UPPER DUCK RIVER WETLANDS & RIPARIAN PLAN OF MANAGEMENT

Prepared for Parramatta City Council

By Applied Ecology Pty Ltd

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Catchment Management Authority Sydney Metropolitan

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DISCLAIMER

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EXECUTIVE SUMMARY

Upper Duck River Wetlands cover approximately 26 ha along the Duck River in inner western Sydney, and is part of the Duck River subcatchment flowing to the Parramatta River near the Silverwater Bridge. The Upper Duck River Wetlands are surrounded by public land owned and managed by Auburn Council in the east, and Parramatta City Council in the west. Major landowners include State Rail Corporation, Australia Post, and others.

The Wetlands are of regional conservation significance, providing home to three Endangered Ecological Communities and several threatened species, and are highly valued by the local community. The subject area provides opportunities for passive recreational activities, and is surrounded by numerous sporting facilities and playing fields in both Local Government Areas (LGAs). Overall, however, the wetlands are in a degraded condition with numerous environmental and hydrological issues.

This plan presents a detailed vegetation management action program. High priority actions include controlling weeds and pollutants at the source, community education, additional shared use footpath/cycleways and the installation of signage.

FUNDING FOR THE PLAN OF MANAGEMENT

Funding for this project was jointly provided by

- Sydney Metropolitan Catchment Management Authority
- Parramatta City Council
- Auburn City Council

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ACRONYMS

ACC	Auburn City Council
EPBC Act	Environmental Protection & Biodiversity Conservation Act
LGA	Local Government Area
LPI NSW	Land & Property Information Dept, NSW
NPWS	National Parks and Wildlife Service
PCC	Parramatta City Council
SMCMA	Sydney Metropolitan Catchment Management Authority
TSC Act	Threatened Species Conservation Act, NSW
WRPoM	Wetlands and Riparian Plan of Management

INTRODUCTION

PROJECT BACKGROUND

The Upper Duck River Wetland and Riparian Plan of Management (referred to as the WRPoM) is confined to the riparian corridor of the upper Duck River between the Clyde weir at Granville and the Sydney Water Supply Pipeline (Munro St, Sefton). The area draining to this section of the river is approximately 20 square kilometres. The WRPoM provides a consistent and agreed maintenance and regeneration program for the Duck River Wetlands within a framework for the necessary collaboration between the relevant state and local government authorities.

The Duck River corridor contains regionally significant areas of natural bushland and wildlife habitat occurring within an otherwise highly urbanised landscape. The open space corridor associated with the Duck River also incorporates numerous recreational facilities of regional significance. As well, the area provides opportunities for passive recreation and there is habitat for a number of native flora and fauna species and sensitive vegetation communities. Since development commenced, the wetland has suffered degradation, with both environmental and hydrological challenges. These challenges and the need to resolve them for the benefit of the local community and the broader environment, has led to the need for a detailed plan of management to guide the conservation and management of the Upper Duck River Wetlands into the future.

There is no existing Plan of Management for the Upper Duck River Wetlands. Current management has been implemented as part of the Duck River Management Plan (EDAW, 1996), which is well over a decade old. Parramatta City Council and Auburn Council aim to address this dearth of specific management plans for the Upper Duck River Wetlands through the development of the Upper Duck River WRPoM.

Several plans address various aspects of management of the lower Duck River, including:

- Lower Duck River Riparian Management Plan 2002
- Duck River Floodplain Risk Management Study and Plan 2011
- Parramatta River Estuary Processes Study 2011
- Parramatta River Estuary Management Plan 2012 (currently in draft)

The entire catchment is managed holistically through the Duck River Masterplan, written in conjunction with this WRPoM, which retains a focus on the high value freshwater reaches in the catchment.

The aim of this overarching Plan is to ensure that the natural area reserves of the Upper Duck River wetlands retain their environmental, recreational, scenic, cultural and social values by addressing key management issues such as conservation, access and public safety

The WRPoM for Upper Duck River Wetlands and Riparian Corridor has been developed to fulfil the above overarching aim. More specifically it provides:

1. A description of environmental areas and values
2. A description of the management issues
3. A list of prioritised works and activities including:
    - Measures to manage threats to biodiversity values
    - Measures to address the issue of surrounding land uses encroaching into the wetlands
    - Identification of recreation areas, values and appropriate future recreation options
    - Activities and management actions aiming to engage the local community

PURPOSE OF THE PLAN

Parramatta and Auburn Councils are preparing a Riparian and Wetland Plan of Management with the support of funding allocated by Sydney Metropolitan CMA. The preparation of a specific WRPoM for Upper Duck River will contribute to achieving several state, catchment and local targets. Relevant state and catchment targets are:

- By 2015 there is an improvement in the condition of important wetlands, and the extent of those wetlands is maintained. (NSW State Plan - Wetland Target E4.8)
- By 2016 there is an improvement in the condition and extent of wetlands. (Sydney Metropolitan Catchment Management Authority Catchment Action Plan May 2009 - Wetland Target CTW2)

Applied Ecology P/L was contracted to prepare the new Plan of Management for Upper Duck River Wetlands and Riparian Corridor for Parramatta and Auburn Councils, with Council direction and consultation with the community and interest groups. The Plan identifies works and actions for long-term sustainable management of the wetland. It builds on two key documents recently prepared by/for Council:

- Draft Biodiversity Management Plan for Parramatta LGA (Ecological Australia, 2011)
- Draft Duck River Floodplain Risk Management Study and Plan (Molino Stewart/WMA, 2011)

CONSULTATIVE FRAMEWORK

A range of stakeholders were consulted during the preparation of this Plan of Management. Representation was sought from local government, special interest groups, residents and the broader community. Around 350 people were invited to a public meeting as part of the plan development process. They were provided with alternatives for lodging comments and suggestions through online portals on Parramatta and Auburn Councils' websites, via email or mail.

Around 35 of these attended the meeting, and participated in a vigorous brainstorming session. Many of the participants indicated that they had not previously taken the opportunity to be involved in the community consultative process, despite a number of these being held over the last 10 or 15 years. Feedback from stakeholders was used to guide preparation of the WRPoM, particularly identifying the actions and their priorities. All of the suggestions were considered during the formulation of the WRPoM, and most were directly incorporated. Key findings from the

community survey and consultation process are listed below:

- There is a need to reserve some areas specifically for nature conservation, with restricted access.
- A need was identified to conserve, maintain and improve the integrity of natural bushland.
- Strategies for managing the huge volume of rubbish in the catchment were discussed, and solutions included public education through specific programs in schools, for local businesses, cultural groups with non-English speaking backgrounds, and appointment of council rangers to specifically target littering and dumping of rubbish
- Manage water pollution including impacts from development and surrounding land use activities; better management of sediment traps and SQIDs
- The need for coordination between Auburn and Parramatta councils was highlighted; also the need to liaise with Bankstown Council to manage inputs from higher in the catchment.
- Programs to involve the local community more in the natural resources of the Upper Duck River Wetlands, increasing awareness of the assets and problems of the catchment through information brochures, signage, guided walks, schools programs, "Adopt a Reach" programs for local factories and corporate identities.
- Need for appropriate development controls to conserve the natural assets of Upper Duck River throughout ongoing urban development and population expansion in the area, including WSUD, BASIX, maintaining setbacks, buffer trees in the urban footprint

The draft plan was placed on public exhibition by Parramatta City Council from July 23rd to August 20th 2012 and open for comment until the 3rd of September 2012. Similarly the draft plan was exhibited by Auburn City Council from the September 5th to the October 16th. The documents were available via council websites, libraries and customer service centres. There were no submissions generated and the plan was subsequently adopted by each council in November 2012.

POLICIES AND FRAMEWORK FOR MANAGEMENT

Legislation and policy that has been taken into consideration in the development of this Plan of Management is listed below. A summary of the content of these plans, and their implications and/or requirements for management of wetlands is provided in Appendix One. Please refer to the Duck River Catchment Waterways Maintenance and Rehabilitation Master Plan (prepared for Parramatta City Council by Applied Ecology, 2012) for a full explanation of the legislation/policy and its applicability to this WRPoM.

- Local Government Act 1993
- Environmental Planning and Assessment Act 1979
- Threatened Species Conservation Act 1995 and Priority Action Statements
- Fisheries Management Act 1994
- Protection of Environment Operations Act 1997
- Environmental Protection and Biodiversity Conservation Act 1999 (Commonwealth)
- State Environment Planning Policies for Infrastructure, Bushland in Urban Areas (SEPP 19)
- Parramatta Local Environment Plan 2011
- Parramatta Development Control Plan 2011

- Parramatta Biodiversity Management Plan 2011
- Greenweb Planting Local Provenance Species Policy

There are a number of other plans that relate to this WRPoM. These include:

- Duck River Management Plan (EDAW, 1996)
- Lower Duck River Foreshores Improvement Plan (EDAW/DUAP, 1998)
- Duck River Stormwater Management Plan (SKM, 1999)
- Lower Duck River Riparian Management Plan (EP, 2002)
- Draft Wetlands GIS and Prioritisation Project for the SMCMA (EA, 2011)
- Duck River Remediation Plan for Railcorp (PB, 2009)
- Draft Duck River Floodplain Risk Management Study and Plan (Molino Stewart/WMA, 2011)
- PCC Natural Areas Plan of Management
- PCC Open Space Plan
- PCC Sport and Recreation Plan

Additional management plans for Auburn City Council areas were also considered in the preparation of this WRPoM:

- ACC Plan of Management for Auburn Botanic Gardens Precinct
- ACC Plan of Management for Duck River Foreshore
- ACC Plan of Management for Natural Area Bushland within Peter Hislop Park 2001
- ACC Plan of Management for Natural Area Bushland within the Auburn Golf Course 2001
- ACC Plan of Management for Oriole Park – Clubhouse Building and Surrounds 2001
- ACC Plan of Management for Parks
- ACC Plan of Management for Sportsgrounds
- ACC Plan of Management for General Community Use 2001

The WRPoM also considered and incorporated strategies and plans developed by Sydney Metropolitan CMA including: Sydney Metropolitan CMA Catchment Action Plan, A Wetland Prioritisation Technique, Rapid Fauna Habitat Assessment and Waterways Health Strategy.

SITE DESCRIPTION AND CONTEXT

LOCATION AND SETTING

Duck River passes through three local government areas, with the upstream section in Bankstown LGA (Figure 1). The river then forms the boundary between Parramatta and Auburn LGAs until it discharges to Parramatta River at Silverwater.

In all, the Duck River sub-catchment of Parramatta River covers an area of approximately 104 square kilometres (SMCMA, 2012). Duck River is tidal from its mouth at Parramatta River to the Clyde Weir near the Main Western Railway Line at Granville, and freshwater above the weir.

Landuse in the catchment is predominantly residential, with major areas of industrial and commercial development, and a smaller proportion of open space, which includes sportsgrounds, parks, areas of General Community Use, areas of Cultural Significance and natural areas.

STUDY AREA CONTEXT

UPPER DUCK RIVER RIPARIAN AND WETLAND PLAN OF MANAGEMENT

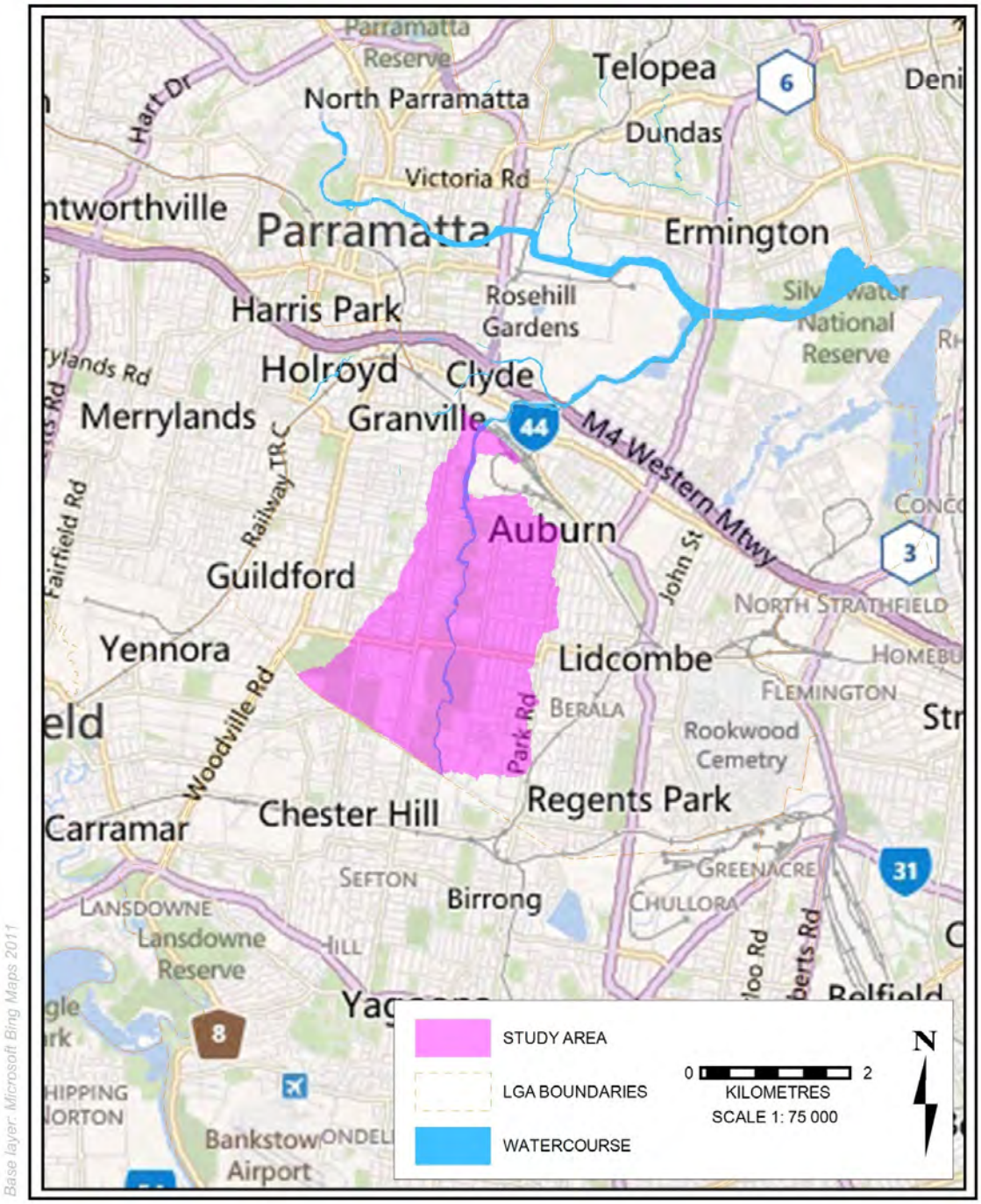

Figure 1. Study area for Upper Duck River Wetlands and Riparian Plan of Management

REACH PLAN

The Upper Duck River was divided into sections to facilitate the development of this management plan. These sections, or reaches lie predominantly along the main channel, and are categorised as follows: DUCK RIVER 4A = DR 4A, and is a main channel reach. Smaller wetlands are located in a couple of side channels, and have a level of connectivity with the main channel. For this reason, these unnamed reaches were included in this WRPoM.

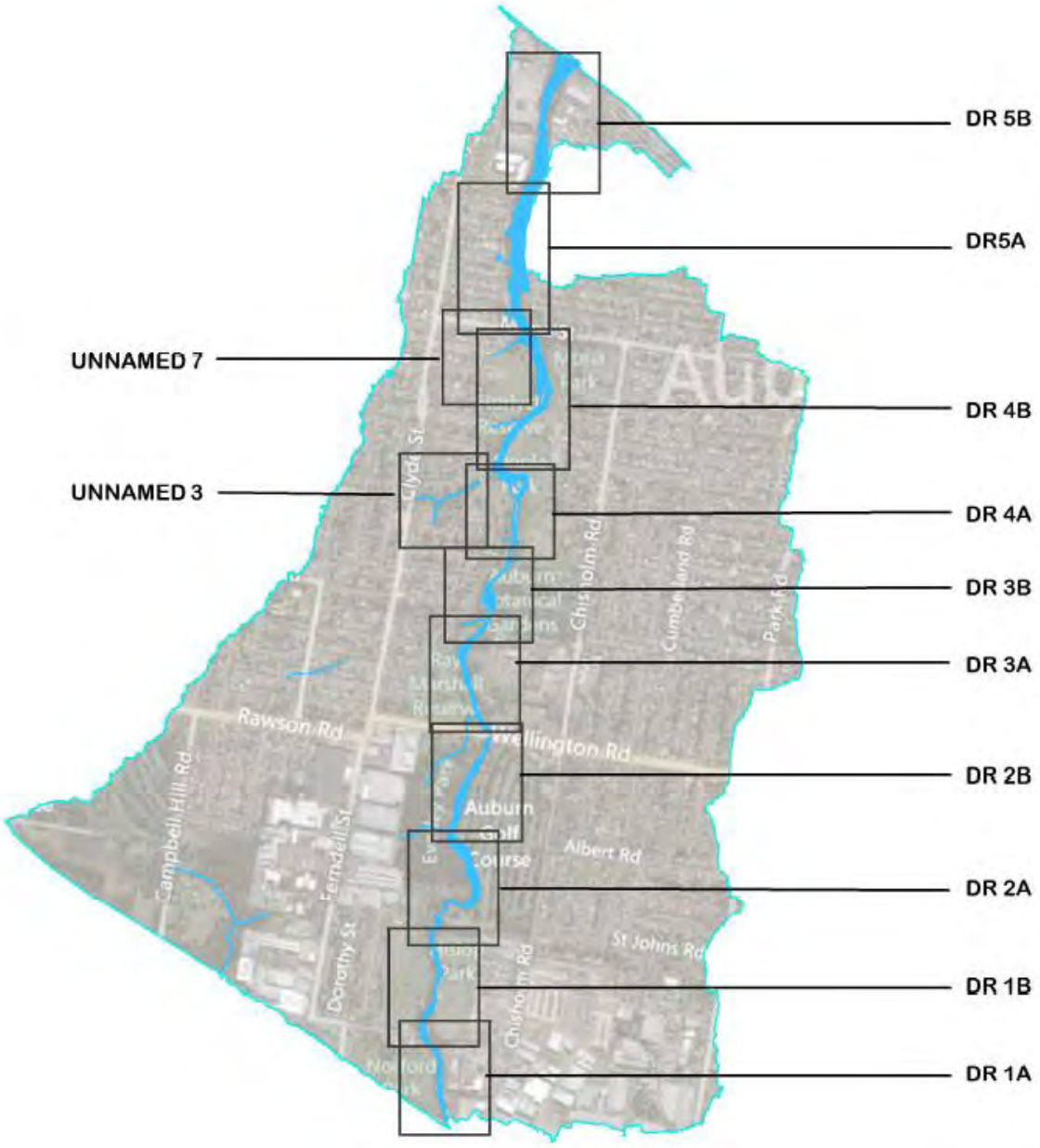

Figure 2. A series of reaches were identified in Upper Duck River, and have been used for management purposes

NSW WETLAND CATEGORY

The Duck River corridor contains regionally significant areas of natural bushland and wildlife habitat occurring within an otherwise highly urbanised landscape. The open space corridor associated with the Duck River includes numerous recreation facilities of regional significance. The Upper Duck River riparian and wetland zones incorporate the following NSW State listed Endangered Ecological Communities (EECs):

- Cumberland River Flat Forest
- Cumberland Swamp Oak Riparian Forest
- Coastal Freshwater Reed land

Each of these constitute a different wetland under the NSW Wetland Category naming system (Table 1; Claus et al, 2011).

Table 1. NSW Wetland Category for freshwater ecosystems found in Upper Duck River Wetlands (Claus et al, 2011)

VEGETATION COMMUNITY	WETLAND CODE	WETLAND SYSTEM & CLIMATE	SUB-CLIMATE	WATER SOURCE	WATER REGIME	VEGETATION
Coastal Freshwater Reedland EEC	PTC 2a	Palustrine Temperate	Coastal	River fed floodplain	Permanently wet	Sedgeland/ grassland/ herbs
Cumberland Swamp Oak Riparian Forest EEC	PTC 2d	Palustrine Temperate	Coastal	River fed floodplain	Periodically inundated	Forest
Cumberland River Flat Forest EEC	PTC 2d	Palustrine Temperate	Coastal	River fed floodplain	Periodically inundated	Forest

LAND TENURE AND ZONING; PERMITTED LAND USE

Zonage for land in the Parramatta and Auburn LGA sections of the Duck River catchment is shown in Figure 3.

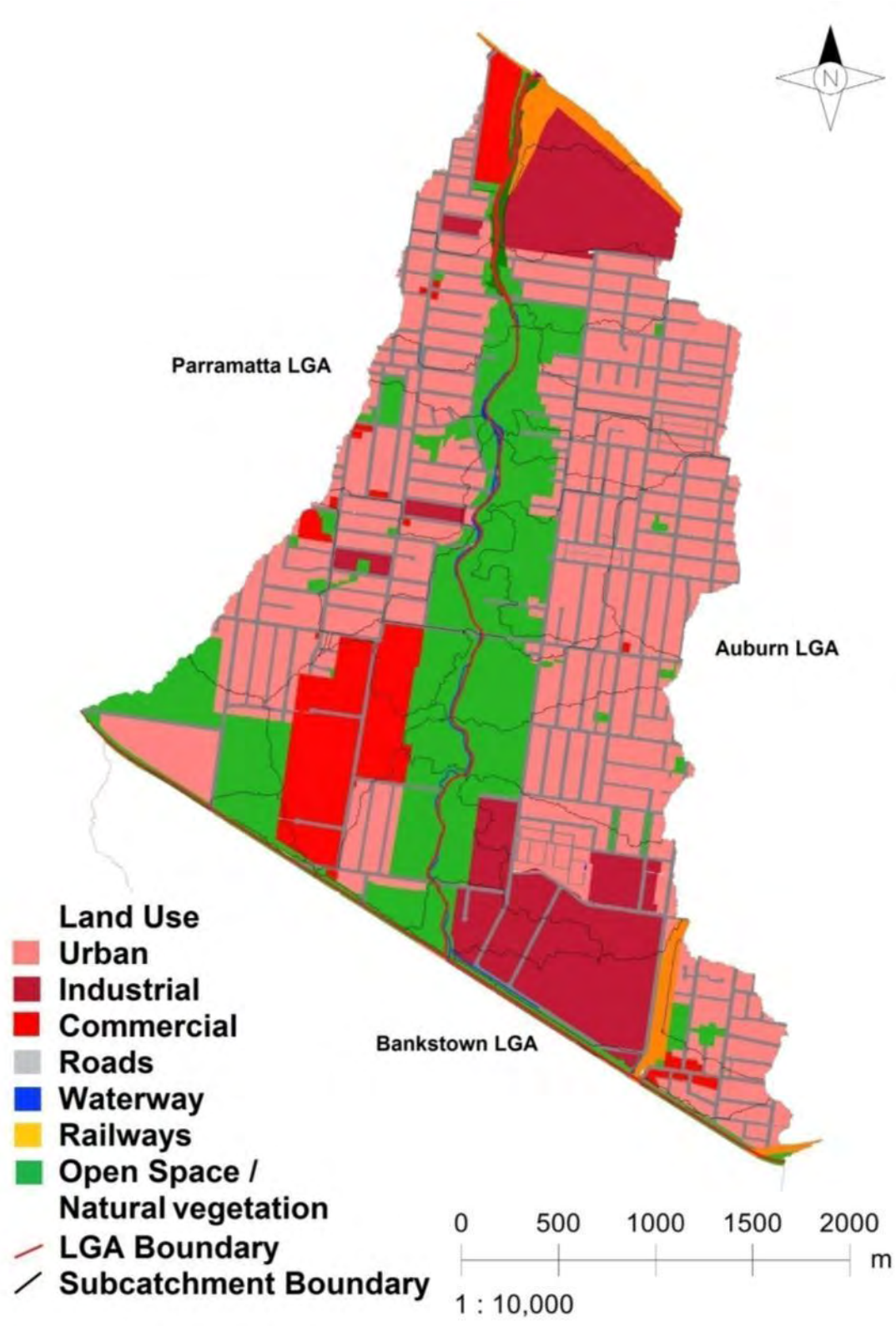

Figure 3. Land use in the Upper Duck River catchment (Parramatta and Auburn LGAs)

Land to the east of Upper Duck River Wetlands in Auburn City Council is zoned:

- SP2 Infrastructure (Railway)
- IN1 General industrial
- R2 Low density residential
- RE1 Public recreation
- SP2 Water supply system

Land to the west of Upper Duck River Wetlands in Parramatta City Council is zoned:

- W1 Natural waterways
- SP2 Infrastructure (Railway)
- IN1 General industrial
- R2 Low density residential
- RE1 Public recreation
- E2 Environmental conservation
- SP2 Water supply system

Management objectives for each of the above zones are described in Table 2.

Table 2. Management objectives for land use zones in the Upper Duck River catchment

ZONE	MANAGEMENT OBJECTIVES FOR ZONES
W1 Natural waterways	• To protect the ecological and scenic values of natural waterways. • To prevent development that would have an adverse effect on the natural values of waterways in this zone. • To provide for sustainable fishing industries and recreational fishing. • To provide for cultural and scientific study of natural waterways. • To enable works associated with the rehabilitation of land towards its natural state.
SP2 Infrastructure (Railway)	• To provide for infrastructure and related uses. • To prevent development that is not compatible with or that may detract from the provision of infrastructure.
IN1 General industrial	• To provide a wide range of industrial and warehouse land uses. • To encourage employment opportunities. • To minimise any adverse effect of industry on other land uses. • To support and protect industrial land for industrial uses. • To facilitate a range of non-industrial land uses that serve the needs of workers and visitors.
R2 Low density residential	• To provide for the housing needs of the community within a low density residential environment. • To enable other land uses that provide facilities or services to meet the day to day needs of residents. • To ensure that non-residential land uses are located in a context and setting that minimises impacts on the amenity of a low density residential environment. • To allow for a range of community facilities to be provided to serve the needs of residents, workers and visitors in residential neighbourhoods.
RE1 Public recreation	• To enable land to be used for public open space or recreational

ZONE	MANAGEMENT OBJECTIVES FOR ZONES
	purposes. • To provide a range of recreational settings and activities and compatible land uses. • To protect and enhance the natural environment for recreational purposes.
E2 Environmental conservation	• To protect, manage and restore areas of high ecological, scientific, cultural or aesthetic values. • To prevent development that could destroy, damage or otherwise have an adverse effect on those values.
SP2 Water supply system	• To protect the ecological and scenic values of natural waterways. • To prevent development that would have an adverse effect on the natural values of waterways in this zone. • To provide for sustainable fishing industries and recreational fishing. • To provide for cultural and scientific study of natural waterways. • To enable works associated with the rehabilitation of land towards its natural state.

A range of land use actions are permitted in each of the zones, with some permitted without consent, while others require development consent before they are permitted (Table 3).

Table 3. Permitted land uses in each of the zones around the Upper Duck River Wetlands

ZONE	PERMITTED WITHOUT CONSENT	PERMITTED WITH CONSENT
W1 Natural waterways	Environmental protection works; Flood mitigation works	Environmental facilities; Roads
SP2 Infrastructure (Railway)	Nil	The purpose shown on the Land Zoning Map, including any development that is ordinarily incidental or ancillary to development for that purpose; Environmental protection works; Flood mitigation works; Recreation areas; Roads
IN1 General industrial	Nil	Building identification signs; Business identification signs; Depots; Food and drink premises; Freight transport facilities; Garden centres; General industries; Hardware and building supplies; Horticulture; Industrial training facilities; Kiosks; Landscaping material supplies; Light industries; Liquid fuel depots; Neighbourhood shops; Plant nurseries; Roads; Rural supplies; Timber yards; Vehicle sales or hire premises; Warehouse or distribution centres
R2 Low density residential	Home occupations	Bed and breakfast accommodation; Boarding houses; Building identification signs; Business identification signs; Community facilities; Dual occupancies; Dwelling houses; Educational establishments; Emergency services facilities; Environmental facilities; Environmental protection works; Exhibition homes; Exhibition villages; Flood mitigation works; Group homes; Health consulting rooms; Home-based child care; Home businesses; Home industries;

ZONE	PERMITTED WITHOUT CONSENT	PERMITTED WITH CONSENT
		Hospitals; Hostels; Neighbourhood shops; Public administration buildings; Recreation areas; Recreation facilities (indoor); Recreation facilities (outdoor); Roads; Seniors housing; Water recycling facilities
RE1 Public recreation	Environmental protection works; Flood mitigation works	Boat launching ramps; Boat sheds; Charter and tourism boating facilities; Community facilities; Environmental facilities; Information and education facilities; Jetties; Kiosks; Markets; Recreation areas, Recreation facilities (indoor); Recreation facilities (major); Recreation facilities (outdoor); Restaurants or cafes; Roads; Take away food and drink premises; Water recreation structures; Water recycling facilities
E2 Environmental conservation	Environmental protection works; Flood mitigation works	Environmental facilities; Roads
SP2 Water supply system	Nil	The purpose shown on the Land Zoning Map, including any development that is ordinarily incidental or ancillary to development for that purpose; Environmental protection works; Flood mitigation works; Recreation areas; Roads

HISTORY OF THE SITE

The Duck River catchment and river have undergone significant changes since European settlement including:

- Extensive urbanisation and industrialisation resulting in catchment hardening;
- Land clearing;
- Channelisation and lining of sections of the Duck River and side creeks resulting in hydraulically efficient drainage system;
- Construction of barrages and weirs along the Duck River including the Clyde Weir, Mackay Road causeway and Boundary Road weir; and
- Introduction of additional pollutant sources such as agriculture, and now urbanisation and sewage infrastructure.

The landscape and river prior to European settlement has been captured in maps, journals and paintings and a selection of these historic sources relating to the estuarine environment have been collated and reviewed by McLoughlin (2000). These sources and descriptions are reproduced in Figure 4.

Table 1. Description of the Foreshore Vegetation of the Parramatta River, 1788–1933.

	Observation	Location	Year	Observer and Source
1	*...about 4 mile higher than where the ships lay, the country was open and improved the farther we went up & in most places not any underwood, grass very long.*	Upper harbour	1788	Lt. William Bradley, Bradley 1969, p. 75
2	*...along the bank the grass was tolerably rich and succulent, and in height nearly up to the middle, interspersed with a plant much resembling the indigo.*	Above Duck River	1788	Surgeon John White, White 1962, p. 127
3	*The banks of it were now pleasant, the trees immensely large, and at a considerable distance from each other; and the land around us flat and rather low, but well covered in the kind of grass just mentioned.*	Above Clay Cliff Creek	1788	Surgeon John White, White 1962, p. 128
4	*About two miles below this settlement, the harbour becomes quite narrow, being not more than ten or twelve yards across, and the banks are about six feet high: here the country has the appearance of a park. In rowing up this branch, we saw a flock of about thirty kangaroos or paderong, but they were only visible during their leaps, as the long grass hid them from our view...*	3–4 km down-stream from Parramatta	1790	Lt. Phillip Gidley King, King 1968, p. 402

Figure 4. Descriptions of foreshore vegetation of Parramatta River, 1788-1933 (from McLoughlin, 2000)

Aerial photographs provide a more objective means of gauging catchment change and a selection of photographs from 2008 and 1943 showing the same river stretches are shown in Figures 5-8. The photographs show that by 1943, much of the Duck River catchment either had already undergone urbanisation or was in the process of doing so. Large sections of the upper catchment remained rural with some stands of trees still present.

Figure 5. 2008 and 1943 Aerial Photography:. Source: LPI NSW, Spatial Information Exchange

Figure 6. 2008 and 1943 Aerial Photography:. Source: LPI NSW, Spatial Information Exchange

Figure 7. 2008 and 1943 Aerial Photography:. Source: LPI NSW, Spatial Information Exchange

Figure 8. 2008 and 1943 Aerial Photography:. Source: LPI NSW, Spatial Information Exchange

Stream and Channel Morphology

The changes in the catchment since European Settlement are likely to have resulted in:

- Larger runoff volumes, higher peak flow rates and higher frequency of surface runoff;
- Decreased low flow volumes;
- Increased channel erosion and incision and sedimentation in dead zones/pools;
- Higher nutrient loads and more sunlight; and
- Lower water tables delivering subsurface flows and baseflows to the stream.

These impacts are typical of urban developments in Eastern Australia. These changes typically would have begun following land settlement and are not necessarily very recent changes. Closer aerial photograph inspection of selected Duck River sections indicate extensive riverbank erosion in 1943 that has since undergone partial revegetation (Figure 9a and 8b). The aerial photographs of 1943 show a number of similar areas of apparent riverbank erosion indicating that substantial changes to catchment hydrology and bank stability had occurred prior to this time.

Figure 9. A. Upper Duck River Wellington Road 1943 and B. 2008:. Source: LPI NSW, Spatial Information Exchange

SOILS AND GEOLOGY

Soils commonly found in the Upper Duck River catchment developed on the Wianamatta Shales, and belong to the Birrong Grouping. They are deep, usually greater than 250cm, and are described as yellow podsols, with yellow solodics found on older alluvial terraces. The subsoils are often saline, with the overall soil profile subject to seasonal waterlogging. The soils are highly erodable and of very low soil fertility (Benson & Howell 1990).

As Duck River passes through Auburn, the topsoil is grey in colour, and of about 30-45 cm in depth, overlying a softer, more easily erodable subsoil. The subsoils are deep, tough and elastic clays which range in colour from red to yellow and yellow-white. The white clays developed on the exposed Minchinbury sandstones at Duck River were once highly prized by the local tile and pipeworks (Duck River Sydney, undated).

As clay soils dry, they are prone to cracking, with larger fractures persisting for many years. The soils in the Duck River area are highly fractured, a feature which becomes accentuated by erosion to give a raised block-like appearance to the surface. In wet seasons, the soils quickly become saturated and most water runs off the surface, rather than percolating into the subsoil. The soil groups in the Upper Duck River Wetlands area have been described as follows:

Birrong Soils: Typical of floodplains of watercourses such as Duck River. Soils are predominant adjacent to all major water courses in the catchment.

Disturbed Areas: The landform along the waterways has been altered through progressive infill for land reclamation. These areas of infill are referred to as disturbed soil areas and typically comprise variable, unidentified fill materials. Significant disturbed areas exist adjacent to Duck River, particularly towards the downstream end of the catchment, and around Parramatta River.

Characteristics of each soil landscape are described in Table 4 (derived from DLWC 1:100 000 Soil Landscape Map, 1989).

Table 4. Soil landscape characteristics for soils mapped in the Duck River catchment

SOIL LANDSCAPE	SOIL DEPTH	EROSION HAZARD		URBAN CAPABILITY
		CONCENTRATED FLOWS	NON-CONCENTRATED FLOWS	
Birrong	>250cm		Low to Moderate	Not capable without drainage works
Disturbed	40-60cm	Low to High	Low to Extreme	Capable with restrictive conditions

ACID SULPHATE SOILS

Acid Sulphate Soils (ASS) means naturally occurring sediments and soils containing iron sulphides (principally pyrite) or their precursors or oxidation products, whose exposure to oxygen leads to the generation of sulphuric acid, for example by drainage or excavation (Table 5).

Table 5. Acid Sulphate Soils classes of land and permissible works

CLASS OF LAND	PERMISSIBLE WORKS
1	Any works.
2	Works below the natural ground surface. Works by which the watertable is likely to be lowered.
3	Works more than 1 metre below the natural ground surface. Works by which the watertable is likely to be lowered more than 1 metre below the natural ground surface.
4	Works more than 2 metres below the natural ground surface. Works by which the watertable is likely to be lowered more than 2 metres below the natural ground surface.
5	Works within 500 metres of adjacent Class 1, 2, 3 or 4 land that is below 5 metres Australian Height Datum and by which the watertable is likely to be lowered below 1 metre Australian Height Datum on adjacent Class 1, 2, 3 or 4 land.

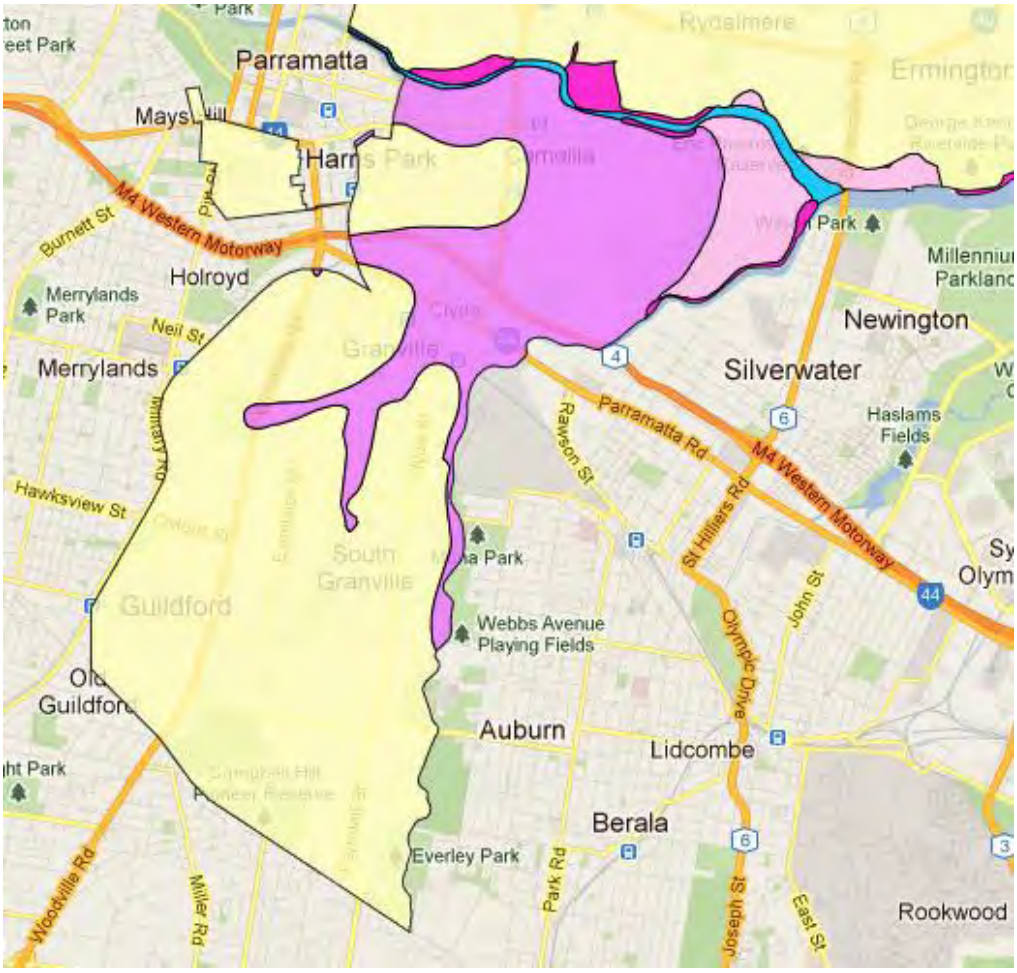

Figure 10. Acid Sulphate Soils probability mapping for Duck River catchment (PCC, 2012)

Land around the Upper Duck River Wetlands is classified as ASS Class 4 for areas downstream (north) of Webbs Avenue Playing Fields (Figure 10). Away from the main riparian area and all areas upstream of Webbs Avenue Playing Fields, soils are classified as Class 5.

There is a low probability of ASS 1 to 3m below ground surface adjacent to all waterways, predominantly towards the downstream section of each waterway. There is a high probability of ASS at or near the surface and at depths greater than 3m in the estuarine region of Duck River, outside the study area.

HYDROLOGY AND CLIMATE CHANGE

CATCHMENT ANALYSIS

The Upper Duck River Catchment and land use, as used in the recently developed catchment Duck River Catchment Analysis Model (SMCMA 2012) is shown in Figure 9. The majority of land within the catchment is related to urban land uses such as residential, road, industrial and commercial land use (Figure 11). The land uses classifications shown differ slightly from Council Land Use zoning maps because the catchment model uses land use classes to generate stormwater runoff and pollutant export. However Council based land use zones are generally consistent with those used for catchment model classification.

The study area for the Upper Duck River WRPoM extends from the Sydney Water Pipeline to the Clyde Street Weir. This area represents approximately half of the Upper Duck River catchment area shown in Figure 12. The SW pipeline and the Duck River form the boundary between three LGAs. Bankstown LGA is south of the Pipeline and represents approximately 50% of the catchment area to the Clyde Street Weir. Parramatta LGA to the west of the Duck River represents approximately 20% of the catchment and Auburn to the east of the Duck River represents the remainder 30% of the catchment.

Figure 11. In some areas there is little buffering between the urban environment and the wetlands

Figure 12. Aerial image of the Duck River catchment, with SW pipeline crossing diagonally through the middle

Land use (as used in the SMCMA catchment model) between the Sydney water Pipeline and Clyde Street Weir is presented in Table 6 and in Figure 13. The analysis shows that the majority of the catchment is urbanised, however a substantial proportion of the Duck River corridor is natural

vegetation and open space. As well, a large proportion of the catchment is impervious due to ongoing industrial and residential development (Figure 14).

Table 6. Duck River Catchment land use between Sydney Water Pipeline and Clyde Street weir

LANDUSE	AREA (km2)	AREA (%)
Urban/Residential	3.64	38.8%
Industrial	1.29	13.7%
Commercial	0.68	7.2%
Roadway	1.52	16.2%
Waterway	0.02	0.3%
Rail corridor	0.18	1.9%
Open Space	2.05	21.9%
Total	9.39	100%

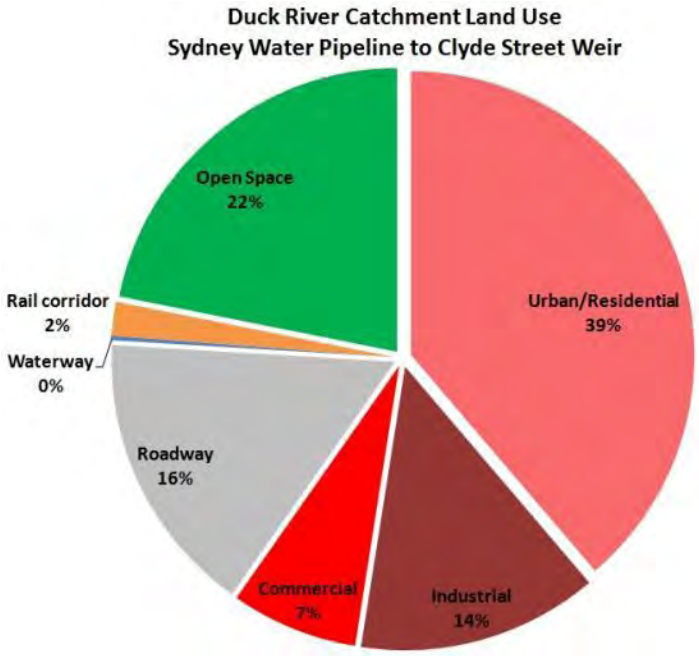

Figure 13. Land Use breakdown for the Upper Duck River Wetlands catchment

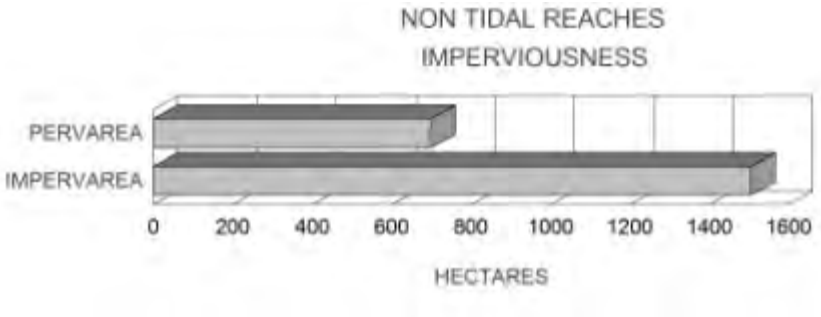

Figure 14. Proportion of land area with developed impervious surface for Upper Duck River Wetlands catchment

FLOW REGIME

The flow regime in the Duck River catchment is not currently monitored, although a surface water monitoring station at Mackay Road, South Granville (ID 213209) is reported in the Australian Natural Resources Atlas (ANRA 2009). Inspection of this site (Figure 15) shows a constructed weir possibly suitable for flow measurement. A number of constructed weirs alter the flow regime in the catchment including the downstream weir (Clyde street), the Mackay Road 'stepping stones' weir in Figure 15 and the Boundary Road Weir (380m downstream of the Sydney Water Pipeline). These weirs, particularly the Mackay Road and Clyde Road structures create large pondages, slowing the flow and extending the time it takes for very low flows to exit the catchment.

Figure 15. The 'Stepping Stones' Weir at Mackay Road, South Granville (ID 213209) looking (a) downstream and (b) upstream

The Duck River catchment hydrology has recently been modelled using the RAFTS flood modelling software combined with Source Catchment s water quality modelling (SMCMA 2012). The Sydney Metropolitan CMA has made draft results from this model available to this study to provide an indication of the overall flow regime in the absence of stream flow records. This modelling covers only a relatively short period between 2003 and 2008 and should not be interpreted as being indicative of the entire range of conditions in the Duck River. Furthermore, the weirs along the Duck River are not currently in the catchment model, indicating that modelled low flows are not likely to be representative of field conditions. Nevertheless, this modelling provides insight to the responsiveness of the catchment to rainfall and volume of runoff generated from rainfall in this highly urbanised catchment.

Figure 16 shows the cumulative modelled flows from upstream of the study site (Sydney Water Pipeline) and at the Clyde Weir (most downstream extent of the study site) for 2006 to 2008. The results show the impact of several large runoff events during this period, however even small, regular rainfall events contribute to the overall discharge. This characteristic is typical of urbanised catchments where impervious surfaces contribute to regular catchment flows, unlike undeveloped catchments, where surface runoff is more likely to be generated from medium to large events only. Annual modelled runoff coefficients (the amount of rainfall that is converted to runoff) range from 30% to 50% depending on the amount of rainfall falling in the year, with high rainfall

years typically resulting in a higher proportion of rainfall being converted to runoff.

A typical hydrograph obtained through modelling the Duck River demonstrates the typical response to rainfall (Figure 17). The runoff response to rainfall is swift and peak runoff rates can be reached in just a few hours or less from the time of rainfall. The hydrograph recession is similarly swift.

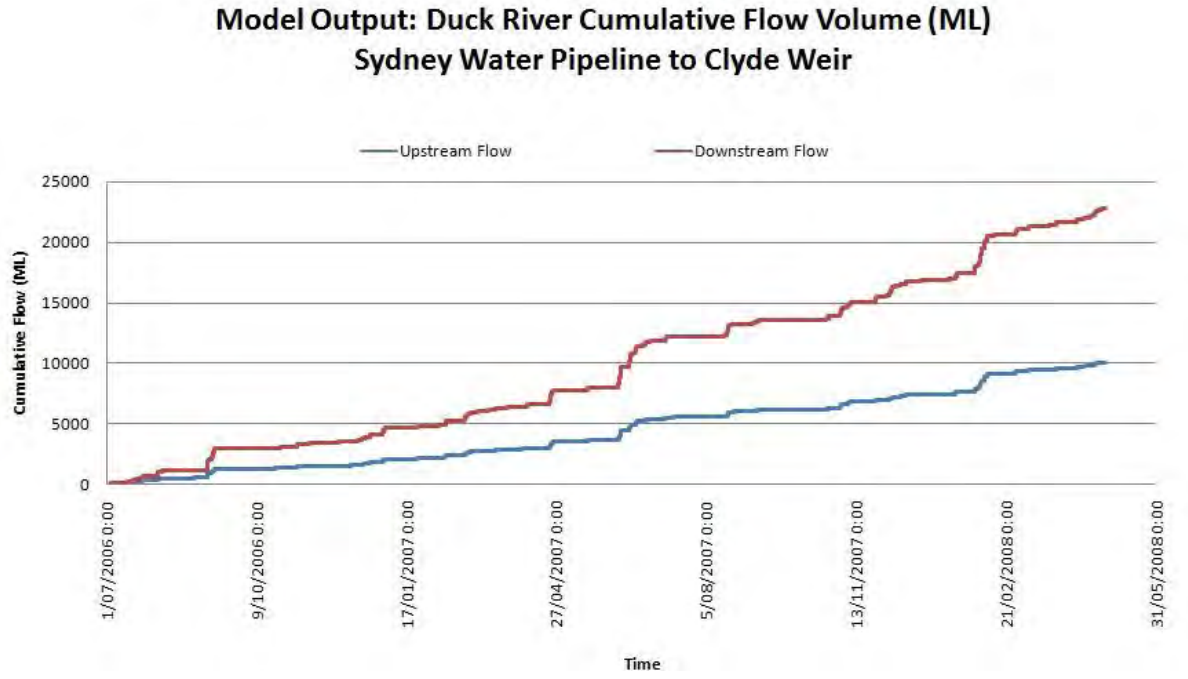

Figure 16. Cumulative modeled flows for the Duck River showing flows upstream of the study site and downstream of the study site. The difference between these curve therefore represents the flows entering the Duck River and wetlands between the Sydney Water Pipeline

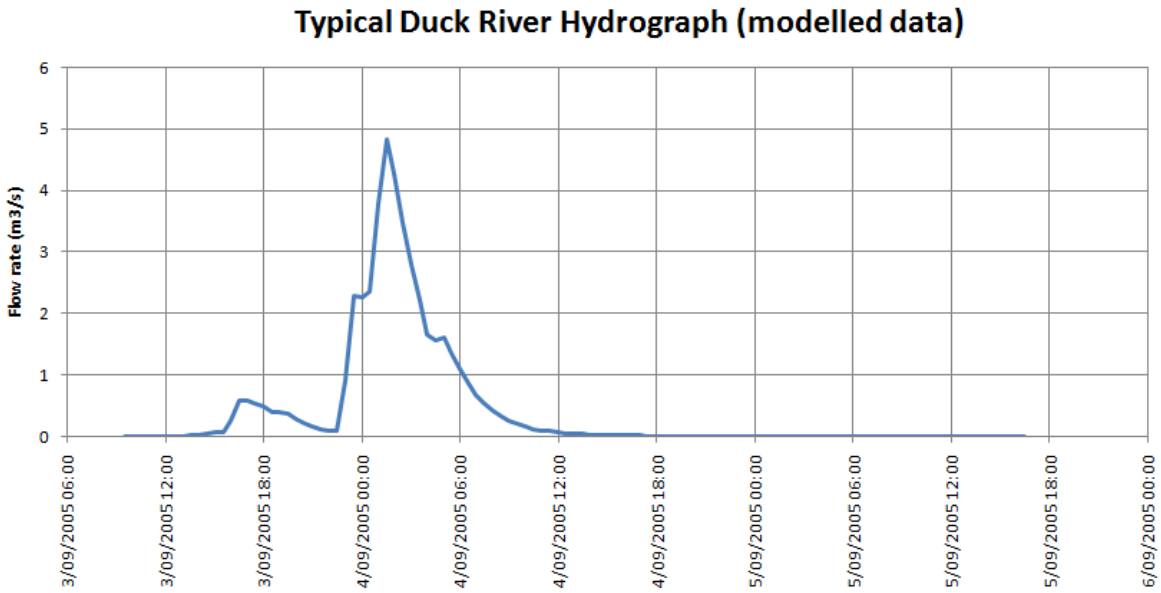

Figure 17. A typical modeled hydrograph for the Duck River

The following points summarise the flow regime for the Duck River:

- The flow regime is altered due to a number of structures resulting in large pools and likely retention of low flows;
- The high proportion of urbanised catchment results in regular runoff events, even following small amounts of rainfall;
- The amount of rainfall converted to runoff for any given year is typically between 30% and 50%
- The modelled runoff response to rainfall is swift with rapid increases in flows and similarly rapid decreases in storm flow rates.

