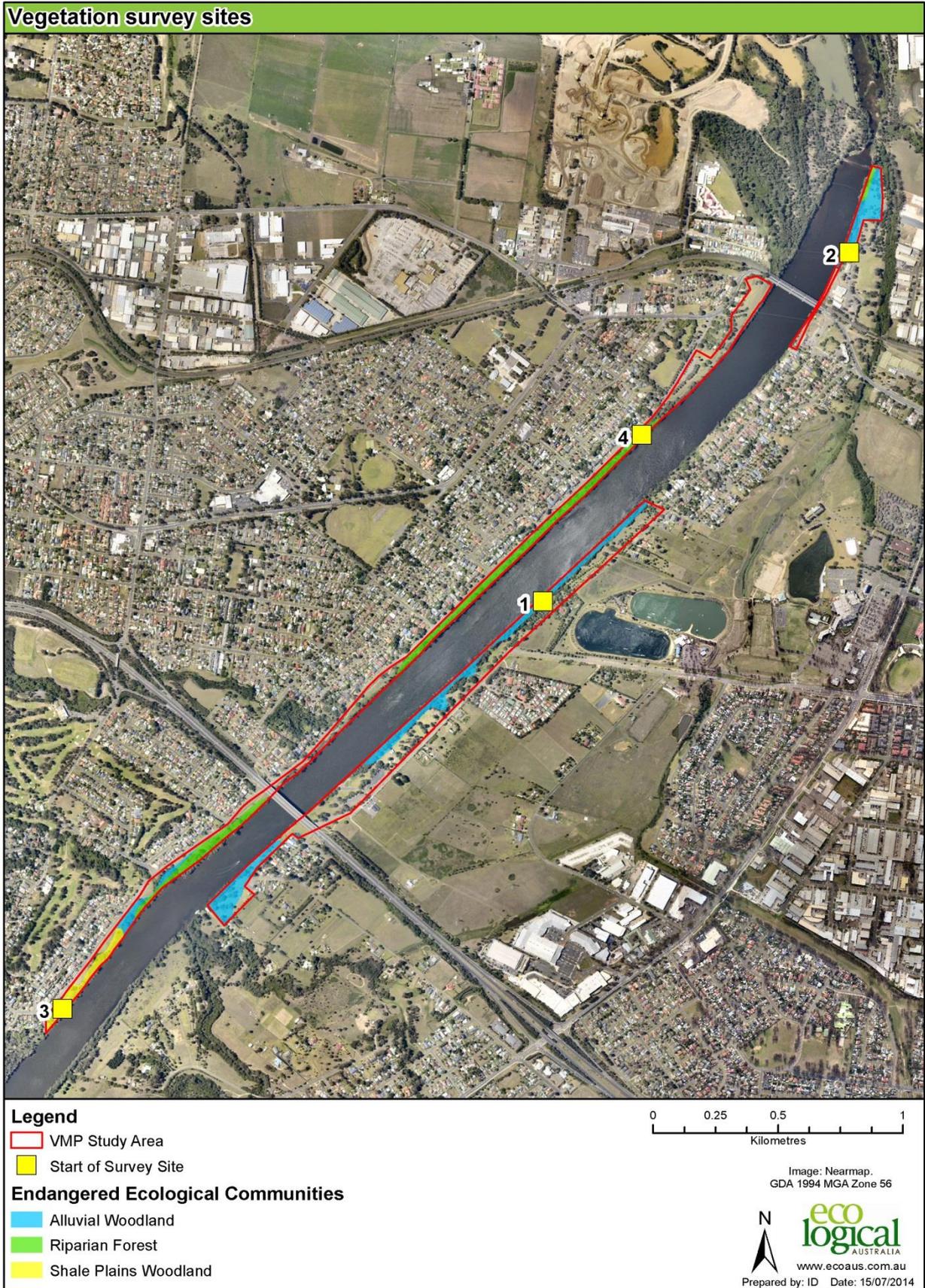


Figure 5: Vegetation survey site locations (19-20th March 2014)

Survey Site 1 (Alluvial Woodland) is positioned within a section of Alluvial Woodland with the quadrat vegetation including both woodland and mown exotic grassland. The site is located between the river and a pedestrian path. Bush regeneration activity is evident both within the survey site and nearby. No evidence of exotic fauna was present at the time of survey. Vegetation characteristics include:

- a groundcover consisting of 34% native species, 44% exotic species, 20% organic litter and 2% bare ground
- the projected crown cover from the native overstorey is 82% of the transect length with an average cover of 58.5%
- no exotic overstorey
- the projected crown cover from the native midstorey is 54% of the transect length
- the projected crown cover from the exotic midstorey represents 4% of the transect length
- 14 native species and 18 exotic species.