INFLOWS AND OUTFLOWS

The majority of incoming flows in the Upper Duck River Wetlands are from the upstream reaches – about half of the catchment is located upstream of the wetlands in Bankstown LGA. Additional inflows are predominantly via stormwater pipes, most of which discharge directly to the main channel. Minor stream inflows enter via open channels at DUCK RIVER 2B, where Smalls Creek flows through Duck River Bushland Reserve, and an unnamed stream crosses Auburn Golf Course (Figure 19).

Three weirs are located in the Upper Duck River Wetlands catchment. The first is 400m below the upper limit of the wetlands, the second is stepped weir creating a shallow pool around an island in the mid catchment, and the third forms the downstream limit of the wetlands and the boundary between the freshwater reaches and tidal reaches. All outflows from the wetlands are via the main channel and pass across the lower weir.

TIDAL FLUSHING

The Clyde Street Weir forms the downstream boundary of the study area and also the boundary to the tidal zone. The Duck River downstream of this point is predominantly tidal (Figure 18), but no saline flows are believed to extend upstream of this point.

Figure 18. Downstream of the Clyde Street Weir the Duck River is predominantly tidal

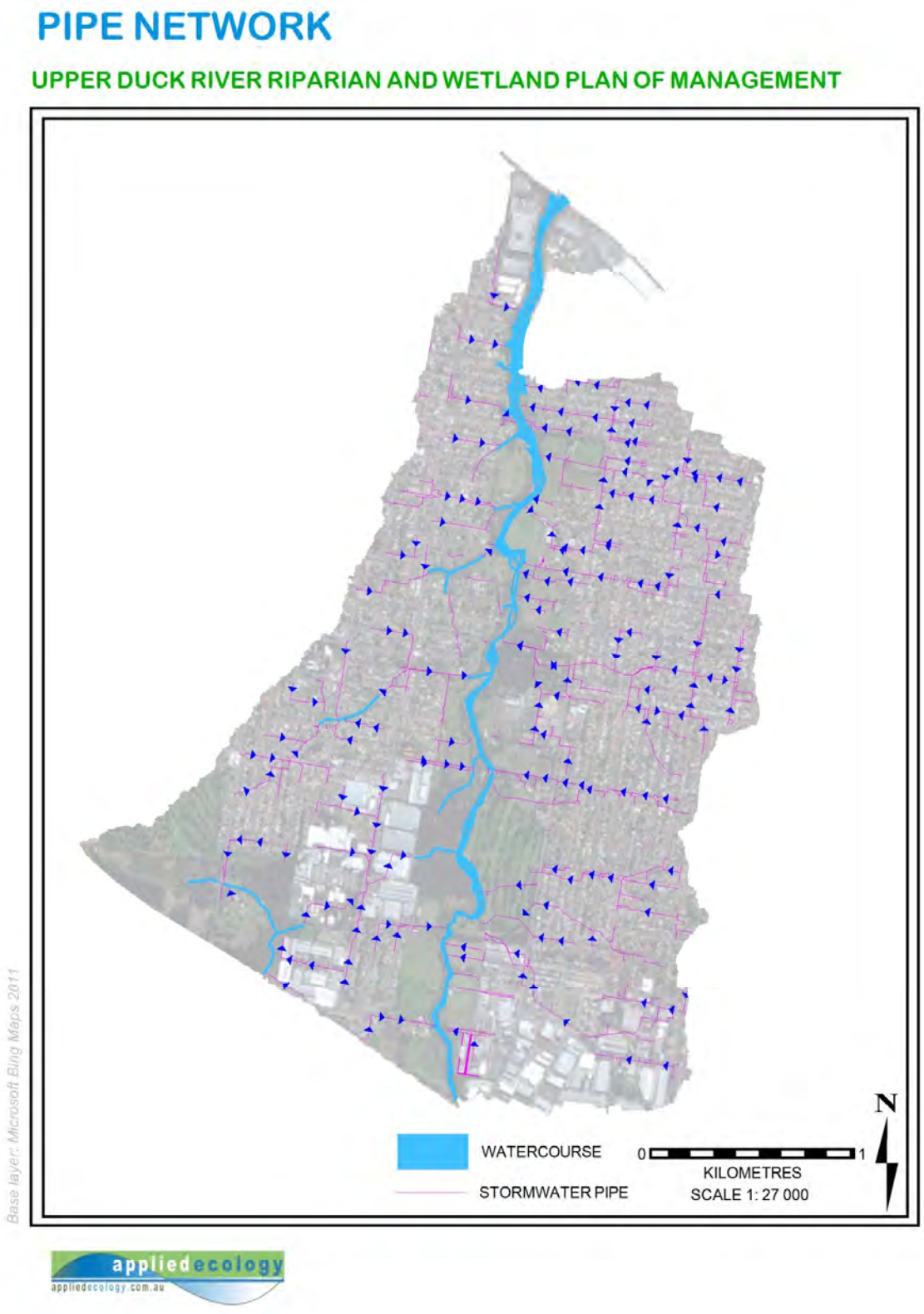

Figure 17. Stormwater piped network and open channels for Upper Duck River catchment

(← indicates direction of flow)

WATER QUALITY

Water quality in the Duck River between the Sydney Water Pipeline and Clyde Weir is not typically sampled. Laxton et al (2008) presents data collected in the Parramatta LGA from 1995 to 2008 and one site, just downstream of the study area (Parramatta Road crossing) represents the water quality in the Duck River, but is tidally influenced in dry weather. The results of this monitoring program for the Duck River site from 2007 are presented in Table 7-9 and have been extracted from Laxton et al (2008).

Table 7. Duck River Water Quality, Parramatta Road Crossing, 2007

	Temperature (C)	Salinity PPT	pH	DO (% saturation)
Minimum	10.86	0.06	7.01	35.3
10th Percentile	11.35	1.22	7.03	44.1
Median	19.15	11.22	7.24	58.9
90th percentile	22.89	26.39	7.4	73.8
Maximum	23.6	28.1	7.45	89.4
Trigger value estuaries	-	-	7.0-8.5	80-110
Trigger value Lowland Rivers	-	-	6.5-8.0	85-110

Table 8. Duck River Nutrient Water Quality, Parramatta Road Crossing, 2007

	Ammonia (mgN/L	Organic N (mgN/L)	Oxidised N (mgN/L)	Total Nitrogen (mgN/L)	Ortho-phosphate (mgP/L)	Total Phosphorus mgP/L
Minimum	0.03	0.241	0.037	0.497	0.009	0.0431
10th Percentile	0.065	0.261	0.061	0.694	0.0107	0.0468
Median	0.244	0.651	0.39	1.241	0.0233	0.1183
90th percentile	0.334	1.423	0.78	1.995	0.0841	0.3301
Maximum	0.34	1.44	0.846	2.443	0.113	0.5298
Trigger value estuaries	0.015		0.015	0.3		0.03
Trigger value Lowland Rivers	0.02		0.04	0.5		0.05

Table 9. Duck River Water Quality, Parramatta Road Crossing, 2007

	Turbidity	TSS mg/L	Chlorophyll-a ug/L	Faecal Coliforms CFU/100ml
Minimum	0.09	2	2.26	12
10th Percentile	3.9	2.2	2.78	51.9
Median	8.1	7	10.39	222
90th percentile	55.4	19.1	26.32	1900
Maximum	275	49	27.44	10000

	Turbidity	TSS mg/L	Chlorophyll-a ug/L	Faecal Coliforms CFU/100ml
Trigger value estuaries	0.5 - 10		4	
Trigger value Lowland Rivers	6 to 50		5	

The data in Tables 7-9 show that for most parameters, median or minimum water quality values exceed default Aquatic Ecosystem trigger values (ANZECC 2000). These triggers are generally not applicable to urbanised systems as the Duck River. Nevertheless they do provide both an aspiration target for at least median water quality values and an indication of the general poor water quality at this site.

The 2007 snapshot of poor water quality in the Duck River summarised in Tables 7-9 is also highlighted in Laxton et al (2008), where the median nutrient concentrations in the Duck River have always exceeded trigger values for any of the previous years that were sampled (1995-2007).

Point Source Pollution

No pollution point sources (licensed discharges) have been identified at the study site. The Shell Refinery further downstream in the estuary is licensed to discharge to the Duck River.

Diffuse Source Pollution

Diffuse source pollution includes sediments, nutrients and gross pollutants (litter). Quantification of these pollutants generally required monitoring stream flows and sampling water quality according to some flow trigger so that water quality in baseflows and event flows can be characterised. Streamflow monitoring is not currently carried out on the Duck River; therefore quantification of diffuse pollution through direct monitoring is not carried out. Two diffuse pollution studies of the Duck River have been identified for this review:

1. Sydney Water 'Clean Waterways Program' study (1993-1994); and
2. SMCMA (2012) Source Catchments water quality modelling, Lower Parramatta River Study.

Langston (2003) summarises results of a Sydney Water study undertaking pollutant load monitoring on the Duck River between 1993 and 1994, prior to the water quality data collection programs by Laxton (2008). Langston (2003) reports the following pollutant exports rates found through this monitoring study:

- Suspended Solids: 117 – 118 kg/ha/y
- Total Nitrogen: 1.48 - 1.72 kg/ha/y
- Total Phosphorus: 0.18 - 0.22 kg/ha/y

The loading rates found by this monitoring study appear low by urban standards (Bartley and Spiers 2010) which may be due to the dry years over which this study took place. 1993 and 1994 were dry years. Approximately 600mm and 560mm of rain fell in these years on the Duck catchment compared to average rainfall of approximately 950mm.

The second study (SMCMA, 2012) is a modelling study that derived the following pollutant loading rates for the Duck River Catchment (2004-2006 modelled data):

- Suspended Solids: - kg/ha/yr (data under review)

- Total Nitrogen: 13.5 kg/ha/yr
- Total Phosphorus: 1.9 kg/ha/yr

Results in the modelling study indicate loading rates approximately 10 times that estimated in 1993-1994. Duck River annual rainfall in the 2004-2006 period was also low at 680-750mm. The pollutant loading rates estimated by the SMCMA model correspond to mean pollutant concentrations found in literature (Bartley and Spiers 2010), however without further monitoring and/or more detailed long term modelling the correct diffuse pollution loading rates are unlikely to be derived with any further certainty.

Gross pollutant loading rates have not been estimated for the Duck River catchment by the SMCMA model, however, anecdotal evidence from nearby catchments operating gross pollutant booms may provide some indication of gross pollutant loads. Haslams Creek draining to the Sydney Olympic site has a number of gross pollutant booms capturing floating debris in stormwater runoff. Approximately 30 tonnes rubbish/year are removed from these booms. Gross pollutants are clearly a problem on the Duck River and some management interventions have been implemented to address it. Figure 20 shows litter suspended in trees at the Mackay Road weir following a large storm event (March 2012) and Figure 21 shows a full litter basket requiring at the end of a stormwater pipe, just prior to discharge to the Duck River (March 2012).

Figure 20. Litter caught in trees at Mackay Road weir (12th March 2012)

Figure 21. Full litter basket, prior to discharge to Duck River (12th March 2012)

CLIMATE VARIABILITY AND CLIMATE CHANGE

Climate change projections for the Sydney region have been presented in CSIRO (2007) and are reproduced in Figure 22. More recently, Hunter (2012) reviewed and summarised the potential impacts of climate change on stormwater infrastructure in the Sydney Metropolitan area and presented the following key points (extracted directly from Hunter, 2012):

- Sea Levels will rise, with respect to the 1990 mean sea level, by 0.4m (2050) and 0.9m (2100). (DECCW, 2009/708).
- Rainfall Intensities for extreme events (40-year ARI, 24-hour duration) will increase by at least 12%. (CSIRO, 2007b)
- Current criteria used in the design of floodplain infrastructure will need to be assessed to accommodate projected increases in rainfall intensities, runoff volumes and flood levels.
- Seasonal Runoff Volumes will increase by as much as: 26% (Summer); 19% (Autumn); 7% (Winter) and 4% (Spring), (DECC, 2008/519). Water balance assessments, undertaken to assess the viability of stormwater harvesting and reuse schemes should be based on revised rainfall data, and take into account projected changes in rainfall intensities and seasonal patterns.
- Existing drainage systems (including pipelines, channels, basins, and on site detention) will be under-designed in the future and the existing Prescribed Site Discharge and Site Storage Requirements, currently used in the design of On Site Detention systems, will have to be re-assessed to accommodate increased runoff peak flows and volumes and downstream.
- Dryland Salinity may become more widespread, especially in western Sydney due to changing climatic conditions, and low-lying coastal areas may experience local increases in groundwater salinity as a consequence of a rising sea level.

- Populations Density will increase to 6,000,000 (2036). (DOP, 2010b).

The literature review undertaken by Hunter (2012) resulted in the following general recommendations that may have some relevance to this Plan of Management:

- Design Rainfall Intensities be increased by 15%; and
- Mean High Water Level, for closed and protected tidal waters in the Sydney Region, be 1.0 m (AHD) in the short-term (2050) and 1.5 m (AHD) in the long-term (2100).

These recommendations may have implications for management actions for the Duck River riparian zone and wetlands.

- Sea level rise implications at the Clyde Street weir may need to be investigated;
- Flood studies undertaken in the study area indicate low flood risks, however future studies taking into account higher rainfall intensities may result in changes to this risk classification.
- Erosion rehabilitation, vegetation management and channel form works will need to consider higher rainfall intensities and therefore larger peak flows and associated erosion.

Table 2. Current and Projected Climate Change in the Sydney Catchments

	Present (1990)[1]	Projected Change	
		2030	2070
Temperature			
Average	17 – 26°C[2]	+0.2 – +1.6°C	+0.7 – +4.8°C
No. Days below 0°C	0	0	0
No. Days above 35°C	3	4 – 6	4 – 18
No. Days above 40°C	0	0 – 1	1 – 4
Rainfall			
Annual Average	1,094 mm	-13 – +7%	-40 – +20%
Extreme Rainfall[3]		-3 – +12%	-7 – +10%
Evaporation		+1 – +8%	+2 – +24%
No. Droughts per decade[4]	3	2 – 5	1 – 9
Extreme Winds		-5 – +8%	-16 – +24%
No. Fire Days[5]	9	9 – 11	10 – 15

1 Present day conditions for temperature and rainfall represent long-term averages from the Bureau of Meteorology. For extreme temperatures, the present average is based on 1964-2003. For fire danger, the present average is based on 1974-2003. For drought, the present average is for a period centred on 1990.
2 Range represents average July and January maximum temperature.
3 Defined as 1 in 40 year 1-day rainfall total. Values represent the range in seasonal projections from a limited set of climate models for central eastern NSW. However, given strong spatial gradients in extreme rainfall projections (see Hennessy et al., 2004b), these regional results may not be applicable for Sydney.
4 The values for drought represent average monthly drought frequencies, based upon the Bureau of Meteorology's criteria for serious rainfall deficiency (see also Burke et al., 2006).
5 Number of days annually with a "very high" or "extreme" fire danger index. Changes are for 2020 and 2050, respectively, as in Hennessy et al. (2005).

Figure 22. Current and projected climate change in the Sydney Region (extracted from CSIRO 2007)

ECOLOGICAL ASSETS AND VALUES

PHYSICAL GEOGRAPHY

The Duck River catchment generally flows north/south with the eastern and western sides being moderately sloping; it becomes flatter towards the downstream reach from Parramatta Road to its confluence with Parramatta River near Silverwater Bridge.

The headwaters of the Duck River are in Bankstown. Within the headwaters area, two sub-catchments have been defined - that of Duck River and the smaller sub-catchment of Wolumba. The Duck River commences in the suburb of Yagoona West and the drainage path travels in a northerly direction through the suburbs of Birrong and Sefton before crossing under the Sydney Water (SW) pipeline which forms the boundary between BCC and PCC LGAs.

Within BCC, the open channel is almost entirely concrete lined with the upper parts draining by overland flow and a pit and pipe network. There are approximately five kilometres of open channel system with wider sections as the upstream catchment increases. There are closed channels under roads and railways.

Downstream of the SW pipeline, the channel is in a semi natural state (unlined) and it is crossed by several bridges and pipelines. PCC is on the western side and ACC on the east. In places the channel is deeply incised and anecdotal evidence suggests that, in places, the floodplain has been filled or landscaped for sporting fields or areas of open space. The main channel is vegetated to varying extents and in places extensive bank re-vegetation has occurred. In the lower parts the channel is lined by mangroves.

In this reach, the Duck River corridor contains regionally significant areas of natural bushland and wildlife habitat, interspersed amongst numerous sports fields and areas of open space used for passive recreation (Norford, Hislop, Everley, Progress, Oriole and Mona Parks, Ray Marshall Reserve, Horylck Reserve, Rosnay Golf Course and the Auburn Botanic Gardens).

THREATENED FLORA AND FAUNA SPECIES IN THE CATCHMENT

Threatened Species

Six species of threatened fauna have been recorded from the Duck River riparian corridor, listed in Table 10. A description of each species is presented in Appendix Two, along with a summary of key threats.

Table 10. Threatened fauna species found in Upper Duck River catchment

SPECIES NAME	EPBC/ TSC Act *	DATE/LOCATION OF RECENT RECORD(S)
Green and Golden Bell Frog (*Litoria aurea*)	V (EPBC), E (TSC)	Several records from around Camelia (most recent reports include October 1999, January 2000, April 2000), one from Duck Creek in Granville (reported in 1966), and several records from A'Becketts Creek upper reaches in Holroyd LGA.
Little Eagle (*Hieraetus morphnoides*)	V (TSC)	One record only, from Duck River Bushland Reserve in 2007.
Spotted-tailed Quoll (*Dasyurus maculatus*)	E (EPBC), V (TSC)	One record only, from the vicinity of Mona St in 1993.
Grey-headed Flying Fox	V (EPBC),	A number of records from Clyde Weir, Granville to the

SPECIES NAME	EPBC/ TSC Act *	DATE/LOCATION OF RECENT RECORD(S)
(*Pteropus poliocephalus*)	V (TSC)	confluence with Parramatta River (most recently reported December, 2008). A roosting camp is currently located on Duck River immediately upstream from Clyde Weir.
Eastern Bentwing Bat (*Miniopterus schreibersii oceanensis*)	V (TSC)	One record from Duck River Bushland Reserve (October, 2008), and one from nearby at Campbell Hill Pioneer Reserve (October, 2008).
Cumberland Plain Land Snail (*Meridolum corneovirens*)	E (TSC)	Recently recorded (February, 2012) in Duck River Bushland Reserve during fauna surveys. One reported record previously in July 2007 from Duck River Bushland Reserve.

* V = vulnerable, E = Endangered; EPBC = Environmental Protection & Biodiversity Conservation Act, TSC = Threatened Species Conservation Act (NSW)

Three species of threatened flora have been recorded from the Duck River riparian corridor. A description of each species is presented in Appendix Two, along with a summary of key threats. These species are listed in Table 11.

Table 11. Threatened flora species found in Upper Duck River catchment

SPECIES NAME	EPBC/ TSC Act	DATE/LOCATION OF RECENT RECORD(S)
Narrow-leaf Wilsonia (*Wilsonia backhousei*)	V (TSC)	Recently recorded from tidal mudflats around Camelia industrial area.
Glandular Pink-bell (*Tetratheca glandulosa*)	V (EPBC), V (TSC)	A single record from the vicinity of Horlyck Park in 1887.
Downy Wattle (*Acacia pubescens*)	V (EPBC), V (TSC)	Currently recorded from a number of locations in Duck River Bushland Reserve.

* V = vulnerable, E = Endangered; EPBC = Environmental Protection & Biodiversity Conservation Act, TSC = Threatened Species Conservation Act (NSW)

JAMBA, CAMBA or RoKAMBA species at the site

Nine species of birds listed under the JAMBA, CAMBA and RoKAMBA agreements have been recorded within a 5km radius from Duck River (Table 12). Of these, the nearest records were from Millenium Parklands at Silverwater, while others were from Homebush Creek/Bay and Newington. Most recent records for each species ranged from June 1986 (Curlew Sandpiper) to November 2011 (Caspian Tern). No migratory wetland bird species has been recorded from the Duck River Wetlands, and these species are unlikely to be affected by any works in the area, other than to potentially use the proposed improved habitat.

Table 12. JAMBA, CAMBA AND RoKAMBA species recorded in or near Upper Duck River wetlands

SCIENTIFIC NAME	COMMON NAME	LEGAL STATUS	NO. OF RECORDS	DATE/ LOCATION OF MOST RECENT SIGHTING
Ardea ibis	Cattle Egret		2	May 2002, Newington
Haliaeetus leucogaster	White-bellied Sea-Eagle		1	June 2004, Millenium Parklands, Silverwater
Actitis hypoleucos	Common Sandpiper		11	October 2007, Millenium Parklands, Silverwater
Calidris	Sharp-tailed		15	October 2006, Millenium

SCIENTIFIC NAME	COMMON NAME	LEGAL STATUS	NO. OF RECORDS	DATE/ LOCATION OF MOST RECENT SIGHTING
acuminate	Sandpiper			Parklands, Silverwater
Calidris ferruginea	Curlew Sandpiper	E (EPBC)	11	June 1986, Newington
Gallinago hardwickii	Latham's Snipe		4	October 2005, Millenium Parklands, Silverwater
Limosa lapponica	Bar-tailed Godwit		1	November 2005, Homebush Creek/Bay
Tringa nebularia	Common Greenshank		1	February 1986, Newington
Hydroprogne caspia	Caspian Tern		2	November 2011, Homebush Creek/Bay October 2004, Millenium Parklands, Silverwater

* V = vulnerable, E = Endangered; EPBC = Environmental Protection & Biodiversity Conservation Act, TSC = Threatened Species Conservation Act (NSW)

OTHER FLORA AND FAUNA

Fauna present

In recent surveys Applied Ecology P/L staff recorded 58 species of birds in the Duck River catchment riparian corridors and associated reserves (see Appendix Two for a full list of species), focussing on the area upstream of Clyde Weir. This included 9 species of introduced birds, and 3 threatened species. Distribution across the catchment was not consistent, with more birds recorded along the main Duck River corridor (28 species south of Ray Marshall Reserve to the Sydney Water Pipeline, and 43 between Clyde Weir and Ray Marshall Reserve), and at Campbell Hill-Waddangalli Reserves (31 species). Avian diversity was considerably lower in all of the minor tributaries surveyed.

In addition, 5 species of frog were recorded, 7 lizards and one snake species, 7 bats (including 3 threatened species), 4 introduced mammals, 2 fish, a turtle and one significant invertebrate, the endangered Cumberland Plain Land Snail (Figure 23; see Appendix Three for a full list of species). Once again, areas of higher diversity were concentrated in the larger bushland reserves, and considerably lower in all of the tributaries surveyed.

Figure 23. Cumberland Plain Land Snails at Duck River Bushland Reserve, a threatened species

Flora present

As part of their works report, Bushit P/L compiled a list of all native species recorded on work sites along Duck River between November, 2010 and October, 2011, providing an up to date snapshot of floristic diversity in the riparian corridor. They recorded 259 native plant species, including one threatened species (see Appendix Four for a full list of species). Ironically this list doesn't include the Duck River Bushland Reserve, where the most intact bushland is conserved.

Native flora species was recorded in a single survey for Duck River Bushland Reserve during recent flora and fauna surveys conducted by Applied Ecology P/L. This survey recorded 100 species of native flora in the reserve (see Duck River Masterplan for a full list of species), a number of which were not reported elsewhere by Bushit in 2011.

- Sydney Coastal Freshwater Wetlands EEC
- Cumberland Riverflat Forest EEC
- Cumberland Swamp Oak Riparian Forest EEC
- Cooks River/Castlereagh Ironbark Forest EEC

VEGETATION COMMUNITIES PRESENT

The Duck River Catchment and riparian corridor has a range of vegetation types, forming a mosaic of communities with varying degrees of disturbance and degradation, mainly through the impacts of weed establishment. Vegetation in the riparian corridor has been mapped as Urban/Exotic or Weeds/Exotic, or is one of a number of communities that are listed as Endangered Ecological Communities (EECs). These include (Figure 24):

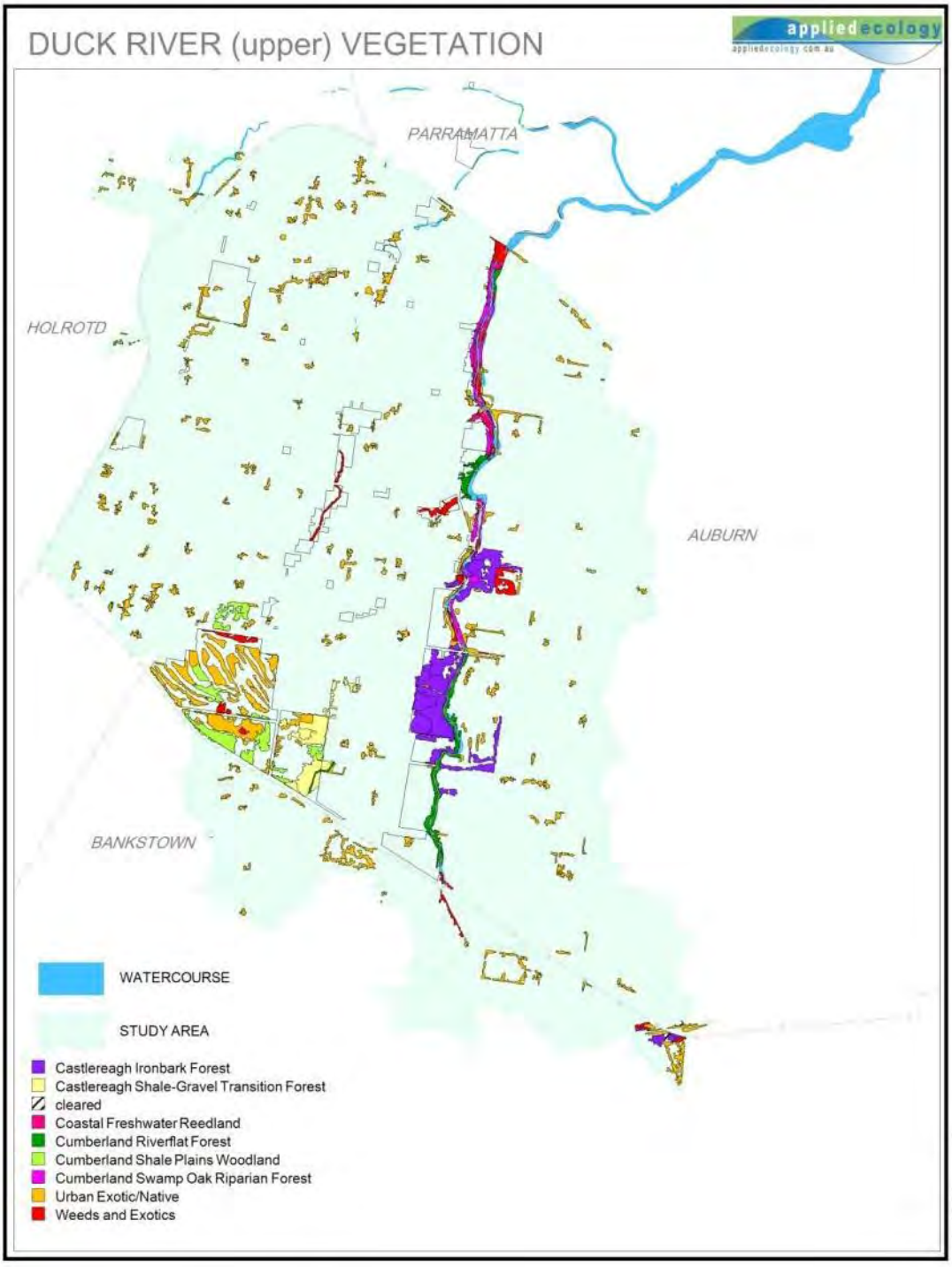

Figure 24. Vegetation communities present in the Upper Duck River catchment

Cumberland Swamp Oak Riparian Forest (Swamp Oak Floodplain Forest EEC)

This community is found on the coastal floodplains of NSW. It has a dense to sparse tree layer in which *Casuarina glauca* (swamp oak) is the dominant species. Other trees including *Acmena smithii* (lilly pilly), *Glochidion ferdinandi*. (cheese trees) and *Melaleuca* spp. (paperbarks) may be present as subordinate species, and are found most frequently in stands of the community northwards from Gosford. The understorey is characterised by frequent occurrences of vines, *Parsonsia straminea, Geitonoplesium cymosum* and *Stephania japonica* var. *discolor*, a sparse cover of shrubs, and a continuous groundcover of forbs, sedges, grasses and leaf litter. The composition of the ground stratum varies depending on levels of salinity in the groundwater. Under less saline conditions prominent ground layer plants include forbs such *Centella asiatica, Commelina cyanea, Persicaria decipiens* and *Viola banksii*; graminoids such as *Carex appressa, Gahnia clarkei, Lomandra longifolia, Oplismenus imbecillis*; and the fern *Hypolepis muelleri*. On the fringes of coastal estuaries, where soils are more saline, the ground layer may include *Baumea juncea, Juncus kraussii, Phragmites australis, Selliera radicans* and other saltmarsh species.

Main threats for this community include:

- 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
- Activation of acid sulfate soils
- Removal of dead wood
- Rubbish dumping
- Frequent burning which reduces the diversity of woody plant species

Cumberland Riverflat Forest (Riverflat Eucalypt Forest EEC)

As the name suggests, this EEC is found on the river flats of the coastal floodplains. It has a tall open tree layer of eucalypts, which may exceed 40 m in height, but can be considerably shorter in regrowth stands or under conditions of lower site quality. While the composition of the tree stratum varies considerably, the most widespread and abundant dominant trees include *Eucalyptus tereticornis* (forest red gum), *E. amplifolia* (cabbage gum), *Angophora floribunda* (rough-barked apple) and *A. subvelutina* (broad-leaved apple). A layer of small trees may be present, including *Melaleuca decora, M. styphelioides* (prickly-leaved teatree), *Backhousia myrtifolia* (grey myrtle), *Melia azaderach* (white cedar), *Casuarina cunninghamiana* (river oak) and *C. glauca* (swamp oak). Scattered shrubs include *Bursaria spinosa , Solanum prinophyllum, Rubus parvifolius, Breynia oblongifolia, Ozothamnus diosmifolius, Hymenanthera dentata, Acacia floribunda* and *Phyllanthus gunnii*. The groundcover is composed of abundant forbs, scramblers and grasses including *Microlaena stipoides, Dichondra repens, Glycine clandestina, Oplismenus aemulus, Desmodium gunnii, Pratia purpurascens, Entolasia marginata, Oxalis perennans* and *Veronica plebeia* . The composition and structure of the understorey is influenced by grazing and fire history, changes to hydrology and soil salinity and other disturbance, and may have a substantial component of exotic shrubs, grasses, vines and forbs.

Main threats for this community include:

- 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
- Activation of acid sulfate soils
- Removal of dead wood
- Rubbish dumping
- Frequent burning which reduces the diversity of woody plant species

Coastal Freshwater Reedland (Freshwater Wetlands on the Coastal Floodplain EEC)
Associated with coastal areas subject to periodic flooding and in which standing fresh water persists for at least part of the year in most years. Typically occurs on silts, muds or humic loams in low-lying parts of floodplains, alluvial flats, depressions, drainage lines, backswamps, lagoons and lakes but may also occur in backbarrier landforms where floodplains adjoin coastal sandplains. Generally occur below 20 m elevation on level areas. They are dominated by herbaceous plants and have very few woody species.

The structure and composition of the community varies both spatially and temporally depending on the water regime: Those that lack standing water most of the time are usually dominated by dense grassland or sedgeland vegetation, often forming a turf less than 0.5 metre tall and dominated by amphibious plants including *Paspalum distichum* (water couch), *Leersia hexandra* (swamp rice-grass), *Pseudoraphis spinescens* (mud grass) and *Carex appressa* (tussock sedge). Where they are subject to regular inundation and drying the vegetation may include large emergent sedges over 1 metre tall, such as *Baumea articulata, Eleocharis equisetina* and *Lepironia articulata*, as well as emergent or floating herbs such as *Hydrocharis dubia* (frogbit), *Philydrum lanuginosum* (frogsmouth), *Ludwigia peploides* subsp. *montevidensis* (water primrose), *Marsilea mutica* (nardoo) and *Myriophyllum* spp. (milfoils). As standing water becomes deeper or more permanent, amphibious and emergent plants become less abundant, while floating and submerged aquatic herbs become more abundant.

Main threats for this community include:

- Land clearing
- Flood mitigation and drainage works
- Filling associated with urban and industrial development
- Continuing fragmentation and degradation
- Pollution and eutrophication from urban and agricultural runoff
- Weed invasion
- Anthropogenic climate change
- Activation of acid sulfate soils
- Overgrazing, trampling by livestock, soil disturbance by pigs
- Dumping of landfill, rubbish and garden refuse
- Native fauna is threatened by predation, particularly by mosquito fish and cane toads

Cooks River/Castlereagh Ironbark Forest EEC
Ranges from open forest to low woodland, with a canopy dominated by Broad-leaved Ironbark *Eucalyptus fibrosa* and Paperbark *Melaleuca decora*. The canopy may also include other eucalypts such as Woolybutt *E. longifolia*. The dense shrubby understorey consists of *Melaleuca nodosa* and Peach Heath *Lissanthe strigosa*, with a range of 'pea' flower shrubs, such as *Dillwynia tenuifolia, Pultenaea villosa* and *Daviesia ulicifolia* (can be locally abundant). The sparse ground layer contains a range of grasses and herbs. Has a very restricted natural distribution and mainly occurs on clay soils derived from the deposits of ancient river systems (alluvium), or on shale soils of the Wianamatta Shales. Can intergrade into Shale-Gravel Transition Forest (where the alluvium is shallow), Castlereagh Swamp Woodland (in moist depressions) and Castlereagh Scribbly Gum Woodland (on more sandy soils). Most species in the community are able to regenerate from lignotubers and buds beneath the bark as well as seeds stored in the soil.

Main threats for this community include:

- Further clearing for urban and rural development or shale/clay extraction
- and the subsequent impacts from fragmentation
- Urban run-off, which leads to increased nutrients and sedimentation
- Weed invasion
- Inappropriate fire regimes, which have altered the appropriate floristic and structural diversity

This community adjoins the riparian zone at Duck River Bushland Reserve, on Wellington Rd. Access, impacts and actions for communities directly associated with the riparian channel need to consider potential impacts for this EEC.

Management of EECs
EECs face a very high risk of extinction in NSW in the near future (DECC 2005). Threats to these wetland communities include (DECC 2005a,b,c):

- Activation of acid sulfate soils
- Anthropogenic climate change
- Changes in water quality, particularly increased nutrients and sedimentation
- Continuing fragmentation and degradation
- Dumping of landfill, rubbish and garden refuse
- Flood mitigation and drainage works
- Habitat degradation resulting from altered hydrology/nutrient levels, weed invasion, off-road vehicles, illegal waste dumping and sand extraction
- Habitat loss and fragmentation due to clearing and filling associated with urban development
- Inappropriate fire regimes

- Land clearing
- Land-filling and earthworks associated with urban and industrial development
- Management of water and tidal flows
- Native fauna is threatened by predation, particularly by Gambusia and cane toads
- Pollution and eutrophication from urban and agricultural runoff
- Rubbish dumping
- Weed invasion

Strategies required to recover EECs have been identified by DECCW in the Priority Action Statement (2005). Possible actions for the EECs at Upper Duck River Wetlands are listed in Table 13. Not all actions may be relevant or feasible at Upper Duck River Wetlands. All management recommendations put forward in this PoM are consistent with the required recovery actions.

Table 13. Actions from the Priority Action Statement that are relevant for EECs in Upper Duck River catchment

RECOVERY ACTION	SWAMP OAK FLOODPLAIN FOREST	RIVERFLAT EUCALYPT FOREST	SYDNEY FRESHWATER WETLANDS
Undertake weed control as required using removal methods that will not damage the community.	√	√	√
Protect and actively manage wetlands through conservation mechanisms such as covenanting and the preparation/implementation of site-specific vegetation management plans.	√	√	√
Improve vegetative connectivity within and between remnants through revegetation / regeneration programs and provide vegetative buffers around these remnants.	√	√	√
Ensure that the fire sensitivity of the community is considered when planning hazard reduction and asset management burning.	√	√	
Promote public involvement in restoration activities.	√		
Install storm water control mechanisms to prevent offsite impacts from adjacent development.			√
Restore natural drainage conditions.			√
Control access to remnants by installing fencing and signage and rationalising informal tracks through the community.			√

Vegetated buffer

Upper Duck River Wetlands are longitudinal wetlands that follow the course of the river. As such they have a large perimeter to area ratio, increasing edge effects on the system. Management is further complicated by the division in responsibility for management, with west and east banks managed by different councils.

Overall extent for vegetated buffers for the Upper Duck River Wetlands are summarised in the following table (Table 14).

Table 14. Overall extent for vegetated buffers on both banks of Upper Duck River Wetlands

REACH	LENGTH (m)	EAST BANK (ACC)			WEST BANK (PCC)		
		MIN WIDTH (m)	MAX WIDTH (m)	% VEG COVERED	MIN WIDTH (m)	MAX WIDTH (m)	% VEG COVERED
DUCK RIVER 1A	400	10	60	100	7	20	100
DUCK RIVER 1B	570	7	45	100	10	35	100
DUCK RIVER 2A	540	0	15	50	60	320	100
DUCK RIVER 2B	480	0	10	30	95	230	100
DUCK RIVER 3A	440	0	35	85	10	85	100
DUCK RIVER 3B	410	0	30	40	2	55	80
DUCK RIVER 4A	400	5	30	100	0	40	85
DUCK RIVER 4B	710	7	30	100	25	70	100
DUCK RIVER 5A	620	10	45	100	25	70	100
DUCK RIVER 5B	600	15	45	100	20	35	100
UNNAMED 3	305+125	n/a			0	60	85
UNNAMED 7	180	n/a			5	40	100

Overall condition for vegetated buffers for the Upper Duck River Wetlands are summarised in the following table (Table 15).

Table 15 Overall condition for vegetated buffers around Upper Duck River Wetlands

REACH	EAST BANK OVERALL CONDITION (ACC)	WEST BANK OVERALL CONDITION (PCC)
DUCK RIVER 1A	Mostly narrow and highly degraded; vines cover canopy species, understorey weeds Area of revegetation at upstream end, some weeds present	Narrow strip of degraded vegetation, some weeds and areas with few natives present
DUCK RIVER 1B	Mostly steep, narrow and highly degraded; vines cover canopy species, understorey weeds	Narrow strip of degraded vegetation, some weeds present
DUCK RIVER 2A	Very narrow and steep, lots of vines and understorey weeds, recent spraying for weed control; bounded by golf course	Narrow riparian strip of bushland with revegetation area adjoining, some weeds mostly along very steep bank
DUCK RIVER 2B	Very narrow and steep, lots of vines and understorey weeds, recent spraying for weed control; bounded by golf course	Degraded riparian vegetation, lots of weeds, with intact bushland adjoining
DUCK RIVER 3A	Mostly steep, narrow and highly degraded; vines cover canopy species, understorey weeds	Degraded riparian vegetation, lots of vines and understorey weeds, with small areas of intact bushland adjoining
DUCK RIVER 3B	Riparian vegetation very narrow or absent, highly degraded	Narrow strip of degraded vegetation, lots of weeds present
DUCK RIVER 4A	Riparian vegetation very narrow and steep, highly degraded	Narrow strip of degraded vegetation, lots of weeds present; some revegetation in adjoining areas
DUCK RIVER 4B	Riparian vegetation very narrow and steep, highly degraded or poorly maintained revegetation areas	Fairly good riparian vegetation with reasonable buffer width along most of reach, adjoins extensive reedlands
DUCK RIVER 5A	Mostly steep, narrow and highly degraded; vines cover canopy species, understorey weeds, adjoins extensive reedlands	Narrow to moderate strip of riparian vegetation with some weeds along most of reach, adjoins extensive reedlands
DUCK RIVER 5B	Mostly steep, narrow and highly degraded; vines cover canopy species, understorey weeds, adjoins extensive reedlands	Mostly steep, narrow and highly degraded; vines cover canopy species, understorey weeds, adjoins extensive reedlands
UNNAMED 3	n/a	Modified channel upstream with areas of dense weeds and better bushland, highly degraded, lots of weeds surrounding medium sized reedland
UNNAMED 7	n/a	Modified channel upstream, highly degraded, lots of weeds surrounding small reedland

Weed species present

Non-native plants fall into a number of categories, including noxious weeds, environmental weeds, and exotics. Exotics generally do not spread on their own; however, if they do they are usually classed as environmental weeds. Noxious weeds are environmental weeds that have been identified as having a significant commercial impact on the environment, such as crops or livestock, or to be ecosystem transforming plants that have a major detrimental effect on native bushland, waterways etc.

Noxious weed treatment requirements

Under the Noxious Weeds Act, declared noxious weeds must be controlled according to the conditions for the relevant weed class (Table 16).

Table 16. Classes of noxious weeds and their control requirements (DII, 2012)

WEED CLASS	CONTROL OBJECTIVES	CONTROL MEASURE
Class 1	The control objectives for weed control class 1 is to prevent the introduction and establishment of those plants in NSW.	The plant must be eradicated from the land and the land must be kept free of the plant. Class 1 weeds are notifiable and as such the presence of the weed on land must be notified to the local control authority (Wyong Shire Council) within 72 hours of detection
Class 2	The control objectives for weed control class 2 is to prevent the introduction and establishment of those plants in parts of NSW	The plant must be eradicated from the land and the land must be kept free of the plant. Class 2 weeds are notifiable and as such the presence of the weed on land must be notified to the local control authority (Parramatta/Auburn City Council) within 72 hours of detection
Class 3	The control objectives for weed control class 3 is to reduce the area and the impact of those plants in parts of NSW	The plant must be fully and continuously suppressed and destroyed
Class 4	The control objective for weed control class 4 is to minimise the negative impact of these plants on the economy, community or environment of NSW	The growth and spread of the plants must be controlled according to the measures specified in a management plan published by the local control authority
Class 5	To prevent the introduction of those plants into NSW, the spread of those plants within NSW or from NSW to another jurisdiction	The requirements in the Noxious Weeds Act 1993 for a notifiable weed must be complied with and as such must not be sold or purchased and must not be moved from the land

Treatment methods:

Treatment methods for noxious and environmental weeds recorded during recent surveys of the site are listed in the following table (Table 17). Use of herbicides should only be undertaken by appropriately trained personnel. Check label permit directions for use, ensure the herbicide is licensed for use around waterways, consider off target kill, read the accompanying MSDS and be aware of health and safety implications of using

herbicides. Always use appropriate PPE. When in doubt, check with council's noxious/environmental weeds control officers for advice.

Table 17. Recommended treatment methods for weeds recorded in the Upper Duck River Wetlands and Riparian Corridor during surveys in April, 2012

SPECIES NAME	NOXIOUS WEED CLASS	PLANT FORM	TREATMENT(S)
Acacia baileyana		tree/shrub	stem inject, cut and paint
Acer negundo		tree/shrub	stem inject, cut and paint
Acetosa sagittata		scrambler	spray, dig rootballs
Ageratina adenophora		herb	hand pull, spray
Alternanthera philoxeroides	3	herb (aquatic)	hand pull, spray
Alternanthera pungens		herb	hand pull, spray
Amaranthus viridus		herb	hand pull, spray
Ambrosia tenuifolia		herb	hand pull, spray
Anredera cordifolia	4	climber	scrape and paint
Araujia sericifera		climber	scrape and paint
Asparagus aethiopicus	4	climber	crown
Asparagus asparagoides	4	climber	crown
Atriplex prostrata		herb	hand pull, spray
Bidens pilosa		annual	hand pull, spray
Bidens subalternans		annual	hand pull, spray
Briza subaristata		grass/ graminoid	crown, spray
Bromus catharticus		grass/ graminoid	crown, spray
Bryophyllum delagoense		succulent herb	hand pull, spray
Cardiospermum grandiflorum	4	climber	scrape and paint
Cerastium fontanum ssp vulgare		herb	hand pull, spray
Cestrum parqui	3	tree/shrub	stem inject, cut and paint
Chenopodium album		herb	hand pull, spray
Chloris gayana		grass/ graminoid	crown, spray
Chlorophytum comosum		grass/ graminoid	crown, spray
Chrysanthemum coronarium		herb	hand pull, spray
Cinnamomum camphora		tree/shrub	stem inject, cut and paint
Cirsium vulgare		annual	hand pull, spray
Conyza spp		annual	hand pull, spray
Cyclospermum leptophyllum		herb	hand pull, spray
Cynodon dactylon		grass/ graminoid	crown, spray
Cyperus brevifolius		grass/ graminoid	crown, spray
Cyperus congestus		grass/ graminoid	crown, spray
Cyperus rotundatus		grass/ graminoid	crown, spray
Digitaria sanguinalis		grass/ graminoid	crown, spray
Echinochloa crus-galli		grass/ graminoid	crown, spray
Ehrharta erecta		grass/ graminoid	crown, spray
Eleusine tristachya		grass/ graminoid	crown, spray

SPECIES NAME	NOXIOUS WEED CLASS	PLANT FORM	TREATMENT(S)
Eragrostis curvula		grass/ graminoid	crown, spray
Erythrina christa-galli		tree/shrub	stem inject, cut and paint
Euphorbia peplus		herb	hand pull, spray
Galinsoga parviflora		herb	hand pull, spray
Galium aparine		herb	hand pull, spray
Gamochaeta calviceps		herb	hand pull, spray
Genista monspessulana	3	tree/shrub	cut and paint
Hirschfeldia incana		herb	hand pull, spray
Hypochaeris radicata		herb	hand pull, spray
Ipomoea indica	4	climber	scrape and paint
Lactuca serriola		herb	hand pull, spray
Lantana camara	4	tree/shrub	spray, cut and paint
Ligustrum lucidum	4	tree/shrub	stem inject, cut and paint
Ligustrum sinense	4	tree/shrub	stem inject, cut and paint
Lonicera japonica		climber	scrape and paint
Malva sp		herb	hand pull, spray
Modiola caroliana		herb	hand pull, spray
Morus alba		tree/shrub	stem inject, cut and paint
Nothoscordum borbonicum		grass/ graminoid	crown, spray
Ochna serrulata		tree/shrub	stem inject, cut and paint
Oxalis pes-caprae	5	herb	hand pull, spray
Parietaria judaica	4	herb	hand pull, spray
Paspalum dilatatum		grass/ graminoid	crown, spray
Paspalum quadrifarium		grass/ graminoid	crown, spray
Paspalum urvillei		grass/ graminoid	crown, spray
Passiflora subpeltata		climber	scrape and paint, crown rootball, spray
Pavonia hastata		herb	hand pull, spray
Pennisetum clandestinum		grass/ graminoid	crown, spray
Physalis peruviana		herb	hand pull, spray
Plantago lanceolata		grass/ graminoid	crown, spray
Plantago major		herb	hand pull, spray
Ricinus communis	4	tree/shrub	cut and paint
Rubus fruticosus aggregate species	4	climber	scrape and paint, crown rootball, spray
Rumex crispus		herb	hand pull, spray
Rumex obtusifolius		herb	hand pull, spray
Sagittaria platyphylla	5	herb (aquatic)	spray, mechanical
Salix babylonica		tree/shrub	stem inject, cut and paint
Senecio madagascariensis		tree/shrub	cut and paint
Senna pendula var glabrata		tree/shrub	stem inject, cut and paint
Setaria palmifolia		grass/ graminoid	crown, spray
Setaria parviflora		grass/ graminoid	crown, spray

SPECIES NAME	NOXIOUS WEED CLASS	PLANT FORM	TREATMENT(S)
Sida rhombifolia		herb	hand pull, spray
Solanum nigrum		herb	hand pull, spray
Sonchus asper		herb	hand pull, spray
Sporobolus africanus		grass/ graminoid	crown, spray
Stachys arvensis		herb	hand pull, spray
Stellaria media		herb	hand pull, spray
Taraxacum spp		herb	hand pull, spray
Thunbergia alata		climber	hand pull, spray
Tradescantia albiflora		herb	hand pull, spray
Trifolium repens		herb	hand pull, spray
Tropaeolum majus		herb	hand pull, spray
Verbena bonariensis		herb	hand pull, spray
Verbena rigida		herb	hand pull, spray
Xanthium occidentale		tree/shrub	cut and paint

Habitat value and connectivity

The Upper Duck River Wetlands form a regional corridor of major significance. The river links remnant patches of bushland around Auburn, South Granville and Chester Hill with Parramatta River. Degraded sections of the riverine corridor provide stepping stone habitat opportunities between areas of better bushland. It links a suite of wetlands habitats that are all classed as Endangered Ecological Communities, and is home to a number of threatened flora and fauna species.

There is potential to extend this corridor to link with reserves in the upper reaches of Duck River (Bankstown LGA), and through to Cooks River in the south, although this is outside the scope of this plan.

The Upper Duck River Wetlands provide a typical mosaic of vegetation communities as core habitat assets, so that some areas provide more of a particular habitat resource and some areas provide a wider range of habitat resources (Table 18). Reaches with limited resources are also important for their buffering capacity.

Table 18. Habitat resources recorded in surveyed reaches of Upper Duck River Wetlands in April, 2012

REACH	HOLLOW BEARING TREES	FALLEN TIMBER	ROCKY OUTCROPS	DEAD TREES	OPEN WATER	INSTREAM MACRO-PHYTES	SNAGS
DUCK RIVER 1A	√	√	√			√	
DUCK RIVER 1B	√	√	√				
DUCK RIVER 2A		√					
DUCK RIVER 2B	√	√					
DUCK RIVER 3A	√	√			√	√	
DUCK RIVER 3B	√				√	√	
DUCK RIVER 4A				√	√	√	√
DUCK RIVER 4B	√	√			√	√	
DUCK RIVER 5A	√	√			√	√	√
DUCK RIVER 5B	√	√		√	√	√	√

REACH	HOLLOW BEARING TREES	FALLEN TIMBER	ROCKY OUTCROPS	DEAD TREES	OPEN WATER	INSTREAM MACRO-PHYTES	SNAGS
UNNAMED 3						√	
UNNAMED 7		√				√	

Fish passage

There are a number of major and minor barriers to fish passage within the catchment. The first weir is located 400m from the top of the study area, aligned with Boundary Rd and forming the division between reaches DUCK RIVER 1A and DUCK RIVER 1B . This weir has low flow holes in the bottom, allowing for unrestricted baseflows and providing fish passage at the site (Figure 25).

Figure 25. Boundary Rd weir, near the upper limit of the study area

The second weir is at Mackay Rd, in reach DUCK RIVER 4 where it forms the boundary between DUCK RIVER 4A and DUCK RIVER 4B. Known as the stepping stone weir, regular slots in the upper section and irregularly placed rocks in the lower section form a moderately effective fish passage (Figure 26). The lower weir face functions as a (constructed) riffle zone.

Figure 26. Stepping Stones weir, near Mackay Rd, located mid catchment

The lower limit of the Upper Duck River Wetlands (reach DUCK RIVER 5B) is formed by the main weir at Clyde, adjacent to the railway line, and forming the boundary between tidal and non-tidal parts of the river (Figure 27). This weir forms an effective barrier to fish passage. As such, it keeps the carp upstream separate from the downstream environment, although these fish will cross this type of barrier and swim further upstream during a flood event. Most of the aquatic vertebrates recorded in

Upper Duck River Wetlands were carp and gambusia, with several short-finned eels and a couple of side-necked turtles.

Figure 27. Clyde Weir and the railway bridge form the lower limit of the freshwater reaches of Duck River

SOCIAL VALUES

INDIGENOUS HERITAGE

The Duck River appears to have been the boundary between two major groups of indigenous people prior to the European settlement of New South Wales.

The Auburn area was located on the border between the Darug inland group and the Eora/Dharawal coastal group of Aboriginal people. The Wangal and Wategoro, sub-groups or clans, are the groups most often recognised as the original inhabitants of the Auburn / Homebush Bay region. Bennelong, one of the most famous Aboriginals of the time, was a member of Wangal, as was his wife, Barangaroo. Pemulwuy, who organised tribes to resist the white settlement of the Sydney region from 1790 to 1802 was also a member of the Wangal. The agreed boundary between Burramattagal country and their neighbours, the Wategora clan, seems to have been the Duck River (McClymont, 2008). The Auburn area was once used by Aboriginal people as a market place for the exchange of goods, a site for ritual battles and a 'Law Place' for ceremonies.

Further to the west, the original inhabitants of the area that is now Parramatta belonged to the Darug (Dharug, Daruk) language group. The clan that occupied the area was known as the Burramattagal. The Bidjigal occupied the areas to the north and west. The Burramattagal relied on the mixed food sources available from the river and the surrounding woods (Kass, 2008). The southern riverbank and the mostly freshwater stream now known as Clay Cliff Creek were vital sources of their food and living resources. In their seasonal rotation of campsites around their territory, the clan would have found that the reasonably abundant fish, shellfish, bird life, reptiles and marsupials large and small contributed greatly to their daily quest for food (McClymont, 2008).

A number of searches were conducted to identify whether there were Aboriginal heritage items, places or other relevant information for the Upper Duck River area. These included searches of the National

Native Title Tribunal (Table 19) with the following results.

Table 19. National Native Title Tribunal search results

TRIBUNAL DATABASE SEARCHED	SEARCH RESULT
Schedule of Applications	no relevant entries
Register of Native Title Claims	no relevant entries
National Native Title Register	no relevant entries
Register of Indigenous Land Use Agreements	no relevant entries
Notified Indigenous Land Use Agreements	no relevant entries

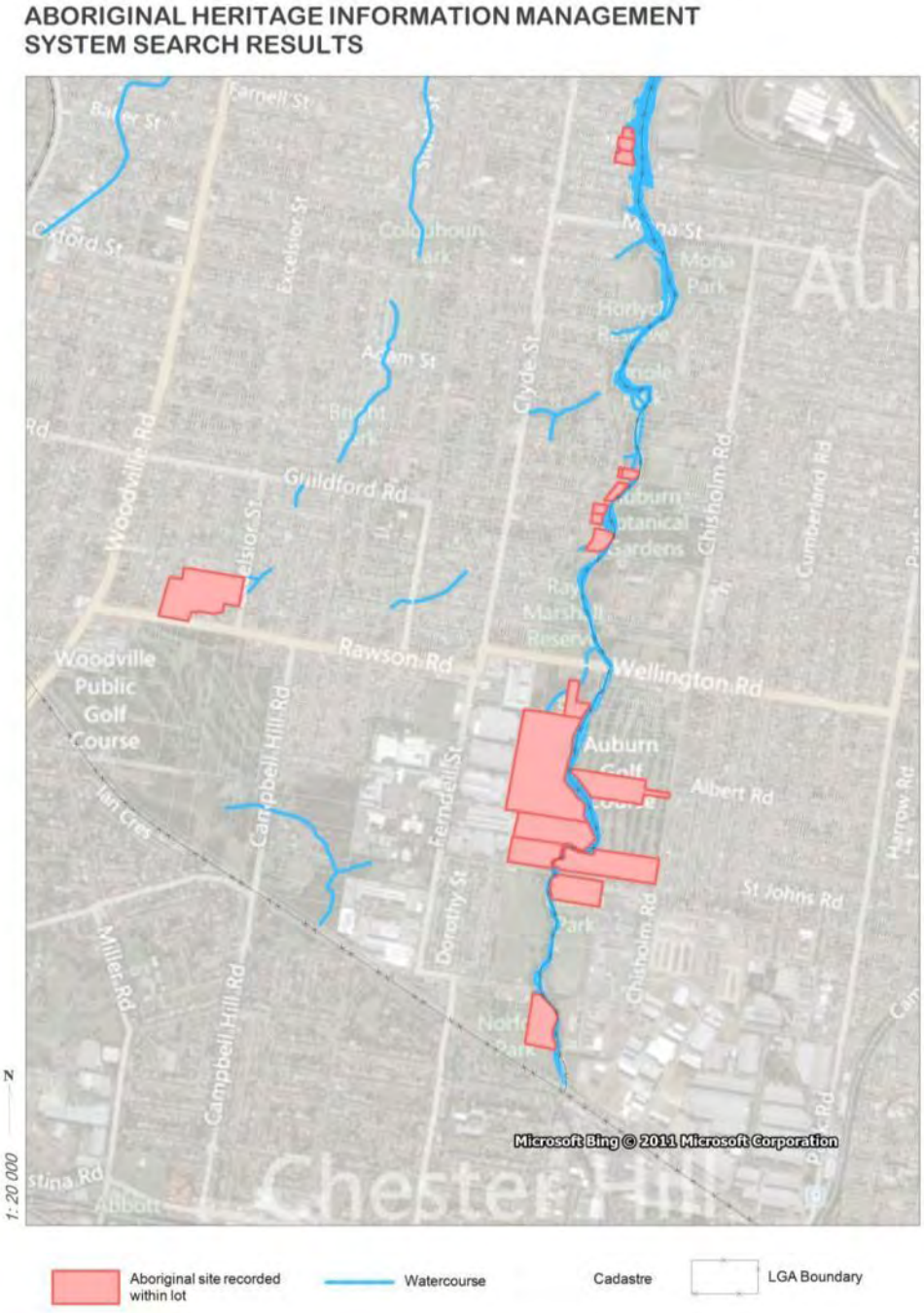

Figure 28. Indicative locations of indigenous heritage items along Upper Duck River

Further searches were conducted with the Aboriginal Heritage Information Management Service (AHIMS database; Appendix 6, Table A6). Basic searches for heritage items on properties by individual lot numbers revealed that there are numerous indigenous heritage items located at various points along the Upper Duck River (Figure 28). Mary Dallas Consulting (2002) identified a number of these heritage item locations, but also reported that all of the Upper Duck River Wetlands and Riparian Corridor was classified as high sensitivity for indigenous heritage potential. Before any works can be conducted in these areas a full search of the AHIMS database should be conducted, and if heritage items are located then Aboriginal Heritage Impact Permit must be obtained under Part 6 of the National Parks and Wildlife Act 1974.

NON-INDIGENOUS HERITAGE

On 5 February 1788, soon after the landing of Captain Arthur Phillip at Sydney Cove, Captain John Hunter and Lieutenant William Bradley sailed up what is now known as the Parramatta River, as far as Homebush Bay. Captain Hunter was the first white person to set foot within what is now the Auburn LGA.

Ten days later, Governor Phillip, along with a well-armed party in three boats, reached Homebush Bay. They ventured about 3 kilometres inland. The following day a party of explorers traced the river in a westerly direction, coming to the place where the Duck River enters the Parramatta River. They explored the tributary as far as the depth of water permitted. The party entered the mouth of Duck River while exploring the Parramatta River. Seeing a group of wild ducks taking flight from a reed bed, and thinking it might be a breeding ground for ducks, Governor Phillip named the waterway Duck River. The ducks were most likely specimens of *Porphyrio porphyrio* (Eastern Swamp Hen), but the name Duck River stuck.

Granville remained relatively untouched by European colonisation for many years. Early governors did make land grants to soldiers, officials and a handful of families who had established themselves as the elite of Parramatta. The Wentworths (D'Arcy Wentworth and his son William Charles) held land on the Duck River. The largest landowner in the district was the merchant Garnham Blaxcell, who snapped up some small grants given to members of the New South Wales Corps, and then received a massive consolidated grant of 1,125 acres (455 hectares) in 1806. This area is now bounded by Clyde Street and Parramatta, Woodville and Rawson roads. The forest was a resort for timber-getters, charcoal burners and men who trapped the prevalent native dogs; the original name for Woodville Road was Dog Trap Road.

The soil in what is now Auburn LGA proved too poor for agriculture, but early industries included timber-getting, and brick-making, which began with the establishment of the Duck River Brickworks by Charles Linney. In the 1850s, the construction of the Sydney-Parramatta railway brought large-scale deforestation and much of the useable timber was cut out by 1860. The railway line, opened with much ceremony in 1855, actually terminated on Dog Trap Road at a station called Parramatta Junction. In 1860 the railway was extended into Parramatta proper. The opening of the railway made suburban development possible, and the township of Auburn emerged from subdivisions by John Yelverton Mills near the railway station.

During the 1860s, subdivision of the old Jamieson estate began. Although James Bergan established a tweed mill close to the railway, many of the first buyers were

orchardists and farmers. There was room also for middle-class villas, occupied by men who were responsible for renaming, not just the disreputable Dog Trap Road, but the whole area. In the 1880s it became Granville, in honour of the then British Foreign Minister, Lord Granville. Five years later, the Municipality of Granville was declared: it encompassed all or part of the modern suburbs of Camellia, Rosehill, Harris Park, Granville, Clyde, and South Granville. The municipality – which took in Guildford in 1906 – lasted until 1949 when it was subsumed in the enlarged City of Parramatta.

Granville municipality grew quickly in the 1880s and 1890s, as industrialists were attracted by its road, rail and water access: the municipality also gained gas street lighting and a connection to the metropolitan water supply in this period. Hudson Brothers, manufacturers of railway rolling stock, chose a site on the Duck River at Granville to establish works, which opened in 1883 and covered 14 acres (5.6 hectares). Other new enterprises in Granville included James Brunton's six-storey flour mill and William Ritchie's factory producing agricultural machinery. The workers in these large factories – along with those in smaller tanneries and brickworks – boosted the area's population and stimulated the subdivision of existing farm lots.

During the 1920s, developments in building and the growth of motor transport brought more manufacturers to the Municipality of Granville. Private developers and the War Services Homes Commission tried to meet the resulting demand for housing: between 1921 and 1933 the number of 'occupied dwellings' in Granville municipality rose by 54 per cent. By 1933, however, the Depression was devastating the area. Male unemployment was over 20 per cent and the Granville Council struggled to provide relief works.

After World War II, state planning policies – which designated Parramatta as a growth centre – and federal immigration programs impacted on Granville, which had been reduced in size and status to become one of many suburbs of the City of Parramatta. At first, industrial expansion continued, but mainly in South Granville, while the Housing Commission built estates to accommodate an urban population growing as a result of the baby boom and immigration. The area was developed with an unusually high proportion of low income and/or non-English-speaking families.

In the immediate post-war period, growth was boosted by government initiativess. But it was the gazettal of the Strata Title Act of 1961 that had the greatest impact throughout the suburb, permitting the erection of multi-unit housing blocks. By the 1960s and 1970s, the number of Middle Eastern immigrants settling in Auburn had grown, making Auburn one of the main Arabic / Middle Eastern centres in Sydney, vying only with Canterbury. In the 1991 census, 47 per cent of the population of the municipality had been born overseas.

A number of cultural structures and precincts have been recorded around the Upper Duck River catchment (Figure 29). Preservation of these is an important part of the conservation process for the wetlands and riparian corridor.

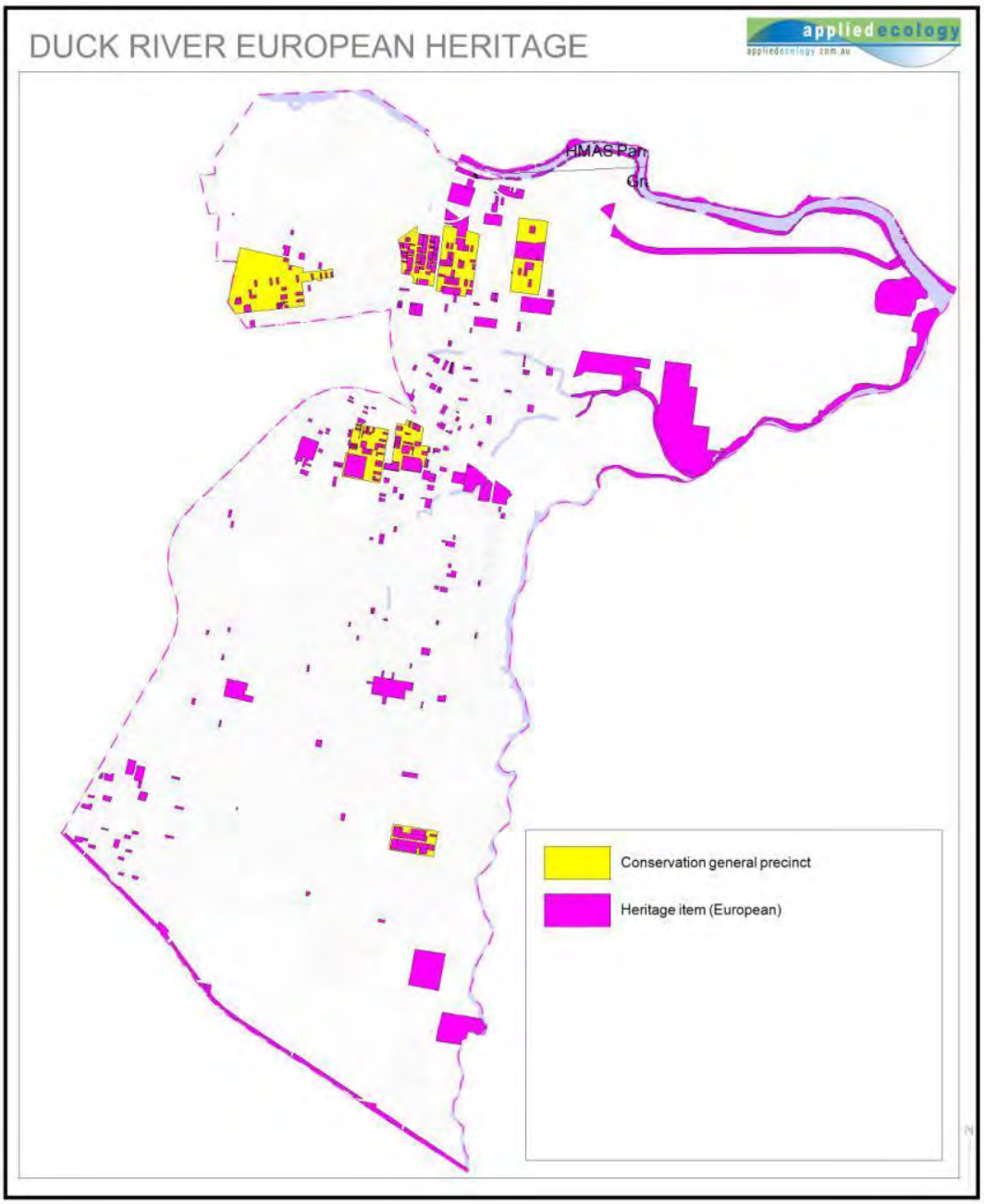

Figure 29. European heritage items and conservation precincts around the Upper Duck River catchment

COMMUNITY INVOLVEMENT

Community environmental education, awareness and participation in EEC/ Wetland Management is currently being achieved through the following activities:

Bushcare Groups

Mighty Duck River Restoration Collective This Bushcare group works in Duck River Reserve between Seventh Ave and Mona St, generally meeting monthly. The group's aim is to widen the riparian corridor, maintenance of plantings, spot spray, mulch and plant, maintenance weed control. They have implemented the following grant programs in recent years:

- Mighty Duck River Restoration Collective (MDRRC). Protection of

endangered remnants and wetland along the Duck River. NSW Government 2002 Restoration and Rehabilitation - community grants

- Mighty Duck River Restoration Collective (MDRRC) Stage 2. Protection of endangered remnants and wetland along the Duck River. NSW Government 2003 Restoration and Rehabilitation - community grants

Friends of Duck River work mainly in Duck River Bushland Reserve, meeting monthly. Their aims are to encourage native regeneration through edge weeding, maintenance of core bushland edges, some planting

Prince of Duck River meet irregularly on the Auburn side of Duck River. Their current area of work is between Prince Park and Hislop Park, Auburn

Auburn Botanic Gardens Bushcare Group meet monthly for 3 hours. Their current focus is in the riparian zone around Auburn Botanic Gardens

Parramatta City Council bush regeneration contracts

The Parramatta City Council Natural Areas Plan of Management (2006) encourages the support of bushcare activities through the implementation of contract bush regeneration. Sites which have ongoing bushcare support are able to incorporate their activities into an ongoing maintenance program. Towards this end, Parramatta Council has sought funding and implemented a considerable amount of bush regeneration works (Table 20).

Table 20. Bush regeneration activities in the Duck River catchment from 2007/8 to 2011/2.

LOCATION	YEAR	DESCRIPTION OF WORKS
Parramatta Rd	2007/08	Planting 500 tubes, control vines and woody weeds
	2008/09	Planting 500 tubes, control vines and woody weeds
	2009/10	Planting 400 tubes, control vines and woody weeds
	2010/11	Planting 440 tubes, direct seed, maintain plantings and mulch, control vines and woody weeds
	2011/12	Planting 295 tubes, install silt fencing, control vines, mulch, spot spray and direct seed
Duck River Reserve: rear Australia Post	2007/08	Planting 500 tubes, reduce vines and woody weeds
	2008/09	Planting 200 tubes, control vines and woody weeds
	2009/10	Planting 200 tubes, secondary weeding
	2010/11	Manage habitat for snakes and security, control vines and woody weeds
	2011/12	Planting 200 tubes, maintain drainage line, reduce woody weeds
Duck River Reserve: Bangor St to Neilson St	2007/08	Planting 500 tubes, secondary weeding and control vines
	2008/09	Planting 1600 tubes, secondary weeding and control vines
	2009/10	Planting 1760 tubes, secondary weeding, and mulching, install log barrier and fencing
	2010/11	Planting 280 tubes, spot spray, direct seed
	2011/12	Planting 580 tubes, secondary weeding, target

LOCATION	YEAR	DESCRIPTION OF WORKS
		woody weeds, spot spray and maintain plantings
Duck River Reserve: Heath St	2007/08	Planting 280 tubes, target woody weeds
	2008/09	Planting 280 tubes, secondary weeding
	2009/10	Planting 280 tubes
	2010/11	Planting 80 tubes, maintain plantings, followup woody weeds
	2011/12	Planting 420 tubes, control woody weeds
Horlyck Reserve: Mona St	2007/08	Planting 200 tubes, target woody weeds and vines
	2008/09	Planting 200 tubes, target weeding for vines and woody weeds
	2009/10	Planting 200 tubes, target vines and woody weeds, reduce large woody weed infestation
	2010/11	Planting 80 tubes, target woody weeds, spot spray groundcover weeds
	2011/12	Planting 100 tubes, spot spray and maintain plantings
Horlyck Reserve: Riverside remnants	2007/08	Secondary weeding
	2008/09	Secondary weeding
	2009/10	Target weeding for vines and woody weeds
	2010/11	Planting 20 tubes, target vines and woody weeds
	2011/12	Planting 20 tubes, target weeding
Duck River Reserve: Mons St to Chiswick Rd	2007/08	Planting 1770 tubes, maintain plantings
	2008/09	Planting 1100 tubes, restaking boundary logs after flooding, secondary weed control
	2009/10	Planting 1180 tubes, secondary weed control for vines and grasses
	2010/11	Planting 390 tubes, spot spray, control Morning Glory and reduce woody weeds
	2011/12	Planting 280 tubes, maintain plantings
Clyde St Reserve	2007/08	Planting 200 tubes
	2008/09	Planting 400 tubes
	2009/10	Planting 400 tubes, maintain plantings
	2010/11	Planting 80 tubes, maintain plantings
	2011/12	Planting 220 tubes, maintain plantings
Ray Marshall Reserve	2007/08	Planting 1000 tubes, mulch edges
	2008/09	Planting 700 tubes
	2009/10	Planting 700 tubes
	2010/11	Planting 300 tubes, spot spray and direct seed
	2011/12	Planting 340 tubes, maintain plantings
Everley Park and Norford Park	2007/08	Planting 200 tubes, secondary weeding
	2008/09	Planting 1000 tubes, spot spray around plantings
	2009/10	Planting 1000 tubes, spot spray around plantings
	2010/11	Planting 80 tubes, maintain plantings, spot spray
	2011/12	Planting 280 tubes, maintain plantings, spot spray
Campbell Hill Pioneer Reserve	2007/08	Planting 1120 tubes, target noxious and woody weeds, maintain core bushland areas
	2008/09	Planting 1020 tubes, control vines, blackberry and woody weeds, maintain core bushland areas

LOCATION	YEAR	DESCRIPTION OF WORKS
	2009/10	Planting 1520 tubes, spot spray around plantings, control vines, woody weeds and blackberry
Waddangalli Woodland	2007/08	Planting 60 tubes, control Blackberry and woody weeds, maintain core bushland areas
	2008/09	Planting 1000 tubes, reduce woody weeds
	2009/10	Planting 1000 tubes, maintain core bushland areas, reduce blackberry and woody weeds
Duck River Bushland Reserve	2007/08	Planting 1100 tubes, maintain plantings, target weeding, control exotic grasses
	2008/09	Planting 4000 tubes, control vines and woody weeds along creekline, spot spray and maintain plantings
	2009/10	Planting 1200 tubes, spot spray and maintain plantings, maintain core bushland areas

Additional works in the catchment include the Duck River Icon Project (SMCMA 2006-2008). This comprised rehabilitation of riverbanks and an island adjacent to Webb Avenue playing fields and Mackay Road, South Granville. A green corridor linking existing remnant vegetation including Castlereagh Ironbark Forest was established.

INDUSTRY AND COMMUNITY ENVIRONMENTAL EDUCATION, AWARENESS AND PARTICIPATION

In recent years considerable effort has been directed towards improving the health of aquatic ecosystems in Duck River. Two major Environmental Trust Grants have supported this:

(i) **TBL in the Duck River Catchment – a model for Industrial Sustainability (2007-2011) $1.3M** – joint with Auburn Council, Parramatta the lead Council. The grant focussed on working with businesses in the Camellia and Silverwater Industrial areas (lower Duck River) to improve their environmental sustainability across energy, water, travel, waste and biodiversity. The grant also included a capital improvement component associated with cycle way upgrades, riparian weed removal, installation of stormwater pollutant traps and interpretive signage regarding natural and built heritage.

(ii) **Sustainable Water Management in the Duck River Catchment (2009-2012) $1.8M** – joint with Auburn, Bankstown and Parramatta Councils, Auburn the lead Council. The objective was to improve the management of water supply (and seek alternative supply options) to open space and recreational assets across the three Council areas within the catchment. Works within Parramatta Council include: River water extraction licence, storage tanks, treatment technology and new irrigation system for Horlyck Reserve in Granville; amplification of existing dam capacity at Woodville Golf Course; supply of recycled effluent to Granville Park; and studies on future works at Granville Pool and Ray Marshall Reserve.

Another project, also funded by the Environmental Trust and jointly managed by SMCMA, Parramatta Council and Auburn Council is the **Place based capital works within the Duck River Catchment Project**. The Duck River Catchment is more than just an industrial precinct. Auburn and Parramatta

City Councils and local businesses are committed to creating a sense of community and pride in the catchment through improvements to local infrastructure and the landscape. This project aimed to fund capital works such as:

- Improved cycleways and connections
- Installation of seating in public parks
- Improved streetscaping through tree planning and revegetation

Many of the management recommendations of this WRPoM fall into these categories.

In Auburn LGA the footpath/cycleway is very popular, and used regularly along with the exercise equipment nearby. Council currently has plans to update this exercise equipment. Further opportunities for community environmental education and involvement include:

- Clean up Australia Day
- Duck River Community Education Program, which involves an educational walk along duck river, with a talk that discusses the Aboriginal importance for Duck River, history of Duck River since colonisation, impacts affecting Duck River and what Council is doing to improve the quality of Duck River.)
- Duck River Business Action Day (Duck River Clean up day)

RECREATIONAL VALUES

Most of the Upper Duck River riparian corridor is open space: it is zoned Public Recreation in Auburn LGA, while in Parramatta LGA the land is zoned Public Recreation or Environmental Conservation. Open space uses include:

Sports facilities are the predominant land use along the riparian corridor. Sporting facilities include:

- Golf course
- Tennis courts
- Football stadiums
- Numerous other playing fields
- Children's play areas

Additional recreational uses are associated with the shared footpath/cycleway which links these reserves:Duck River Reserve, Granville

- Bangor Park, Auburn
- Mona Park, Auburn
- Oriole Stadium, Auburn
- Webbs Avenue Playing Fields, Auburn
- Auburn Botanic Gardens
- Auburn Community Picnic Area
- Progress Park, Auburn
- Peter Hislop Park, Auburn
- Princes Park, Auburn

While the footpath/cycleway network is extensive in Auburn LGA, there are limited formal links between the two sides of the river, other than via existing road bridges. A number of informal crossing points are utilised, including at the Boundary Rd weir, and the stepping stones weir, Mackay Rd. Improved connection between the two LGAs and expanding the formal path network in Parramatta will improve opportunities for residents to undertake walks of different lengths. Other activities include dog walking, and passive recreation through enjoyment of the natural environment. Additional walking tracks exist through many of the bushland reserves in Parramatta LGA, including Mellita Stadium Reserve, Duck River Bushland Reserve, Ray Marshall Reserve, and Duck River Reserve.

THREATS, RISKS, CONSTRAINTS AND ISSUES

The following table summarises the main issues relevant to the management of the Upper Duck River Wetlands and Riparian Corridor (Table 21). Objectives and actions relating to each of the issues below are presented in the following sections.

Table 21. Constraints and issues associated with identified threats and risks for effective management of Upper Duck River Wetlands and Riparian Corridor

THREATS AND RISKS	CONSTRAINTS AND ISSUES	APPLIES TO REACH
POLLUTION		
Water quality	Water quality issues associated with elevated nutrient levels Potential sources for poor water quality include runoff from roads, leaching of nutrients and pesticides from sports facilities adjoining the river, industrial and other activities	THROUGHOUT
Storm litter and debris	Gross pollutants collect in slack water areas along the creek, intrude into reedlands, and can be seen hanging from riverside tree branches after storm events	THROUGHOUT
Sediment contamination	Unknown sediment condition e.g. source of landfill, acid sulphate soils, legacy of past industrial activities in the area Confirmed presence of contaminated sediments in reaches	DUCK RIVER 5A, 5B
EROSION		
Bank erosion	Undercutting and slumping evident Causes include increased peak flows and destabilisation through loss of riparian vegetation	DUCK RIVER 1A, 1B DUCK RIVER 2A, 2B
Sedimentation	Areas of sediment deposition identified Sediment sources include erosion of banks, ongoing urban development in surrounding areas	UNNAMED 3 UNNAMED 7
Acid Sulphate Soils	Low to moderate risk of ASS, mainly in lower reaches of the catchment	DUCK RIVER 4A to DUCK RIVER 5B
FLOW REGIMES		
Flooding	Highly urbanised catchment, especially upstream in adjoining LGA High proportion of impervious surfaces results in rapid time of concentration for peak flows Bankfull and overbank flooding has been recorded during recent storm events	THROUGHOUT
Setbacks	Very narrow riparian corridors in some parts of the wetlands	DUCK RIVER 4 DUCK RIVER 5

THREATS AND RISKS	CONSTRAINTS AND ISSUES	APPLIES TO REACH
BIODIVERSITY		
Conservation	Management of identified reserves as priority conservation areas, including Duck River Bushland Reserve and Auburn Botanic Gardens Expansion of conservation zones to include areas with threatened species present Conservation of non-rare species	THROUGHOUT especially DUCK RIVER 2A, 2B, 3B
Regional habitat corridor	Upper Duck River wetlands form regional habitat corridor between Parramatta River and core bushland reserves	THROUGHOUT
Native flora	Threatened species recorded at a number of sites Significant plant diversity overall, and in some individual reserves Endangered Ecological Communities present	THROUGHOUT especially DUCK RIVER 2B
Native fauna	Threatened and migratory species recorded on site. Significant bird diversity. Availability of open water for water birds	THROUGHOUT
Fish passage	Fish passage is blocked by weir at Clyde, near the railway line, forming a distinct barrier between tidal and non-tidal habitats Two weirs upstream provide minor impediments to fish passage	DUCK RIVER 1A DUCK RIVER 4A, 4B DUCK RIVER 5B
PLANT COMMUNITIES		
Freshwater reedlands	Weed encroachment Build up of storm litter and debris Poor water quality reducing overall health of community	DUCK RIVER 1A DUCK RIVER 4A to DUCK RIVER 5B
Swamp Oak Floodplain Forest	Weed encroachment, especially vines and understorey weeds Poor species diversity, reducing overall health of community Poor connectivity, small reserve sizes, high perimeter to core ratio producing increased edge effects	THROUGHOUT
Riverflat Eucalypt Forest	Weed encroachment, especially vines and understorey weeds Poor species diversity, reducing overall health of community Poor connectivity, small reserve sizes, high perimeter to core ratio producing increased edge effects	THROUGHOUT
Bushland restoration	Current contract bush regeneration in progress (2011-2014) at 11 sites in 7 reserves in the UDR wetlands Significant opportunities for restoration including establishing additional Bushcare groups	THROUGHOUT
Revegetation	Revegetation requires ongoing supply of local provenance plants with good species diversity Not all species for revegetation can be cultivated from strictly local stock	THROUGHOUT

THREATS AND RISKS	CONSTRAINTS AND ISSUES	APPLIES TO REACH
PEST PLANTS AND ANIMALS		
Noxious weeds	Weed invasion is serious threat to biodiversity values and extensive management required Aquatic weeds include *Alternanthera philoxeroides*. Very limited access to some parts of wetland for weed control (ie. wet areas only accessible by boat)	THROUGHOUT
Environmental weeds	Weed invasion is serious threat to biodiversity values and extensive management required. Aquatic weeds include *Alternanthera philoxeroides*. Very limited access to some parts of wetland for weed control (ie. wet areas only accessible by boat) Weed inputs from garden escapes and dumping, washed down from upstream	THROUGHOUT
Introduced animals	Introduced animals include foxes, cats, dogs, ducks and geese Introduced fish include Carp and Gambusia, Introduced birds include Bulbuls, Indian Mynas, and others Each of these present ongoing threats to native wildlife	THROUGHOUT
LAND MANAGEMENT		
Fire regimes	High potential for arson fires in urban environment Fire management for biodiversity and asset management may be required Recommended fire interval for forested wetlands (i.e. Swamp Oak Floodplain Forest and Riverflat Eucalypt Forest) is 10-35 years and no fire is recommended in Sydney Freshwater Wetlands The Asset Protection Zone (APZ) for forested wetlands on gently sloping land is 15m	THROUGHOUT
Zoning for conservation	Representation of appropriate level of conservation through application of relevant land zoning in LEP/DCP	THROUGHOUT
Public safety	Inappropriate use of footpath/cycleway Swimming Fishing and eating fish caught in the river Activities associated with chemical weed and other pest control activities	THROUGHOUT
Encroachment	Dumping of rubbish and garden waste Encroachment by adjoining industrial premises	DUCK RIVER 5B
Community involvement	Engage community to encourage best practise management of properties adjoining wetland, including landscaping with appropriate native species. Encourage community participation through Council coordinated activities e.g. Bushcare, tours and talks, monitoring activities. Promote awareness of biodiversity through signage and provision of educational information	DUCK RIVER 1B to DUCK RIVER 4B

THREATS AND RISKS	CONSTRAINTS AND ISSUES	APPLIES TO REACH
Sustainability	Climate change and sea level rise (SLR): risk to wetland from climate change and sea level rise unknown. Council's commitment to management is critical to success of programs. Water Sensitive Urban Design for infill developments and redevelopment. Endangered Ecological Communities (EECs): management to ensure long-term viability of these vegetation communities and their associated fauna	THROUGHOUT
Heritage conservation	Indigenous heritage conservation through information signage European heritage conservation through information signage	DUCK RIVER 3A to DUCK RIVER 4B
Aesthetic values	Passive recreation; sporting facilities Interaction with the natural environment	THROUGHOUT
Passive recreation	Opportunities for passive recreation include walking, cycling, bird watching, picnicking, informal ball games and other games	THROUGHOUT
Footpath/cycleway	A shared footpath/cycleway has been constructed along much of the Auburn side of the river/wetlands Need for links to cycleway from Parramatta side, also links on Parramatta side to provide short and long round trip routes	DUCK RIVER 3A to DUCK RIVER 4B
Sporting facilities	Numerous sporting facilities exist on both sides of the river/wetlands including a golf course, two major sporting arenas, tennis courts, and a number of school and local sports ovals	DUCK RIVER 1A to DUCK RIVER 4B
Illegal access by motorbikes	Inappropriate use of footpath/cycleways by children and adults on unregistered motorbikes has been reported by residents	DUCK RIVER 3A to DUCK RIVER 4B
Cultural use (the "backyard substitute")	Use of public open space for recreation by family groups, especially for picnicking	DUCK RIVER 3A to DUCK RIVER 4B
Fishing and swimming	Water quality is not suitable for primary contact No fish or other organisms collected from Duck River should be eaten	THROUGHOUT

MANAGEMENT OBJECTIVES, STRATEGIES AND ACTIONS

Existing condition for reaches

A series of drawing sheets have been prepared for each reach identified in the Upper Duck River Wetlands and Riparian corridor. The first drawing sheet shows the site location and context, with subcatchment extent, reticulated drainage and discharge point(s), and a sketch showing the existing site condition, including location and condition of each vegetation community.

A series of condition scores are provided to develop an overall understanding of the ecosystem health for that section of the wetlands (Table 22). Each component of the overall condition is scored as indicated, with a maximum possible total of 26 for a reach. Contributing factors to these scores are explained in Table 22.

Table 22. Reach condition scores and how they are calculated

SCORE	CALCULATED FROM
GEOMORPHIC CONDITION (/5)	Geomorphology: score /2.5, deductions for overall extent of modification, erosion, sediment deposition Hydrology: score /2.5, deductions for modifications (eg. weirs, channelized, etc), storm damage, storm debris **Condition score = Geomorphology score + Hydrology score**
RIPARIAN VEGETATION (/5)	**Vegetation score = (Percent riparian vegetation cover) x (percent native species) x 5** eg. (70% cover x 60% native) x 5 = score of 2.1
INSTREAM HABITAT (/10)	Wetlands: score /4 for overall extent and condition of wetlands Habitat: score /4 with points added for complexity and extent of habitat elements present (see Table 18) Fish passage: score /2, deductions for barriers such as weirs, or partial barriers to passage eg. stepping stones weir **Habitat score = Wetlands score + Habitat score + Fish passage score**
SENSITIVITY (/6)	Endangered Ecological Communities: score 1 for each EEC present Threatened Species: score 1 for a species present Indigenous heritage: score 1 for an item present European heritage: score 1 for an item present **Sensitivity score = EEC score + TS score + Indigenous heritage score + European heritage score**
OVERALL SCORE	Overall score = sum of individual scores Maximum possible = 26 Maximum score allocated = 18.9

Priority category is allocated based on the individual condition scores (Table 23). It reflects the key values for that reach, and underpins targeted management objectives and actions.

Table 23. Individual scores, overall score and priority category for WRPoM reaches

REACH NAME	GEOMOR-PHOLOGY SCORE	RIPARIAN VEGETATION SCORE	INSTREAM HABITAT SCORE	SENSITIVITY SCORE	CONDITION SCORE	PRIORITY CATEGORY
DUCK RIVER 1A	2.5	1.75	5.2	4	13.45	PROTECT DOWNSTREAM HABITAT
DUCK RIVER 1B	3.5	2.75	5.8	2	14.05	GOOD HYDRO-GEOMORPHOLOGY
DUCK RIVER 2A	2.5	2	7.2	2	13.7	GOOD INSTREAM HABITAT
DUCK RIVER 2B	3	2.6	7.3	6	18.9	HIGH SENSITIVITY, GOOD RIPARIAN HABITAT
DUCK RIVER 3A	4	1.1	7.5	3	15.6	GOOD INSTREAM HABITAT
DUCK RIVER 3B	4	1.25	7.4	3	15.65	GOOD INSTREAM HABITAT
DUCK RIVER 4A	3	0.75	6	4	13.75	GOOD HYDRO-GEOMORPHOLOGY
DUCK RIVER 4B	3.5	1.1	7.8	4	16.4	GOOD HYDRO-GEOMORPHOLOGY, GOOD INSTREAM HABITAT
DUCK RIVER 5A	3.3	1	7.5	4	15.8	GOOD HYDRO-GEOMORPHOLOGY, GOOD INSTREAM HABITAT
DUCK RIVER 5B	2.5	0.4875	7.8	6	16.7875	HIGH SENSITIVITY, GOOD INSTREAM HABITAT
UNNAMED 3 BENNETT RD	3	3.325	7	3	16.325	GOOD HYDRO-GEOMORPHOLOGY
UNNAMED 7 BANKSIA ST	2.5	0.4	5	2	9.9	PROTECT DOWNSTREAM HABITAT

Reach trajectory

Stream condition can be improving, remaining stable, or deteriorating. The reach trajectory summarises its probable pathway based on current condition and types of impacts currently operating in that reach. The stream trajectory was determined for the reach's ecological attributes (including riparian vegetation and instream habitat) and its geomorphic condition. The probable fate of that reach at this point in time is indicated by a coloured triangle: a green triangle pointing upwards indicates the reach is improving, an orange triangle pointing sideways indicates the reach is stable (neither improving nor deteriorating), and a red triangle pointing downwards indicates a deterioriating reach.

WORKS PLANS

A complete list of actions is provided in the following tables. Actions are grouped according to their management objective:

- **Biodiversity enhancement** actions aim to improve the overall health of the wetlands and riparian zones by removing or reducing a problem, or improving or expanding an asset
- **Water quality improvement** actions aim to improve the overall health of the wetlands by removing or reducing a problem

- **Erosion control** actions aim to improve the overall condition of riparian zones by stabilising channel banks and beds, and to improve the health of the aquatic environment by reducing the amount of sediment mobilised, with limited disturbance to the surrounding environment (Figure 30)
- **Community and recreation** actions aim to improve the overall amenity of the wetlands and riparian corridor to encourage positive interactions that increase general awareness of the importance of the Upper Duck River wetlands and riparian corridor

Highest priority has been allocated to protecting, maintaining and restoring areas of high ecological and/or geomorphic resilience. The timetable for implementation is as follows:

- **Urgent priority** to be implemented as soon as possible
- **High priority** to be implemented within three years
- **Medium priority** to be implemented within six years
- **Low priority** to be implemented within ten years
- **Ongoing maintenance** refers to actions that are to be carried out for the duration of the WRPoM

Primary responsibility for implementation of the actions provided in the WRPoM falls to Parramatta City Council, Auburn City Council, or jointly to both councils.

Figure 30. Urban streambank restoration that preserves natural heritage resources is a key part of this project

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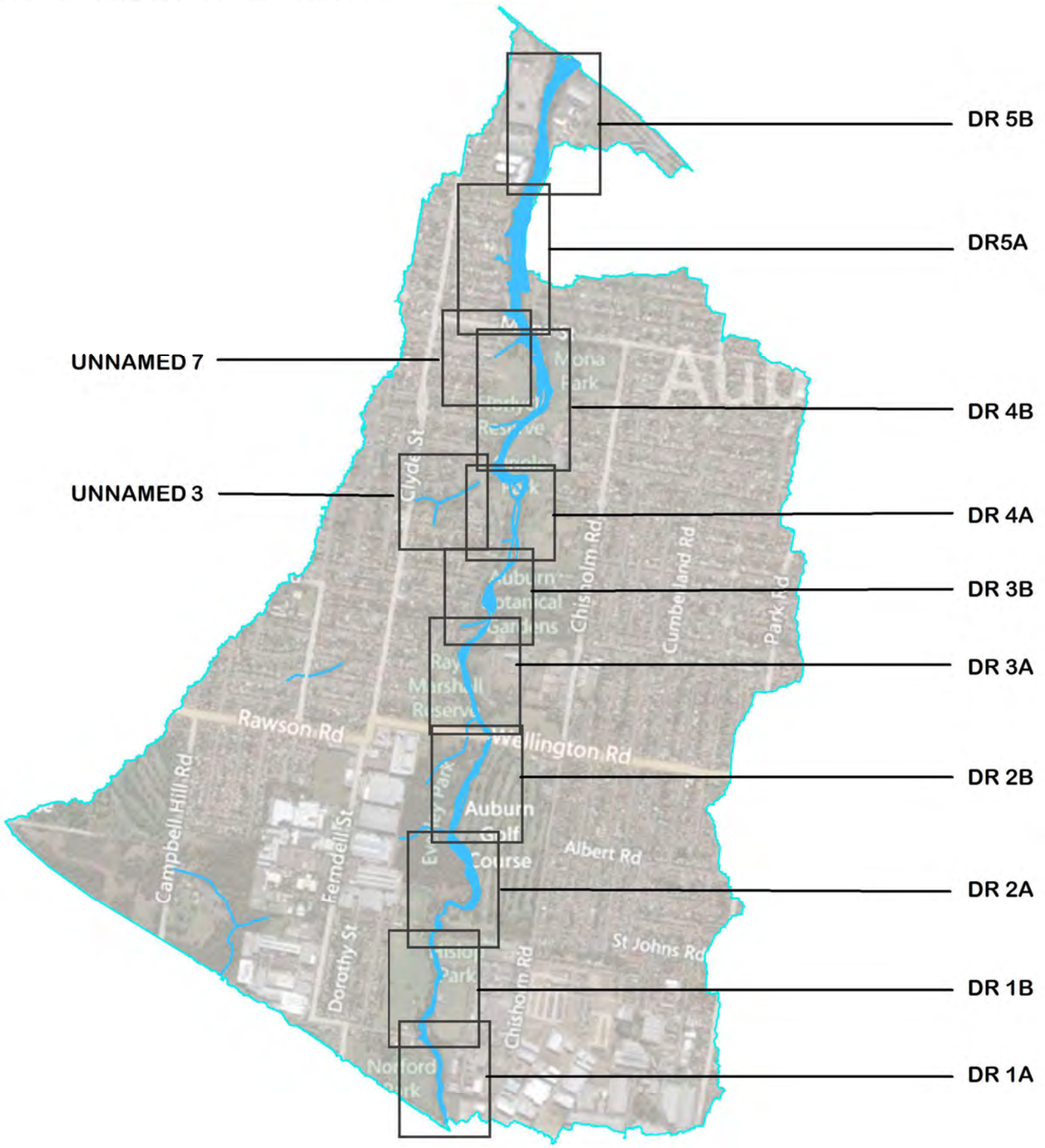
WORKPLAN OVERVIEW

UPPER DUCK RIVER RIPARIAN AND WETLAND PLAN OF MANAGEMENT



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ZONE DUCK RIVER 1A

Refer to drawing sheet DUCK RIVER 1A p1 for site context and existing condition, and sheet DUCK RIVER 1A p2 for works plans and supporting information. Numbers in column one refer to numbered work zones on the drawing. Areas for each work zone are indicated on the drawing sheet and have been used to calculate costs for each action.

Table 24. Management actions and works required for DUCK RIVER 1A – joint responsibility by Parramatta and Auburn Councils

NO.	ACTION/WORKS REQUIRED	PRIORITY	AREA	COST	RESPONSIBILITY
5	Water quality improvement: install trash rack, use appropriate height to accommodate flood flows	Urgent	N/A	$250-500K	PCC/ACC
10	Biodiversity enhancement: control carp populations	Medium	N/A	$3-5K per event	PCC/ACC

Table 25. Management actions and works required for DUCK RIVER 1A –Parramatta City Council's area of responsibility

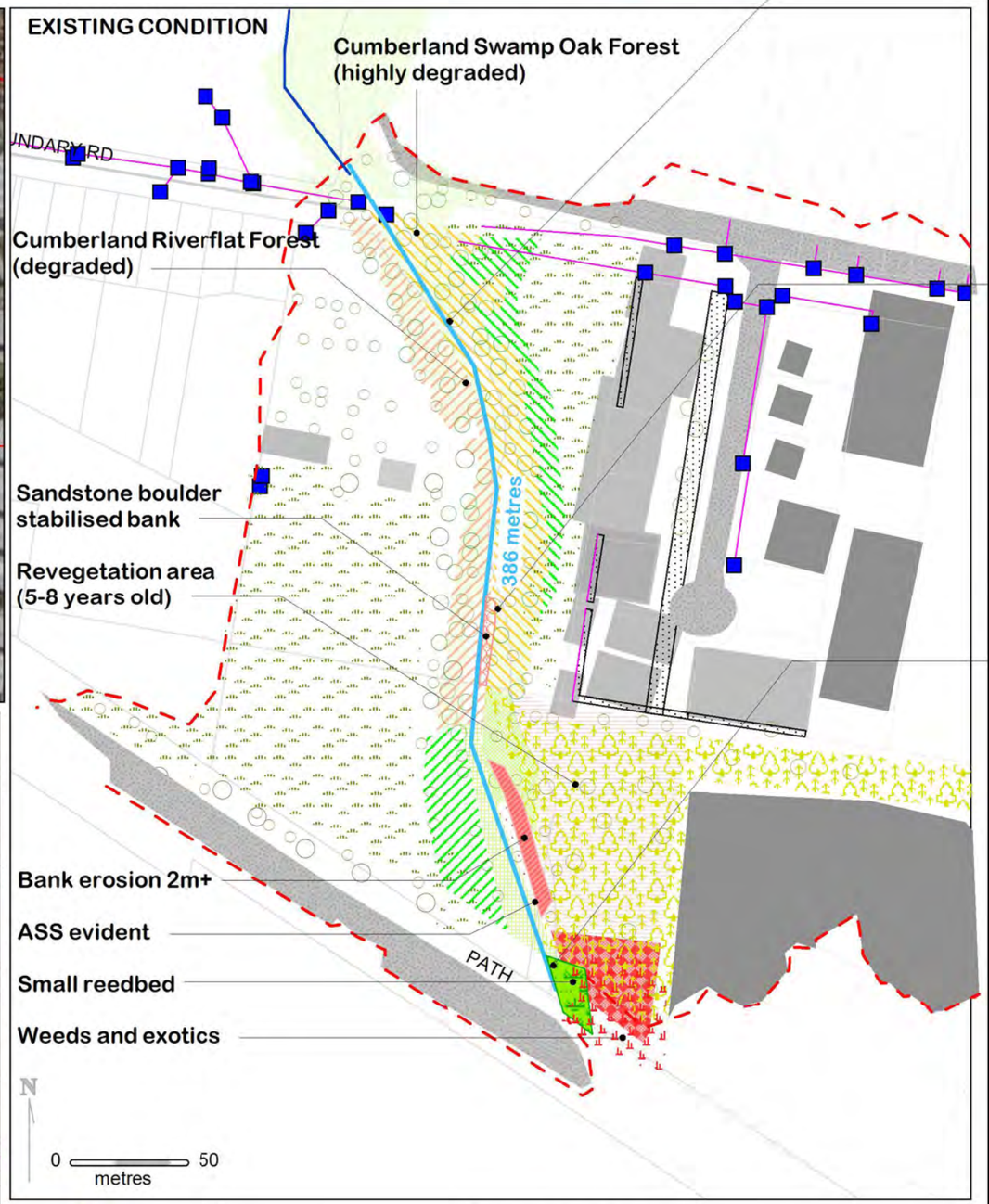
NO.	ACTION/WORKS REQUIRED	PRIORITY	AREA	COST	RESPONSIBILITY
2	Biodiversity enhancement: bush regeneration weeding and infill planting for diversity with Cumberland Riverflat Forest species	High	0.40ha	$2-6K	PCC
4	Biodiversity enhancement: bush regeneration weeding and revegetation planting with Cumberland Riverflat Forest species	High	0.088ha	$1-3K	PCC
3	Biodiversity enhancement: riparian buffer expansion planting with Cumberland Riverflat Forest species	Low	0.20ha	$4-6K	PCC

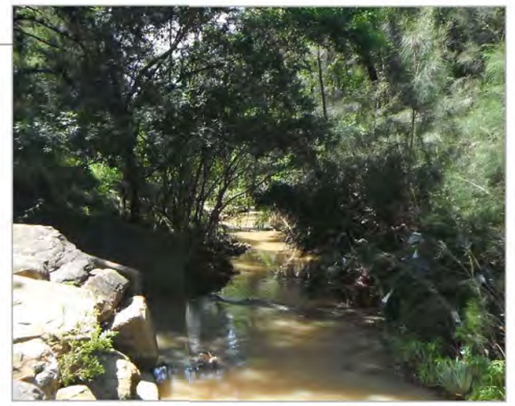
Table 26. Management actions and works required for DUCK RIVER 1A –Auburn City Council's area of responsibility

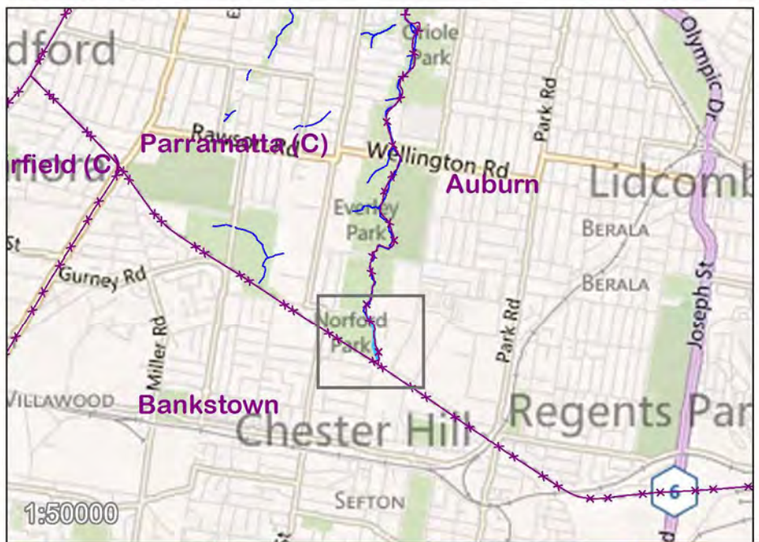
NO.	ACTION/WORKS REQUIRED	PRIORITY	AREA	COST	RESPONSIBILITY
7	Erosion control: toe protection and bank stabilisation works	Urgent	50m	$25-50K	ACC
9	Erosion control: toe protection and bank stabilisation works	Urgent	30m	$25-50K	ACC
1	Biodiversity enhancement: primary weed control of vines	High	0.56ha	$20-30K	ACC
6	Biodiversity enhancement: primary weed control, revegetation with Cumberland Riverflat Forest species	High	0.16ha	$10-15K	ACC
4	Biodiversity enhancement: bush regeneration weeding and revegetation planting with Cumberland Riverflat Forest species	High	0.022ha	$2-5K	ACC
1	Biodiversity enhancement: primary weed control and revegetation with Cumberland Riverflat Forest species	Medium	0.56ha	$20-30K	ACC
10	Biodiversity enhancement: riparian buffer expansion planting with Cumberland Riverflat Forest species	Low	0.22ha	$10-15K	ACC
8	Biodiversity enhancement: bush regeneration weed control	Ongoing	0.76ha	$4-12K	ACC

REACH: DUCK RIVER 1A

SITE CONTEXT







HYDRO-GEO MORPHOLOGY	RIPARIAN VEGETATION	INSTREAM HABITAT	SENSITIVITY	TOTAL	PRIORITY CATEGORY	TRAJECTORY
2.5	1.8	5.2	4.0	13.5	PROTECT DOWN-STREAM HABITAT	ECOLOGICAL ATTRIBUTES ▲ GEOMORPHOLOGY ▼