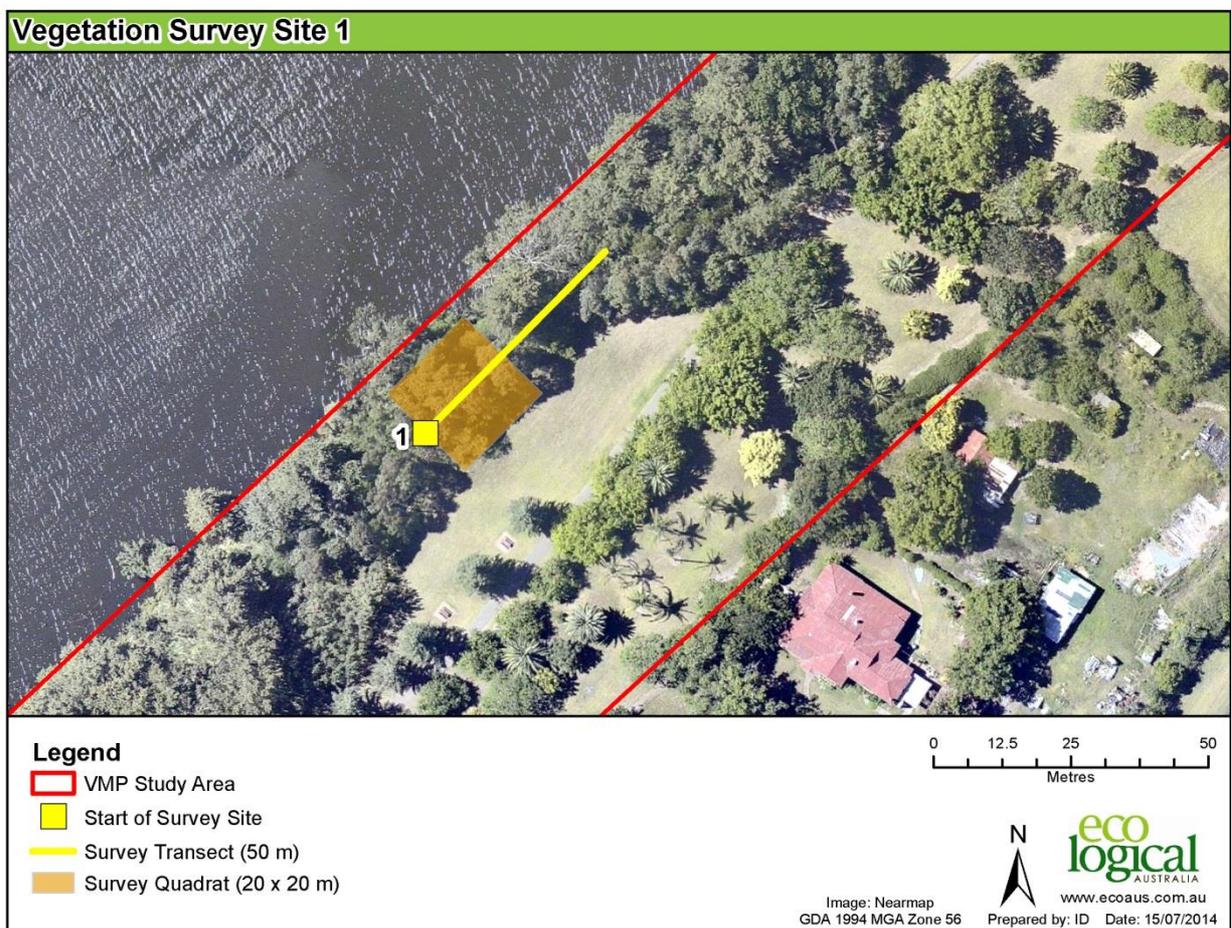


Figure 6: Aerial view of Survey Site 1 (image 2014, Nearmap)



Plate 21: Survey site 1 – photo from start of 50 m transect (facing north east)



Plate 22: Survey site 1 – photo from end of transect (facing south west)

Survey Site 2 (Alluvial Woodland) is located on a steep slope within the north eastern section of the study area, and is situated between a pedestrian path which is adjacent to the river and a road which accesses recreational areas to the east. The vegetation along the river in the vicinity of this site is predominantly Alluvial Woodland, however heavy weed infestations, primarily vines, dominate the steep slope sections. Bush regeneration activity in the form of past plantings along the eastern side of the quadrat is evident. No evidence of exotic fauna was present at the time of survey. Vegetation characteristics include:

- a groundcover consisting of 4% native species, 70% exotic species and 26% organic litter
- the projected crown cover from the native overstorey is 25% of the transect length with an average cover of 24%
- no exotic overstorey
- no projected crown cover from the native midstorey along the transect
- the projected crown cover from the exotic midstorey represents 9% of the transect length
- nine native species and 14 exotic species.