- Stormwater Pipe
- Open Watercourse
- Sub-catchment Boundary
- Reach
- Water quality monitoring point
- Cadastre Lot Boundary
- Stormwater Pit
- Carp control point
- EEC

data collected 20-30/03/2012

REACH: DUCK RIVER 1A

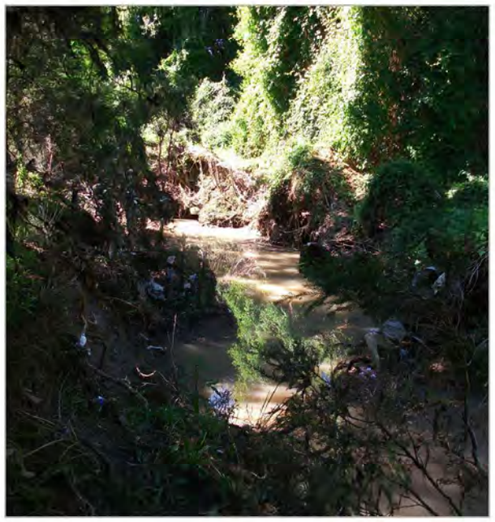
OVERALL OBJECTIVES

1. Improve riparian condition
2. Improve general habitat condition
3. Reduce downstream impacts

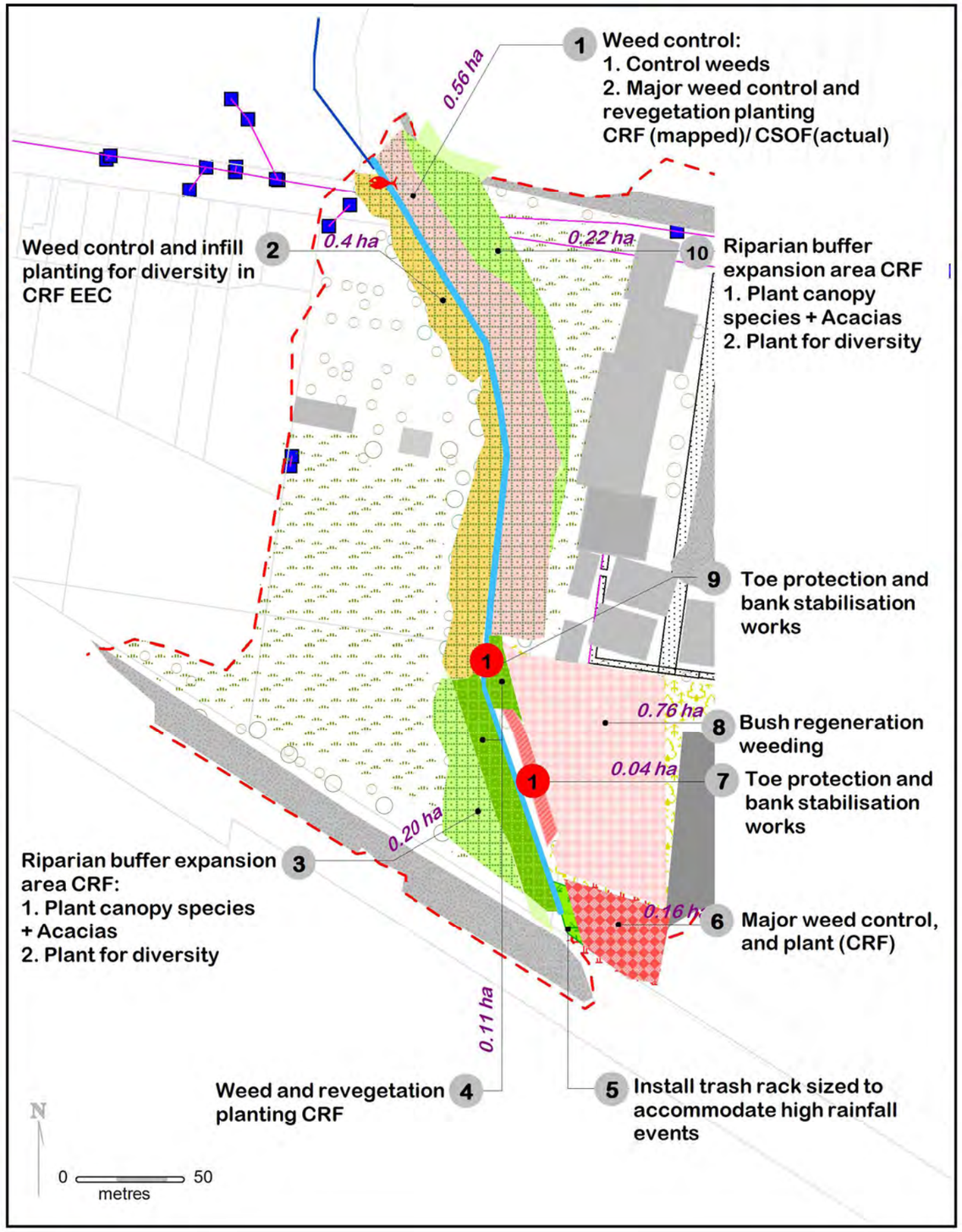
VEGETATION COMMUNITIES

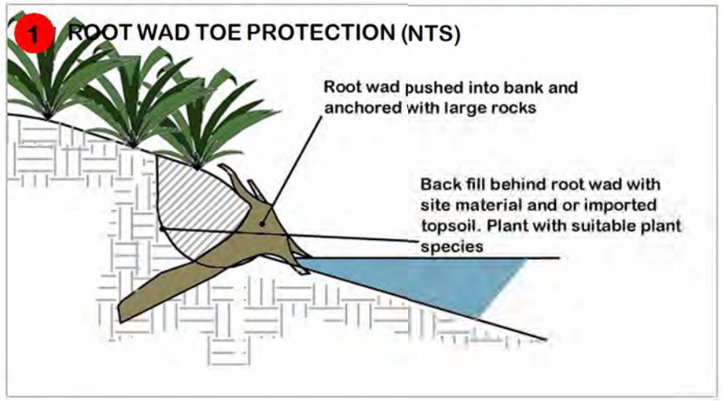
Cumberland Riverflat Forest (CRF)

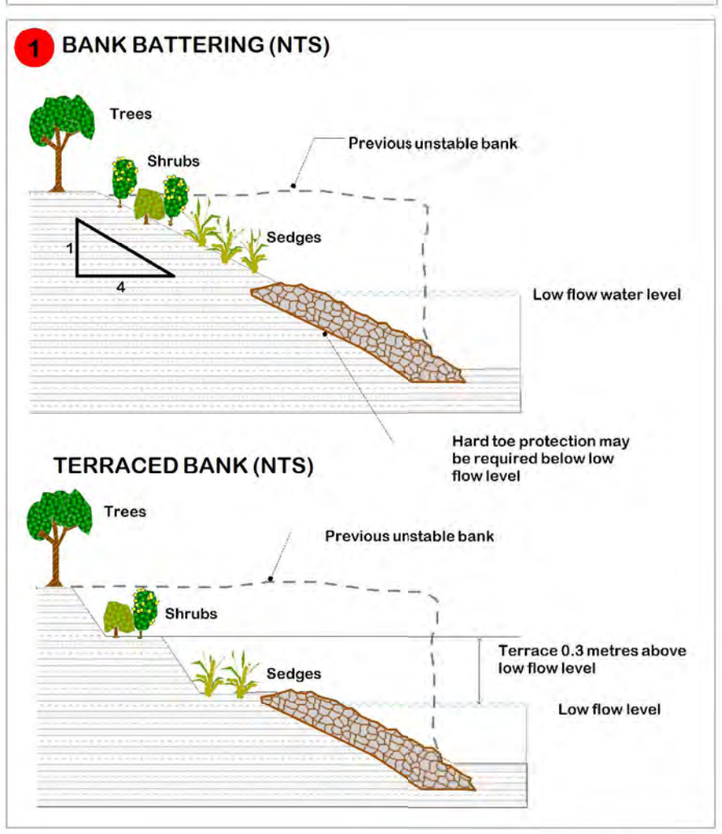
Cumberland Swamp Oak Forest (CSOF)



WORKS PLAN







ZONE DUCK RIVER 1B

Refer to drawing sheet DUCK RIVER 1B p1 for site context and existing condition, and sheet DUCK RIVER 1B p2 for works plans and supporting information. Numbers in column one refer to numbered work zones on the drawing. Areas for each work zone are indicated on the drawing sheet and have been used to calculate costs for each action.

Table 27. Management actions and works required for DUCK RIVER 1B – joint responsibility by Parramatta and Auburn Councils

NO.	ACTION/WORKS REQUIRED	PRIORITY	AREA	COST	RESPONSIBILITY
17	Water quality improvement: water quality monitoring point	Urgent/ongoing	N/A	?	ACC/PCC

Table 28. Management actions and works required for DUCK RIVER 1B –Parramatta City Council's area of responsibility

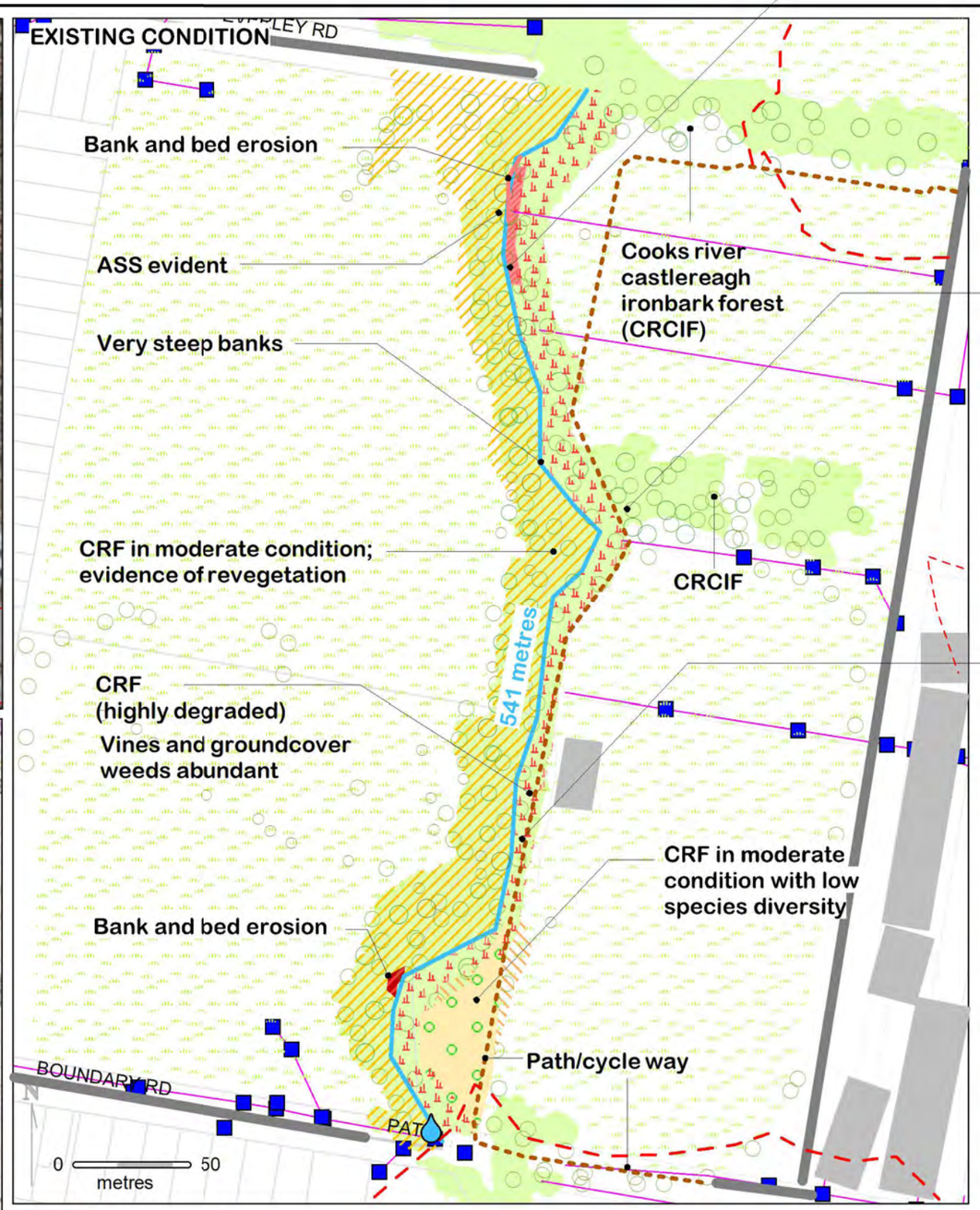
NO.	ACTION/WORKS REQUIRED	PRIORITY	AREA	COST	RESPONSIBILITY
11	Biodiversity enhancement: bush regeneration weeding and infill planting for diversity with Cumberland Riverflat Forest species	High	1.46ha	$10-20K	PCC
13	Erosion control: toe protection works	High	30m	$20-30K	PCC
12	Biodiversity enhancement: riparian buffer expansion planting with Cumberland Riverflat Forest species	Low	0.77ha	$20-25K	PCC

Table 29. Management actions and works required for DUCK RIVER 1B –Auburn City Council's area of responsibility

NO.	ACTION/WORKS REQUIRED	PRIORITY	AREA	COST	RESPONSIBILITY
16	Erosion control: toe protection and bank stabilisation works	Urgent	50m	$25-50K	ACC
17	Water quality improvement: install end of pipe litter control device	Urgent	N/A	$15-20K	ACC
15	Biodiversity enhancement: primary weed control of vines	High	0.73ha	$30-40K	ACC
15	Biodiversity enhancement: primary weed control and revegetation with Cumberland Riverflat Forest species	Medium	0.73ha	$40-50K	ACC
14	Biodiversity enhancement: bush regeneration weed control	Ongoing	0.19ha	$2-4K	ACC

REACH: DUCK RIVER 1B

SITE CONTEXT



HYDRO-GEO MORPHOLOGY	RIPARIAN VEGETATION	INSTREAM HABITAT	SENSITIVITY	TOTAL	PRIORITY CATEGORY	TRAJECTORY
3.5	2.8	7.8	2.0	14.1	GOOD HYDRO-GEOMORPHOLOGY	ECOLOGICAL ATTRIBUTES ▲ GEOMORPHOLOGY ▼

- Stormwater Pipe
- Open Watercourse
- Sub-catchment Boundary
- Reach
- Water quality monitoring point
- Cadastre Lot Boundary
- Stormwater Pit
- EEC

data collected 20-30/03/2012

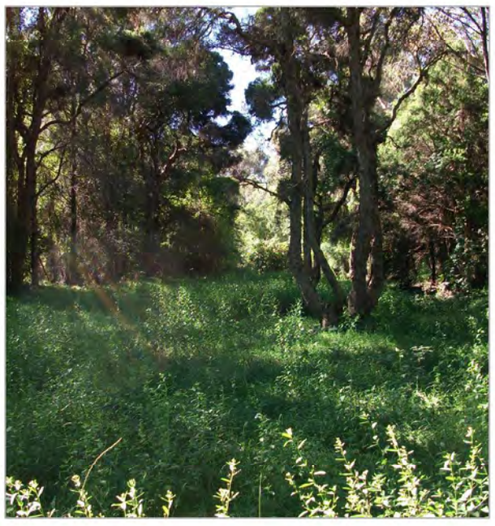
REACH: DUCK RIVER 1B

OVERALL OBJECTIVES

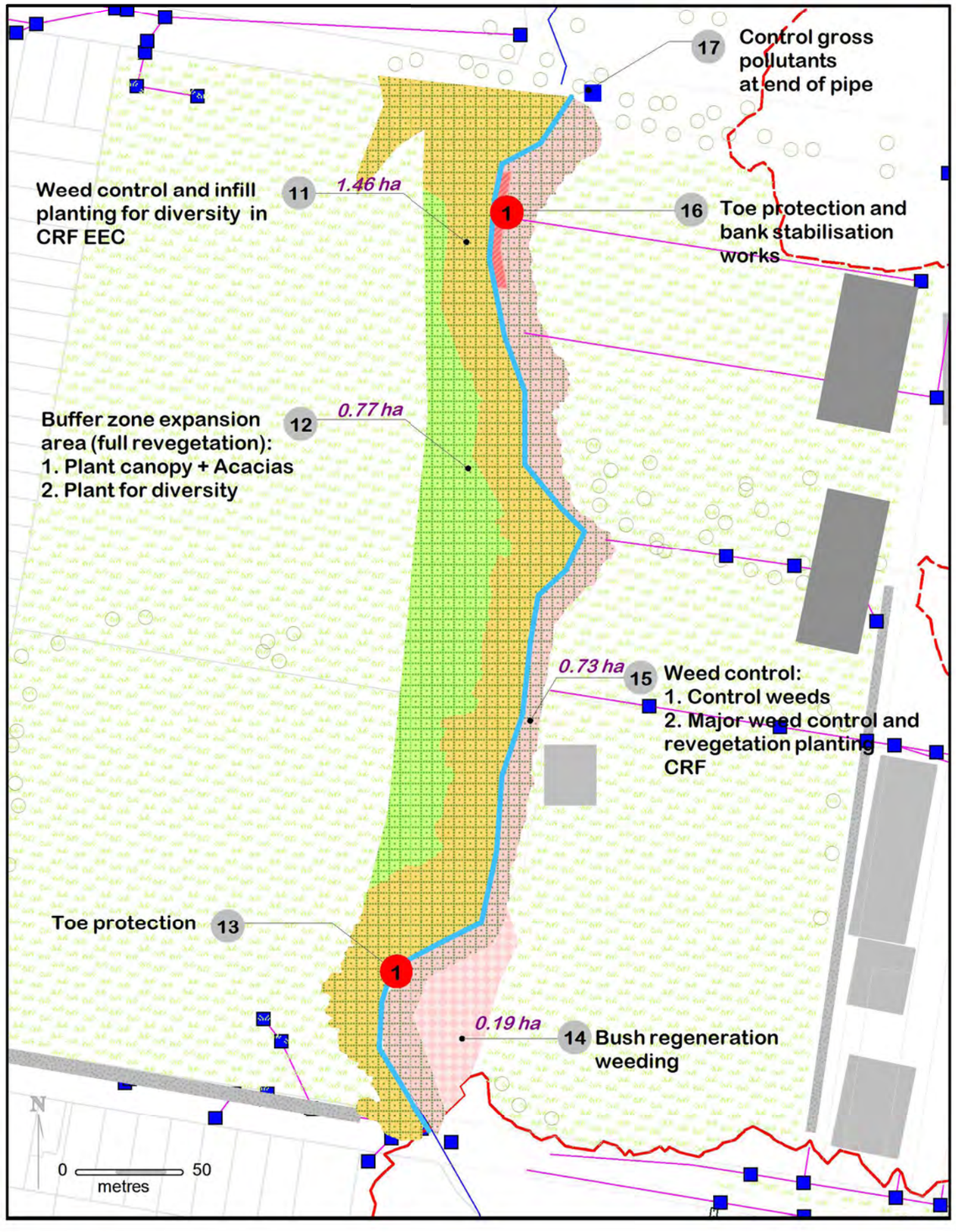
1. Improve riparian condition
2. Improve general habitat condition
3. Reduce downstream impacts

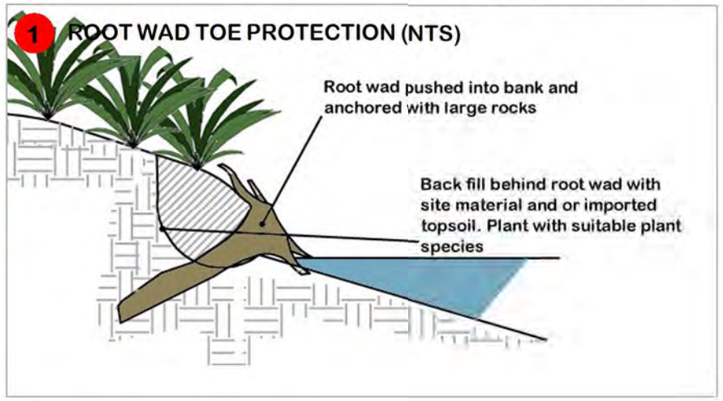
VEGETATION COMMUNITIES

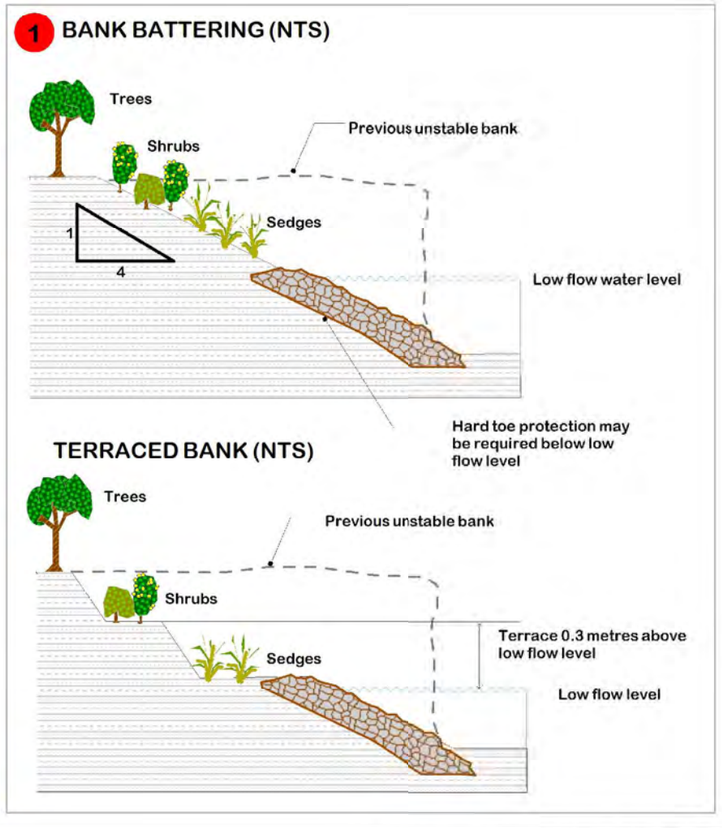
Cumberland Riverflat Forest (CRF)



WORKS PLAN







ZONE DUCK RIVER 2A

Refer to drawing sheet DUCK RIVER 2A p1 for site context and existing condition, and sheet DUCK RIVER 2A p2 for works plans and supporting information. Numbers in column one refer to numbered work zones on the drawing. Areas for each work zone are indicated on the drawing sheet and have been used to calculate costs for each action.

Table 30. Management actions and works required for DUCK RIVER 2A – joint responsibility by Parramatta and Auburn Councils

NO.	ACTION/WORKS REQUIRED	PRIORITY	AREA	COST	RESPONSIBILITY
20	Biodiversity enhancement: control carp populations	Medium	N/A	$3-5K/event	PCC/ACC

Table 31. Management actions and works required for DUCK RIVER 2A –Parramatta City Council's area of responsibility

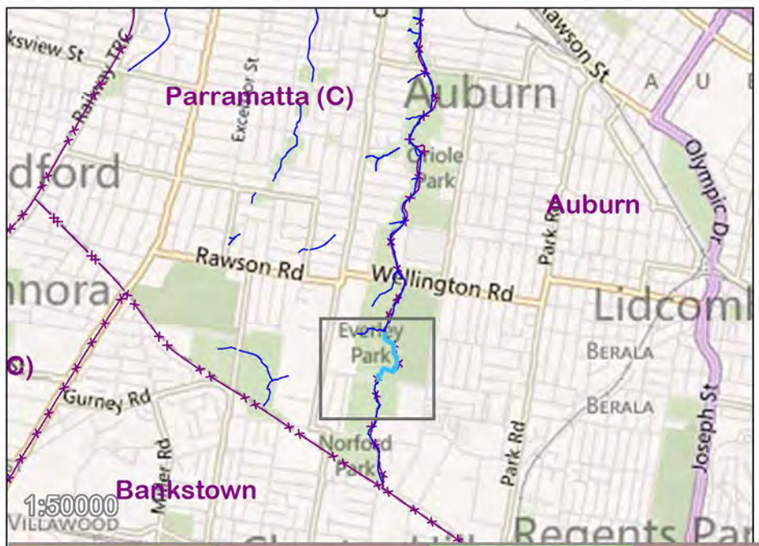
NO.	ACTION/WORKS REQUIRED	PRIORITY	AREA	COST	RESPONSIBILITY
18	Biodiversity enhancement: bush regeneration weeding and infill planting for diversity with Cumberland Riverflat Forest species	High	0.69ha	$5-10K	PCC
19	Biodiversity enhancement: bush regeneration weeding and infill planting for diversity with Cumberland Riverflat Forest species	High	0.71ha	$5-10K	PCC
19	Biodiversity enhancement: riparian buffer expansion planting with Cumberland Riverflat Forest species	Low	0.71ha	$20-25K	PCC
19	Biodiversity enhancement: monitor bank stability and install jute matting with stabilisation planting as required; use Cumberland Riverflat Forest species	Ongoing	0.71ha	$0-15K	PCC

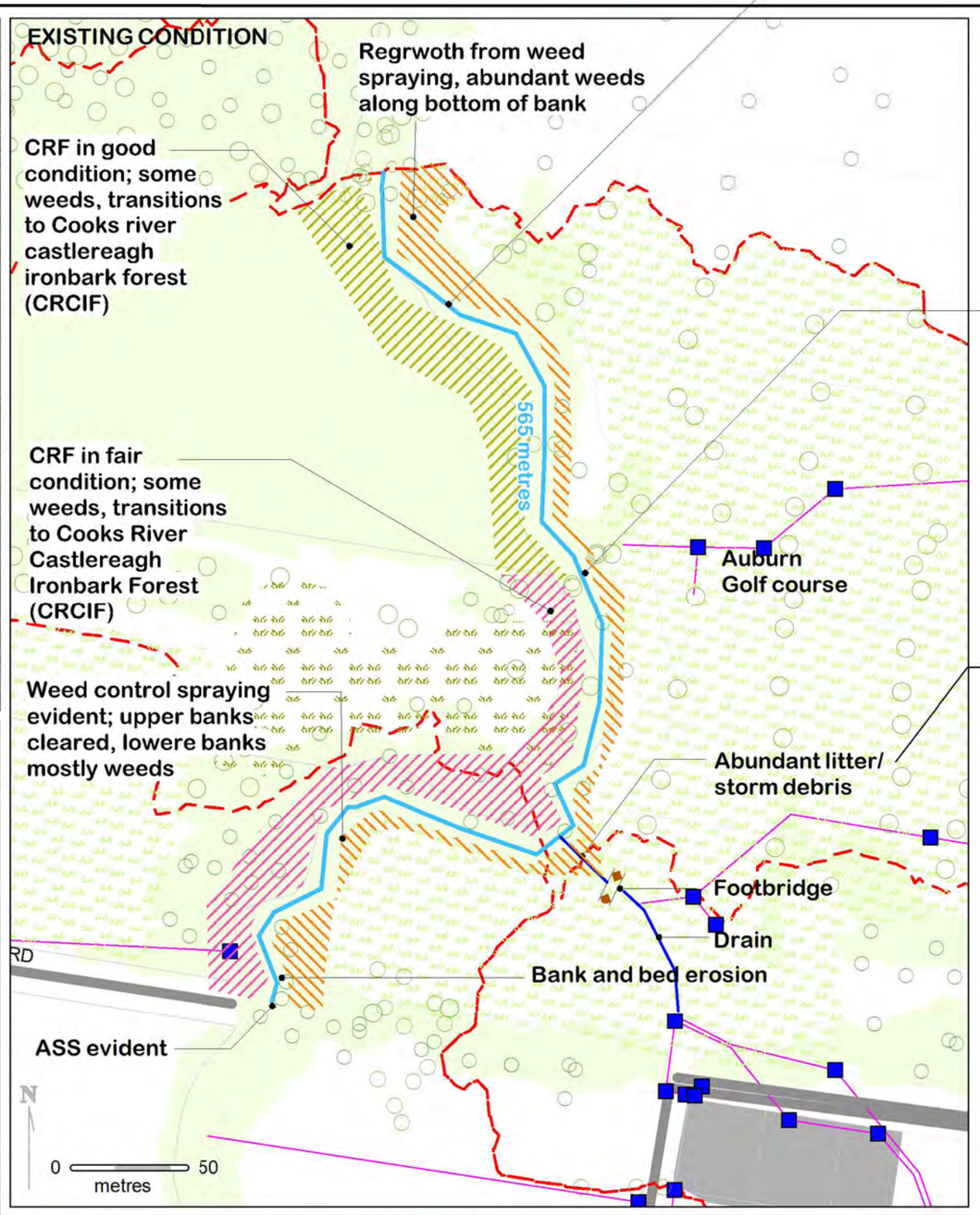
Table 32. Management actions and works required for DUCK RIVER 2A –Auburn City Council's area of responsibility

NO.	ACTION/WORKS REQUIRED	PRIORITY	AREA	COST	RESPONSIBILITY
21	Erosion control: toe protection and bank stabilisation works	Urgent	75m	$30-50K	ACC
20	Erosion control: toe protection and bank stabilisation works	High	35m + 40m	$40-70K	ACC
21	Water quality improvement: install trash rack or similar litter control device	High	N/A	$15-20K	ACC
22	Biodiversity enhancement: weed control, revegetation for stabilisation with Cumberland Riverflat Forest species	High	1.05ha	$40-50K	ACC
22	Biodiversity enhancement: bush regeneration weeding on lower banks and infill planting for stabilisation and diversity with Cumberland Riverflat Forest species	High	1.05ha	$5-15K	ACC

REACH: DUCK RIVER 2A

SITE CONTEXT





HYDRO-GEO MORPHOLOGY	RIPARIAN VEGETATION	INSTREAM HABITAT	SENSITIVITY	TOTAL	PRIORITY CATEGORY	TRAJECTORY
2.5	2.0	7.2	2.0	13.7	GOOD INSTREAM HABITAT	ECOLOGICAL ATTRIBUTES ▲ GEOMORPHOLOGY ▼

- Stormwater Pipe
- Open Watercourse
- Sub-catchment Boundary
- Reach
- Water quality monitoring point
- Cadastre Lot Boundary
- Stormwater Pit
- Carp control point
- EEC

data collected 20-30/03/2012

REACH: DUCK RIVER 2A

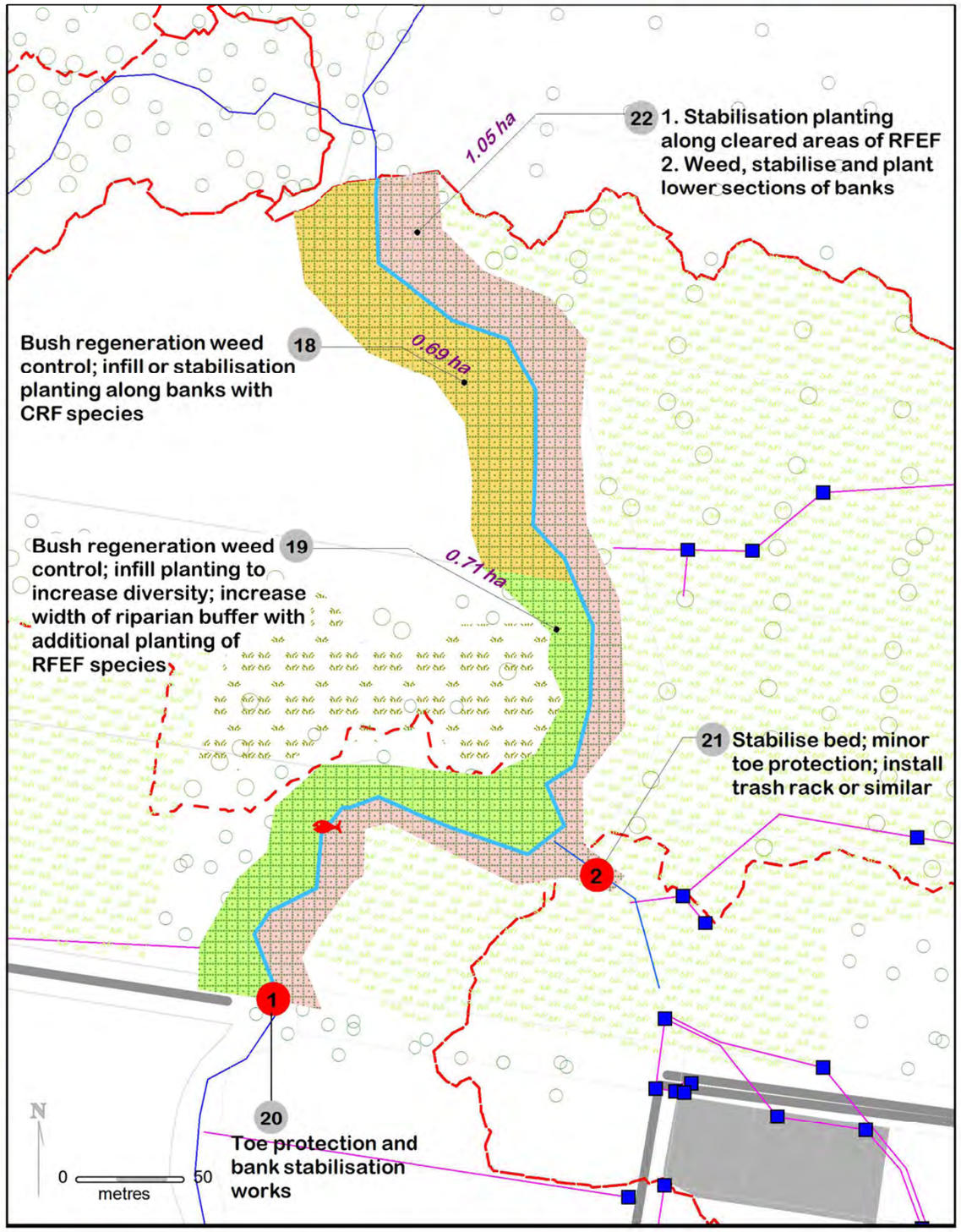
WORKS PLAN

OVERALL OBJECTIVES

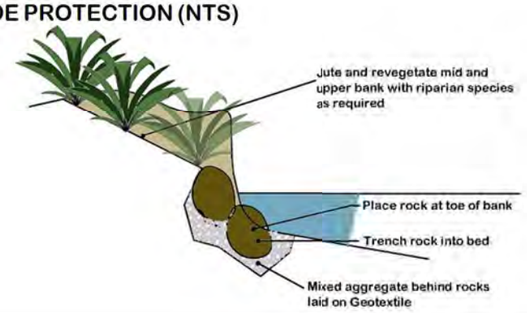
1. Improve riparian condition
2. Improve general habitat condition
3. Reduce downstream impacts

VEGETATION COMMUNITIES

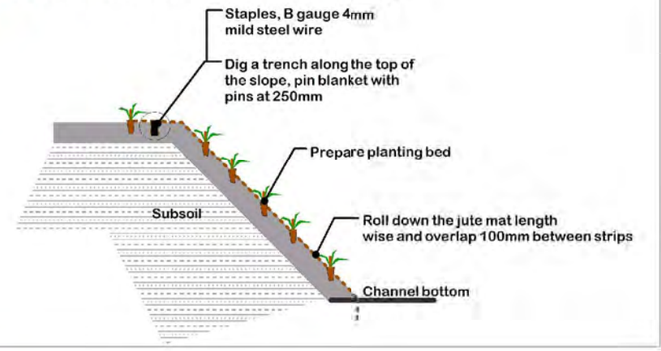
Cumberland Riverflat Forest (CRF)



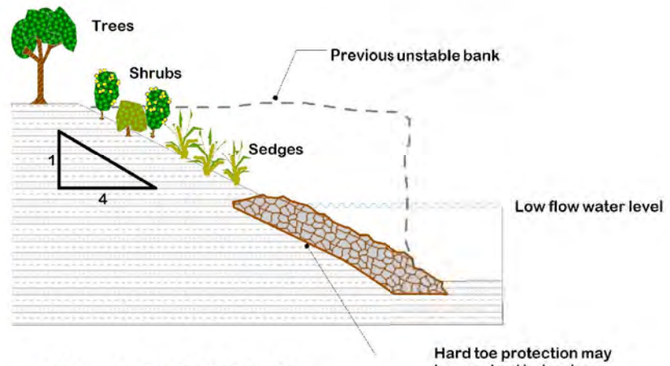
2 TOE PROTECTION (NTS)



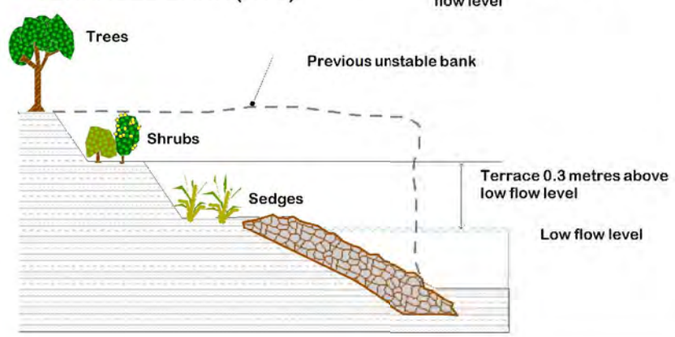
2 JUTE MAT BANK TREATMENT (NTS)



1 BANK BATTERING (NTS)



TERRACED BANK (NTS)



ZONE DUCK RIVER 2B

Refer to drawing sheet DUCK RIVER 2B p1 for site context and existing condition, and sheet DUCK RIVER 2B p2 for works plans and supporting information. Numbers in column one refer to numbered work zones on the drawing. Areas for each work zone are indicated on the drawing sheet and have been used to calculate costs for each action.

Table 33. Management actions and works required for DUCK RIVER 2B – joint responsibility by Parramatta and Auburn Councils

NO.	ACTION/WORKS REQUIRED	PRIORITY	AREA	COST	RESPONSIBILITY
27	Water quality improvement: water quality monitoring point	Urgent/ongoing	N/A	??	ACC/PCC
27	Biodiversity enhancement: control carp populations	Medium	N/A	$3-5K/event	PCC/ACC

Table 34. Management actions and works required for DUCK RIVER 2B –Parramatta City Council's area of responsibility

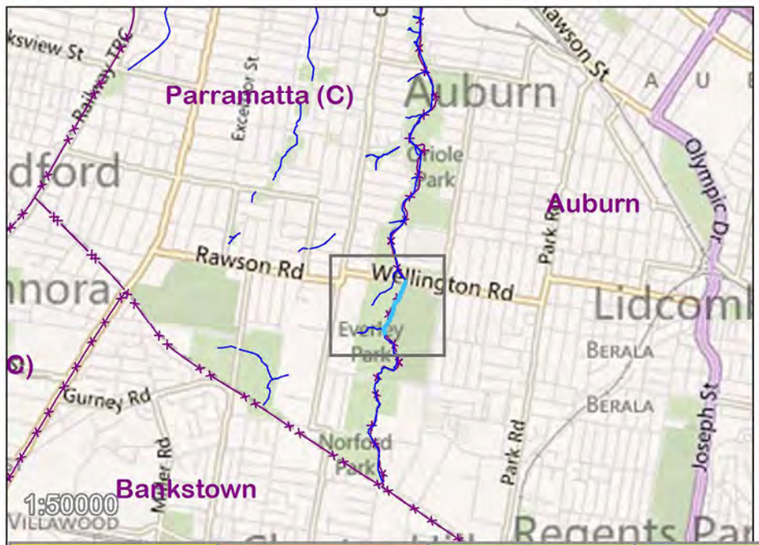
NO.	ACTION/WORKS REQUIRED	PRIORITY	AREA	COST	RESPONSIBILITY
27	Water quality improvement: install end of pipe litter control device	Urgent	N/A	$10-20K	PCC
23	Biodiversity enhancement: bush regeneration weeding and stabilisation planting with Cumberland Riverflat Forest species	High	1.00ha	$10-20K	PCC

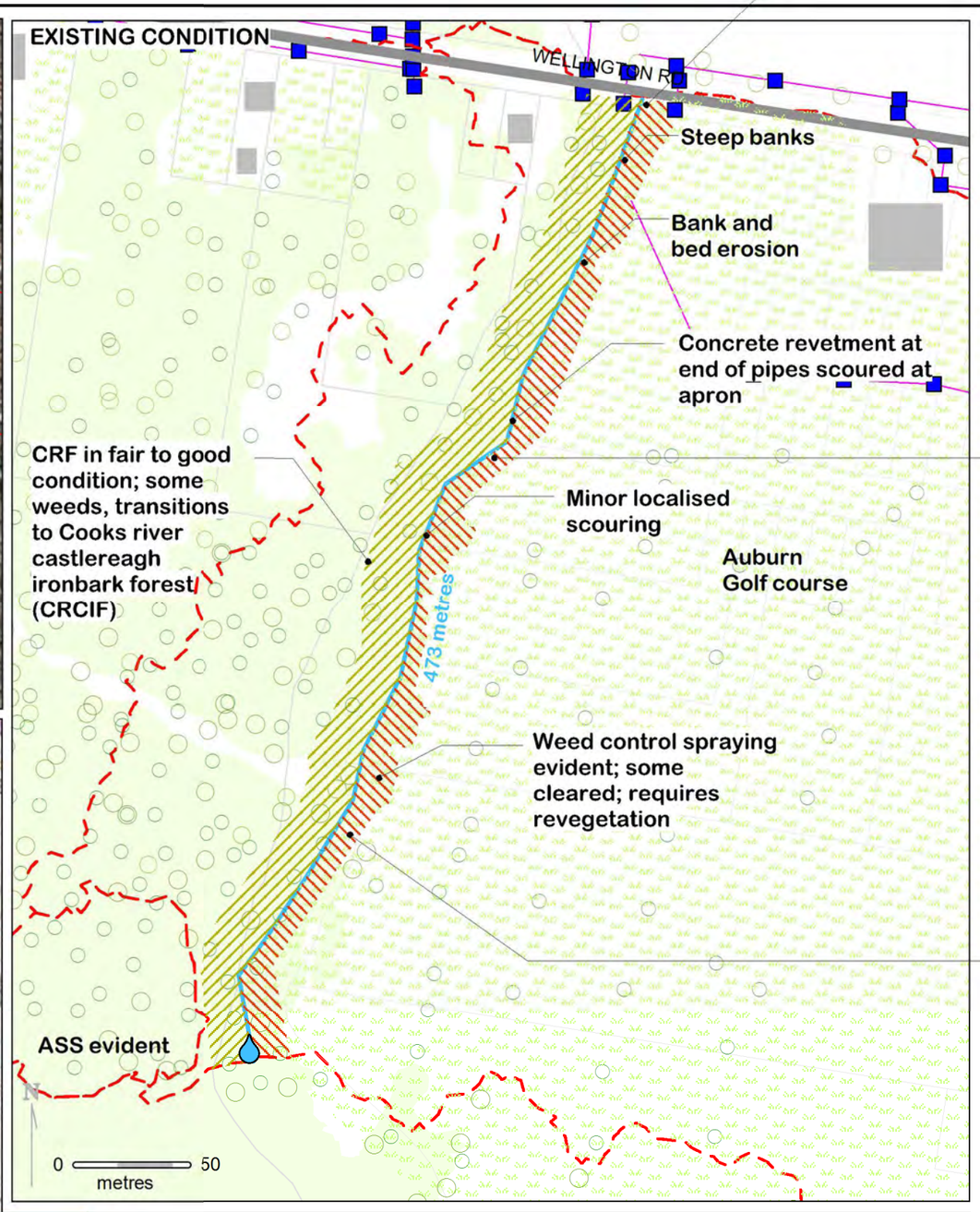
Table 35. Management actions and works required for DUCK RIVER 2B –Auburn City Council's area of responsibility

NO.	ACTION/WORKS REQUIRED	PRIORITY	AREA	COST	RESPONSIBILITY
24	Biodiversity enhancement: primary weed control, revegetation for stabilisation with Cumberland Riverflat Forest species	High	0.69ha	$30-40K	ACC
26	Erosion control: toe protection and outlet protection below concrete revetment	High	30m	$20-40K	ACC
24	Biodiversity enhancement: bush regeneration weeding and infill planting for stabilisation and diversity with Cumberland Riverflat Forest species	Medium	0.69ha	$7-15K	ACC
25	Erosion control: toe protection and bank stabilisation works	Medium	30m	$20-40K	ACC

REACH: DUCK RIVER 2B

SITE CONTEXT





HYDRO-GEO MORPHOLOGY	RIPARIAN VEGETATION	INSTREAM HABITAT	SENSITIVITY	TOTAL	PRIORITY CATEGORY	TRAJECTORY
3.0	2.6	7.3	6.0	18.9	HIGH SENSITIVITY, GOOD RIPARIAN HABITAT	ECOLOGICAL ATTRIBUTES ▲ GEOMORPHOLOGY ▼

- Stormwater Pipe
- Open Watercourse
- Sub-catchment Boundary
- Reach
- Water quality monitoring point
- Cadastre Lot Boundary
- Stormwater Pit
- Carp control point
- EEC

data collected 20-30/03/2012

REACH: DUCK RIVER 2B

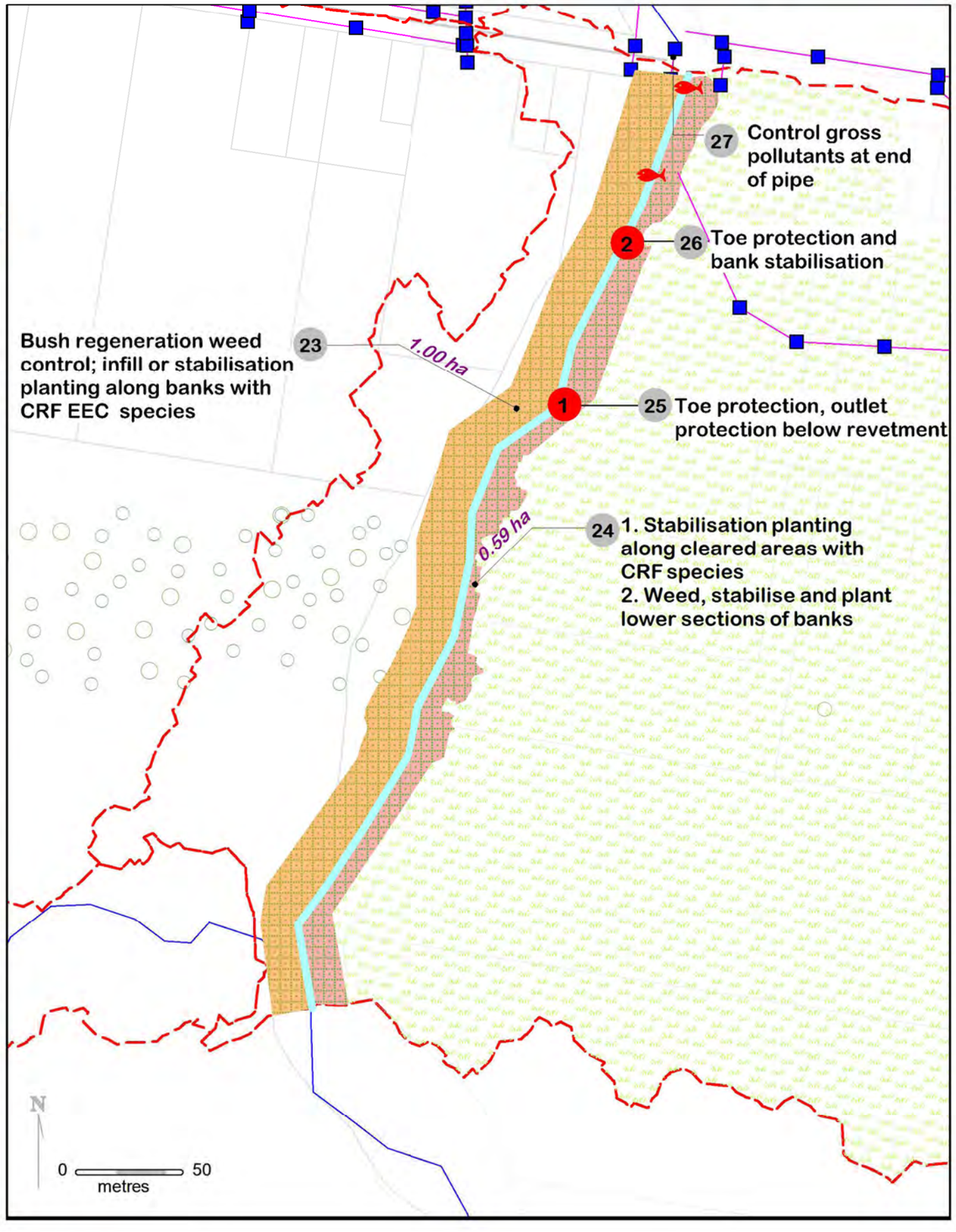
OVERALL OBJECTIVES

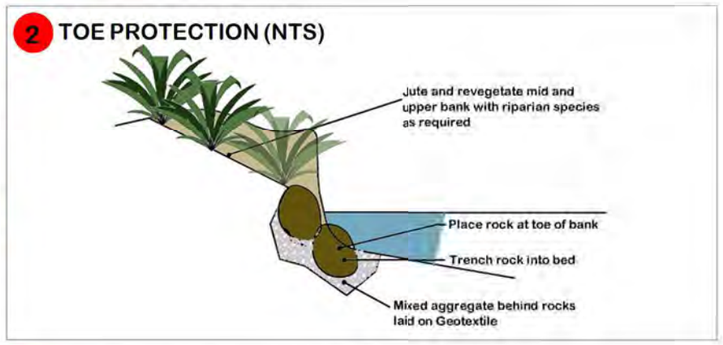
1. Improve riparian condition
2. Improve general habitat condition
3. Reduce downstream impacts

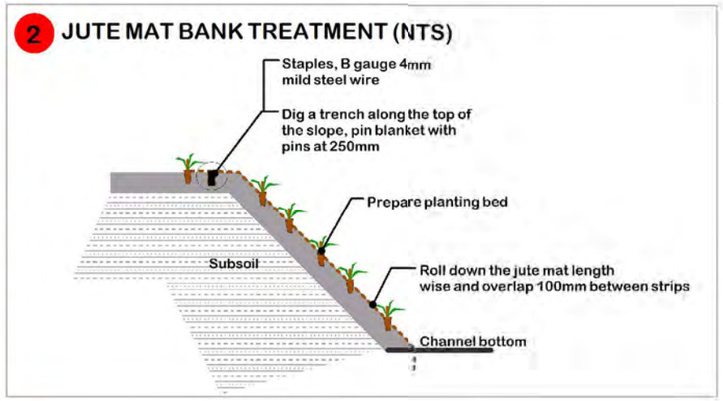
VEGETATION COMMUNITIES

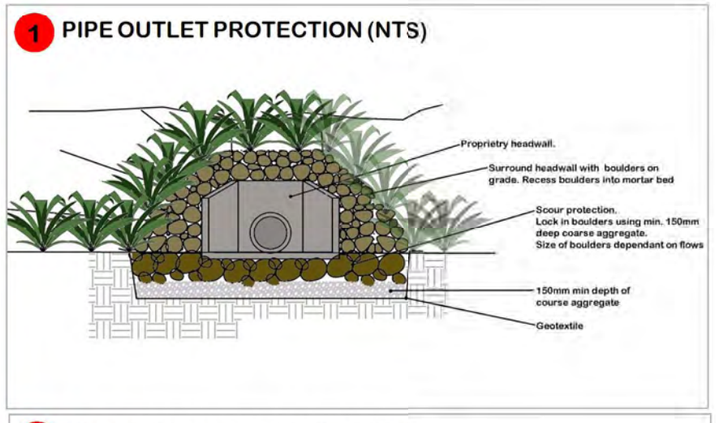
Cumberland Riverflat Forest (CRF)

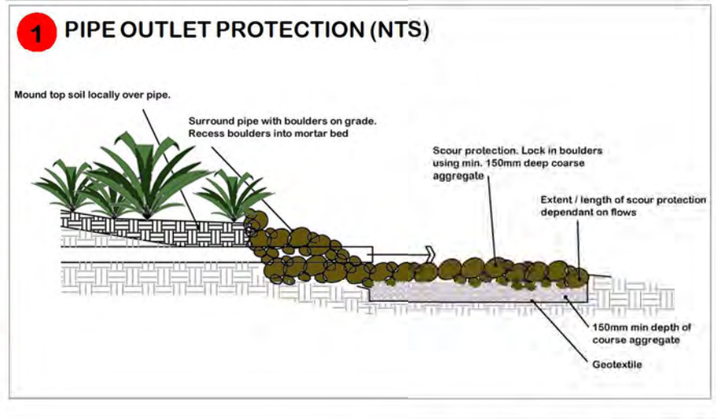
WORKS PLAN











ZONE DUCK RIVER 3A

Refer to drawing sheet DUCK RIVER 3A p1 for site context and existing condition, and sheet DUCK RIVER 3A p2 for works plans and supporting information. Numbers in column one refer to numbered work zones on the drawing. Areas for each work zone are indicated on the drawing sheet and have been used to calculate costs for each action.

Table 36. Management actions and works required for DUCK RIVER 3A – joint responsibility by Parramatta and Auburn Councils

NO.	ACTION/WORKS REQUIRED	PRIORITY	AREA	COST	RESPONSIBILITY
31	Community and recreation: install pedestrian footbridge across river/wetlands	High	N/A	$20-40K	ACC, PCC

Table 37. Management actions and works required for DUCK RIVER 3A –Parramatta City Council's area of responsibility

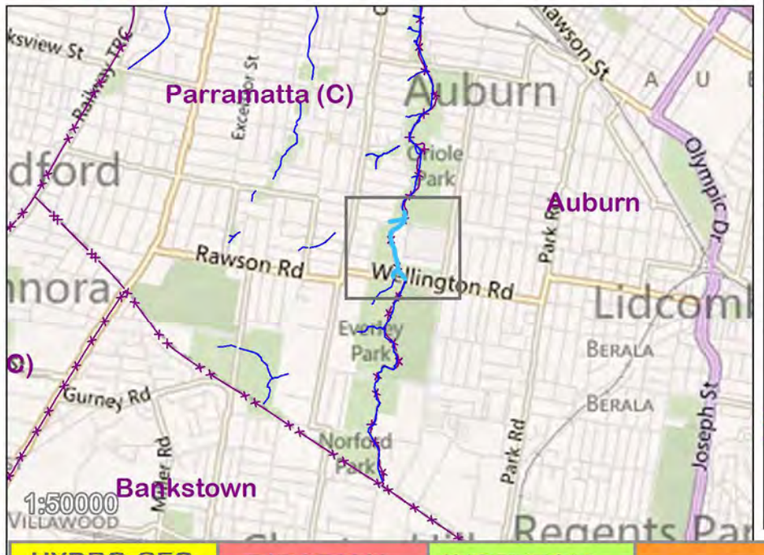
NO.	ACTION/WORKS REQUIRED	PRIORITY	AREA	COST	RESPONSIBILITY
28	Biodiversity enhancement: primary weed control, revegetation for stabilisation with Cumberland Riverflat Forest species	High	0.19ha	$10-15K	PCC
29	Biodiversity enhancement: primary weed control, revegetation for stabilisation and diversity with Cumberland Riverflat Forest species	High	0.52ha	$20-25K	PCC
30	Community and recreation: install seating, informative signage and weather shelters	High	N/A	$15-30K	PCC
31	Community and recreation: formalise existing path by constructing all weather crushed granite footpath for pedestrian access	High	450m	$5-10K	PCC
31	Community and recreation: install informative signage	High	N/A	$2-5K	PCC
32	Biodiversity enhancement: primary weed control of vines	High	0.72ha	$30-40K	PCC
37	Biodiversity enhancement: primary weed control of vines	High	0.24ha	$10-15K	PCC
33	Biodiversity enhancement: bush regeneration weeding and infill planting for diversity with Cumberland Riverflat Forest species	High	0.68ha	$10-20K	PCC
34	Biodiversity enhancement: bush regeneration weed control	High	0.41ha	$5-10K	PCC
37	Biodiversity enhancement: primary weed control and revegetation with Cumberland Riverflat Forest species	Medium	0.24ha	$10-15K	PCC
32	Biodiversity enhancement: primary weed control and revegetation with Cumberland Riverflat Forest species	Medium	0.72ha	$40-50K	PCC
30	Biodiversity enhancement: riparian buffer expansion planting with Cumberland Riverflat Forest species	Low	0.37ha	$10-12K	PCC
29	Biodiversity enhancement: monitor bank stability and install jute matting with stabilisation planting as required; use Cumberland Riverflat Forest species	Ongoing	0.52ha	$0-15K	PCC

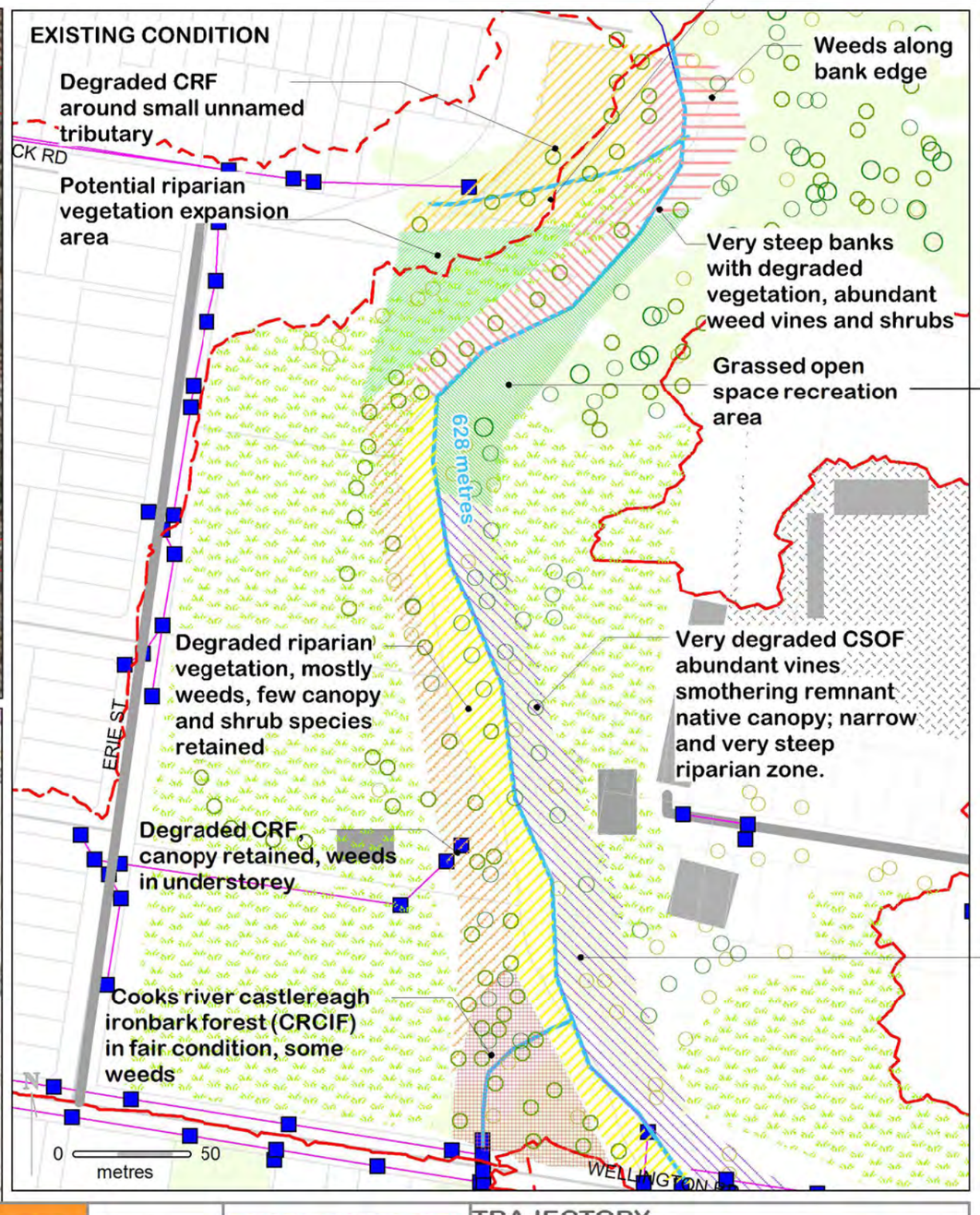
Table 38. Management actions and works required for DUCK RIVER 3A –Auburn City Council's area of responsibility

NO.	ACTION/WORKS REQUIRED	PRIORITY	AREA	COST	RESPONSIBILITY
35	Biodiversity enhancement: primary weed control of vines	High	0.98ha	$40-50K	ACC
36	Biodiversity enhancement: primary weed control, revegetation for stabilisation with Cumberland Swamp Oak Riparian Forest species	High	0.38ha	$25-40K	ACC
36	Community and recreation: install seating	High	N/A	$5-10K	ACC
43	Biodiversity enhancement: bush regeneration weeding and infill planting for diversity with Sydney Turpentine-Ironbark Forest species	High	0.50ha	$20-30K	ACC
35	Biodiversity enhancement: primary weed control and revegetation with Cumberland Swamp Oak Riparian Forest species	Medium	0.98ha	$40-50K	ACC

REACH: DUCK RIVER 3A

SITE CONTEXT





HYDRO-GEO MORPHOLOGY	RIPARIAN VEGETATION	INSTREAM HABITAT	SENSITIVITY	TOTAL	PRIORITY CATEGORY	TRAJECTORY
4.0	1.1	7.5	3.0	15.6	GOOD INSTREAM HABITAT	ECOLOGICAL ATTRIBUTES ▲ GEOMORPHOLOGY ▶

- Stormwater Pipe
- Open Watercourse
- Sub-catchment Boundary
- Reach
- Water quality monitoring point
- Cadastre Lot Boundary
- Stormwater Pit
- EEC

data collected 20-30/03/2012

REACH: DUCK RIVER 3A

WORKS PLAN

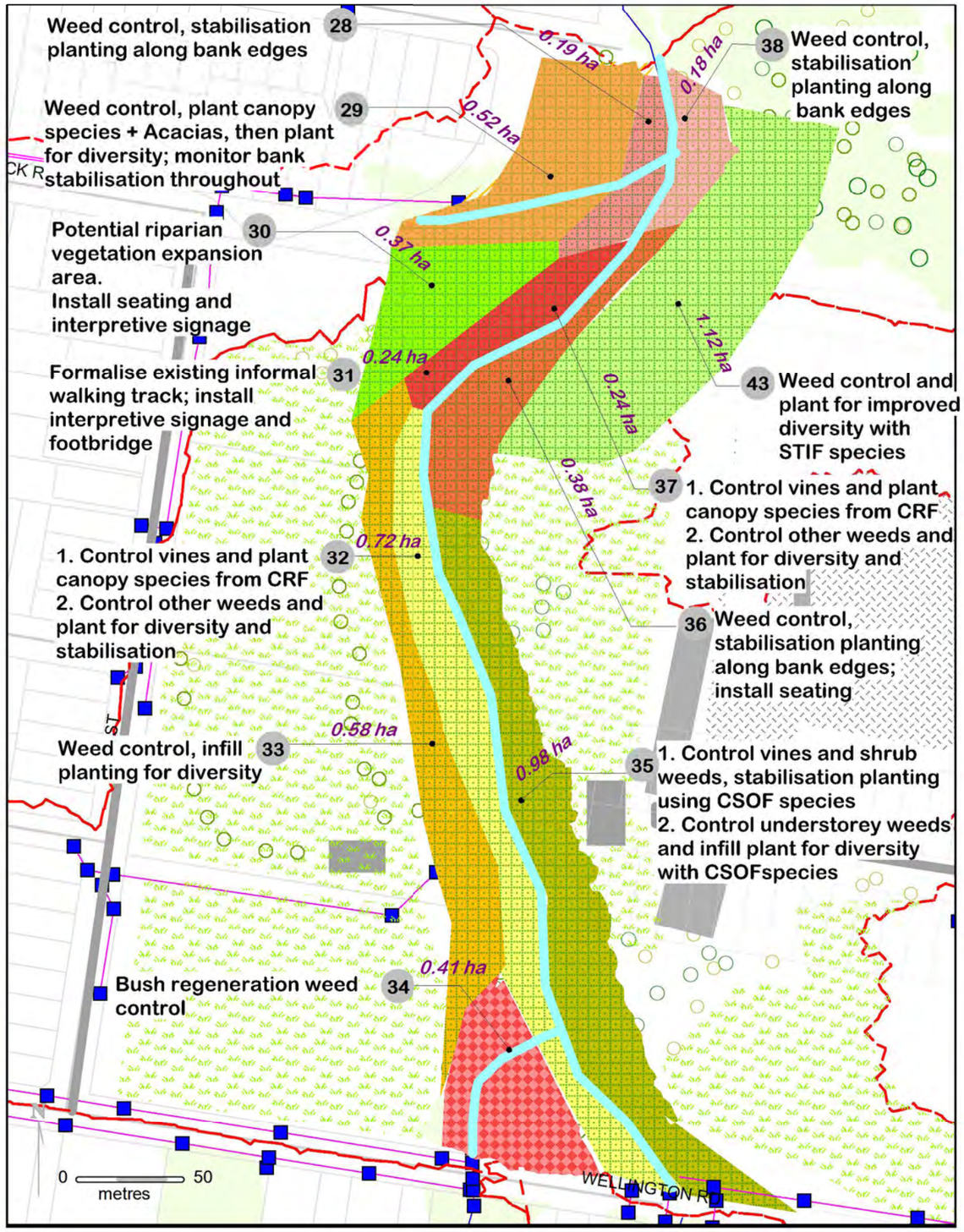
OVERALL OBJECTIVES

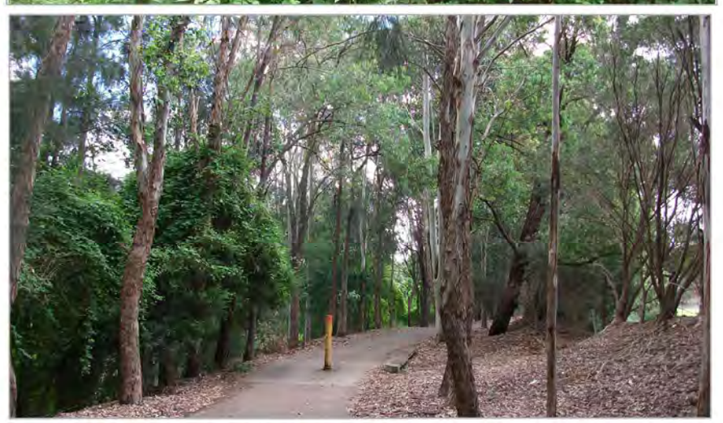
1. Improve riparian condition
2. Improve general habitat condition
3. Reduce downstream impacts

VEGETATION COMMUNITIES

Cumberland Riverflat Forest (CRF)

Cumberland Swamp Oak Forest (CSOF)





ZONE DUCK RIVER 3B

Refer to drawing sheet DUCK RIVER 3B p1 for site context and existing condition, and sheet DUCK RIVER 3B p2 for works plans and supporting information. Numbers in column one refer to numbered work zones on the drawing. Areas for each work zone are indicated on the drawing sheet and have been used to calculate costs for each action.

Table 39. Management actions and works required for DUCK RIVER 3B – joint responsibility by Parramatta and Auburn Councils

NO.	ACTION/WORKS REQUIRED	PRIORITY	AREA	COST	RESPONSIBILITY
39	Biodiversity enhancement: control carp populations	Medium	N/A	$3-5K/event	PCC/ACC
41	Biodiversity enhancement: control carp populations	Medium	N/A	$3-5K/event	PCC/ACC

Table 40. Management actions and works required for DUCK RIVER 3B –Parramatta City Council's area of responsibility

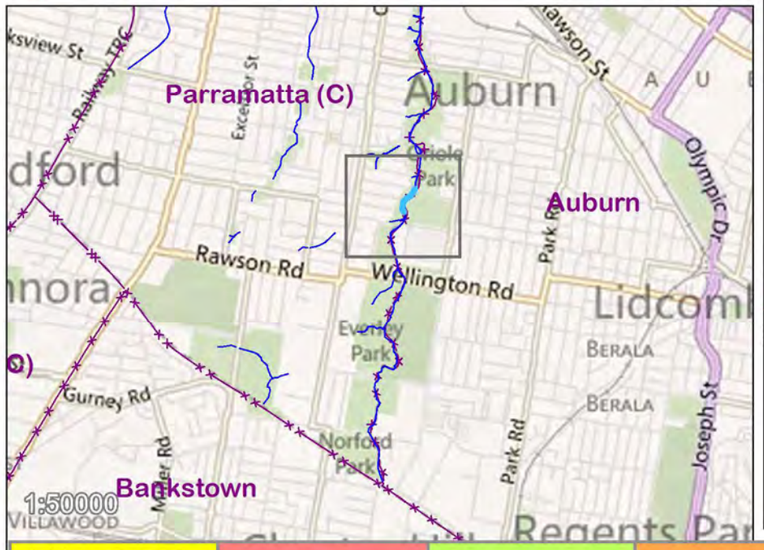
NO.	ACTION/WORKS REQUIRED	PRIORITY	AREA	COST	RESPONSIBILITY
40	Biodiversity enhancement: bush regeneration weeding and infill planting for diversity with Cumberland Riverflat Forest species	High	0.68ha	$8-12K	PCC
40	Monitor bank stability and install jute matting with stabilisation planting as required; use Cumberland Riverflat Forest species	Ongoing	130m	$0-10K	PCC

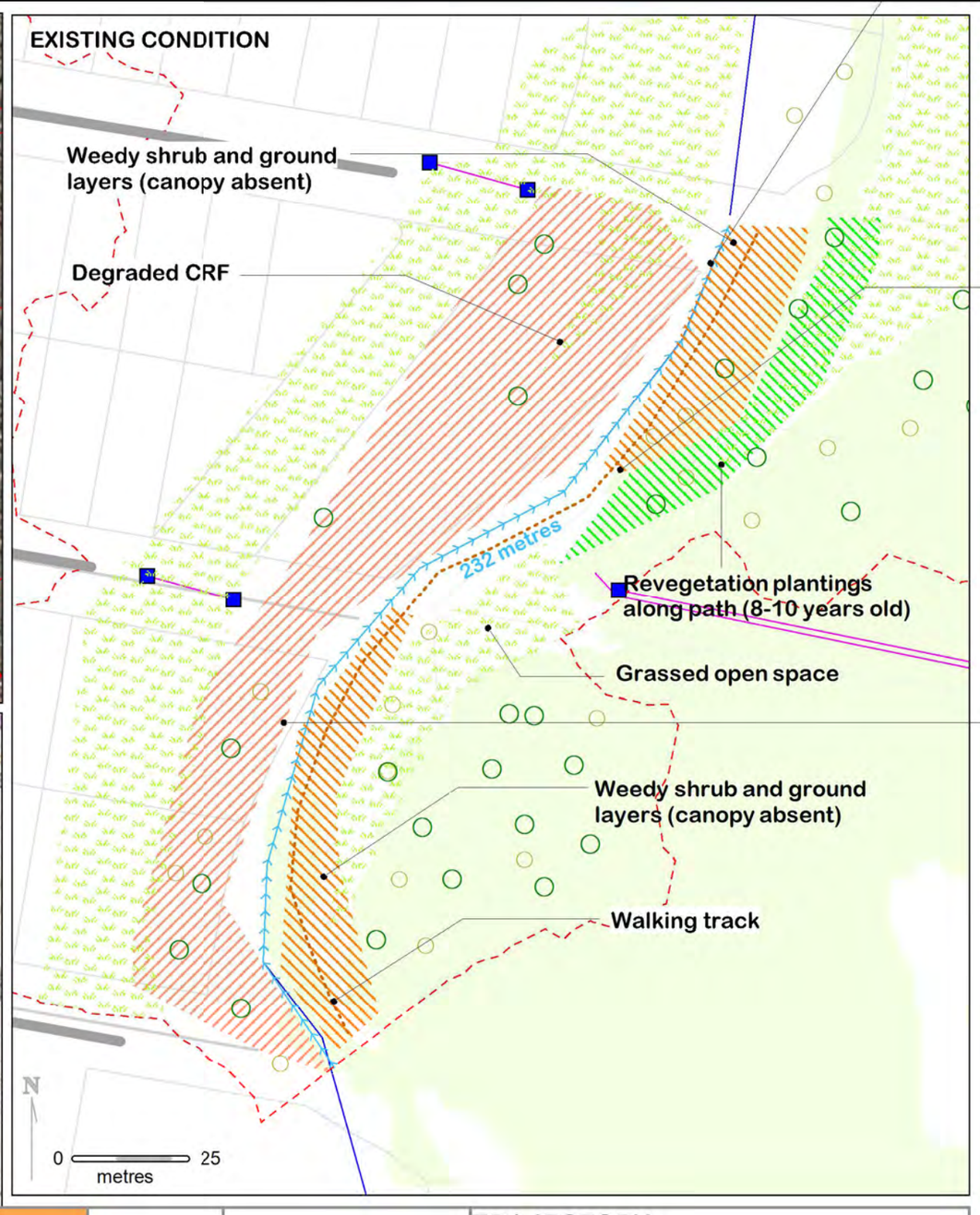
Table 41. Management actions and works required for DUCK RIVER 3B –Auburn City Council's area of responsibility

NO.	ACTION/WORKS REQUIRED	PRIORITY	AREA	COST	RESPONSIBILITY
41	Biodiversity enhancement: primary weed control, revegetation with graminoids and low shrubs to 1m; use Cumberland Swamp Oak Riparian Forest species	High	0.15ha	$3-5K	ACC
42	Community and recreation: install seating and interpretive signage	High	N/A	$10-15K	ACC
43	Biodiversity enhancement: bush regeneration weeding and infill planting for diversity with Sydney Turpentine-Ironbark Forest species	High	0.10ha	$3-5K	ACC
39	Biodiversity enhancement: bush regeneration weeding and planting for stabilisation and diversity with Cumberland Swamp Oak Riparian Forest species	High	0.12ha	$3-5K	ACC
42	Community and recreation: manage as grassed open space	Ongoing	0.17ha	$2-5K/year	ACC

REACH: DUCK RIVER 3B

SITE CONTEXT





HYDRO-GEO MORPHOLOGY	RIPARIAN VEGETATION	INSTREAM HABITAT	SENSITIVITY	TOTAL	PRIORITY CATEGORY	TRAJECTORY
4.0	1.3	7.4	3.0	15.7	GOOD INSTREAM HABITAT	ECOLOGICAL ATTRIBUTES ▶ GEOMORPHOLOGY ▶

- Stormwater Pipe
- Open Watercourse
- Sub-catchment Boundary
- Reach
- Water quality monitoring point
- Cadastre Lot Boundary
- Stormwater Pit
- Carp control point
- EEC

data collected 20-30/03/2012

REACH: DUCK RIVER 3B

OVERALL OBJECTIVES

1. Improve riparian condition
2. Improve general habitat condition
3. Reduce downstream impacts

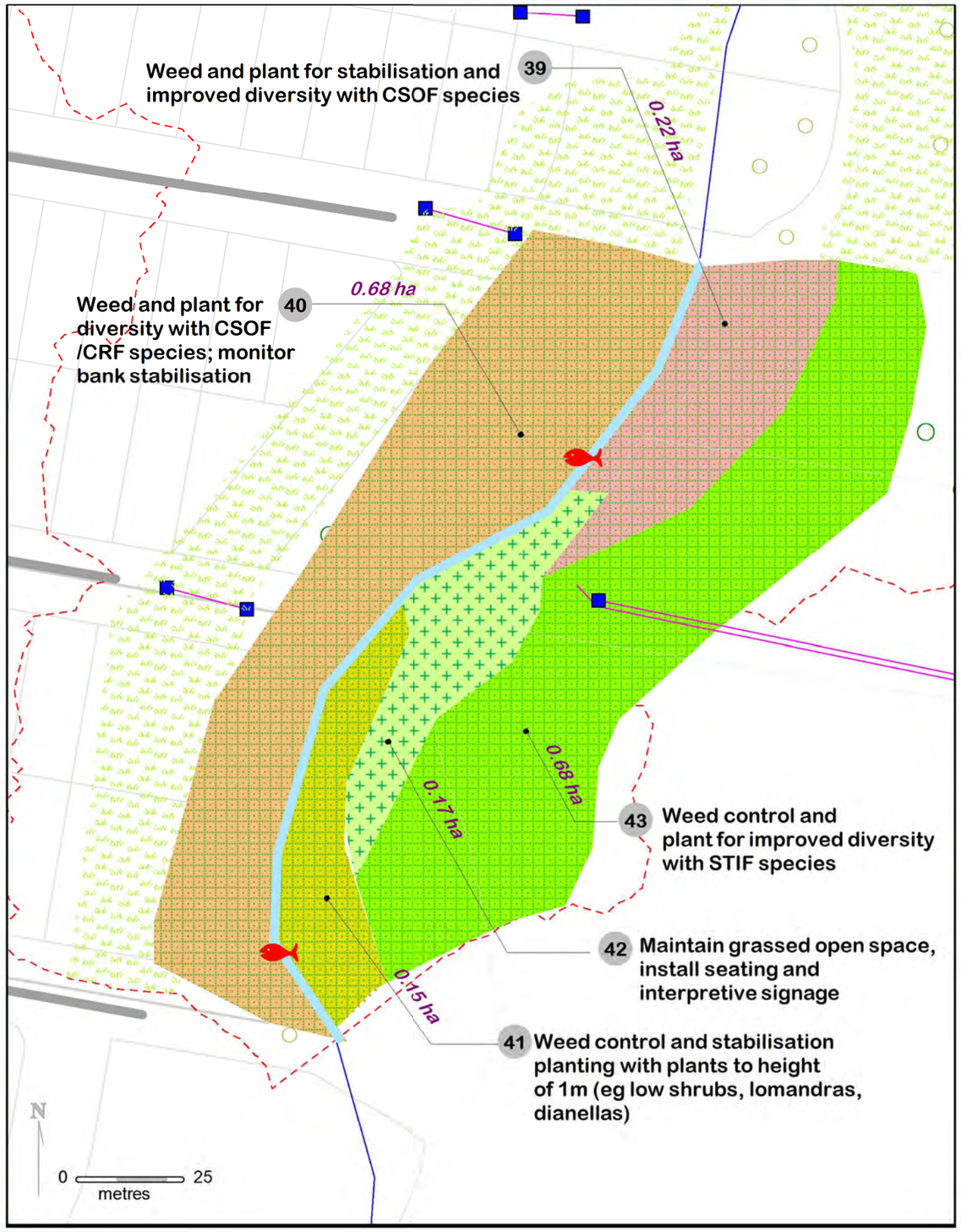
VEGETATION COMMUNITIES

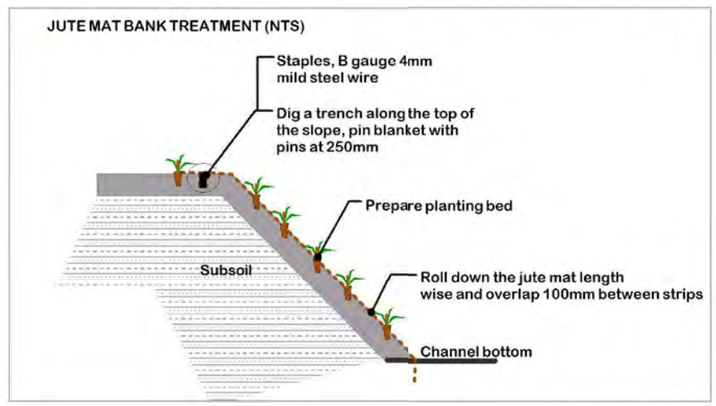
Cumberland Riverflat Forest (CRF)

Cumberland Swamp Oak Forest (CSOF)

Sydney Turpentine-Ironbark Forest (STIF)

WORKS PLAN





ZONE DUCK RIVER 4A

Refer to drawing sheet DUCK RIVER 4A p1 for site context and existing condition, and sheet DUCK RIVER 4A p2 for works plans and supporting information. Numbers in column one refer to numbered work zones on the drawing. Areas for each work zone are indicated on the drawing sheet and have been used to calculate costs for each action.

Table 42. Management actions and works required for DUCK RIVER 4A – joint responsibility by Parramatta and Auburn Councils

NO.	ACTION/WORKS REQUIRED	PRIORITY	AREA	COST	RESPONSIBILITY
44	Community and recreation: improve safety at causeway crossing (stepping stones weir)	Urgent	N/A	??	ACC, PCC
53	Biodiversity enhancement: primary weed control, revegetation with Cumberland Swamp Oak Riparian Forest species	High	0.13ha	$4-8K	PCC,ACC
52	Biodiversity enhancement: control carp populations	Medium	N/A	$3-5K/event	PCC/ACC
46	Biodiversity enhancement: control carp populations	Medium	N/A	$3-5K/event	PCC/ACC

Table 43. Management actions and works required for DUCK RIVER 4A –Parramatta City Council's area of responsibility

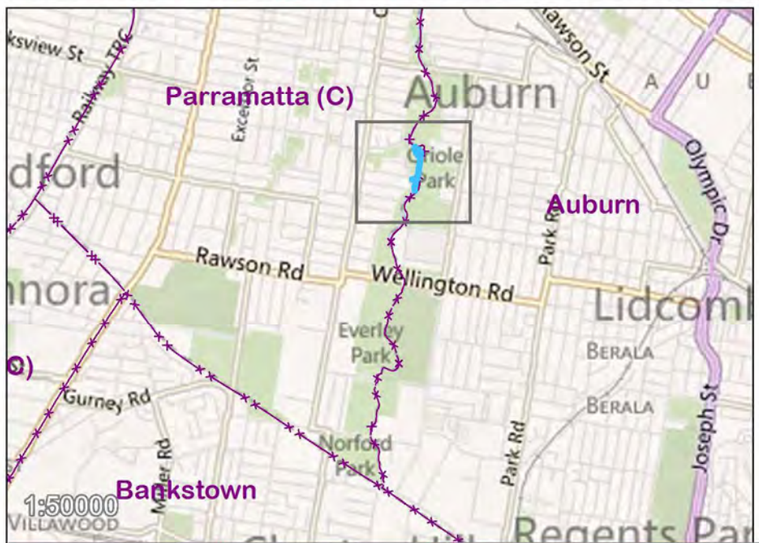
NO.	ACTION/WORKS REQUIRED	PRIORITY	AREA	COST	RESPONSIBILITY
45	Biodiversity enhancement: bush regeneration weeding and infill planting for diversity with Cumberland Riverflat Forest species	High	0.23ha	$5-10K	PCC
47	Biodiversity enhancement: bush regeneration weeding and infill planting for diversity with Cumberland Riverflat Forest species	High	0.73ha	$10-15K	PCC
48	Water quality improvement: remove litter and debris from fringing reeds; consider installation of floating trash trap	High	N/A	$5-10K	PCC
46	Community and recreation: manage as grassed open space	Ongoing	N/A	$2-5K/year	PCC
46	Community and recreation: maintain existing seating and signage	Ongoing	N/A	$2-5K/year	PCC
49	Community and recreation: manage as grassed open space	Ongoing	N/A	$2-5K/year	PCC

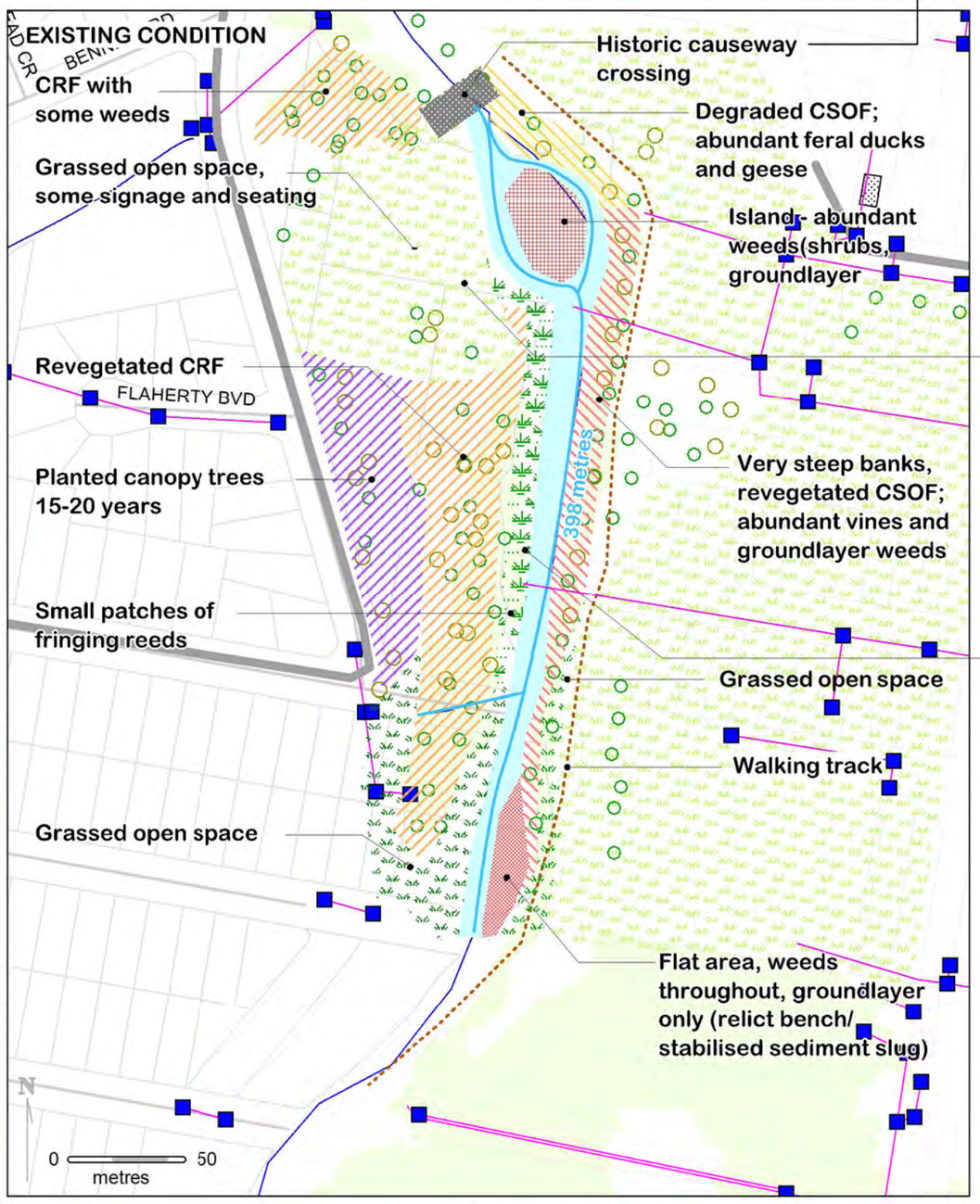
Table 44. Management actions and works required for DUCK RIVER 4A –Auburn City Council's area of responsibility

NO.	ACTION/WORKS REQUIRED	PRIORITY	AREA	COST	RESPONSIBILITY
50	Biodiversity enhancement: primary weed control, revegetation with Cumberland Swamp Oak Riparian Forest species	High	0.07ha	$2-5K	ACC
52	Biodiversity enhancement: primary weed control of vines	High	0.34ha	$15-20K	ACC
54	Community and recreation: formalise existing path with all-weather crushed granite pedestrian footpath	High	270m	$3-5K	ACC
55	Community and recreation: install seating and informative signage	High	N/A	$5-10K	ACC
56	Biodiversity enhancement: control/remove introduced ducks and geese	High, Ongoing	N/A	$53-5K	ACC
52	Biodiversity enhancement: primary weed control and revegetation with Cumberland Swamp Oak Riparian Forest species	Medium	0.34ha	$15-25K	ACC
51	Community and recreation: manage as grassed open space	Ongoing	N/A	$2-5K/year	ACC

REACH: DUCK RIVER 4A

SITE CONTEXT





HYDRO-GEO MORPHOLOGY	RIPARIAN VEGETATION	INSTREAM HABITAT	SENSITIVITY	TOTAL	PRIORITY CATEGORY	TRAJECTORY
3.0	0.8	6.0	4.0	13.8	GOOD HYDRO-GEOMORPHOLOGY	ECOLOGICAL ATTRIBUTES GEOMORPHOLOGY

- Stormwater Pipe
- Open Watercourse
- Sub-catchment Boundary
- Reach
- Water quality monitoring point
- Cadastre Lot Boundary
- Stormwater Pit
- Carp control point
- EEC

data collected 20-30/03/2012

REACH: DUCK RIVER 4A

WORKS PLAN

OVERALL OBJECTIVES

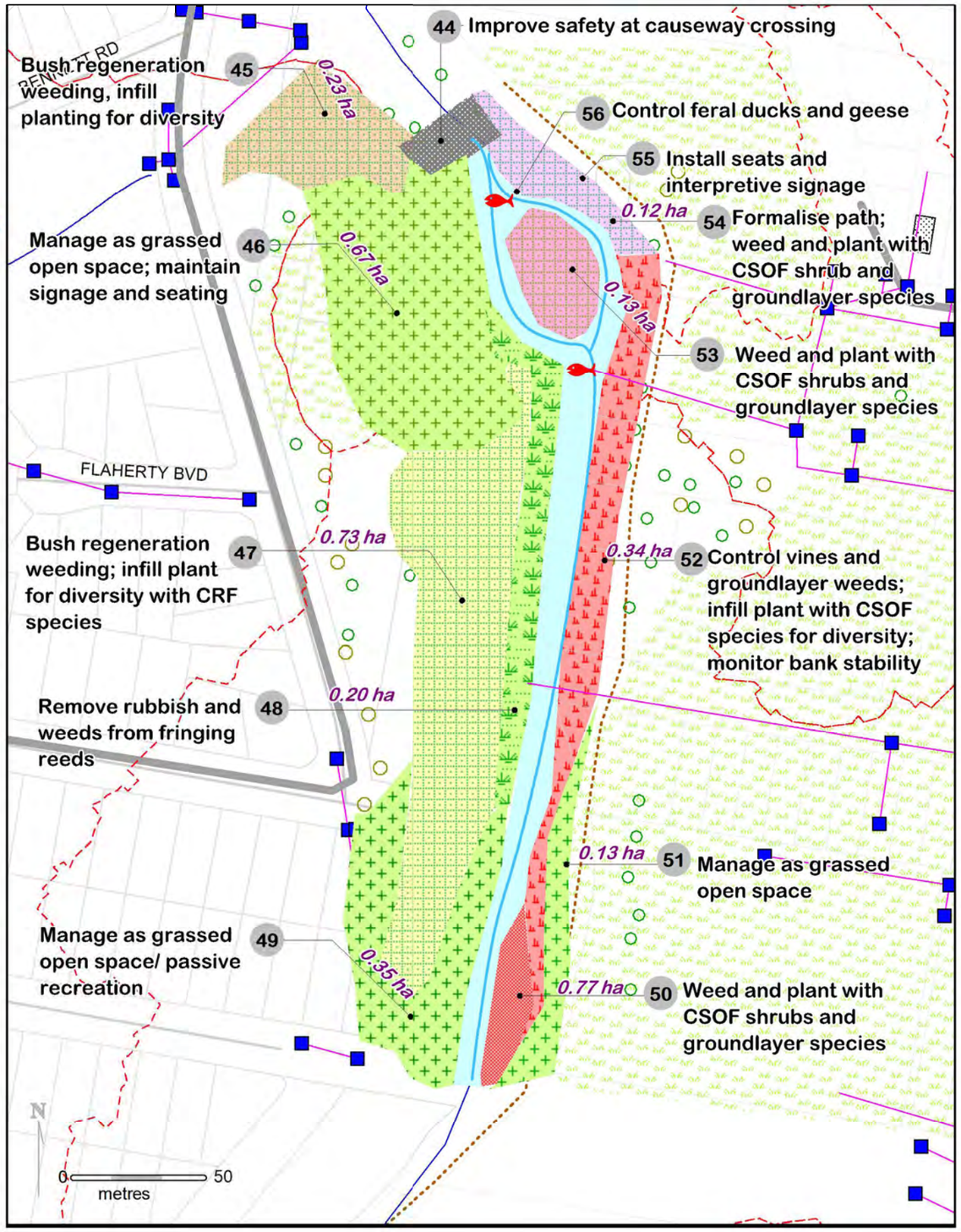
1. Improve riparian condition
2. Improve general habitat condition
3. Reduce downstream impacts

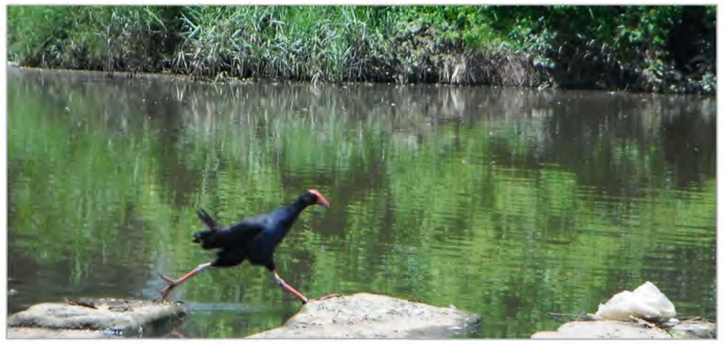
VEGETATION COMMUNITIES

Cumberland Riverflat Forest (CRF)

Cumberland Swamp Oak Forest (CSOF)

Coastal Freshwater Reedlands





ZONE DUCK RIVER 4B

Refer to drawing sheet DUCK RIVER 4B p1 for site context and existing condition, and sheet DUCK RIVER 4B p2 for works plans and supporting information. Numbers in column one refer to numbered work zones on the drawing. Areas for each work zone are indicated on the drawing sheet and have been used to calculate costs for each action.

Table 45. Management actions and works required for DUCK RIVER 4B – joint responsibility by Parramatta and Auburn Councils

NO.	ACTION/WORKS REQUIRED	PRIORITY	AREA	COST	RESPONSIBILITY
68	Biodiversity enhancement: control aquatic noxious weeds	Urgent	0.02ha	$5-10K	PCC/ACC
68	Water quality improvement: water quality monitoring point	Urgent/ongoing	N/A	??	ACC/PCC
62	Biodiversity enhancement: control carp populations	Medium	N/A	$3-5K/event	PCC/ACC
64	Biodiversity enhancement: control carp populations	Medium	N/A	$3-5K/event	PCC/ACC
68	Biodiversity enhancement: control carp populations	Medium	N/A	$3-5K/event	PCC/ACC

Table 46. Management actions and works required for DUCK RIVER 4B –Parramatta City Council's area of responsibility

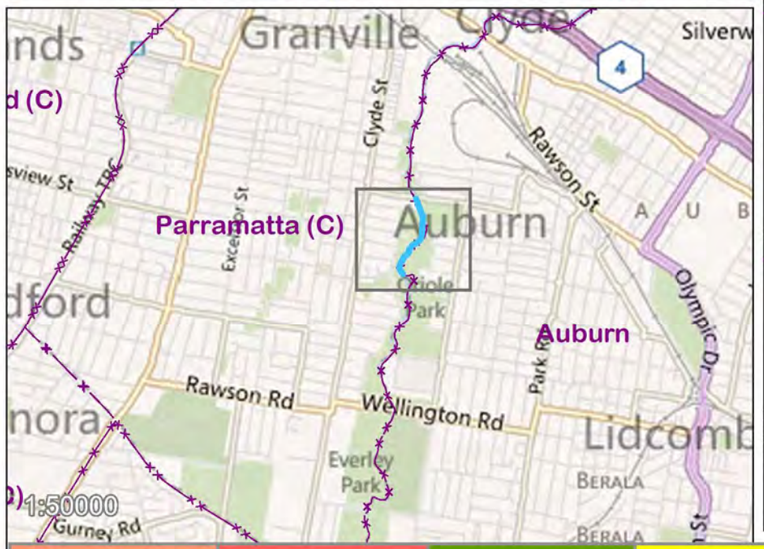
NO.	ACTION/WORKS REQUIRED	PRIORITY	AREA	COST	RESPONSIBILITY
57	Biodiversity enhancement: fringing buffer planting with Cumberland Swamp Oak Riparian Forest species	High	0.15ha	$3-5K	PCC
58	Community and recreation: install concrete footpath/cycleway to provide linkages with existing road and footpath network	High	360m	$30-40K	PCC
59	Biodiversity enhancement: primary weed control of vines, and plant canopy species (Cumberland Swamp Oak Riparian Forest)	High	0.32ha	$12-15K	PCC
60	Biodiversity enhancement: bush regeneration weeding and infill planting for diversity with Cumberland Swamp Oak Riparian Forest species	High	0.60ha	$5-10K	PCC
61	Biodiversity enhancement: primary weed control of vines	High	0.05ha	$3-5K	PCC
62	Biodiversity enhancement: primary weed control of vines	High	0.39ha	$15-20K	PCC
63	Biodiversity enhancement: bush regeneration weeding and infill planting for diversity with Cumberland Riverflat Forest species	High	1.47ha	$20-30K	PCC
61	Biodiversity enhancement: primary weed control and revegetation with Cumberland Swamp Oak Riparian Forest species	Medium	0.05ha	$3-5K	PCC
62	Biodiversity enhancement: primary weed control and revegetation with Cumberland Riverflat Forest species	Medium	0.39ha	$15-20K	PCC
57	Community and recreation: manage as grassed open space	Ongoing	N/A	$2-5K/year	PCC

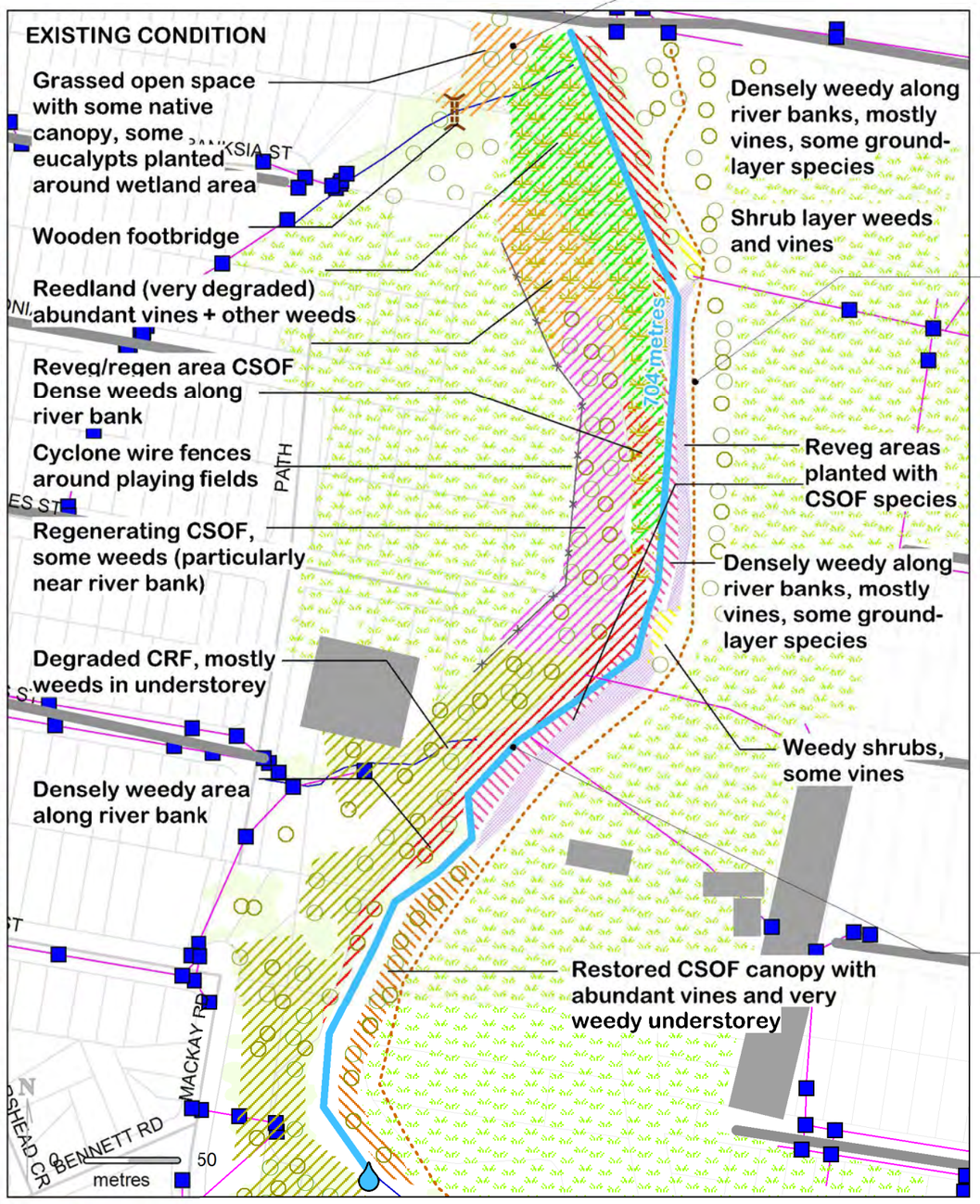
Table 47. Management actions and works required for DUCK RIVER 4B –Auburn City Council's area of responsibility

NO.	ACTION/WORKS REQUIRED	PRIORITY	AREA	COST	RESPONSIBILITY
64	Biodiversity enhancement: primary weed control of vines	High	0.25ha	$10-15K	ACC
65	Biodiversity enhancement: primary weed control of vines, and infill planting for diversity (Cumberland Swamp Oak Riparian Forest)	High	0.25ha	$10-15K	ACC
66	Biodiversity enhancement: primary weed control of vines, and plant canopy species (Cumberland Swamp Oak Riparian Forest)	High	0.24ha	$10-15K	ACC
67	Biodiversity enhancement: primary weed control of vines, and plant canopy species (Cumberland Swamp Oak Riparian Forest)	High	0.11ha	$5-10K	ACC
68	Biodiversity enhancement: primary weed control of vines and other weeds	High	0.81ha	$35-40K	ACC
68	Biodiversity enhancement: plant fringing vegetation species (Coastal Freshwater Reedlands)	High	500m^2	$1-2K	ACC
66	Biodiversity enhancement: primary weed control, revegetation with Cumberland Swamp Oak Riparian Forest species	Medium	0.24ha	$10-15K	ACC
64	Biodiversity enhancement: primary weed control and revegetation with Cumberland Swamp Oak Riparian Forest species	Medium	0.25ha	$10-15K	ACC
67	Biodiversity enhancement: primary weed control, revegetation with Cumberland Swamp Oak Riparian Forest species	Medium	0.11ha	$5-10K	ACC

REACH: DUCK RIVER 4B

SITE CONTEXT





HYDRO-GEO MORPHOLOGY	RIPARIAN VEGETATION	INSTREAM HABITAT	SENSITIVITY	TOTAL	PRIORITY CATEGORY	TRAJECTORY
3.5	1.1	7.8	4.0	16.4	GOOD HYDRO-GEOMORPHOLOGY, GOOD INSTREAM HABITAT	ECOLOGICAL ATTRIBUTES ▲ GEOMORPHOLOGY ▶

- Stormwater Pipe
- Open Watercourse
- Sub-catchment Boundary
- Reach
- Water quality monitoring point
- Cadastre Lot Boundary
- Stormwater Pit
- Carp control point
- EEC

data collected 20-30/03/2012

REACH: DUCK RIVER 4B

WORKS PLAN

OVERALL OBJECTIVES

1. Improve riparian condition

2. Improve general habitat condition

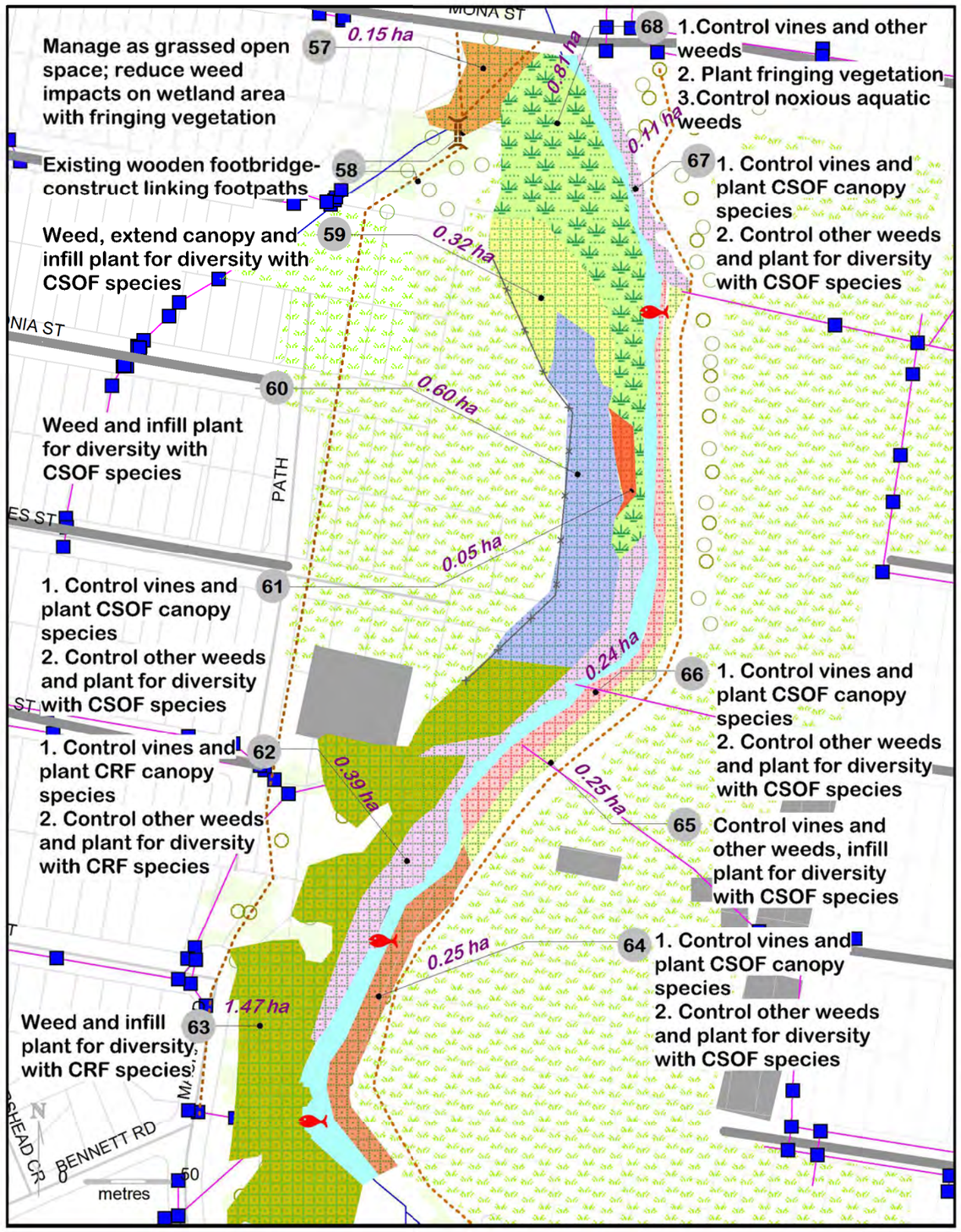
3. Reduce downstream impacts

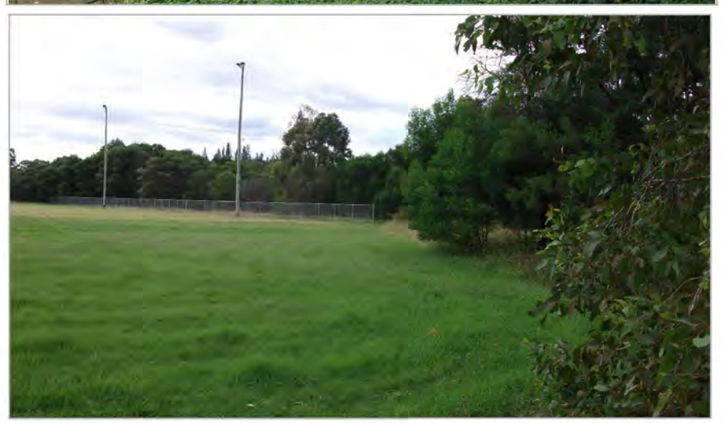
VEGETATION COMMUNITIES

Cumberland Riverflat Forest (CRF)

Cumberland Swamp Oak Forest (CSOF)

Coastal Freshwater Reedlands





ZONE DUCK RIVER 5A

Refer to drawing sheet DUCK RIVER 5A p1 for site context and existing condition, and sheet DUCK RIVER 5A p2 for works plans and supporting information. Numbers in column one refer to numbered work zones on the drawing. Areas for each work zone are indicated on the drawing sheet and have been used to calculate costs for each action.