Figure 7: Aerial view of Survey Site 2 (image 2014, Nearmap)

Date & Time: Thu Mar 20 12:37:58 EST 2014
Position: 033.74455°S / 150.68412°E
Altitude: 29m
Azimuth/Bearing: 017° N17E 0302mils (True)
Elevation Grade: -003%
Horizon Grade: -001%
Zoom: 1X
Transect 2 Start



Plate 23: Survey site 2 – photo from start of 50 m transect (facing north east)

Date & Time: Thu Mar 20 12:59:03 EST 2014
Position: 033.74408°S / 150.68435°E
Altitude: 32m
Azimuth/Bearing: 210° S30W 3733mils (True)
Elevation Grade: -014%
Horizon Grade: -002%
Zoom: 1X
Transect 2 End



Plate 24: Survey site 2 – photo from end of transect (facing south west)

Survey Site 3 (Shale Plains Woodland) is located in the south west of the study site. Remnant trees from Shale Plains Woodland are nearby; however the only native species within this survey site are recently planted and are more representative of Alluvial Woodland or Riparian Forest. The survey site is heavily weed infested and is adjacent to a cleared area dominated by exotic grasses. The survey site is located on a bench beside a steep slope down to the river and vegetation consists woody, herbaceous and vine weed species. No evidence of exotic fauna was present at the time of survey. Vegetation characteristics include:

- a groundcover consisting of 2% native species, 86% exotic species and 12% organic litter
- no native overstorey
- no exotic overstorey
- the projected crown cover from the native midstorey is 2% of the transect length
- the projected crown cover from the exotic midstorey represents 13% of the transect length
- five native species (four recently planted) and 16 exotic species.



Figure 8: Aerial view of Survey Site 3 (image 2014, Nearmap)



Plate 25: Survey site 3 – photo from near start of 50 m transect (photo blocked by vines at actual start) (facing north east)



Plate 26: Survey site 3 – photo from end of transect (facing south west)

Survey Site 4 (Riparian Forest) is located on the western bank of the Nepean River adjacent to River Road in a narrow strip of Riparian Forest. As the vegetation strip is relatively narrow in this area the quadrat is positioned directly between the river and road and includes a pedestrian path. Vegetation in this vicinity includes both canopy and groundcover weed species. No evidence of exotic fauna was present at the time of survey. Vegetation characteristics include:

- a groundcover consisting of 6% native species, 74% exotic species, 18% organic litter and 2% bare ground
- the projected crown cover from the native over storey is 30% of the transect length with an average cover of 23%
- the projected crown cover from the exotic over storey is 31% of the transect length
- the projected crown cover from the native mid storey is 7% of the transect length
- the projected crown cover from the exotic mid storey represents 31% of the transect length
- six native species and 14 exotic species



Figure 9: Aerial view of Survey Site 4 (image 2014, Nearmap)



Plate 27: Survey site 4 – photo from start of 50 m transect (facing north east)



Plate 28: Survey site 4 – photo from end of transect (facing south west)

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logical
AUSTRALIA



HEAD OFFICE

Suite 4, Level 1
2-4 Merton Street
Sutherland NSW 2232
T 02 8536 8600
F 02 9542 5622

SYDNEY

Level 6
299 Sussex Street
Sydney NSW 2000
T 02 8536 8650
F 02 9264 0717

ST GEORGES BASIN

8/128 Island Point Road
St Georges Basin NSW 2540
T 02 4443 5555
F 02 4443 6655

CANBERRA

Level 2
11 London Circuit
Canberra ACT 2601
T 02 6103 0145
F 02 6103 0148

NEWCASTLE

Suites 28 & 29, Level 7
19 Bolton Street
Newcastle NSW 2300
T 02 4910 0125
F 02 4910 0126

NAROOMA

5/20 Cauty Street
Narooma NSW 2546
T 02 4476 1151
F 02 4476 1161

COFFS HARBOUR

35 Orlando Street
Coffs Harbour Jetty NSW 2450
T 02 6651 5484
F 02 6651 6890

ARMIDALE

92 Taylor Street
Armidale NSW 2350
T 02 8081 2681
F 02 6772 1279

MUDGEE

Unit 1, Level 1
79 Market Street
Mudgee NSW 2850
T 02 4302 1230
F 02 6372 9230

PERTH

Suite 1 & 2
49 Ord Street
West Perth WA 6005
T 08 9227 1070
F 08 9322 1358

WOLLONGONG

Suite 204, Level 2
62 Moore Street
Austinmer NSW 2515
T 02 4201 2200
F 02 4268 4361

GOSFORD

Suite 5, Baker One
1-5 Baker Street
Gosford NSW 2250
T 02 4302 1220
F 02 4322 2897

DARWIN

16/56 Marina Boulevard
Cullen Bay NT 0820
T 08 8989 5601

BRISBANE

51 Amelia Street
Fortitude Valley QLD 4006
T 07 3503 7193

1300 646 131
www.ecoaus.com.au