Table 48. Management actions and works required for DUCK RIVER 5A – joint responsibility by Parramatta and Auburn Councils

NO.	ACTION/WORKS REQUIRED	PRIORITY	AREA	COST	RESPONSIBILITY
73	Water quality improvement: remove litter and debris from fringing reeds; consider installation of floating trash trap	Urgent	N/A	$5-10K	PCC/ACC
73	Biodiversity enhancement: primary weed control of vines and other weeds	High	1.3ha	$55-70K	PCC/ACC
71	Biodiversity enhancement: control carp populations	Medium	0.69ha	$3-5K/event	PCC/ACC
72	Biodiversity enhancement: control carp populations	Medium	0.54ha	$3-5K/event	PCC/ACC

Table 49. Management actions and works required for DUCK RIVER 5A –Parramatta City Council's area of responsibility

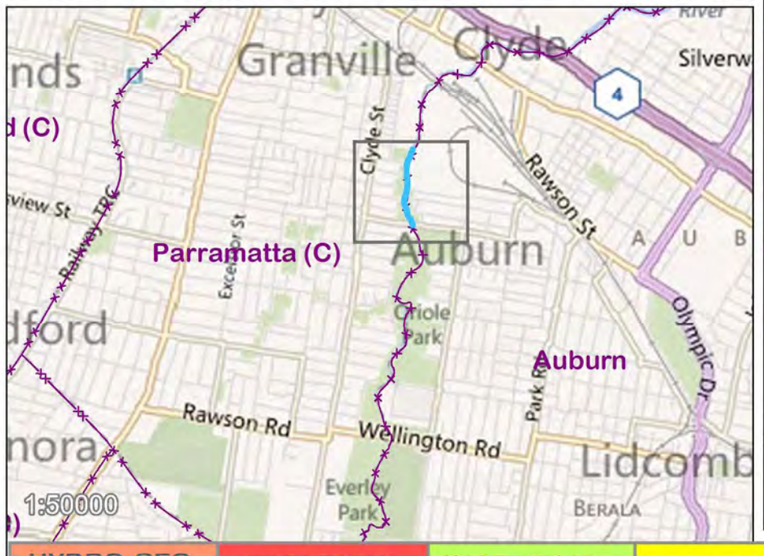
NO.	ACTION/WORKS REQUIRED	PRIORITY	AREA	COST	RESPONSIBILITY
70	Biodiversity enhancement: bush regeneration weeding and infill planting for diversity with Cumberland Swamp Oak Riparian Forest species	High	0.82ha	$40-50K	PCC
71	Biodiversity enhancement: primary weed control of vines, and plant canopy species (Cumberland Swamp Oak Riparian Forest)	High	0.69ha	$30-40K	PCC
71	Biodiversity enhancement: primary weed control, revegetation with Cumberland Swamp Oak Riparian Forest species	Medium	0.69ha	$30-40K	PCC

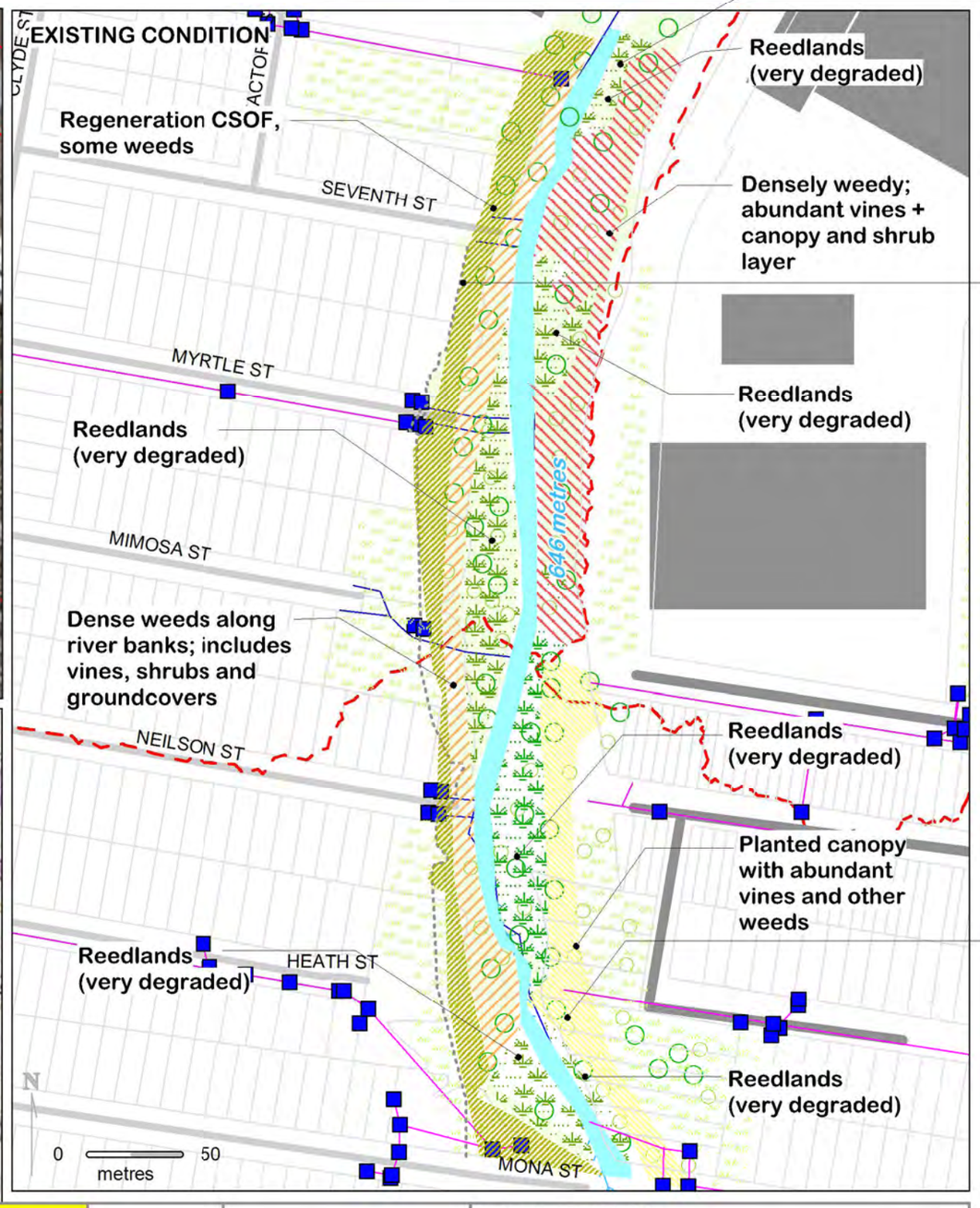
Table 50. Management actions and works required for DUCK RIVER 5A –Auburn City Council's area of responsibility

NO.	ACTION/WORKS REQUIRED	PRIORITY	AREA	COST	RESPONSIBILITY
69	Biodiversity enhancement: primary weed control of vines, and plant canopy species (Cumberland Swamp Oak Riparian Forest)	High	0.83ha	$35-45K	ACC
72	Biodiversity enhancement: primary weed control of vines, and plant canopy species (Cumberland Swamp Oak Riparian Forest)	High	0.54ha	$20-30K	ACC
69	Biodiversity enhancement: primary weed control, revegetation with Cumberland Swamp Oak Riparian Forest species	Medium	0.83ha	$40-50K	ACC
72	Biodiversity enhancement: primary weed control, revegetation with Cumberland Swamp Oak Riparian Forest species	Medium	0.54ha	$20-30K	ACC

REACH: DUCK RIVER 5A

SITE CONTEXT





HYDRO-GEO MORPHOLOGY	RIPARIAN VEGETATION	INSTREAM HABITAT	SENSITIVITY	TOTAL	PRIORITY CATEGORY	TRAJECTORY
3.3	1.0	7.5	4.0	15.8	GOOD HYDRO-GEOMORPHOLOGY, GOOD INSTREAM HABITAT	ECOLOGICAL ATTRIBUTES ▲ GEOMORPHOLOGY ▶

- Stormwater Pipe
- Open Watercourse
- Sub-catchment Boundary
- Reach
- Water quality monitoring point
- Cadastre Lot Boundary
- Stormwater Pit
- Carp control point
- EEC

data collected 20-30/03/2012

REACH: DUCK RIVER 5A

OVERALL OBJECTIVES

1. Improve riparian condition

2. Improve general habitat condition

3. Reduce downstream impacts

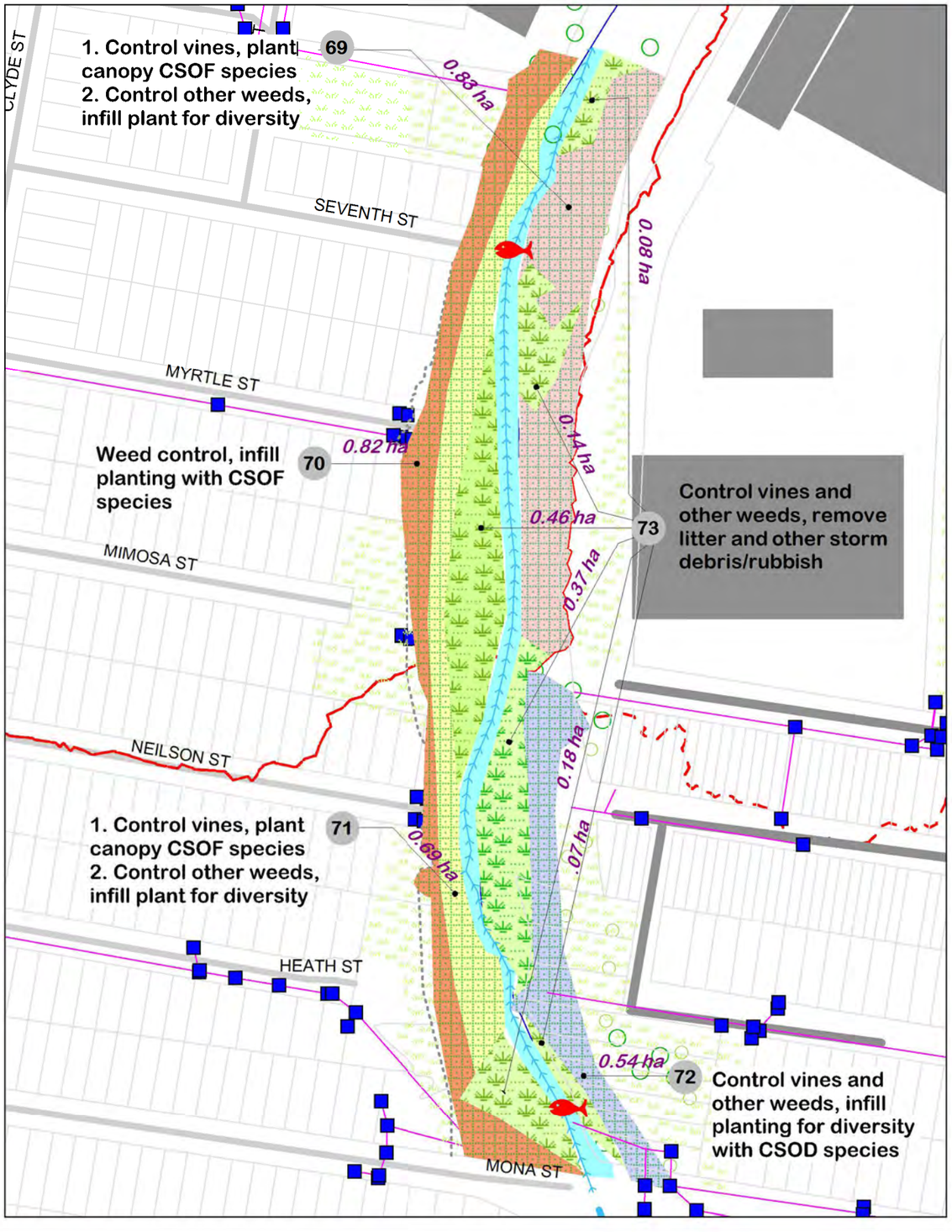
VEGETATION COMMUNITIES

Cumberland Riverflat Forest (CRF)

Cumberland Swamp Oak Forest (CSOF)

Coastal Freshwater Reedlands

WORKS PLAN



ZONE DUCK RIVER 5B

Refer to drawing sheet DUCK RIVER 5B p1 for site context and existing condition, and sheet DUCK RIVER 5B p2 for works plans and supporting information. Numbers in column one refer to numbered work zones on the drawing. Areas for each work zone are indicated on the drawing sheet and have been used to calculate costs for each action.

Table 51. Management actions and works required for DUCK RIVER 5B – joint responsibility by Parramatta and Auburn Councils

NO.	ACTION/WORKS REQUIRED	PRIORITY	AREA	COST	RESPONSIBILITY
81	Water quality improvement: remove litter and debris from fringing reeds; consider installation of floating trash trap	Urgent	N/A	$5-10K	PCC/ACC
81	Water quality improvement: water quality monitoring point	Urgent/ongoing	N/A	?	ACC/PCC
74	Biodiversity enhancement: control carp populations	Medium	N/A	$3-5K/event	PCC/ACC

Table 52. Management actions and works required for DUCK RIVER 5B –Parramatta City Council's area of responsibility

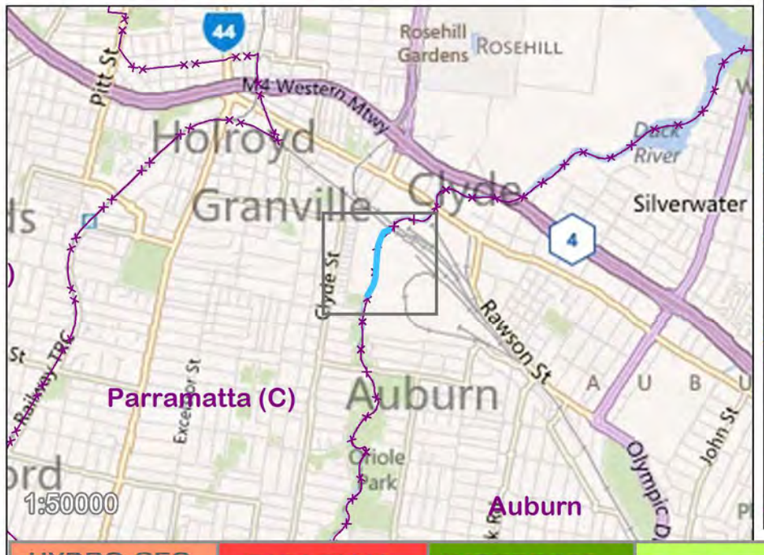
NO.	ACTION/WORKS REQUIRED	PRIORITY	AREA	COST	RESPONSIBILITY
75	Biodiversity enhancement: primary weed control of vines, and plant canopy species (Cumberland Riverflat Forest)	High	0.37ha	$20-30K	PCC
77	Biodiversity enhancement: primary weed control of vines, and plant for diversity with Cumberland Swamp Oak Riparian Forest species	High	0.27ha	$15-20K	PCC
74	Biodiversity enhancement: primary weed control of vines, and plant canopy species (Cumberland Swamp Oak Riparian Forest)	High	0.54ha	$25-35K	PCC
76	Biodiversity enhancement: primary weed control of vines, and plant canopy species (Cumberland Riverflat Forest)	High	0.43ha	$25-30K	PCC
74	Biodiversity enhancement: primary weed control, revegetation with Cumberland Swamp Oak Riparian Forest species	Medium	0.54ha	$25-30K	PCC
76	Biodiversity enhancement: primary weed control, revegetation with Cumberland Riverflat Forest species	Medium	0.43ha	$25-30K	PCC
81	Biodiversity enhancement: primary weed control of vines and other weeds	Medium	0.20ha	$10-15K	PCC

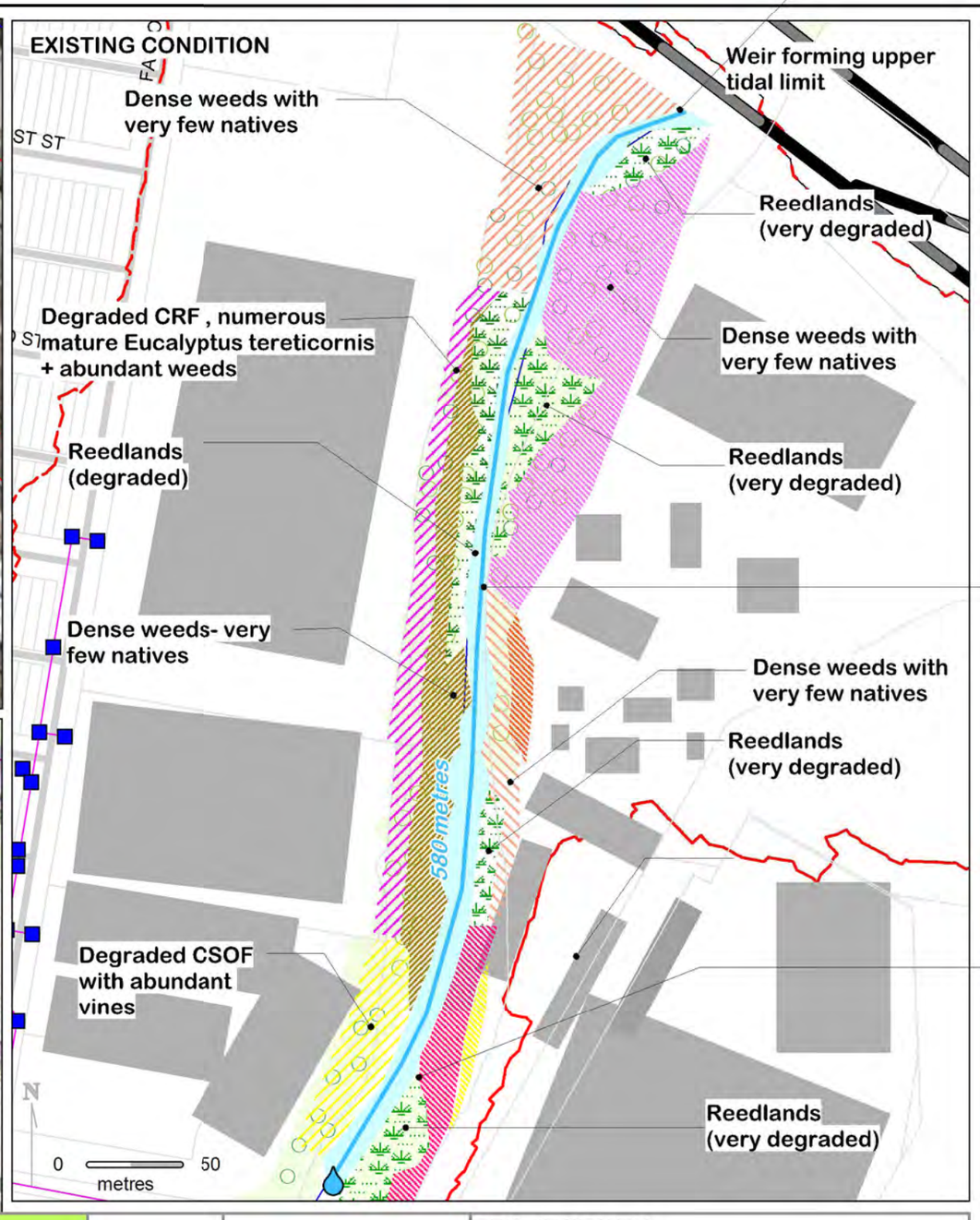
Table 53. Management actions and works required for DUCK RIVER 5B –Auburn City Council's area of responsibility

NO.	ACTION/WORKS REQUIRED	PRIORITY	AREA	COST	RESPONSIBILITY
79	Water quality improvement: remove litter and debris from fringing reeds; consider installation of floating trash trap	Urgent	N/A	$5-10K	ACC
78	Biodiversity enhancement: primary weed control of vines, and plant canopy species (Cumberland Riverflat Forest)	High	0.04ha	$3-5K	ACC
79	Biodiversity enhancement: primary weed control of vines and other weeds	High	0.20ha	$10-15K	ACC
80	Biodiversity enhancement: primary weed control of vines, and plant for diversity with Cumberland Swamp Oak Riparian Forest species	High	0.06ha	$3-5K	ACC
74	Biodiversity enhancement: primary weed control of vines, and plant canopy species (Cumberland Swamp Oak Riparian Forest)	High	0.84ha	$40-50K	ACC
76	Biodiversity enhancement: primary weed control of vines, and plant canopy species (Cumberland Riverflat Forest)	High	0.40ha	$20-25K	PCC
74	Biodiversity enhancement: primary weed control, revegetation with Cumberland Swamp Oak Riparian Forest species	Medium	0.84ha	$40-50K	ACC
76	Biodiversity enhancement: primary weed control, revegetation with Cumberland Riverflat Forest species	Medium	0.40ha	$20-25K	PCC
81	Biodiversity enhancement: primary weed control of vines and other weeds	Medium	0.29ha	$10-15K	PCC

REACH: DUCK RIVER 5B

SITE CONTEXT





HYDRO-GEO MORPHOLOGY	RIPARIAN VEGETATION	INSTREAM HABITAT	SENSITIVITY	TOTAL	PRIORITY CATEGORY	TRAJECTORY
2.5	0.5	7.8	6.0	16.8	HIGH SENSITIVITY, GOOD INSTREAM HABITAT	ECOLOGICAL ATTRIBUTES ▼ GEOMORPHOLOGY ▶

- Stormwater Pipe
- Open Watercourse
- Sub-catchment Boundary
- Reach
- Water quality monitoring point
- Cadastre Lot Boundary
- Stormwater Pit
- Carp control point
- EEC

data collected 20-30/03/2012

REACH: DUCK RIVER 5B

WORKS PLAN

OVERALL OBJECTIVES

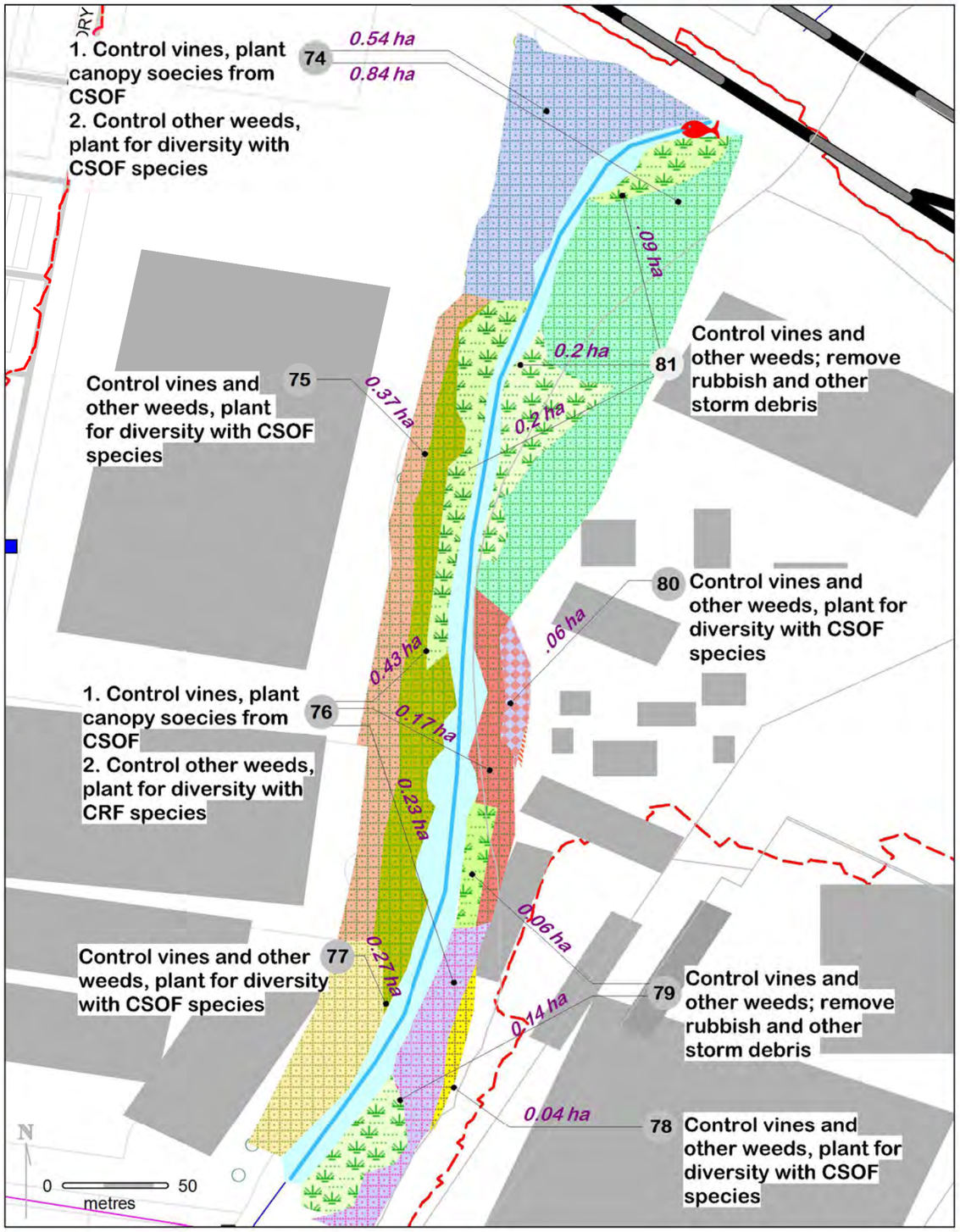
1. Improve riparian condition
2. Improve general habitat condition
3. Reduce downstream impacts

VEGETATION COMMUNITIES

Cumberland Riverflat Forest (CRF)

Cumberland Swamp Oak Forest (CSOF)

Coastal Freshwater Reedlands



ZONE UNNAMED 3

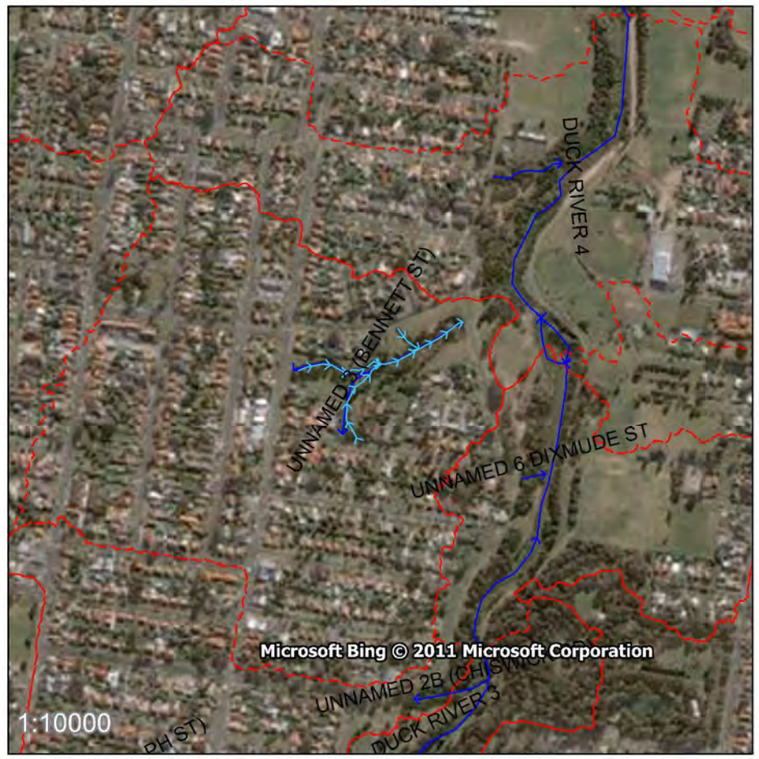
Refer to drawing sheet UNNAMED 3 p1 for site context and existing condition, and sheet UNNAMED 3 p2 for works plans and supporting information. Numbers in column one refer to numbered work zones on the drawing. Areas for each work zone are indicated on the drawing sheet and have been used to calculate costs for each action.

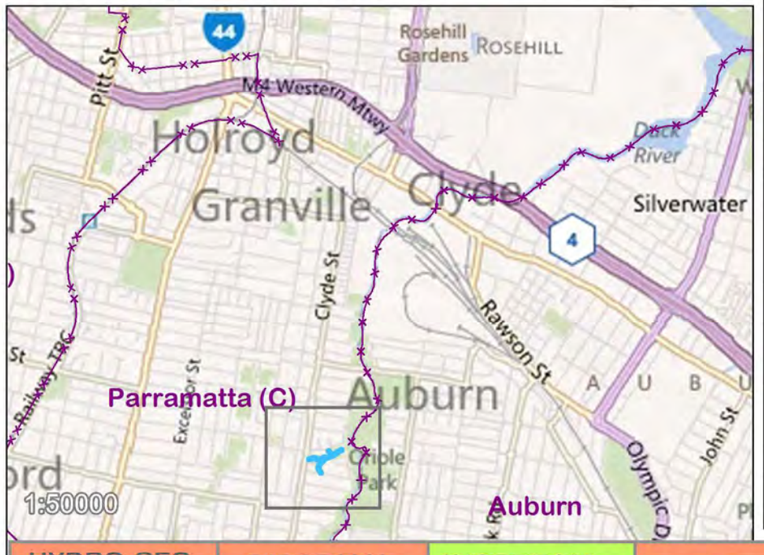
Table 54. Management actions and works required for UNNAMED 3 –Parramatta City Council's area of responsibility

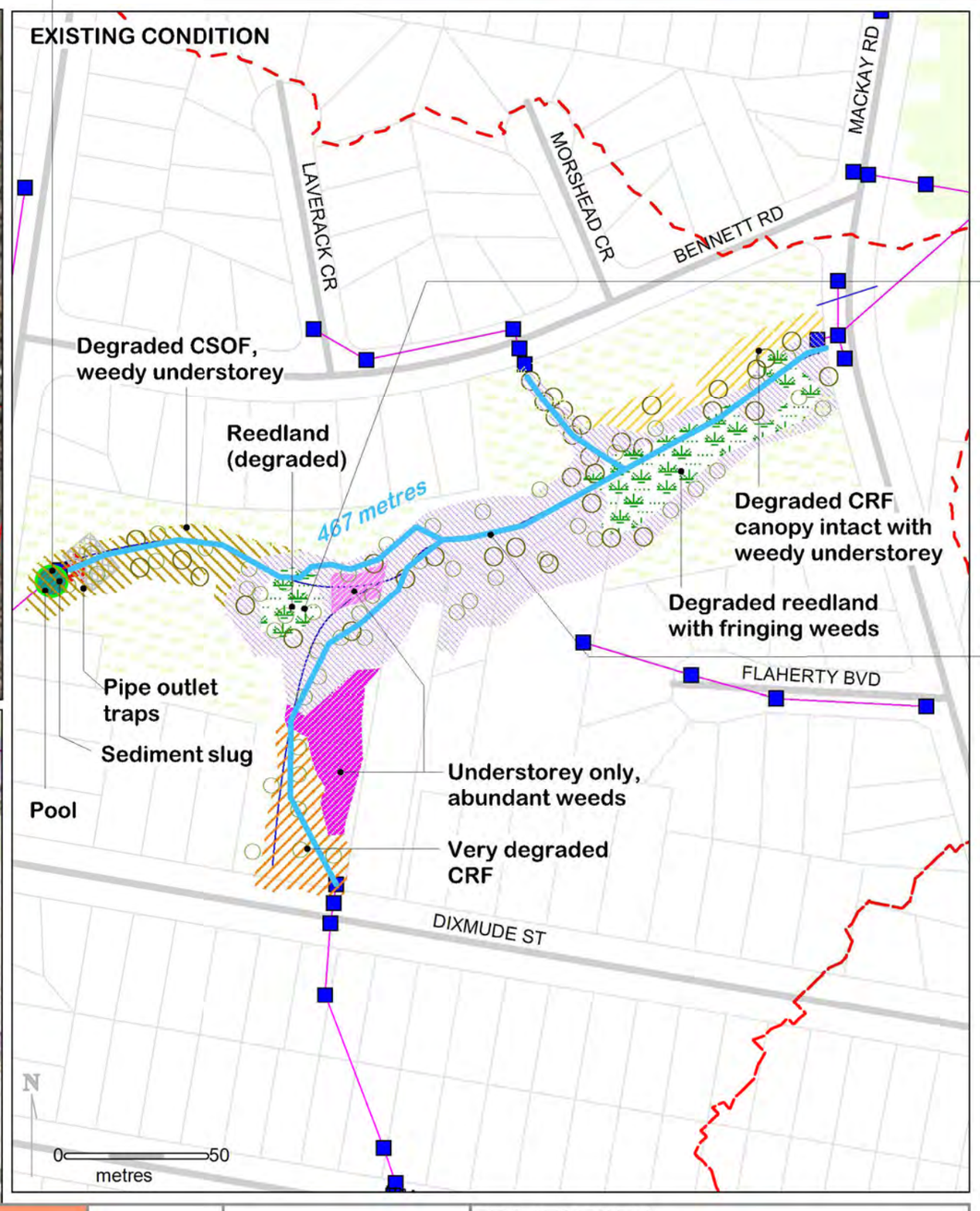
NO.	ACTION/WORKS REQUIRED	PRIORITY	AREA	COST	RESPONSIBILITY
89	Water quality improvement: remove litter and debris from fringing reeds	Urgent	N/A	$1-2K	PCC
82	Water quality improvement: remove sediment plug and other rubbish/storm debris	High	N/A	$3-5K	PCC
84	Biodiversity enhancement: bush regeneration weeding and infill planting for diversity with Cumberland Swamp Oak Riparian Forest species	High	0.16ha	$10-15K	PCC
85	Biodiversity enhancement: bush regeneration weeding and fringing planting for diversity with Cumberland Swamp Oak Riparian Forest species	High	0.04ha	$3-5K	PCC
86	Biodiversity enhancement: primary weed control, and plant canopy species (Cumberland Swamp Oak Riparian Forest)	High	0.28ha	$15-20K	PCC
87	Biodiversity enhancement: primary weed control, and plant canopy species (Cumberland Swamp Oak Riparian Forest)	High	0.12ha	$10-15K	PCC
88	Biodiversity enhancement: primary weed control of vines, and plant canopy species (Cumberland Swamp Oak Riparian Forest)	High	0.64ha	$25-35K	PCC
89	Biodiversity enhancement: primary weed control of vines and other weeds	High	0.15ha	$10-15K	PCC
90	Biodiversity enhancement: bush regeneration weeding and infill planting for diversity with Cumberland Riverflat Forest species	High	0.09ha	$8-10K	PCC
86	Biodiversity enhancement: secondary weed control, revegetation by infill planting with Cumberland Swamp Oak Riparian Forest species	Medium	0.28ha	$15-20K	PCC
87	Biodiversity enhancement: secondary weed control, revegetation by infill planting with Cumberland Swamp Oak Riparian Forest species	Medium	0.12ha	$10-15K	PCC
88	Biodiversity enhancement: primary weed control, revegetation with Cumberland Swamp Oak Riparian Forest species	Medium	0.64ha	$25-35K	PCC
83	Water quality improvement: maintain mesh trash traps regularly; prepare and implement an Operations and Maintenance Plan	Ongoing	N/A	$2-5K/year	PCC
88	Monitor bank stability and install jute matting with stabilisation planting as required; use Cumberland Swamp Oak Riparian Forest species	Ongoing	0.64ha	$0-15K	PCC

REACH: UNNAMED 3 BENNETT STREET

SITE CONTEXT







HYDRO-GEO MORPHOLOGY	RIPARIAN VEGETATION	INSTREAM HABITAT	SENSITIVITY	TOTAL	PRIORITY CATEGORY	TRAJECTORY
3.0	3.3	7.0	3.0	16.3	GOOD HYDRO-GEOMORPHOLOGY	ECOLOGICAL ATTRIBUTES ▶ GEOMORPHOLOGY ▶

- Stormwater Pipe
- Open Watercourse
- Sub-catchment Boundary
- Reach
- Cadastre Lot Boundary
- Stormwater Pit
- Carp control point
- EEC

data collected 20-30/03/2012

REACH: UNNAMED 3 BENNETT STREET

WORKS PLAN

OVERALL OBJECTIVES

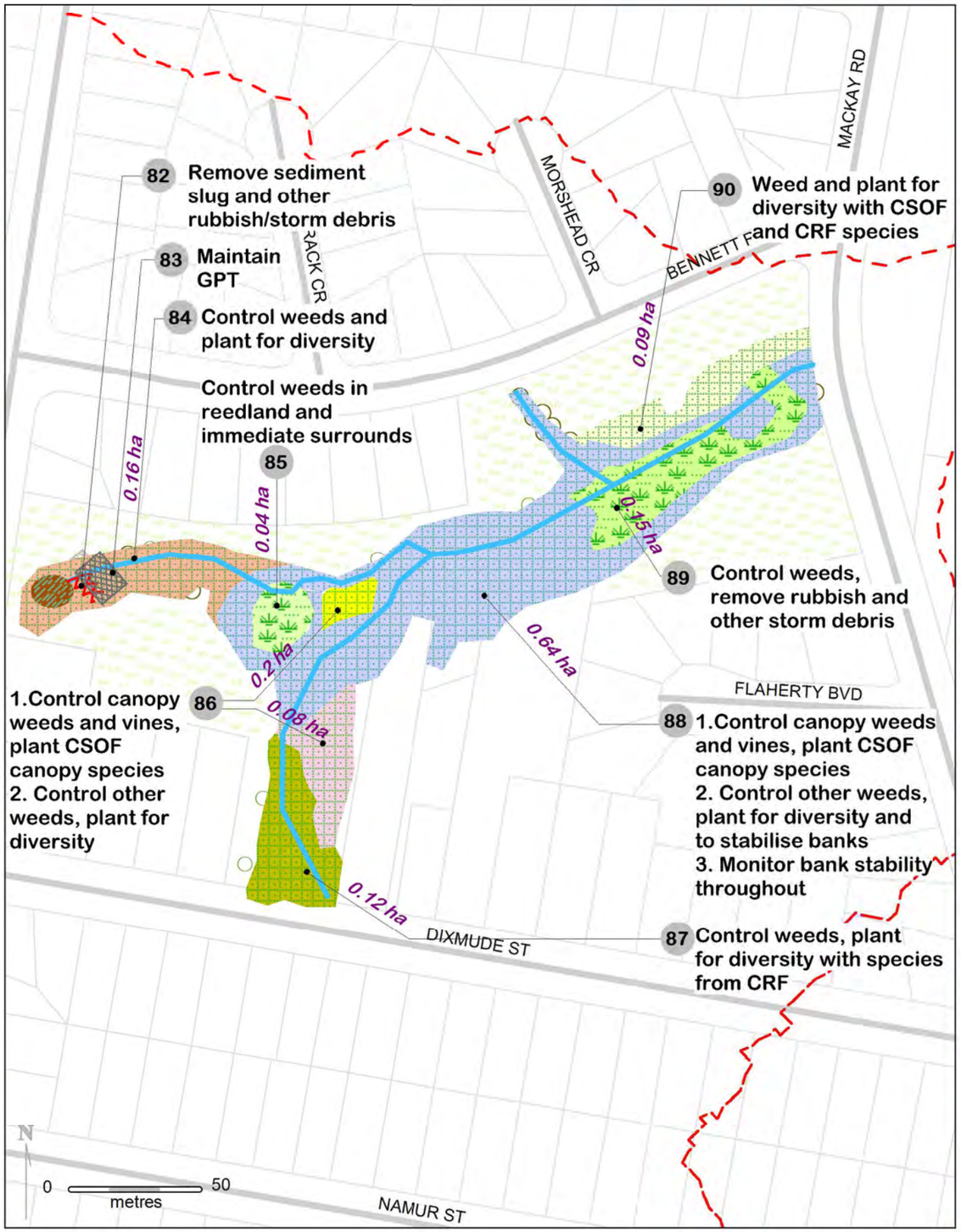
1. Improve riparian condition
2. Improve general habitat condition
3. Reduce downstream impacts

VEGETATION COMMUNITIES

Cumberland Riverflat Forest (CRF)

Cumberland Swamp Oak Forest (CSOF)

Coastal Freshwater Reedlands



ZONE UNNAMED 7

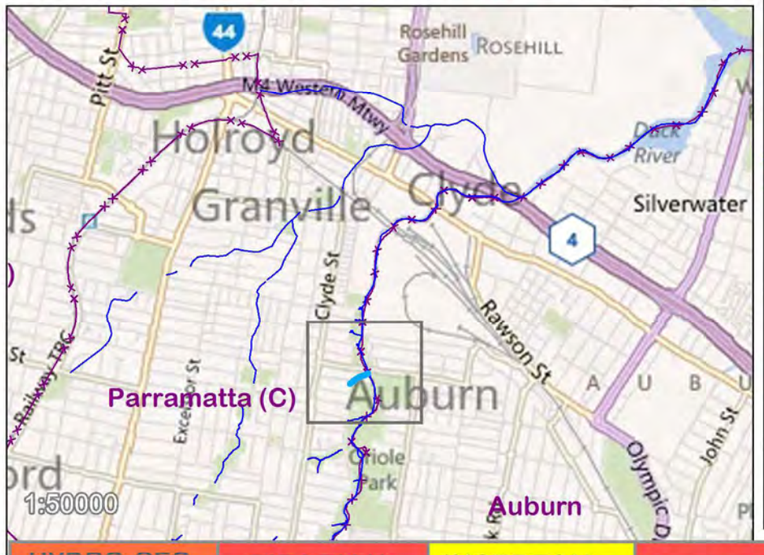
Refer to drawing sheet UNNAMED 7 p1 for site context and existing condition, and sheet UNNAMED 7 p2 for works plans and supporting information. Numbers in column one refer to numbered work zones on the drawing. Areas for each work zone are indicated on the drawing sheet and have been used to calculate costs for each action.

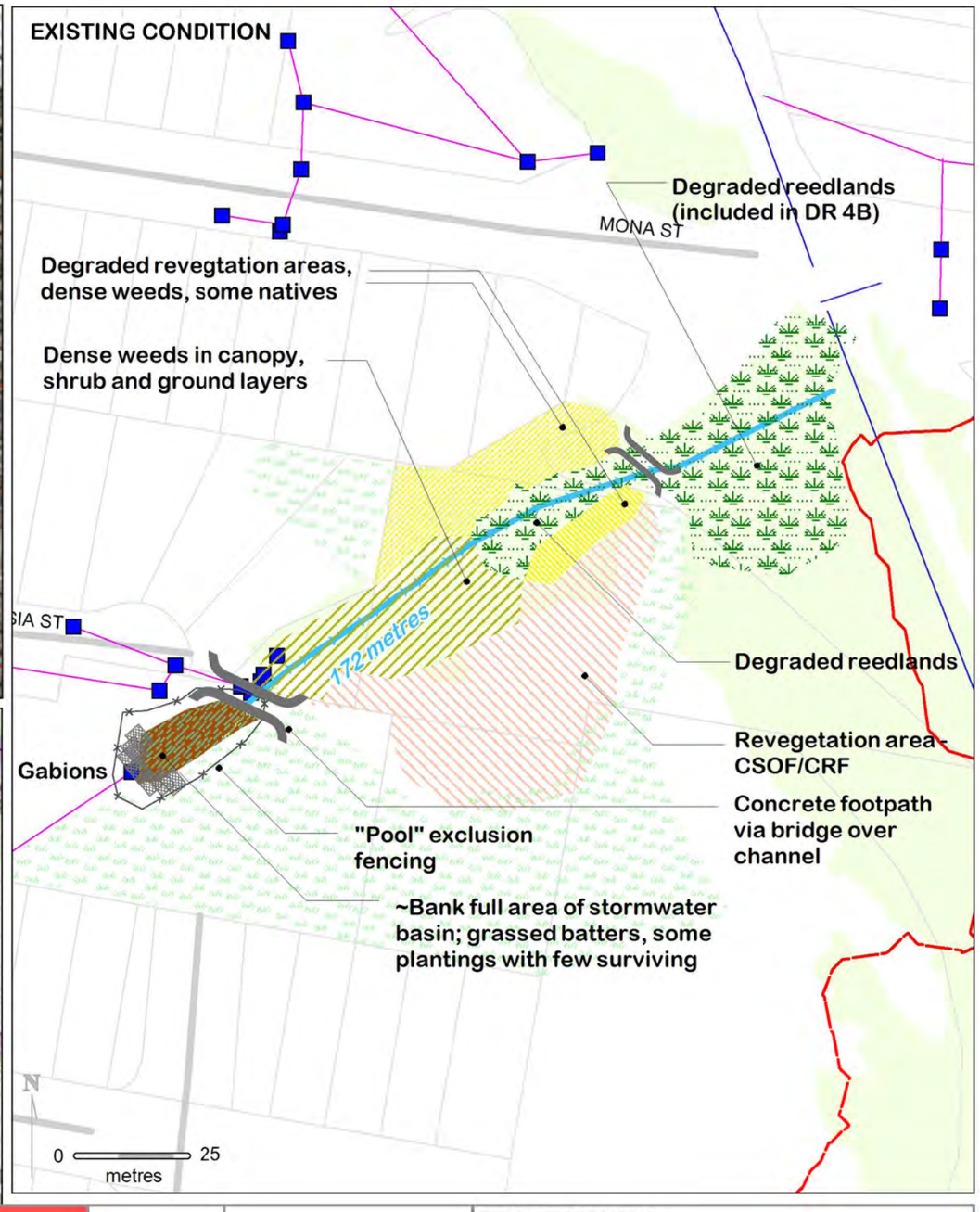
Table 55. Management actions and works required for UNNAMED 7 –Parramatta City Council's area of responsibility

NO.	ACTION/WORKS REQUIRED	PRIORITY	AREA	COST	RESPONSIBILITY
92	Water quality improvement: liaise with landholder to reinstall and maintain trash rack above detention basin, or install trash rack below footbridge	Urgent	N/A	??	PCC
93	Water quality improvement: remove litter and debris from fringing vegetation upstream of reedlands	Urgent	N/A	$1-2K	PCC
96	Water quality improvement: remove litter and debris from fringing reeds	Urgent	N/A	$1-2K	PCC
94	Biodiversity enhancement: bush regeneration weeding and infill planting for diversity with Cumberland Swamp Oak Riparian Forest species	High	0.22ha	$10-15K	PCC
95	Biodiversity enhancement: primary weed control of vines, and plant canopy species (Cumberland Swamp Oak Riparian Forest)	High	0.08ha	$5-10K	PCC
91	Biodiversity enhancement: primary weed control of vines, and plant canopy species (Cumberland Swamp Oak Riparian Forest)	High	0.11ha	$5-10K	PCC
96	Biodiversity enhancement: primary weed control of vines and other weeds	High	0.05ha	$3-5K	PCC
97	Community and recreation: install concrete footpath/cycleway to connect between footbridges	High	40m	$3-5K	PCC
91	Biodiversity enhancement: primary weed control, revegetation with Cumberland Swamp Oak Riparian Forest species	Medium	0.11ha	$5-10K	PCC
95	Biodiversity enhancement: primary weed control, revegetation for stabilisation with Cumberland Swamp Oak Riparian Forest species	Medium	0.10ha	$5-10K	PCC
95	Monitor bank stability and install jute matting with stabilisation planting as required; use Cumberland Swamp Oak Riparian Forest species	Ongoing	0.10ha	$0-5K	PCC

REACH: UNNAMED 7 BANKSIA STREET

SITE CONTEXT





HYDRO-GEO MORPHOLOGY	RIPARIAN VEGETATION	INSTREAM HABITAT	SENSITIVITY	TOTAL	PRIORITY CATEGORY	TRAJECTORY
2.5	0.4	5.0	2.0	9.9	PROTECT DOWN-STREAM HABITAT	ECOLOGICAL ATTRIBUTES ▼ GEOMORPHOLOGY ▼

- Stormwater Pipe
- Open Watercourse
- Sub-catchment Boundary
- Reach
- Cadastre Lot Boundary
- Stormwater Pit
- Carp control point
- EEC

data collected 20-30/03/2012

REACH: UNNAMED 7 BANKSIA STREET

WORKS PLAN

OVERALL OBJECTIVES

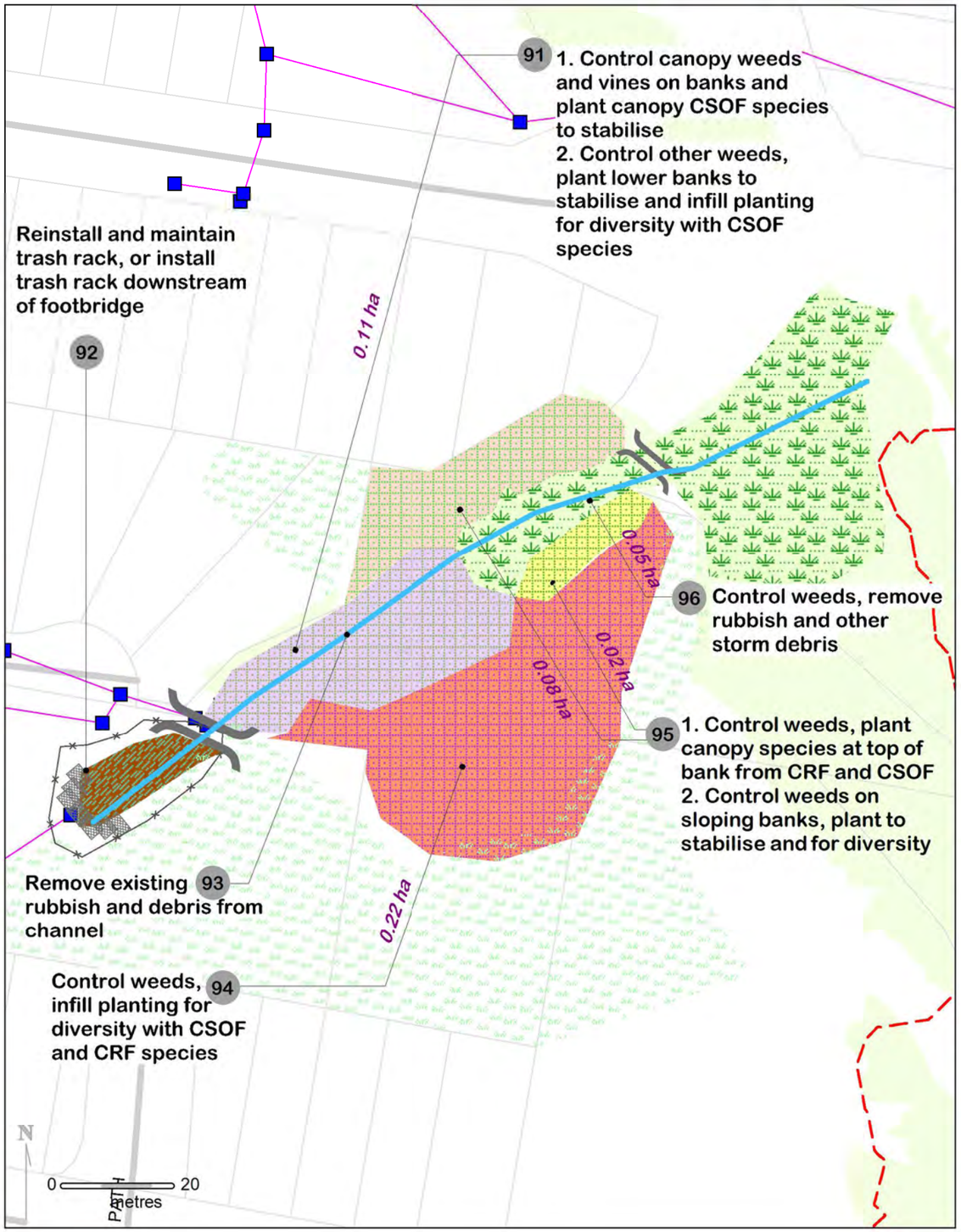
1. Improve riparian condition
2. Improve general habitat condition
3. Reduce downstream impacts

VEGETATION COMMUNITIES

Cumberland Riverflat Forest (CRF)

Cumberland Swamp Oak Forest (CSOF)

Coastal Freshwater Reedlands



IMPLEMENTATION OF THE PLAN

A prioritisation process should aim to

1) maintain and protect areas in good condition, or with specific important assets
2) maintain and improve areas in fair condition
3) reduce the impacts from areas in poor condition

Some broad rules for the prioritisation process are:

- **Rarity** (rare reaches have higher priority than common) and other High Conservation Value criteria
- **General condition** based on assessment of assets and problems (reaches in good condition are easier to fix than those in bad condition)
- **Trajectory** (deteriorating reaches should at least be stabilised before improving reaches that are improving on their own accord)*
- **Ease** (reaches that are easy to improve, before those that are hard)

(* Note: trajectory will also be affected by the condition of reaches immediately upstream)

A combination of field survey data and results from desktop surveys was used to inform decisions about the prioritisation process (Table 56).

Table 56. Desktop and field survey components that contribute to the prioritisation process

RANKING CRITERIA	SURVEY COMPONENT(S)
Rarity	• Threatened species present • EECs present • Migratory species present • Cultural heritage items present
General condition	Determined from the overall score (see previous section and site context drawing sheets)
Trajectory	Stream condition can be improving, remaining stable, or deteriorating. The reach trajectory summarises its probable pathway based on current condition and types of impacts currently operating in that reach. The trajectory was determined for the reach's ecological attributes (including riparian vegetation and instream habitat) and its hydrologic and geomorphic condition (based on presence of erosion, sediment deposition, deposition of storm debris).
Ease	Determined from additional data, including: • "good streams" are easier to fix than "bad streams" • Land tenure (public land is "easier" than private) • Presence of bushcare group (community support for ongoing works)

GUIDELINES FOR BIODIVERSITY ENHANCEMENT

Table 57. Guidelines and comments for biodiversity enhancement works required

WORKS REQUIRED	GUIDELINES AND COMMENTS
Bush regeneration weed control	Applies to bushland areas where there is existing native canopy with some native understorey and some native groundcover. These areas usually require removal of weeds to improve their overall condition; planting should not be required.
Primary weed control	Applies to bushland areas where there are considerable weed impacts in the canopy, midstorey and groundlayers. A staged removal of weeds is recommended, generally starting with woody weeds and shrubs, then groundlayer weeds. NOTE: noxious weeds should be treated as the first priority. In many cases, supplementary planting will be required (see below). A primary weed control program must include secondary and subsequent weed control activities. Most weeds are not effectively controlled by one treatment. Target weed species and floristic groups that have been identified as key threatening processes (NSW Dept Environment & Heritage): • Invasion and establishment of exotic vines and scramblers • Invasion and establishment of Scotch Broom • Invasion, establishment and spread of Lantana • Invasion of native plant communities by exotic perennial grasses
Primary weed control of vines	Applies to bushland areas where there is significant impacts from exotic vines. NOTE: Invasion of exotic vines and scramblers is listed as a key threatening process. Control of vines should be followed by a reassessment of the ecological condition of the bushland. Generally, further primary weed control will be required. Vines must be controlled before any planting is commenced, as young plants can quickly become smothered. Ongoing control of vines should be implemented.
Local provenance plant propagation	Local provenance species should be used for replanting where possible. When estimating the number of species, allowance should be made for replacement planting and on-going maintenance. A list of flora species for revegetation in each of the identified vegetation communities is provided in Appendix Five: Flora for Revegetation.
Planting guidelines	Undertake weed control activities first. Soil must be properly prepared before planting. Dig a hole that is big enough to loosen the soil around where the plant will go. Use native plant food and water retention crystals in the hole. Water in well and mulch or use a weed suppression mat. See section Appendix Five.

WORKS REQUIRED	GUIDELINES AND COMMENTS
Infill planting for diversity	Dense weed infestations can suppress local native plant diversity. In areas where there are dense infestations over a large area, with little good bushland nearby, there is limited opportunities for improving floristic diversity by natural regeneration. Consider which vegetation layers need supplementing, and whether this can be achieved by direct seeding. Choose species from the appropriate vegetation communities provided in Appendix Five.
Planting for stabilisation	Removal of a dense weed infestation can create bare areas. The best way to stabilise these areas is to establish a good vegetation cover as quickly as possible using local native species. Consider a combination of brush matting and tubestock planting. Brush matting with native plant material that includes fruiting or seeding structures is a method of direct seeding that also provides temporary cover for potential erosion points. Brush matting should be installed to a depth of 0.5m. Monitor for compaction, erosion and vandalism. Choose nearby bushland areas as a source for the brush, and never over-harvest. A maximum of 10% of the whole plant should be harvested at any time. Do not reharvest for brush matting from the same plant for 5 years. Choose species from the appropriate vegetation communities provided in Appendix Five. Give priority to species that develop deep roots quickly, or provide good groundcover – a mixture of these is best.
Revegetation planting	Applies to areas that have little or no native species present. These areas are generally targeted to improve connectivity between adjoining areas of better bushland. See comments for stabilisation planting and infill planting for diversity (above). Consider a staged planting program (see riparian buffer expansion planting). Choose species from the appropriate vegetation communities provided in Appendix Five
Riparian buffer expansion planting	Applies to areas where there is potential to expand the existing riparian buffer. Generally this buffer is currently narrow, and provides limited benefits to the wetlands. Riparian buffer expansion planting involves the complete recreation of native bushland. A staged planting program will achieve the best results. Plant colonising species first, along with canopy species. Generally accepted density for revegetation with trees is one per $5m^2$. These can be evenly distributed or clumped together; however, clumping can provide protection against wind and storms during the first five years of growth. Colonising species such as acacias help to promote soil heath which improves the establishment of eucalypts and other tree species. Faster growing shrubs also provide some protection for saplings. Once these plants are well established, infill plant with additional shrubs and groundcover species to improve the diversity of the buffer area.
Plant fringing vegetation	Applies to areas with multiple use demands to be managed. Protection of wetland areas is best managed through the establishment of a fringing buffer of native vegetation. This is the normal

WORKS REQUIRED	GUIDELINES AND COMMENTS
	condition for these wetlands. Width of this fringing buffer is determined by the availability of land for planting around the wetland perimeter.
Monitor bank stability and install jute matting with stabilisation planting	Applies to areas with very steep banks. Weed control activities can create bare areas. In steeper areas, brush matting and tubestock planting may not be enough. Additional stabilisation can be achieved by installing jute mesh or jute matting, and planting into this at regular intervals (minimum 4 plants per m2). Where minor erosion points are apparent, consider the use of brush check dams and/or coir logs to provide temporary stabilisation during plant establishment. For more serious erosion, further consultation is recommended; these may require hard engineered solutions.
Control/remove introduced ducks and geese	This may require some community liaison before implementation. A number of local residents feed the ducks and geese as part of their regular activities. Contact a pest bird control company for removal of pest waterbird species. Engage the community in ongoing monitoring to ensure they do not become re-established in the area.
Control carp populations	A carp control program should be developed. This can include considerable community input, and may provide an effective way of engaging and educating additional members of the community. See Appendix Seven for details.

GUIDELINES FOR WATER QUALITY IMPROVEMENT

Table 58. Guidelines and comments for water quality improvement works required

WORKS REQUIRED	GUIDELINES AND COMMENTS
Install trash rack, use appropriate height to accommodate flood flows	This needs to be properly sized and installed. Preparation and implementation of an operations and maintenance plan is a major component of the success of this type of structure. See section # for examples.
Install end of pipe litter control device	This needs to be properly sized and installed. Preparation and implementation of an operations and maintenance plan is a major component of the success of this type of structure. See section # for examples.
Install trash trap or similar litter control device	This needs to be properly sized and installed. Preparation and implementation of an operations and maintenance plan is a major component of the success of this type of structure. See section # for examples.
Maintain mesh trash traps regularly; prepare and implement an Operations and Maintenance Plan	Prepare an Operations and Maintenance Manual and schedule for all GPTs and other SQIDs in the Upper Duck River catchment, and ensure the recommendations are implemented
Remove litter and debris from fringing reeds; consider installation of floating trash trap	Use of booms to control litter in Duck River has proved unsuccessful. Netting, dragging and hand collection of litter/storm debris around wetlands can be conducted by boat. This will provide an initial clean up of the area; however, this needs to be maintained
Remove sediment plug and other rubbish/storm debris	Must be conducted by suitably qualified and experienced earthworks operator – type of machinery should be determined during a preliminary site inspection
Water quality monitoring point	Liaise with local primary and high schools to implement a Streamwatch monitoring program at a number of points along the main channel of Duck River. This will help to identify what the main pollution loadings are, and where they are coming from. Results of these monitoring programs can then be used to inform a targeted water quality improvement program.

GUIDELINES FOR EROSION CONTROL

Table 59. Guidelines and comments for erosion control works required

WORKS REQUIRED	GUIDELINES AND COMMENTS
Toe protection works	This needs to be properly sized and installed. See Appendix Seven for examples.
Bank stabilisation works	This needs to be properly sized and installed. See Appendix Seven for examples.
Outlet protection	This needs to be properly sized and installed. See Appendix Seven for examples.

GUIDELINES FOR COMMUNITY AND RECREATION

Table 60. Guidelines and comments for community and recreation works required

WORKS REQUIRED	GUIDELINES AND COMMENTS
Install seating	Must comply with relevant design standards and guidelines for urban infrastructure
Install informative signage	Must comply with relevant design standards and guidelines for urban infrastructure
Install weather shelters	Must comply with relevant design standards and guidelines for urban infrastructure
Formalise existing path by constructing all weather crushed granite footpath for pedestrian access	Must comply with relevant design standards and guidelines for urban infrastructure
Concrete footpath/cycleway to provide linkages with existing road and footpath network	Must comply with relevant design standards and guidelines for urban infrastructure
Install pedestrian footbridge across river/wetlands	Must comply with relevant design standards and guidelines for urban infrastructure
Manage as grassed open space	Create a clear delineation between grassed open space zones and bushland management zones. Use timber edging or similar method. Prevent the spread of exotic grasses and other environmental weeds to adjoining bushland. Avoid use of fertilizers and herbicides that may affect bushland health or water quality in nearby waterways.

FUNDING SOURCES

Potential funding sources to undertake on ground, research and monitoring works include:

- Parramatta City Council
- Auburn City Council
- Sydney Metropolitan CMA
- NSW Environmental Trust
- Office of Environment and heritage
- Australian Government Caring For Our County
- Corporate sponsorship
- More potential sources from: http://grantslink.gov.au/grant-categories/environment-and-nature

Additional funding and in kind contributions should be sought from a range of sources, for example:

- Future Council levies for projects that undertake environmental works.
- Bushcare volunteers and other community groups (e.g. schools, scouts) can assist with bush
- regeneration and revegetation; with supervision, plants and equipment provided by Council.
- Sponsorship from local businesses and sports clubs

For National Tree Day 2011, Auburn City Council and Community Pride hosted a community tree planting in the Auburn Botanical Gardens, along the Duck River. Over 180 volunteers, including scout groups, religious groups, local businesses and families, participated on the day, planting, mulching and watering over 2,200 native tube stock. The day finished with a community BBQ and was a great success overall.

Each year, hundreds of Parramatta residents gather on National Tree Day to plant more indigenous plants. Sitting alongside the Parramatta River at Ermington lies the George Kendall Riverside Park where over 16,000 native plants have been planted in the last 4 years. With the help of Parramatta City Council and local citizens, George Kendall Riverside Bushcare group has transformed their local park into an area nurtured and appreciated by the community.

Source: **http://treeday.planetark.org/involved/ (accessed May 2012)**

MONITORING, EVALUATION AND REPORTING

Monitoring of Upper Duck River Wetlands and Riparian Corridor will enable land managers to:

- Collect long term information on the success of management actions introduced as part of this Management Plan;
- Collect information on the quality of water in the wetland/river, and trends in water quality;
- Collect information on the occurrence of threatened species and health of endangered ecological communities within the wetland;
- Collect information on the occurrence and control of feral pests in the wetland;
- Provide an evaluation of management actions;
- Provide recommendations for future management actions.

MONITORING BUSHLAND FOR WEED CONTROL

Baseline monitoring is recommended for all weed control works. This provides a benchmark against which any changes can be measured. Vegetation monitoring can be conducted using a combination of techniques, including:

- photopoint monitoring
- nested quadrats
- transects

Photopoint monitoring

Choose several points from where you can take indicative photographs of the site. Make sure it can be easily relocated. A paint mark or tag on a fence post, or a white star picket can be used. Take photos at regular intervals (3-6 months) from this point to record changes in the site. This will record germination, weed outbreaks, growth and species diversity. It helps to have a recognisable feature in each photo, such as a tree, a line of hills of a building. Use a compass and take each photo on the same compass bearing, eg. due north, 45°NE.

A few tips:

- Try and take photos when the light is not full sun. This creates areas of shadow and/or overexposure in the photo, and this will make it difficult to see changes in the vegetation
- When you take the photo, make sure that you record the time and date, the location/number of the photopoint, a GPS point if possible, and the direction the photo was taken

Nested quadrats

A simple method is to mark out small sections of the site (quadrats) and within these areas record the species names and their relative abundance (common, uncommon, rare) and height (short, medium, tall). Quadrat sampling can be simple, with one quadrat, or nested. Nested quadrats use different sizes to monitor different layers of vegetation. They generally have one common corner, and sizes are 1-2m^2 for groundcovers, 5-10m^2 for shrub layer plants, and 10-20m^2 for canopy species. The size of quadrats should be determined to suit the size of the area to be monitored.

At least one corner (the shared corner) should be marked with a post, or a white star picket can be used. Take samples at regular intervals (3-6 months) from this point to record changes in the site. Monitor at three or four

sample points, more if the site is large or highly variable. Each time you monitor, record the date of the observations and any general notes or observations about the site

Transects

Transects are useful when gradients are evident in the vegetation. Examples of places where transects would be appropriate are ecotones such as between heath and forest, through a riparian zone, or across a break in slope or fire boundary. Transects are an example of systematic sampling where data are collected at fixed intervals along a line or from contiguous or discontinuous quadrats.

Line transects are used when you want to illustrate the changes in a plant community along a gradient or linear pattern. They can usually be completed fairly quickly though this depends on the data you collect. A transect line can be made by laying a tape measure along the gradient of the area you want to study. The tape measure should be pulled tight and fixed. Its position should be carefully considered to be certain it is aligned along the strongest gradient.

The species touching the line can be recorded along the entire length of the line or at each marked point. If the slope is also measured it can be included in the profile diagram. Line transects do not produce as much information on the relative densities of the individual species as belt transects. A line transect tells you what is present at the sample points but it does not give you much information about how much is present. If detailed density information is required a belt transect should be carried out.

A closely spaced series of quadrats or a set of contiguous quadrats in a transect will be needed. The quadrats should extend from one side of the ecotone, through it, to the other side. The number needed will depend on the spatial scale of the ecotone. The quadrat size should be consistent with that needed for measuring canopy trees, shrubs or ground cover. You should use at least three transects for descriptive purposes. Identify the plants in the quadrat and estimate or determine their abundance. The height of the plants in the quadrat can also be recorded, or use diameter at breast height for larger trees.

MONITORING THE SUCCESS OF PLANTING

To measure survival in sites where tubestock has been used, you will need to know how many of each species were planted. Monitor for survival at one, three and 10 months after planting. For small plantings, count the number of plants of each species that are surviving, divide it by the number of plants established of that species and multiply by 100 to express as % survival.

$$\% \text{ survival} = \frac{\text{number of remaining plants}}{\text{number of plants established}} \times 100$$

REPORTING

Results of monitoring should be used to develop performance measures for biodiversity enhancement objectives such as weed control activities and planting. These should be reported annually, along with progress towards objectives for water quality improvement, erosion control, and community and recreation outcomes. Performance measures for objectives and actions are provided in the following sections.

BIODIVERSITY ENHANCEMENT

Table 61. Performance measures and monitoring methods for biodiversity enhancement works

WORKS REQUIRED	PERFORMANCE MEASURES	MONITORING METHOD
Bush regeneration weed control	Noxious and main environmental weeds controlled and eradicated from catchment	Use quadrat and/or transect surveys to quantify changes
Primary weed control	Noxious and main environmental weeds controlled and eradicated from catchment	Use quadrat and/or transect surveys to quantify changes
Primary weed control of vines	All exotic vine species controlled and eradicated from catchment	Use quadrat and/or transect surveys to quantify changes
Infill planting for diversity	Local provenance species propagated for planting Diversity of bushland shrub and groundlayer significantly increased	Maintain records of species planted (with locations) and survivorship to quantify changes
Planting for stabilisation	Local provenance species propagated for planting Appropriate species selected and planted Plants maintained and supplementary planting installed when survival falls below 95% Maintain records of species planted (with locations) and survivorship to quantify changes	Maintain records of species planted (with locations) and survivorship to quantify changes
Revegetation planting	Local provenance species propagated for planting Appropriate species selected and planted Plants maintained and supplementary planting installed when survival falls below 95% Maintain records of species planted (with locations) and survivorship to quantify changes	Maintain records of species planted (with locations) and survivorship to quantify changes
Riparian buffer expansion planting	Local provenance species propagated for planting Appropriate species selected and planted Staged planting process initiated and implemented Plants maintained and supplementary planting installed when survival falls below 95% Maintain records of species planted (with locations) and survivorship to quantify changes	Maintain records of species planted (with locations) and survivorship to quantify changes
Plant fringing vegetation	Local provenance species propagated for planting Fringing buffer for reedlands	Maintain records of species planted (with locations) and survivorship to quantify

WORKS REQUIRED	PERFORMANCE MEASURES	MONITORING METHOD
	established and/or consolidated Maintain records of species planted (with locations) and survivorship to quantify changes	changes
Monitor bank stability and install jute matting with stabilisation planting	Ongoing monitoring of bank stability in weed control zones Erosion and unstable banks identified and treated as per directions for steep banks (see section on Implementation of the Plan)	Project based works records
Control/remove introduced ducks and geese	Significant reduction in introduced duck and geese populations	Project based works records
Control carp populations	Significant reduction in carp populations	Count of number of carp caught during community fishing program(s)
Control aquatic noxious weeds such as Alligator Weed and Sagittaria	Significant reduction in extent of aquatic noxious weeds	Photopoint monitoring

WATER QUALITY IMPROVEMENT

Table 62. Performance measures for water quality improvement works

WORKS REQUIRED	PERFORMANCE MEASURES
Install trash rack, use appropriate height to accommodate flood flows	Funding obtained Trash rack installed Operations Manual prepared and implemented
Install end of pipe litter control device	Funding obtained End of pipe control device installed Operations Manual prepared and implemented
Install trash trap or similar litter control device	Funding obtained Trash trap installed Operations Manual prepared and implemented
prepare and implement Operations and Maintenance Plans for all GPTs and other SQIDs in the catchment	Maintenance schedule prepared and implemented
Remove litter and debris from fringing reeds; consider installation of floating trash trap	Litter/debris removed Regular litter patrols implemented in wetlands areas Options and suitability of floating trash rack assessed; effective solution installed at appropriate locations
Remove sediment plug and other rubbish/storm debris	Correct operation of trash trap downstream
Water quality monitoring point	Four or more schools engaged in regular Streamwatch monitoring programs at designated monitoring points Results collated by PCC; key point and diffuse pollutant sources identified and water quality improvement plans designed and implemented to address sources

EROSION CONTROL

Table 63. Performance measures for erosion control works

WORKS REQUIRED	PERFORMANCE MEASURES
Toe protection works	Stabilisation measures designed and implemented.
Bank stabilisation works	Stabilisation measures designed and implemented.
Outlet protection	Stabilisation measures designed and implemented.

COMMUNITY AND RECREATION

Table 64. Performance measures for community and recreation works

WORKS REQUIRED	PERFORMANCE MEASURES
Install seating	Funding obtained Seating installed
Install informative signage	Funding obtained Informative signs designed and installed
Install weather shelters	Funding obtained Shelters designed and constructed
Formalise existing path by constructing all weather crushed granite footpath for pedestrian access	Funding obtained, or project adopted by TAFE (eg. Conservation and Restoration, Trackwork) Walking track and steps constructed
Concrete footpath/cycleway to provide linkages with existing road and footpath network	Funding obtained Footpath/cycleway constructed
Install pedestrian footbridge across river/wetlands	Funding obtained Pedestrian footbridge constructed
Manage as grassed open space	Clear delineation between bushland and grassed open space installed. Weed management principles to protect adjoining bushland adopted and implemented

TIMEFRAME FOR REVIEW

Review of the WRPoM should be conducted in two ways over different timeframes:

- Review of progress of works allowing for environmental considerations
- Revision/rewriting of the WRPoM

Review of progress of works

Rate of progress of environmental restoration works are affected by a range of variables that are generally beyond the control of implementing authorities, including:

- Seasonal variables
- Rainfall regime
- Bushfire
- Vandalism
- Availability of seed for local provenance plant propagation
- Availability of local provenance tubestock suitably matured for planting

In the normal course of rehabilitation program, works follow a sequential path, with each taking a period of time that may be affected by any of these variables. Thus the rehabilitation program is effectively a dynamic strategy, changing as works are completed, additional works are required, or new issues arise. Regular review should be conducted annually at a minimum to determine progress. An annual review will allow for modification of the implementation program as required.

Revision/rewriting of the WRPoM

The WRPoM is considered current for a minimum period of 5 years. Annual review will extend the relevant lifespan of the plan, and retain a works focus on appropriate objectives and issues. The WRPoM should be updated as required, or within 3 years from completion or the last review.

Revision of the WRPoM should consider the following aspects:

- Results of bushland rehabilitation activities
- Results of water quality monitoring
- Whether short and medium term management objectives have been completed
- Whether any new issues arise that have not been previously addressed
- Whether existing management objectives are still current and appropriate

The WRPoM should be revised earlier if any of the following occurs:

- a significant change occurs in the catchment due to fire, flood or other catastrophic event
- additional information becomes available that changes the objectives or desired outcomes of management
- new issues are raised which require immediate attention
- additional funding for works becomes available
- data becomes available that indicates that the objections are not able to be achieved

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APPENDIX ONE: OVERVIEW OF LEGISLATION

Table A 1. Overview of legislation and applicability for wetlands management

LEGISLATION OR POLICY TITLE	DESCRIPTION SUMMARY	EFFECTS ON MAINTENANCE AND REHABILITATION ACTIVITIES IN WATERWAY CORRIDORS
COMMONWEALTH (LEGISLATION)		
Environment Protection and Biodiversity Conservation Act 1999	The main objects of this Act are: "_ to provide for the protection of the environment, especially those aspects of the environment that are matters of national environmental significance" and "_ to promote ecological sustainable development through the conservation and ecologically sustainable use of natural resources".	A Commonwealth Act supporting Ecologically Sustainable Development (ESD), providing a significant overlap with NSW State Legislation such as the Environmental Planning & Assessment Act 1979 and the Threatened Species Conservation Act 1995. Future activities in waterway corridors should be undertaken within a framework of ESD. If approvals are required, NSW system can be accredited upon application being made to the Commonwealth Department.
COMMONWEALTH (POLICIES)		
National Strategy for Ecologically Sustainable Development (1992)	A National Strategy which has as its principal goal: "Development that improves the total quality of life, both now and in the future, in a way that maintains the ecological processes on which life depends." A core objective of the Strategy is: "_ to protect biological diversity and maintain essential ecological processes and life support systems."	The National Strategy is implemented at the local level through the application of state and local government legislation and policies. Future activities in waterways corridors should be undertaken within a framework of ESD.
National Strategy for the Conservation of Australia's Biological Diversity	This National Strategy provides the framework for protecting Australia's Biodiversity. The Strategy's stated aim is "to bridge the gap between current activities and those measures necessary to ensure effective identification, conservation and ecologically sustainable use of Australia's biological diversity."	The National Strategy supports programs such as native vegetation protection and management, feral weed and pest control and management of threatened species habitat, among others. These are activities which may form part of waterways maintenance and rehabilitation master plans.

LEGISATION OR POLICY TITLE	DESCRIPTION SUMMARY	EFFECTS ON MAINTENANCE AND REHABILITATION ACTIVITIES IN WATERWAY CORRIDORS
Wetlands Policy of the Commonwealth Government of Australia	This policy provides strategies to ensure that the activities of the Government promote the conservation, ecologically sustainable use and enhancement, where possible, of wetlands functions. Among others, those strategies include: "Involving the Australian people in wetlands management" and "working in partnership with State/Territory and Local Governments".	The policy seeks to promote and support local government efforts in wetlands conservation and management, through encouragement of the preparation of local wetlands policies. Such local policies may form part of future waterway maintenance and rehabilitation master plans.
Local Agenda 21	In 1992, at a UN conference on environment and development, Agenda 21 was endorsed, and set out how both developed and developing countries could work towards sustainable development. Local authorities were one of the groups recognised as being fundamental in working towards sustainable development (and hence "Local" Agenda 21). At the local level in Australia, the 1997 "Newcastle Declaration" (made at an international conference focussing on the challenge of sustainability for local government) clarified and re-stated the commitment of local government in Australia to Agenda 21 and sustainable development.	The application of the principles of Local Agenda 21 during the preparation and implementation of waterway maintenance and rehabilitation master plans will ensure management within a framework of ESD. Stakeholder and Focus Group meetings were designed to involve the community through the development of specific "Vision" for Duck River catchment.
STATE (LEGISLATION)		
Catchment Management Act 1989	This is an Act to implement the total catchment management of natural resources. The Act promotes the sustainable use of natural resources and seeks to provide for, among others, stable soil and protective vegetation cover within water catchments.	The Act and its accompanying Regulation support total catchment management practices through the establishment of Catchment Management Boards.
Environmental Planning & Assessment Act, 1979	This Act and its accompanying Regulation are the primary legislation for landuse planning in NSW. The Act encourages, among other things: • the "proper management, development and conservation of natural and artificial resources"; • the "protection of the environment, including the protection and conservation of native animals and plants, including threatened species, populations and ecological communities, and their habitats"; and • "ecological sustainable development".	The Act ensures that future activities in the waterway corridors are undertaken within a framework of ESD, and that future maintenance and rehabilitation activities are permissible within each landuse zone within which the waterway corridor lies, and that the environmental impact of any activity or work has been properly assessed.
Fisheries Management Act 1994	This Act aims to "conserve develop and share the fishery resources of the State for the benefit of present and future generations". Among other things, the Act aims to "conserve threatened species, populations and ecological communities of fish and marine vegetation" and "to promote ecologically sustainable development".	This Act will ensure that any future activities in the waterway corridors will maintain and enhance aquatic habitat. Approvals may be required under this Act depending on the nature of the proposed works.

LEGISLATION OR POLICY TITLE	DESCRIPTION SUMMARY	EFFECTS ON MAINTENANCE AND REHABILITATION ACTIVITIES IN WATERWAY CORRIDORS
Local Government Act 1993	This is an Act to guide the operation of Local Government. It requires Councils among other things, "to carry out activities, appropriate to the current and future needs of local communities …..". The Act directs Councils to prepare plans of management for, among others, community land. Where community land is categorised as a "natural area", and is further categorised as a "watercourse", specific directions are made as to the core management objectives. Where land is categorised as a "natural area" the core management objectives include: • to "conserve biodiversity and maintain ecosystem function"; • to "maintain the land,..., in its natural state and setting"; • to "provide for the restoration and regeneration of the land …..". Where land is further categorised as a "watercourse" the core management objectives also include: • to "manage watercourses so as to protect the biodiversity and ecological values of the instream environment, particularly in relation to water quality and water flows"; • to "manage watercourses so as to protect the riparian environment, particularly in relation to riparian vegetation and habitats and bank stability"; • to "restore degraded watercourses"; and • to "promote community education and community access to and use of the watercourse".	The Council's management of its waterways, and in particular the preparation of waterways Maintenance and Rehabilitation master plans, is driven through compliance with this Act.
Soil Conservation Act 1938	This Act makes provision for the conservation of soil resources and for the mitigation of soil erosion.	A landowner may be directed under the provisions of this Act to undertake remedial works to reduce an erosion hazard. Should the bed or banks of any waterway be identified as such a hazard, Council, as a landowner, may be directed to carry out such works. The Masterplans will identify appropriate works.
Protection of the Environment Administration Act 1991	The principal objective of this Act is to constitute the Environment Protection Authority and to provide for the integrated administration of environmental protection. The Act requires that regard be had to the need for ecologically sustainable development.	This Act ensures that future activities within waterway corridors are undertaken within a framework of ESD.

LEGISLATION OR POLICY TITLE	DESCRIPTION SUMMARY	EFFECTS ON MAINTENANCE AND REHABILITATION ACTIVITIES IN WATERWAY CORRIDORS
Protection of the Environment Operations Act 1997	This Act has as one of its objectives, among other things, to "protect, restore and enhance the quality of the environment in New South Wales having regard to the need to maintain ecologically sustainable development". The Act provides for a range of key pollution control legislation including waters, noise and air. These Regulations enable the classification of waters in NSW and regulate the permissible discharge of pollutants to those waters.	Parts of this Act regulate the discharge of pollutants into waterways in NSW.
Noxious Weeds Act 1993	This act aims to ensure appropriate measures for the control of noxious weeds throughout NSW, and requires control of weed species listed under various schedules.	As a landowner, Council has an obligation to control noxious weeds along waterway corridors. Noxious weeds declared in Parramatta LGA and recorded in Duck River catchment include: • Alligator Weed – Class 3 • Asparagus Fern – Class 4 • Asthma Weed – Class 4 • Balloon Vine – Class 4 • Blackberry – Class 4 • Bridal Creeper – Class 4 • Castor Oil Plant – Class 4 • Lantana – Class 4 • Large-leaved Privet – Class 4 • Madeira Vine – Class 4 • Montpellier Broom – Class 3 • Morning Glory – Class 4 • Sagittaria – Class 5 • Small-leaved Privet – Class 4
Threatened Species Conservation Act 1995	An Act to conserve threatened species, populations and ecological communities. Among other things, the objects of this Act include: • to "conserve biological diversity and promote ecologically sustainable development" and • to "protect the critical habitat of those threatened species, populations and ecological communities that are endangered".	Where any activities, proposed to be carried out in the Masterplans, are located within or adjacent to an endangered species or critical habitat, compliance with this Act may require the preparation of an eight part test to assess likely impacts and if necessary, the preparation of a Species Impact Statement, or may require the provision of alternative conservation measures.

LEGISLATION OR POLICY TITLE	DESCRIPTION SUMMARY	EFFECTS ON MAINTENANCE AND REHABILITATION ACTIVITIES IN WATERWAY CORRIDORS
Water Management Act 2000	This Act replaces the Water Act 1912 and the River and Foreshores Improvement Act 1948 and provides for "the protection, conservation and ecologically sustainable development of the water sources of the state". The Act sets out water management principles which include: • "water sources, floodplains and dependant ecosystems (including groundwaters and wetlands) should be protected and restored and, where possible, land should not be degraded"; • "habitats animals and plants that benefit from water or are potentially affected by managed activities should be protected and (in the case of habitats) restored".	This Act ensures that future activities in the waterway corridors are undertaken within a framework of ESD. If a 'controlled activity' is proposed on 'waterfront land', an approval is required under the Water Management Act. (s91) 'Controlled activities' include, inter alia: • the removal of material or vegetation from land by excavation or any other means; • the deposition of material on land by landfill or otherwise; or • any activity that affects the quantity or flow of water in a water source. 'Waterfront land' is defined as the bed of any river or lake, and any land lying between the river or lake and a line drawn parallel to and forty metres inland from either the highest bank or shore (in relation to non-tidal waters) or the mean high water mark (in relation to tidal waters).
STATE (POLICY)		
Flood Prone Land Policy	The primary objective of the policy is "to reduce the impact of flooding and flood liability on individual owners and occupiers of floodprone property, and to reduce private and public losses resulting from floods, utilising ecologically positive methods wherever possible". The policy provides for among other things: "… the need to consider ways of maintaining and enhancing the riverine and floodplain ecology in the development of floodplain risk management plans".	Any future activity to be implemented through the master plans will be considered from a floodplain risk management perspective. Impacts of works or activities will be assessed against predicted impacts on flood behaviour. The policy sets out the process leading to the preparation of Floodplain Risk Management Plans, for the waterways and associated floodplains.
Rivers and Estuaries Policy	A Policy which has as its objectives the management of the State's Rivers and Estuaries in ways which: • "slow, halt or reverse the overall degradation in their systems"; • "ensure the long term sustainability of their essential biophysical functions"; and • "maintain the beneficial use of these resources."	One of the principles of this Policy is: "Environmentally degraded areas should be rehabilitated and their biophysical functions restored". This principle will guide the planned activities to be implemented through the Duck River master plans.

LEGISLATION OR POLICY TITLE	DESCRIPTION SUMMARY	EFFECTS ON MAINTENANCE AND REHABILITATION ACTIVITIES IN WATERWAY CORRIDORS
NSW Biodiversity Strategy	A strategy launched by the NSW Government in 1999. The strategy commits all government agencies to biodiversity conservation across all landscapes of the State. Goals of the strategy include, among others: "_ Protecting native species and ecosystems"; "_ Managing natural resources better"; and "_ Involving landowners and communities in biodiversity conservation".	This strategy ensures that State Government authorities involved throughout the preparation and implementation of master plans will focus broadly on biodiversity conservation.
NSW Weirs Policy	The aim of this policy is to reduce and remediate the environmental impact of weirs. Main components of the policy require: _ the limiting of approvals for new and expanded weirs; _ the review of all existing weirs in NSW; and _ the consideration of the need for fishways at each structure.	Elements of this policy will ensure the consideration of fish migration where in-stream structures (eg. a rock riffle) are proposed for implementation in the master plans.
NSW Fisheries – Policy and Guidelines for Aquatic Habitat Management and Fish Conservation	These Policies and Guidelines support one of the principal functions of NSW Fisheries, that is, the protection and management of fish resources, marine vegetation and aquatic habitat. General policies include, among others: "Fish and their aquatic habitats are important natural resources, and impacts on these resources must be assessed, in all development and planning procedures, using a precautionary approach"; and, "Terrestrial areas adjoining freshwater, estuarine and coastal habitats should be carefully managed in order to minimise landuse impacts on these aquatic habitats. As a precautionary approach, foreshore buffer zones at least 50 metres wide should be established and maintained, with their natural features and vegetation prescribed….".	Elements of these policies and guidelines will provide direction as to the protection of aquatic habitat during the preparation and implementation of the waterway master plans.
State Environmental Planning Policy (SEPP) 19 – Bushland in Urban Areas	SEPP 19 offers protection to natural bushland on areas zoned or reserved for public open space purposes	Where any works or activities to be implemented through the Masterplan impacts on areas of urban bushland, the provisions of SEPP 19 will apply. Those provisions relate to the extent that the Council must consider the conservation of any bushland proposed to be disturbed.

LEGISLATION OR POLICY TITLE	DESCRIPTION SUMMARY	EFFECTS ON MAINTENANCE AND REHABILITATION ACTIVITIES IN WATERWAY CORRIDORS
LOCAL GOVERNMENT PLANS		
Draft Parramatta Local Environmental Plan (LEP) 2008	Draft Parramatta LEP 2008 describes the planning controls which apply to landuse zones throughout the Parramatta local government area. Most of the land within the riparian corridor is zoned: • E2 - Environmental conservation • RE1 – Public recreation	Any action or work required through implementation of the Masterplan will be prepared in accordance with the objectives and requirements of the relevant land use zone.
Draft Parramatta Development Control Plan (DCP) 2008	The Draft DCP 2008 provides controls to support the standards set down in the Draft PLEP 2008. This document will consolidate all of Council's existing DCPs into a single document. The controls will include requirements for such issues as setbacks.	Future actions or works proposed to be implemented through the Masterplans will be assessed against the appropriate performance standards set down in Parramatta's Draft DCP 2008.
Parramatta City Council Tree Preservation Order	The purpose of Council's Tree Preservation Order is to: "establish procedures for the proper management of trees in order to minimise the unnecessary loss of significant tree resources".	Any activity or work required through implementation of the Masterplans, where trees or bushland may be impacted, will require consent under Council's Tree Preservation Order.
Stormwater Management Plans (various catchments)	During 1997, the NSW Environment Protection Authority (EPA) issued Notices to Councils in NSW requiring the preparation of Stormwater Management Plans (SMPs) for catchments under each Council's management. In metropolitan Sydney, most of the SMPs were completed and submitted to the EPA during 1999 and 2000. Each plan described existing catchment conditions, and established catchment values through a process of consultation. Management options and implementation strategies were developed to achieve aims and objectives set out in the SMPs.	Development of a "Vision" for each of Council's waterway corridors will be assisted by the range of catchment values developed during preparation of SMPs. It is expected that waterway Masterplans will be consistent with the aims and objectives of each relevant SMP.
Upper Parramatta River Catchment Trust: Green Corridors Vegetation Management Strategy	The Green Corridor Vegetation Management Strategy identifies a network of green corridors in the Upper Parramatta River catchment, which are to be protected and managed for biodiversity conservation. The strategy also provides an overview of the catchment's indigenous vegetation and habitat and identifies opportunities for achieving their conservation and enhancement.	Having regard to the rehabilitation of riparian vegetation along waterway corridors and the conservation of biodiversity, actions and implementation strategies proposed in waterway Masterplans should be consistent with those identified in the Green Corridors Vegetation Management Strategy.

LEGISLATION OR POLICY TITLE	DESCRIPTION SUMMARY	EFFECTS ON MAINTENANCE AND REHABILITATION ACTIVITIES IN WATERWAY CORRIDORS
SPECIFIC PLANS FOR DUCK RIVER		
Duck River Management Plan 1996	The plan described issues associated with the river, providing a management philosophy for the river and presenting strategies for implementation of the plan's recommendations. Key recommendations: • Vegetation: conservation, restoration and management • Wildlife: habitat enhancement and feral animal control • Water: improve stormwater management and water quality	The current Masterplan is consistent with recommendations in this plan
Lower Duck River Foreshores Improvement Plan 1998	Included all tidal reaches in the catchment. Key recommendations: • Preserve indigenous and European heritage • Develop foreshores as a focus for community life and events • Create opportunities for relaxation and privacy • Improve overall health of ecosystems	The current Masterplan is consistent with recommendations in this plan
Duck River Stormwater Management Plan 1999	The primary goal of this plan is to: "facilitate the coordinated management of stormwater within the Duck River catchment, to improve the health and quality of the catchment waterways". Key issues: • Management of erosion • Improve water quality • Manage sewer discharges • Manage estuarine habitats	The current Masterplan is consistent with recommendations in this plan
Lower Duck River Riparian Management Plan 2002	Identified need for ongoing coordinated management of the river. Key issues identified: • Private land • Public access • Community and social needs • The natural environment	The current Masterplan is consistent with recommendations in this plan
Duck Creek Sub-catchment Management Plan 2003	Overall objectives: • Manage stormwater assets in a strategic manner • Implement a catchment focussed unified approach for stormwater management involving both quality and quantity • Systematically identify and address stormwater problems • Ensure ecologically sustainable in social, development principles • • Maintain and enhance the quality of the waterways and adjoining open space and creek corridors	The current Masterplan is consistent with recommendations in this plan

LEGISLATION OR POLICY TITLE	DESCRIPTION SUMMARY	EFFECTS ON MAINTENANCE AND REHABILITATION ACTIVITIES IN WATERWAY CORRIDORS
PCC Open Space Plan 2003	Key issues highlighted: • Natural heritage and biodiversity conservation • Need for increased public awareness of biodiversity values • Public safety • Pressure from urban environment and ongoing development	The current Masterplan is consistent with recommendations in this plan
PCC Sport and Recreation Plan 2005	Main issues: • Personal security in recreation areas • Public access to facilities • Sustainable practices in management of facilities	The current Masterplan is consistent with recommendations in this plan
PCC Natural Areas Plan of Management 2006	The plan relates to all community land categorised as Natural Area (Bushland and Watercourse), other than those with a site specific plan. Key values identified: • Ecological and environmental • Educational and scientific • Health, including physical activity and relaxation • Heritage and cultural • Recreational and social	The current Masterplan is consistent with recommendations in this plan
Draft Duck River Floodplain Risk Management Study and Plan 2011	Applies to Duck Creek, Little Duck Creek and A'Becketts Creek, located in Parramatta LGA. The project included a Flood Study, Floodplain Risk Management Study, Floodplain Risk Management Plan, Plan Implementation, and Review of Plan.	The current Masterplan is consistent with recommendations in this plan

APPENDIX TWO: THREATENED SPECIES

THREATENED FAUNA

Green and Golden Bell Frog (*Litoria aurea*)
A relatively large, stout frog, ranging in size from approximately 45 mm to approximately 100 mm snout to vent length. Diagnostic features are a gold or creamish white stripe running along the side, extending from the upper eyelids almost to the groin, with a narrow dark brown stripe beneath it, from nostril to eye. It also has blue or bluish-green colour on the inside of the thighs. The colour of the body varies. Usually a vivid pea-green, splotched with an almost metallic brassy brown or gold. The backs of some individuals may be almost entirely green; in others golden-brown markings may dominate. Inhabits marshes, dams and stream-sides, particularly those containing bullrushes (*Typha* spp.) or spikerushes (*Eleocharis* spp.).

Optimum habitat includes water-bodies that are unshaded, free of predatory fish such as Plague Minnow (*Gambusia holbrooki*), have a grassy area nearby and diurnal sheltering sites available. Some sites, particularly in the Greater Sydney region occur in highly disturbed areas. Several records from around Camelia (most recent reports include October 1999, January 2000, April 2000), one from Duck Creek in Granville (reported in 1966), and several records from A'Becketts Creek upper reaches in Holroyd LGA.

Main threats for this species include destruction of wetlands; alteration of drainage patterns and stormwater runoff; a fungal pathogen known as Frog Chytrid Fungus; predation by feral animals such as foxes; herbicides and other weed-control measures; road mortality, where populations are already small due to other threats; predation by exotic fish such as Plague Minnow; and loss of suitable breeding habitat through alteration by infilling and destruction of wetlands.

Little Eagle (Hieraetus morphnoides)
The Little Eagle is a medium-sized bird of prey that occurs in two colour forms: either pale brown with an obscure underwing pattern, or dark brown on the upperparts and pale underneath, with a rusty head and a distinctive underwing patter of rufous leading edge, pale 'M' marking and black-barred wingtips. Both forms have a black-streaked head with a slight crest, a pale shoulder band on the upperwings, a rather short and square-tipped barred tail, and feathered legs. Occupies open eucalypt forest, woodland or open woodland. Sheoak or acacia woodlands and riparian woodlands of interior NSW are also used.

Main threats for this species include clearing and degradation of foraging and breeding habitat; urban expansion; rural-residential subdivision and associated land uses (e.g. horse and goat grazing); and secondary poisoning from rabbit baiting. One record only, from Duck River Bushland Reserve in 2007.

Spotted-tailed Quoll (*Dasyurus maculatus*)
The Spotted-tailed Quoll is about the size of a domestic cat, from which it differs most obviously in its shorter legs and pointed face. The average weight of an adult male is about 3500 grams and an adult female about 2000 grams. It has rich-rust to dark-brown fur above, with irregular white spots

on the back and tail, and a pale belly. The spotted tail distinguishes it from all other Australian mammals, including other quoll species. However, the spots may be indistinct on juvenile animals. Mostly nocturnal, although will hunt during the day; spends most of the time on the ground, although also an excellent climber and may raid possum and glider dens and prey on roosting birds. Recorded across a range of habitat types, including rainforest, open forest, woodland, coastal heath and inland riparian forest, from the sub-alpine zone to the coastline. Individual animals use hollow-bearing trees, fallen logs, small caves, rock crevices, boulder fields and rocky-cliff faces as den sites.

Main threats for this species include loss, fragmentation and degradation of habitat; accidental poisoning during wild dog and fox control programs; deliberate poisoning, shooting and trapping may also be an issue; competition with introduced predators such as cats and foxes. One record only, from the vicinity of Mona St in 1993.

Grey-headed Flying Fox (*Pteropus poliocephalus*)
The Grey-headed Flying-fox is the largest Australian bat, with a head and body length of 23 - 29 cm. It has dark grey fur on the body, lighter grey fur on the head and a russet collar encircling the neck. The wing membranes are black and the wingspan can be up to 1 m. It can be distinguished from other flying-foxes by the leg fur, which extends to the ankle. Occur in subtropical and temperate rainforests, tall sclerophyll forests and woodlands, heaths and swamps as well as urban gardens and cultivated fruit crops.

Roosting camps are generally located within 20 km of a regular food source and are commonly found in gullies, close to water, in vegetation with a dense canopy. Individual camps may have tens of thousands of animals and are used for mating, birth and the rearing of young. A camp is currently located on Duck River immediately upstream from Clyde Weir.

Main threats for this species include loss of foraging habitat; disturbance of roosting sites; unregulated shooting; and electrocution on powerlines. A number of records from Clyde Weir, Granville to the confluence with Parramatta River (most recently reported December, 2008).

Eastern Bentwing Bat (Miniopterus schreibersii oceanensis)
The Eastern Bent-wing Bat has chocolate to reddish-brown fur on its back and slightly lighter coloured fur on its belly. It has a short snout and a high 'domed' head with short round ears. The wing membranes attach to the ankle, not to the base of the toe. The last bone of the third finger is much longer than the other finger-bones giving the "bent wing" appearance.

Caves are the primary roosting habitat, but also use derelict mines, storm-water tunnels, buildings and other man-made structures. Form discrete populations centred on a maternity cave that is used annually in spring and summer for the birth and rearing of young. Breeding or roosting colonies can number from 100 to 150,000 individuals. Hunt in forested areas, catching moths and other flying insects above the tree tops.

Main threats for this species include damage to or disturbance of roosting caves, particularly during winter or breeding; loss of foraging habitat; application of pesticides in or adjacent to foraging areas; and predation by feral cats and foxes. One record from Duck River Bushland Reserve (October, 2008), and one from nearby at Campbell Hill Pioneer Reserve (October, 2008).

Cumberland Plain Land Snail (*Meridolum corneovirens*)

Superficially similar to the familiar exotic Garden Snail. It differs most obviously in its 25 - 30 mm diameter shell. While this shell may be almost any shade of brown, it is always uniform in colour, while that of Helix consists of dark patches on a pale background. The Cumberland Land Snail also has a more flattened shell that is very thin and fragile, compared with the thick shell of the Garden Snail.

Primarily inhabits Cumberland Plain Woodland (an endangered ecological community). This community is a grassy, open woodland with occasional dense patches of shrubs. Lives under litter of bark, leaves and logs, or shelters in loose soil around grass clumps. Occasionally shelters under rubbish. Can dig several centimetres into soil to escape drought. Is a fungus specialist. Unlike the Garden Snail, does not eat green plants.

Main threats for this species include clearing and degradation of Cumberland Plain Woodland remnants. There is generally a poor understanding of other threats to this species. One record from Duck River Bushland Reserve. Recently recorded (February, 2012) in Duck River Bushland Reserve during fauna surveys. One reported record previously in July 2007 from Duck River Bushland Reserve.

THREATENED FLORA

Three species of threatened flora have been recorded along the Duck River riparian corridor. These include:

Narrow-leaf Wilsonia (*Wilsonia backhousei*)

Narrow-leafed Wilsonia is a perennial, sprawling, matted shrub less than 15 cm tall. The narrow, pointed, dark green, stalkless leaves are succulent and less than 20 mm long. The single white flowers are also stalkless. This is a species of the margins of salt marshes and lakes. Main threats to this species are trampling, weed competition, rubbish dumping, poor water quality in runoff, and habitat loss through development. Recently recorded from tidal mudflats around Camelia industrial area.

Glandular Pink-bell (*Tetratheca glandulosa*)

Small, spreading shrub which grows 20 - 50cm in height. Stems often become entwined among other small shrubs, sedges and grasses. Leaves are opposite 5 - 10 mm long and 1 mm wide with recurved (rolled under) margins. Leaf margins have small stiff hairs that give them a “toothed” appearance. The flower stalk and sepals (leaf-like structure at base of flower) are covered with dark-red gland-tipped hairs, which distinguishes *T. glandulosa* from other *Tetratheca* species. Associated with shale-sandstone transition habitat where shale-cappings occur over sandstone

Topographically, the plant occupies ridgetops, upper-slopes and to a lesser extent mid-slope sandstone benches. Vegetation structure varies from heaths and scrub to woodlands/open woodlands, and open forest. Vegetation communities correspond broadly to Benson & Howell’s Sydney Sandstone Ridgetop Woodland. Common woodland tree species include: *Corymbia gummifera, C. eximia, Eucalyptus haemastoma, E. punctata, E. racemosa,* and/or *E. sparsifolia*, with an understorey dominated by species from the families Proteaceae, Fabaceae, and Epacridaceae.

Main threats for this species are habitat loss through vegetation clearing and habitat degradation; fire control activities, particularly frequent prescribed burning and mechanical fuel reduction and the

construction/maintenance of fire access tracks; and habitat fragmentation of small, isolated populations. A single record from the vicinity of Horlyck Park in 1887.

Downy Wattle (Acacia pubescens)

A spreading shrub, 1 - 5 m high with brilliant yellow flowers, bipinnate leaves (divided twice pinnately) and conspicuously hairy branchlets. Occurs on alluviums, shales and at the intergrade between shales and sandstones. The soils are characteristically gravely soils, often with ironstone. Occurs in open woodland and forest, in a variety of plant communities, including Cooks River/ Castlereagh Ironbark Forest, Shale/ Gravel Transition Forest and Cumberland Plain Woodland.

Main threats for this species include habitat loss; habitat degradation (through weed invasion, mechanical damage, rubbish dumping, illegal track creation, and inappropriate fire regimes); disease; and hybridisation. Currently recorded from a number of locations in Duck River Bushland Reserve.

APPENDIX THREE: FAUNA RECORDS

AVIAN SPECIES RECORDED IN THE UPPER DUCK RIVER CATCHMENT

Table A 2. Results of recent surveys of birds in Duck River catchment, and their location(s)

COMMON NAME	SPECIES NAME	DUCK RIVER NORTH	DUCK RIVER SOUTH	CAMPBELL HILL-WADDANGALLI	UPPER DUCK CREEK	LOWER DUCK CREEK	LITTLE DUCK CREEK
Number of species by locality		43	28	31	12	6	10
Australasian Darter	*Anhinga melanogaster*	y				y	
Australian Magpie	*Gymnorhina tibicen*	y	y	y	y	y	y
Australian Raven	*Corvus coronoides*	y	y	y			
Australian White Ibis	*Threskiornis molucca*	y	y	y	y		y
Australian Wood Duck	*Chenonetta jabata*	y	y	y			
Azure Kingfisher	*Alcedo azurea*	y					
Barn Swallow	*Hirundo rustica*	y		y			
Bell Miner	*Manorina melanophrys*			y			
Black Bird	*Turdus merula*		y				
Black-faced Cuckoo Shrike	*Coracina novaehollandiae*			y			
Brown Thornbill	*Acanthiza pusilla*		y	y			
Bulbul*	*Pycnonotus jocosus*	y	y	y	y		y
Chestnut Teal	*Anas castanea*	y					
Common Starling*	*Sturnus vulgaris*			y			
Australian Coot	*Fulica atra*	y	y				
Crested Pigeon	*Ocyphaps lophotes*	y	y	y	y		y
Diamond Dove	*Geopelia cuneata*	y					
Domestic pigeon*	*Columba livia* f. *domestica*	y	y	y			
Dusky Moorhen	*Gallinula tenebrosa*	y	y				

COMMON NAME	SPECIES NAME	DUCK RIVER NORTH	DUCK RIVER SOUTH	CAMPBELL HILL-WADDANGALLI	UPPER DUCK CREEK	LOWER DUCK CREEK	LITTLE DUCK CREEK
Eastern Spinebill	*Acanthorhynchus tenuirostris*	y					
Galah	*Eolophus roseicapillus*					y	
Grey Butcherbird	*Cracticus torquatus*			y			
House Sparrow	*Passer domesticus*	y	y	y	y		
Indian (or common) Myna*	*Acridotheres tristis*	y	y	y	y		y
Jacky Winter	*Microeca fascinans*	y					
Koel (Common)	*Eudynamys scolopacea*		y				
Laughing Kookaburra	*Dacelo novaeguineae*	y	y	y			
Lewins Honeyeater	*Meliphaga lewinii*	y				y	
Little wattlebird	*Anthochaera chrysoptera*	y		y			
Magpie-lark (Pee wee)	*Grallina cyanoleuca*	y	y	y	y		y
Mallard	*Anas platyrhynchos*		y				
Masked Lapwing	*Vanellus miles*			y	y		
Noisy Miner	*Manorina melanocephala*	y	y	y	y	y	y
Olive-backed Oriole	*Oriolus sagittatus*	y					
Pacific Black duck	*Anas superciliosa*	y	y	y	y		
Pekin Duck (domestic duck breed)*	*Anas platyrhynchos domestica*	y					
Pied Currawong	*Strepera graculina*	y	y	y	y		
Purple Swamp Hen	*Porphyrio porphyrio*	y					
Rainbow Lorikeet	*Trichoglossus haematodus*	y		y			y
Red-browed Finch	*Neochmia temporalis*	y	y	y			
Red-rumped Parrot	*Psephotus haematonotus*		y				
Reed warbler	*Acrocephalus australis*	y					
Restless Flycatcher	*Myiagra inquieta*	y	y	y			y
Rock Dove*	*Columba livia*		y				
Scarlet Robin**	*Petroica boodang*			y			
Silvereye**	*Zosterops lateralis*			y			
Spotted Turle-Dove*	*Streptopelia chinensis*	y	y	y			y
Striated Pardalote	*Pardalotus striatus*	y	y				
Sulphur-crested Cockatoo	*Cacatua galerita*	y			y		
Superb Fairy-wren	*Malurus cyaneus*	y	y	y		y	
Tawny Frogmouth	*Podargus strigoides*	y	y				
Welcome Swallow	*Hirundo neoxena*	y					
White-plumed Honeyeater	*Lichenostomus penicillatus*	y					
Willie Wagtail	*Rhipidura leucophrys*	y		y			
Yellow Thornbill	*Acanthiza nana*	y					
Yellow-faced Honeyeater	*Lichenostomus chrysops*	y		y			
Yellow-tailed Black Cockatoo	*Calyptorhynchus funereus*	y					

OTHER FAUNA SPECIES RECORDED IN UPPER DUCK RIVER CATCHMENT

Table A 3. Results of recent surveys of other animals in Duck River catchment, and their location(s)

COMMON NAME	SPECIES NAME	DUCK RIVER NORTH	DUCK RIVER SOUTH	CAMPBELL HILL-WADDANGALLI	UPPER DUCK CREEK	LOWER DUCK CREEK	LITTLE DUCK CREEK
FROGS							
Bleating Tree Frog	*Litoria dentata*		y				
Common Froglet	*Crinia signifera*		y				y
Eastern Banjo Frog	*Limnodynastes dumerilii*	y	y	y			y
Peron's Tree Frog	*Litoria peronii*			y			
Green Tree Frog	*Litoria caeralea*	y	y				y
REPTILES							
Delicate or Garden Skink	*Lampropholis delicata*		y			y	
Eastern Blue-tongue Lizard	*Tiliqua scincoides scincoides*	y		y			
Eastern Blue-tongue Lizard	*Tiliqua scincoides*	y					
Eastern Water Dragon	*Physignathus lesueurii*	y	y				
Eastern Water Skink	*Eulamprus quoyii*	y	y	y			
Grass Sun-skink	*Lampropholis guichenoti*	y	y			y	
Jacky Lizard	*Amphibolurus muricatus*		y				
Red-bellied Black Snake	*Pseudechis porphyriacus*	y					
MAMMALS							
Grey-headed Flying-fox**	*Pteropus poliocephalus*	y	y				y
Eastern Bent-wing Bat**	*Miniopterus schreibersii oceanensis*		y	y			
Gould's Wattle Bat	*Chalinolobus gouldii*		y	y			
Long-eared Bat	*Nyctophilus* sp			y			
Southern Freetail Bat (short penis)	*Mormopterus* sp. 2		y				
White-striped Free-tailed Bat	*Tadarida australis*			y			
Yellow-bellied Sheathtail Bat**	*Saccolaimus flaviventris*		y				
Domestic Cat*	*Felis catus*	y	y		y	y	y
Domestic Dog*	*Canis lupus*	y	y	y			y
Rabbit*	*Oryctolagus cuniculus*			y			
Red Fox	*Vulpus vulpus*		y	y			
FISH							
Common Carp*	*Cyprinus carpio*	y	y				
Mosquito Fish*	*Gambusia holbrookii*		y	y			
OTHER HERPS							
Long necked turtle	*Chelodina longicollis*	y					
THREATENED INVERTEBRATES							
Cumberland Land Snail	*Meridolum corneovirens*		y				

APPENDIX FOUR: FLORA RECORDS

NATIVE FLORA SPECIES RECORDED IN UPPER DUCK RIVER CATCHMENT

Table A 4. Results of recent surveys of native flora in Duck River catchment, and their location(s)

SPECIES NAME	COMMON NAME	DUCK RIVER BUSHLAND	UPPER DUCK RIVER (OTHER)
Acacia binervia	Coastal Myall		y
Acacia brownei			y
Acacia decurrens	Sydney Green Wattle	y	y
Acacia falcata		y	y
Acacia longifolia var. longifolia	Sydney Golden Wattle	y	y
Acacia parramattensis	Parramatta Green Wattle	y	y
Acacia pubescens	Downy Wattle	y	y
Acacia stricta	Straight Wattle		y
Acacia ulicifolia	Prickley Moses	y	y
Adiantum aethiopicum	Common Maidenhair Fern	y	y
Agrostis aemula	Blown Grass		y
Agrostis avenacea	Blown Grass		y
Allocasuarina torulosa	Forest Oak		y
Alternathera denticulata	Lesser Joyweed		y
Amyema gaudichaudii			y
Angophora floribunda	Rough Barked Apple	y	y
Aristida ramosa	Three-awn Speargrass	y	y
Aristida vagans	Three-awn Speargrass	y	y
Arthrodium minus	Small Vanilla Lily		y
Arthropoduum milleflorum	Pale Vanilla Lily		y
Asperula conferta	Common Woodruff		y
Asterolasia correifolia			y
Astoloma humifusum			y
Billardiera scandens	Apple Berry	y	y
Boronia polygalifolia	Milkwort Boronia		y
Bossiaea buxifolia			y
Bossiaea prostrata			y
Bothriochloa decipiens			y
Bothrochloa macra			y
Brachiara foliosa			y
Brachychiton populneus	Kurrajong		y
Brachycome angustifolia var. angustifolia			y
Breynia oblongifolia	Coffee Bush	y	y
Brunoniella australis	Blue Trumpet	y	y

SPECIES NAME	COMMON NAME	DUCK RIVER BUSHLAND	UPPER DUCK RIVER (OTHER)
Brunoniella pumilio	Dwarf Trumpet		y
Bursaria spinosa	Blackthorn	y	y
Caesia parviflora	Pale Grass Lily		y
Caesia vittata	Blue Grass lily		y
Callistemon linearifolius	Bottlebrush		y
Callistemon linearis	Narrow-leaved Bottlebrush		y
Callistemon pinifolius	Bottlebrush		y
Callistemon rigidus	Stiff Bottlebrush	y	y
Callistemon salignus	Willow Bottlebrush		y
Calotis cuneifolia	Blue Burr-daisy	y	y
Calotis lappulacea	Wooly-headed Burr-daisy		y
Carex inversa			y
Cassinia aculeata	Dogwood		y
Cassytha glabella	Slender Devil's Twine		y
Cassytha pubescens	Common Devils Twine	y	y
Casuarina glauca	Swamp She-Oak	y	y
Cayratia clematidea		y	
Centella asiatica	Centella	y	y
Centipeda minima	Spreading Sneezeweed		y
Cheilanthes sieberi ssp sieberi	Mulga Fern	y	y
Chorizema parviflorum			y
Clematis aristata	Old Man's Beard		y
Clematis glycinoides var. glycinoides	Forest Clematis, Old Man's Beard	y	y
Commelina cyanea	Scurvy Weed	y	y
Correa reflexa		y	y
Cotula australis			y
Cotula coronopifolia	Water Buttons, Marsh Daisy		y
Crassula sieberana	Austral Stonecrop		y
Cymbopogon refractus	Barbed-wire Grass	y	y
Cynodon dactylon	Common Couch		y
Cyperus gracilis	Slender Sedge	y	
Cyperus mirus	Sedge		y
Cyperus polystachyos	Sedge		y
Austrodanthonia linkii var. fulva	Wallaby Grass	y	y
Austrodanthonia linkii var. linkii	Wallaby Grass		y
Austrodanthonia longifolia	Wallaby Grass		y
Austrodanthonia racemosa	Wallaby Grass	y	y
Austrodanthonia setacea	Wallaby Grass		y
Austrodanthonia tenuior	Wallaby Grass	y	y

SPECIES NAME	COMMON NAME	DUCK RIVER BUSHLAND	UPPER DUCK RIVER (OTHER)
Daviesia ulicifolia		y	y
Dendrophthoe vitellina			y
Desmodium rhytidophyllum			y
Desmodium varians			y
Deyeuxia appressa	Bent Grass		y
Deyeuxia quadriseta	Reed Bent Grass		y
Dianella caerulea	Blue Flax Lily		y
Dianella laevis	Flax Lily		y
Dianella longifolia	Flax Lily	y	
Dianella revoluta	Mauve Flax Lily	y	y
Dichelacne micrantha	Shorthair Plume Grass	y	y
Dichelacne rara	Plume Grass		y
Dichondra repens	Kidney Weed	y	y
Dichopogon strictus	Grass Lily		y
Digitaria parviflora	Small-flower Fingergrass		y
Digitaria ramularis	Fingergrass		y
Dillwynia juniperina	Parrot Pea		y
Dillwynia sieberi		y	
Diuris brevifolia	Double Tail		y
Diuris maculata	Spotted Double Tail		y
Diuris sulphurea	Tiger Orchid		y
Dodonaea triquetra	Hop Bush	y	y
Drosera peltata	Sundew		y
Dysphania littoralis			y
Echinochloa telmatophila			y
Echinopogon caespitosus var. caespitosus	Tufted Hedgehog Grass	y	y
Echinopogon ovatus	Hedgehog Grass	y	y
Einadia hastata	Einadia	y	y
Einadia nutans ssp. nutans	Einadia		y
Einadia polygonoides	Einadia		y
Einadia trigonos	Einadia		y
Entolasia marginata	Right-angle Grass	y	y
Entolasia stricta	Right-angle Grass	y	y
Epilobium billardierianum ssp. billardierianum	Willow Herb		y
Epilobium billardierianum ssp. cinereum	Willow Herb		y
Eragrostis philippica	Love Grass		y
Eragrostis brownii	Browne's Love Grass	y	y

SPECIES NAME	COMMON NAME	DUCK RIVER BUSHLAND	UPPER DUCK RIVER (OTHER)
Eragrostis parviflora	Love Grass		y
Eremophila debilis		y	y
Eriochloa pseudoacrotricha	Early Spring Grass		y
Eucalyptus amplifolia	Cabbage Gum	y	y
Eucalyptus crebra		y	
Eucalyptus fibrosa ssp. fibrosa	Broad-leaved Ironbark	y	y
Eucalyptus globoidea	White Stringybark	y	y
Eucalyptus longifolia	Woolybutt		y
Eucalyptus moluccana	Grey Box	y	y
Eucalyptus moluccana X Eucalyptus fibrosa ssp. fibrosa			y
Eucalyptus punctata ssp. punctata	Grey Gum	y	y
Eucalyptus resinifera	Red Mahogany		y
Eucalyptus tereticornis	Forest Red Gum		y
Euchiton sphaericus		y	
Eustrephus latifolius	Wombat Berry	y	y
Exocarpos cupressiformis	Cherry Ballart	y	y
Exocarpos strictus	Dwarf Currant		y
Gahnia aspera	Saw Sedge	y	y
Gahnia melanocarpa	Saw Sedge		y
Geranium solanderi	Cutleaf Cranesbill		y
Glochidion ferdinandi	Cheese Tree		y
Glossogyne tenuifolia	Cobblers Tack		y
Glycine clandestina	Love Creeper	y	y
Glycine microphylla	Lesser Love Creeper	y	
Glycine tabacina	Love Creeper		y
Gompholobium glabratum	Golden Glory Pea		y
Gonocarpus tetragynus	Poverty Raspwort		y
Goodenia bellidifolia ssp. bellidifolia	Daisy-leaved Goodenia		y
Goodenia hederacea subsp. hederacea	Violet-leaved Goodenia	y	y
Goodenia ovata	Hop Goodenia		y
Goodenia paniculata	Swamp Goodenia		y
Hakea sericea	Bushy Needlebush		y
Hardenbergia violacea	Hardenbergia	y	y
Helichrysum apiculatum	Paper Daisy		y
Helichrysum diosmifolium	Paper Daisy		y
Helichrysum scopioides	Paper Daisy		y
Hibbertia aspera	Guinea Flower		y
Hibbertia diffusa	Guinea Flower		y

SPECIES NAME	COMMON NAME	DUCK RIVER BUSHLAND	UPPER DUCK RIVER (OTHER)
Hibbertia pedunculata	Guinea Flower		y
Hovea longifolia var. longifolia			y
Hydrocotyle peduncularis	Native Pennywort		y
Hypericum gramineum	Native St Johns Wort		y
Hypoxis hygrometrica	Yellow Stars		y
Imperata cylindrica var. major	Blady Grass	y	y
Indigofera australis	Indigofera	y	y
Isotoma fluviatalis ssp. fluviatalis			y
Jacksonia scoparia	Dogwood		y
Juncus bufonius	Juncus		y
Juncus homalocaulis	Juncus		y
Juncus planifolius	Broad-leaf Rush		y
Juncus sarophorus	Juncus		y
Juncus usitatus	Common Rush		y
Kennedia rubicunda	Dusky Coral Pea		y
Kunzea ambigua	Tick Bush		y
Lachnagrostis filiformis		y	
Lagenifera sp.			y
Lagenifera stipatata			y
Lasiopetalum ferrugineum		y	
Lasiopetalum parviflorum	Rusty Petals		y
Laxmannia gracilis		y	
Lepidosperma laterale		y	
Lepidosperma lineare	Sword Sedge		y
Leptospermum attenuatum	Tea Tree		y
Leptospermum flavescens	Tea Tree		y
Leucopogon juniperinus	Bearded Heath	y	y
Leucopogon lanceolatus var. lanceolatus	Lance Beard Heath		y
Linum marginale	Native Flax		y
Lissanthe strigosa	Native Cranberry	y	y
Lomandra filiformis ssp. coriacea	Mat Rush	y	y
Lomandra longifolia	Mat Rush	y	y
Lomandra multiflora ssp. multiflora	Mat Rush	y	y
Macrozamia spiralis	Burrawang	y	y
Maytenus silvestris		y	y
Melaleuca decora	White Feather Honeymyrtle	y	y
Melaleuca erubescens	Pink Honeymyrtle		y
Melaleuca linariifolia	Snow-in-Summer		y

SPECIES NAME	COMMON NAME	DUCK RIVER BUSHLAND	UPPER DUCK RIVER (OTHER)
Melaleuca nodosa	Ball Honeymyrtle	y	y
Melaleuca quinquenervia		y	
Melaleuca sieberi		y	
Melaleuca styphelioides	Prickly-leaved Paperbark	y	y
Mentha saturejoides	Creeping Mint		y
Microlaena stipoides var. stipoides	Weeping Meadow Grass	y	y
Mitrasacme polymorpha	Mitreworts		y
Muellerina eucalyptioides		y	y
Myoporum insulare	Boobialla		y
Notelaea longifolia f. longifolia	Mock Olive	y	y
Notelaea ovata	Mock Olive		y
Olearia microphylla	Bridal Daisy Bush		y
Olearia visciudula	Daisy Bush		y
Homalanthus populifolius	Bleeding Heart Tree	y	y
Omphacomeria acerba			y
Opercularia aspera	Coarse Stinkweed		y
Opercularia diphylla	Stinkweed	y	y
Opercularia varia	Variable Stinkweed		y
Oplismenus imbecillis	Basket Grass		y
Oxalis corniculata			y
Oxalis perennans		y	
Pandorea pandorana ssp. pandorana	Wonga Vine	y	y
Panicum effusum	Hairy Panic		y
Panicum simile	Two-colour Panic		y
Paspalidium aversum			y
Paspalidium criniforme			y
Paspalidium radiatum			y
Paspalum vaginatum	Saltwater Couch		y
Pelargoium inodorum	Wild Geranium		y
Pellaea falcata	Sickle Fern		y
Persicaria lapathifolium	Knotweed		y
Persicaria sp. A, once *Polygonum decipiens*	Knotweed		y
Persoonia linearis	Narrow-leaved Geebung	y	y
Phragmites australis	Giant Reed		y
Phyllanthus gasstroemii	Spurge		y
Pimelea linifolia	Rice Flower	y	y
Pittosporum revolutum	Pittosporum		y
Pittosporum undulatum	Sweet Pittosporum	y	y

SPECIES NAME	COMMON NAME	DUCK RIVER BUSHLAND	UPPER DUCK RIVER (OTHER)
Plectranthus parviflorus	Cockspur		y
Poa labillardierei	Snow Grass	y	
Polymeria calycina	Swamp Bindweed	y	y
Polyscias sambucifolia	Elderberry Panax		y
Pomaderris ferruginea	Rusty Pomaderris		y
Pomaderris lanigera	Wooly Pomaderris		y
Poranthera microphylla			y
Pratia purpurascens	Whiteroot	y	y
Pseuderanthemum variabile	Pastel Flower	y	
Pseudognaphalium luteoalbum	Jersey Cudweed		y
Pterostylis nutans	Parrot's Beak Orchid		y
Pultenaea retusa	Notched Bush Pea		y
Pultenaea villosa	Hairy Bush Pea	y	y
Ranunculus lappaceus	Common Buttercup		y
Rapanea variabilis	Muttonwood		y
Rubus parvifolius	Native Raspberry		y
Rulingia pannosa			y
Rumex brownii	Swamp Dock		y
Sarcopetalum harveyanum	Pearl Vine		y
Scaevola albida	Pale Fan Flower		y
Senecio hispidulum var. hispidulus	Rough Groundsel		y
Senecio hispidulus var. dissectus	Rough Groundsel		y
Senecio linearifolius	Groundsel		y
Senecio quadridentatus	Groundsel		y
Sporobolus creber		y	
Sporobolus elongatus	Couch		y
Stackhousia viminea			y
Austrostipa pubescens	Tall Speargrass		y
Austrostipa rudis ssp. nervosa	Speargrass	y	y
Austrostipa scabra	Speargrass		y
Syncarpia glomulifera	Turpentine		y
Thelymitra pauciflora	Slender Sun Orchid		y
Themeda australis	Kangaroo Grass	y	y
Thysanotus tuberosus	Fringe Lily		y
Tricoryne elatior	Yellow Rush-Lily		y
Tricoryne simplex	Yellow Rush-Lily		y
Triplodiscus pygmaeus			y
Tylophoroa barbata		y	y
Typha domingensis	Bullrush		y

SPECIES NAME	COMMON NAME	DUCK RIVER BUSHLAND	UPPER DUCK RIVER (OTHER)
Typha orientalis	Bullrush		y
Vernonia cinerea var. cinerea			y
Veronica calycina	Speedwell		y
Veronica plebeia	Speedwell		y
Viola betonicifolia	Purple Violet		y
Vittadinia cuneata	Fuzzweed		y
Vittadinia. muelleri	Fuzzweed		y
Wahlenbergia communis	Tufted Bluebell		y
Wahlenbergia gracilis	Native Bluebell		y
Wahlenbergia stricta	Tall Bluebell		y
Xanthorrhoea resinosa ssp. concava	Grass Tree		y
Zieria smithii	Sandfly Zieria	y	y
Zornia dyctiocarpa			y

EXOTIC FLORA SPECIES RECORDED IN UPPER DUCK RIVER CATCHMENT

Table A 5. Results of recent surveys of exotic flora (weeds) in Duck River catchment, and their location(s)

REACH NAME =>	DR#1A		DR#1B		DR#2A		DR#2B		DR#3A		DR#3B		DR#4A		DR#4B		DR#5A		DR#5B		UN#3	UN#7
SPECIES NAME	EAST	WEST	EAST	WEST	EAST	WEST	EAST	WEST	EAST	WEST	EAST	WEST	EAST	WEST	EAST	WEST	EAST	WEST	EAST	WEST		
Acacia baileyana																y						
Acer negundo																y						
Acetosa sagittata																				y		
Ageratina adenophora																			y	y		
Alternanthera philoxeroides					y							y			y			y				
Alternanthera pungens																y						
Amaranthus viridus		y	y	y						y			y		y	y	y					y
Ambrosia tenuifolia																y						
Anredera cordifolia	y	y	y	y	y	y	y	y	y	y	y	y	y		y	y	y	y	y	y	y	
Araujia sericifera	y		y	y	y	y	y	y		y		y	y	y		y	y	y	y	y		y
Asparagus aethiopicus					y											y			y	y		
Asparagus asparagoides												y										
Atriplex prostrata	y		y																			y
Bidens pilosa	y	y	y	y	y	y	y	y		y		y	y	y	y	y	y	y	y	y	y	y
Bidens subalternans			y	y		y							y	y	y	y	y				y	
Briza subaristata																y						
Bromus catharticus		y	y		y		y						y		y	y						
Bryophyllum delagoense												y										
Cardiospermum grandiflorum	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y
Cerastium fontanum ssp vulgare																y				y	y	

REACH NAME =>	DR#1A		DR#1B		DR#2A		DR#2B		DR#3A		DR#3B		DR#4A		DR#4B		DR#5A		DR#5B		UN#3	UN#7
SPECIES NAME	EAST	WEST	EAST	WEST	EAST	WEST	EAST	WEST	EAST	WEST	EAST	WEST	EAST	WEST	EAST	WEST	EAST	WEST	EAST	WEST		
Cestrum parqui	y	y	y	y	y	y	y	y	y	y	y	y		y								y
Chenopodium album									y													
Chloris gayana		y						y								y		y	y	y		
Chlorophytum comosum												y										
Chrysanthemum coronarium									y		y											
Cinnamomum camphora																			y	y		
Cirsium vulgare			y			y		y					y		y				y			
Conyza spp	y			y	y	y	y	y				y	y	y	y	y		y	y	y	y	
Cyclospermum leptophyllum				y																		
Cynodon dactylon		y				y	y	y	y		y	y				y						
Cyperus brevifolius																						
Cyperus congestus	y	y		y				y				y		y	y	y						
Cyperus rotundatus																y						
Digitaria sanguinalis		y	y	y		y	y							y								
Echinochloa crus-galli		y			y								y		y		y		y	y	y	
Ehrharta erecta	y	y	y	y	y	y	y	y	y	y	y	y		y								
Eleusine tristachya	y							y					y			y						
Eragrostis curvula		y		y		y		y				y	y		y	y	y	y	y		y	y
Erythrina christa-galli		y			y		y			y		y		y								y
Euphorbia peplus																y			y	y		
Galinsoga parviflora		y		y												y		y				
Galium aparine		y																				
Gamochaeta calviceps													y		y	y						

REACH NAME =>	DR#1A		DR#1B		DR#2A		DR#2B		DR#3A		DR#3B		DR#4A		DR#4B		DR#5A		DR#5B		UN#3	UN#7
SPECIES NAME	EAST	WEST	EAST	WEST	EAST	WEST	EAST	WEST	EAST	WEST	EAST	WEST	EAST	WEST	EAST	WEST	EAST	WEST	EAST	WEST		
Genista monspessulana			y													y						
Hirschfeldia incana	y	y	y	y	y	y		y								y	y	y	y		y	
Hypochaeris radicata						y	y	y								y		y				
Ipomoea indica	y	y	y	y	y	y	y			y												
Lactuca serriola			y		y											y	y	y	y	y		
Lantana camara		y		y		y			y		y					y			y	y	y	
Ligustrum lucidum	y				y	y	y									y			y	y	y	y
Ligustrum sinense		y		y	y	y	y	y	y		y				y			y	y	y	y	y
Lonicera japonica					y			y														
Malva sp								y						y		y		y			y	
Modiola caroliana		y					y						y	y	y	y		y	y		y	
Morus alba	y	y	y												y	y			y	y	y	y
Nothoscordum borbonicum			y																			
Ochna serrulata				y		y																
Oxalis pes-caprae				y		y		y								y						
Parietaria judaica			y			y		y				y				y		y		y		
Paspalum dilatatum	y		y	y	y	y	y	y					y	y	y	y	y	y	y	y	y	
Paspalum quadrifarium	y																					
Paspalum urvillei	y			y	y	y	y	y				y	y	y	y	y	y	y	y	y	y	
Passiflora subpeltata					y		y															
Pavonia hastata						y		y								y						
Pennisetum clandestinum	y	y	y	y	y	y	y	y		y			y	y	y	y	y	y	y	y	y	y
Physalis peruviana																y						

REACH NAME =>	DR#1A		DR#1B		DR#2A		DR#2B		DR#3A		DR#3B		DR#4A		DR#4B		DR#5A		DR#5B		UN#3	UN#7
SPECIES NAME	EAST	WEST	EAST	WEST	EAST	WEST	EAST	WEST	EAST	WEST	EAST	WEST	EAST	WEST	EAST	WEST	EAST	WEST	EAST	WEST		
Plantago lanceolata	y	y	y	y	y	y	y	y				y	y	y	y	y		y	y	y	y	y
Plantago major															y	y						
Ricinus communis	y		y	y	y			y	y	y	y			y	y	y	y	y			y	
Rubus fruticosus aggregate species				y	y			y														
Rumex crispus	y		y	y	y	y		y				y				y			y		y	
Rumex obtusifolius														y	y	y	y	y	y	y	y	
Sagittaria platyphylla															y	y	y	y				
Salix babylonica	y			y	y		y					y		y	y	y		y	y	y	y	y
Senecio madagascariensis	y	y		y	y	y		y				y				y			y	y	y	
Senna pendula var glabrata		y		y	y				y	y	y											
Setaria palmifolia			y																			
Setaria parviflora	y	y	y	y	y	y	y	y						y		y		y	y		y	
Sida rhombifolia	y	y	y	y	y	y	y	y	y		y	y	y	y	y	y	y	y	y	y	y	
Solanum nigrum		y		y	y		y	y	y		y	y	y	y	y	y	y	y	y	y	y	y
Sonchus asper	y	y	y	y		y		y	y		y			y	y	y	y	y			y	
Sporobolus africanus		y				y							y		y	y						
Stachys arvensis	y																					
Stellaria media		y														y						
Taraxacum spp		y	y	y		y									y	y	y	y	y	y	y	
Thunbergia alata														y								
Tradescantia albiflora	y	y	y		y				y	y	y	y		y	y	y		y	y	y	y	
Trifolium repens						y		y								y						

REACH NAME =>	DR#1A		DR#1B		DR#2A		DR#2B		DR#3A		DR#3B		DR#4A		DR#4B		DR#5A		DR#5B		UN#3	UN#7
SPECIES NAME	EAST	WEST	EAST	WEST	EAST	WEST	EAST	WEST	EAST	WEST	EAST	WEST	EAST	WEST	EAST	WEST	EAST	WEST	EAST	WEST		
Tropaeolum majus	y	y							y	y	y	y		y	y	y				y		
Verbena bonariensis		y	y	y		y		y					y	y	y	y		y	y	y	y	
Verbena rigida	y																					
Xanthium occidentale									y		y			y	y	y		y	y	y		

APPENDIX FIVE: FLORA FOR REVEGETATION

Cumberland Swamp Oak Riparian Forest, S_FoW07

The distinguishing feature is the prominent stands of swamp oak (*Casuarina glauca*) found along or near streams. Often these are relatively young trees, swarming amongst a mix of old and young eucalypts such as rough barked apple (*Angophora floribunda*), forest red gum (*Eucalyptus tereticornis*) and grey box (*Eucalyptus molucanna*). The understorey is typical of the open grassy and herbaceous characteristics of other riverflat forests.

Cumberland Swamp Oak Riparian Forest is a component of River Flat Eucalypt Forest on Coastal Floodplains of the NSW North Coast, Sydney Basin and South East Corner Bioregions, and is listed as an Endangered Ecological Community under the NSW Threatened Species Conservation Act 1995 (TSC Act).

CORE SPECIES	ADDITIONAL SPECIES
TREES & SHRUBS	
Acacia decurrens	*Angophora floribunda*
Bursaria spinosa	*Breynia oblongifolia*
Casuarina glauca	*Eucalyptus baueriana*
Eucalyptus moluccana	*Eucalyptus crebra*
Maytenus silvestris	*Eucalyptus tereticornis*
Melaleuca decora	*Jacksonia scoparia*
Melaleuca nodosa	*Melaleuca styphelioides*
Ozothamnus diosmifolius	*Polyscias sambucifolia*
VINES & GROUNDCOVERS	
Alisma plantago-aquatica	*Adiantum aethiopicum*
Brunoniella australis	*Alternanthera denticulata*
Commelina cyanea	*Arthropodium milleflorum*
Damasonium minus	*Billardiera scandens*
Dichondra repens	*Carex appressa*
Echinopogon ovatus	*Centella asiatica*
Eclipta platyglossa	*Cheilanthes sieberi subsp. Sieberi*
Einadia hastate	*Clematis glycinoides var. glycinoides*
Eleocharis cylindrostachys	*Dianella longifolia*
Entolasia marginata	*Dianella revoluta var. revoluta*
Glycine tabacina	*Dichelachne micrantha*
Pratia purpurascens	*Eragrostis leptostachya*
Senecio hispidulus	*Glycine microphylla*
Veronica plebeia	*Gonocarpus tetragynus*
Wahlenbergia gracilis	*Goodenia ovata*
	Hibbertia diffusa
	Juncus usitatus
	Lomandra longifolia
	Microlaena stipoides var. stipoides
	Oplismenus aemulus
	Oxalis exilis
	Oxalis perennans

	Persicaria decipiens
	Plantago debilis
	Poa labillardierei
	Poranthera microphylla
	Pseuderanthemum variabile
	Setaria distans
	Solanum prinophyllum
	Tetragonia tetragonioides

Cumberland Riverflat Forest, S_FoW06

Cumberland Riverflat Forest is an open eucalypt forest that forms narrower ribbons alongside streams and creeks that drain the Cumberland Plain. Typically the canopy includes one of the rough-barked apple (*Angophora floribunda*) or broad-leaved apple (*Angophora subvelutina*) and one or both of forest red gum (*Eucalyptus tereticornis*) and cabbage gum (*Eucalyptus amplifolia*). However there are a wide variety of other interesting eucalypts that are highly localised.

Cumberland Riverflat Forest is a component of River Flat Eucalypt Forest on Coastal Floodplains of the NSW North Coast, Sydney Basin and South East Corner Bioregions and is listed as an Endangered Ecological Community under the NSW Threatened Species Conservation Act 1995 (TSC Act).

CORE SPECIES	ADDITIONAL SPECIES
TREES & SHRUBS	
Acacia decurrens	*Eucalyptus amplifolia*
Angophora floribunda	*Eucalyptus saligna*
Bursaria spinosa	*Exocarpos cupressiformis*
Eucalyptus baueriana	*Grevillea robusta*
Eucalyptus tereticornis	*Leucopogon juniperinus*
Hibiscus heterophyllus	*Persoonia linearis*
Ozothamnus diosmifolius	*Pittosporum undulatum*
	Trema tomentosa
VINES & GROUNDCOVERS	
Brunoniella australis	*Adiantum aethiopicum*
Cheilanthes sieberi subsp. Sieberi	*Cyperus laevis*
Commelina cyanea	*Dianella longifolia*
Clematis glycinoides var. glycinoides	*Echinopogon caespitosus var. caespitosus*
Desmodium varians	*Einadia trigonos*
Dichondra repens	*Eragrostis leptostachya*
Digitaria parviflora	*Microlaena stipoides var. stipoides*
Echinopogon ovatus	*Pratia purpurascens*
Einadia hastata	*Wahlenbergia gracilis*
Entolasia marginata	*Veronica plebeia*
Glycine clandestina	
Glycine microphylla	
Glycine tabacina	
Marsilea hirsuta	
Oplismenus aemulus	
Oxalis perennans	
Solanum prinophyllum	

Coastal Freshwater Reedland, S_FrW03

Coastal Freshwater Reedland is found on poorly drained alluvial flats and sand depressions across the NSW east coast. These swamps are predominantly freshwater communities although some swamps may be brackish. The reedlands are tall sometimes reaching over 3 metres in height and are dominated by one or two species, predominantly common reed (*Phragmites australis*) and cumbungi (*Typha orientalis*). Other tall reeds include *Elaeocharis sphacelata*. The continous cover of reedlands may include a sparse cover of swamp oak (*Casuarina glauca*) or swamp paperbark (*Melaleuca ericifolia*) on the drier margins of the swamp.

Many of these remaining swamps in the SMCMA area are situated amongst intense urban landuses. In these environments drainage patterns have been altered and weeds are prolific at many sites. Where these swamps occur on muds, sands, silts and loams associated with coastal floodplains they forma component of Freshwater wetlands on coastal floodplains of the NSW North Coast, Sydney Basin and South East Corner bioregions an Endangered Ecological Community listed under Schedule1 of the NSW Threatened Species Act, 1995.

CORE SPECIES	ADDITIONAL SPECIES
TREES & SHRUBS	
Melaleuca ericifolia	*Casuarina glauca*
	Melaleuca decora
	Melaleuca linariifolia
VINES & GROUNDCOVERS	
Blechnum indicum	*Baumea juncea*
Eleocharis sphacelata	*Bolboschoenus fluviatilis*
Hemarthria uncinata var. uncinata	*Carex appressa*
Hydrocotyle verticillata	*Gleichenia dicarpa*
Hypolepis muelleri	*Juncus continuus*
Isachne globosa	*Juncus planifolius*
Juncus kraussii	*Parsonsia straminea*
Phragmites australis	*Philydrum lanuginosum*
Typha orientalis	

Cooks River/Castlereagh Ironbark Forest S_DSF01 (includes Cooks River Clay Plain Scrub Forest)

Castlereagh Ironbark Forest is associated with clay soils derived from Tertiary alluvial deposits. The structure ranges from a moderately tall open eucalypt forest or woodland to a low dense thicket of paperbarks with low emergent eucalypts. The latter is prevalent across the catchment of the Cooks River and is recognised in other classifications as Cooks River Clay Plain Scrub.

Broad-leaved ironbark (*Eucalyptus fibrosa*) is the most commonly recorded eucalypt although at some sites it may be absent. Other species such as woollybutt (*Eucalyptus longifolia*) is a more regular associate although sites often have a diverse canopy composition which reflects subtle grades between substrates sourced from tertiary sand, sandstone bedrock, shale and ironstone gravels. A prominent small tree layer of *Melaleuca decora* features above dense cover of shrubs that include *Melaleuca nodosa*, blackthorn (*Bursaria spinosa*) and peach heath (*Lissanthe strigosa*).

Castlereagh Ironbark Forest is a component of Cooks River/Castlereagh Ironbark Forest in the Sydney Basin an Endangered Ecological Community listed under Schedule 1 of the NSW Threatened Species Conservation Act 1995.

CORE SPECIES	ADDITIONAL SPECIES
TREES & SHRUBS	
Acacia decurrens	*Acacia falcata*
Acacia pubescens	*Acacia parramattensis*
Bursaria spinosa	*Daviesia ulicifolia*
Eucalyptus crebra	*Dillwynia parvifolia*
Eucalyptus fibrosa	*Dillwynia sieberi*
Leucopogon juniperinus	*Eucalyptus eugenioides*
Lissanthe strigosa	*Eucalyptus longifolia*
Melaleuca decora	*Eucalyptus tereticornis*
Melaleuca nodosa	*Exocarpos cupressiformis*
Pultenaea villosa	*Maytenus silvestris*
	Notelaea longifolia
	Ozothamnus diosmifolius
	Persoonia linearis
	Polyscias sambucifolia
VINES & GROUNDCOVERS	
Aristida vagans	*Austrostipa rudis*
Austrodanthonia tenuior	*Billardiera scandens*
Brunoniella australis	*Bossiaea prostrata*
Cheilanthes sieberi subsp. sieberi	*Calotis cuneifolia*
Desmodium varians	*Cymbopogon refractus*
Dianella revoluta var. revolute	*Dianella longifolia*
Dichelachne micrantha	*Einadia hastate*
Dichondra repens	*Entolasia marginata*
Echinopogon caespitosus var. caespitosus	*Entolasia stricta*
Echinopogon ovatus	*Euchiton sphaericus*
Glycine clandestina	*Glycine tabacina*
Glycine microphylla	*Gonocarpus tetragynus*
Goodenia hederacea subsp. hederacea	*Hibbertia pedunculata*
Hardenbergia violacea	*Hypericum gramineum*
Hibbertia aspera subsp. aspera	*Lagenophora stipitata*
Lomandra filiformis	*Laxmannia gracilis*
Lomandra multiflora	*Lepidosperma laterale*
Opercularia diphylla	*Microlaena stipoides var. stipoides*
Oxalis perennans	*Olearia microphylla*
Panicum simile	*Poa labillardierei*
Poranthera microphylla	*Polymeria calycina*
Pratia purpurascens	*Pomax umbellata*
Setaria distans	*Veronica plebeia*
Themeda australis	
Vernonia cinerea var. cinerea	
Wahlenbergia gracilis	

APPENDIX SIX: RESULTS OF AHIMS BASIC SEARCHES

APPENDIX SEVEN: ADDITIONAL INFORMATION FOR GUIDELINES

These revegetation guidelines are designed to specify the processes, techniques and standards required for effective restoration of landscapes for biodiversity conservation. The emphasis is deliberately on restoration. They are designed to assist people and organisations planning revegetation at the landscape-scale as part of an integrated program of protection and repair of existing native vegetation.

WEED CONTROL TECHNIQUES

Cut and paint

This is suitable for coppicing and suckering weeds such as Camphor and Privet, or any weeds which are too large for hand-pulling or have long taproots such as Ochna. This method provides for no soil disturbance and weed eradication is successful.

1. Cut the stem/s 1-2 cm above (a cut stump or stem protruding above the ground can be dangerous to work around and the seed's ability to re-shoot is reduced), ground level using either secateurs, loppers, a pruning saw or a chainsaw, depending on the thickness and toughness of the stem.
2. Immediately apply glyphosate™ (generally 1:1 or 1:1.5 or 100%) to the cut surface of the stem or, with medium and large trees, to the outside edges of the cut surface. (Herbicides need to be applied immediately after the cut is made because the ability of the plant to transport fluids ceases as soon as the tissues are severed.))
3. Search through the leaf litter to locate any exposed stem or root surface. Scrape the exposed stem or root surface slightly with a knife until you can see a light green coloured layer. (Do not scrape too deeply.) Apply the herbicide to the scraped sections, either with a brush, injector or spray bottle.
4. Follow up as required.

Stem injection – Drill & frill

Drilling

A rechargeable drill with a 5mm drill bit, is used to drill holes in the tree. The battery life of the drill will not last very long, so make sure you have charged them up properly. 100mm deep holes are drilled into the sapwood at a downward sloping angle, drilling 1 to 2 holes at a time, then immediately (within 10 seconds) filling the holes with a glyphosate mix dependent on tree type. The holes are drilled approx. 15cm apart in a circular pattern around each and every multi-branch.The holes are easily filled using a drench gun. These are available from the Rural Co-op and Farmcare for approx. $110.00, and are easy to use. The drill method is good in difficult to get to spots (eg. multi-stemmed tree).

Frilling

Use a small axe to cut into the sapwood at a downward angle. Three rows of cuts are made in a brick pattern around all multi-branches, low to the ground. 1 to 3 cuts are made before immediately filling the cuts with a glyphosate mix dependent on tree type. The cuts need to be filled slowly to avoid chemical spills. The axe is easy to use in readily accessible spots. Note: The cordless drill and the axe

could be used together. The axe for the easily accessible trunks and the drill for the hard to get at multi-stems. This way the battery lasts a lot longer.

Scrape and paint

This is a variation of the cut, scrape and paint technique described above, the difference being the plant is not cut but left intact and scraped. This technique is suitable for Madeira Vine, Kudzu, saplings of Camphor Laurel and Privet as it ensures the translocation of the herbicide throughout the entire plant.

1. Scrape several sections of the stem along one side only, in lengths of at least 30 cm. The stem needs to be scraped firmly, exposing the fibres and/or light green coloured layer. Be careful not to sever the stem completely.
2. Each scraped section is immediately painted, prior to scraping the next section, with the recommended diluted glyphosate for the particular weed.

Crown grasses and herbs

Crowning: This technique is useful for weeds such as grasses and asparagus fern, which have their growing points below the surface of the soil. (corms, rhizomes or tufted fibrous root systems).

1. Grasp the leaves or stems of the plant and hold them firmly so that the base of the plant is visible. Any weeds with sharp leaves or stems should be cut back first.
2. Insert a knife close to the base of the plant at an angle, with the tip well under the root system.
3. Cut through the roots close to the base of the plant. Make sure that the hard crown or base of the plant where the roots begin is completely removed. It may require several cuts.
4. Hang the crowned plant matter up off the ground.
5. Follow up on a regular basis.

Manual removal (hand pulling)

Hand pulling: This requires holding the plant stem as close as possible to the base of the plant. Gently tug the plant. This will loosen the soil and allow the plant to come free. The plant may be hung up off the ground or piled in a heap.

Winding up: This process is suitable for plants with surface or climbing runners such as Morning glory.

1. You need to locate a runner, gently pull it along the ground towards you. Roll the runners up for easy removal. Continue doing this until all the runners have been rolled up. Small fibrous roots growing from the runners can be cut with a knife.
2. You should locate the main root system whilst removing the runners. When you do, remove it manually.
3. Do not leave any bits of stem or large roots, as these may reshoot.
4. Bag or compost the runners/roots.
5. Follow up on a regular basis.

Spray

Foliar spraying is a complementary or alternative method to some hand removal techniques. It is used in large areas of weed infestations that have a small native component or small dense areas of weeds with no natives. There are three different spraying techniques.

Spot spray

Spot spraying: is useful in areas with native seedlings present. In circumstances where solitary natives are scattered throughout a weed infestation, the individual trees may be covered or marked with a piece of bright coloured flagging tape. An area of about 10- 50 cm around the base of each native or clump of natives should be hand weeded. Spray units with adjustable nozzles should be set to produce a fine spray, at low to medium pressure. The weed clumps are sprayed with appropriate herbicide at the recommended strength plus a tracer dye. If a native is inadvertently sprayed, remove the affected leaves or immediately rinse off the herbicide with water.

Blanket or Area spray

Selective blanket spraying is used in areas with few or no native seedlings, where weeds have either formed a dense bed or have a large leaf size. Herbicides and concentration varies depending on the weed species, it is a good idea to use a Tracer dye so you can see where you have sprayed. Make sure you thoroughly check the area for natives prior to spraying. Any weeds close to natives should be removed by hand before starting to spray. Alternatively, young natives can be covered with cardboard prior to spraying. Spray units with adjustable nozzles should be set to produce a fine spray, at low to medium pressure

Splatter guns

The splatter gun (or gas gun) control technique involves the low volume, high concentration application of herbicide to the foliage of lantana, bitou bush and similar weeds using a specialised spray device.

This technique is particularly useful in areas of difficult access or sensitive vegetation because the tool is easily portable and causes limited off target damage. Like all management techniques, the splatter gun has limitations, but in general it provides a cheap and efficient method of managing dense infestations in places that are difficult to access, and that can be used as part of an integrated management program.

Herbicide use and requirements

Safety Gear

When using herbicides, it is essential to equip yourself with appropriate safety clothing.

Key items are rubber gloves, overalls, shoes or boots, eye goggles and a hat. An agricultural respirator is required for moderately and highly toxic herbicides. Avoid any parts of your skin being in contact with any herbicide. Immediately wash any parts of your body which come into contact with any herbicide, particularly your hands before eating.

Training, Certification

Weed control should be undertaken by appropriately qualified and experienced professional bush regenerators, or by volunteers under the direct supervision of a appropriately qualified and experienced professional bush regenerator. Selecting the appropriate technique can be a matter of experience, both with local conditions, and the weed species being targeted.

Labels, Permits, MSDS

When using herbicides it is essential that you read the label on the container and follow the manufacturers' instructions. The label describes how the herbicide should be used (method and

concentration, plus additives) for best results to control particular weeds. The permit describes the conditions under which the herbicide can be used in NSW. The MSDS describes a range of information about the chemical constituents in the herbicide, the most important of which is the safety measures required for use and first aid/medical treatment required following exposure.

Herbicides and additives

Glyphosate

Glyphosate is a systemic chemical which is inactivated upon contact with the soil. Roundup Bioactive™ and Weedmanster 360™ are products with improved surfactants, making them safer to use near waterways. Do not use Glyphosate within 6 hours of rainfall and where there is likelihood of rain within 24 hours.

LI 700®

LI 700® is a penetrant , which facilitates the transfer of the herbicide through the surface tissue and is often used for plants with waxy leaves, such as Madeira Vine and Wandering Jew. (Oils are also used for this purpose.) Manufacturer's instructions should be followed when using any penetrant.

This will help the chemical stick to the leaves, is rain-fast within minutes and helps spread the chemical evenly over the plant.

Tracer Dyes

Tracer Dyes are used with herbicides to improve efficiency and safety. The tracer allows areas/plants that have been treated to be identified. The tracer alerts anyone entering the treated area that a herbicide has been used for a short period of time. It also helps to ensure that the target plants are treated and non-target plants avoided.

Commonly used tracer is a red fluorescent dye such as Spraymate Marker Dye®. Manufacturer's instructions should be followed.

Metsulphuron Methyl

Metsulfuron is a non-residual herbicide, which is the active ingredient in Brushkiller® and Brushoff®.

Weed control – alternative methods

Repeated sprays with a knockdown herbicide (such as glyphosate) are effective in that they exhaust the soil weed seedbank, resulting in less weeds germinating after the planting. Residual herbicides prevent the weed seeds in the soil from germinating until the effect of the herbicide diminishes over time. Care should be used in the selection of herbicides: consider factors such as the development of herbicide resistance, residue in the soil, impacts on native plants and waterways. Alternatives to herbicides should always be considered.

Scalping (removing some of the surface soil) removes the majority of weed seeds and is very effective in a range of soils, although it may expose subsoils that are prone to cracking as they dry. Non-chemical methods include mulching with newspaper, straw, sawdust or similar; flaming; repeated cultivation and hand-chipping. Mowing reduces the vigour of the competing plants but is not as effective as complete removal. Many direct seeding machines have a built in scalping blade or

disc to do weed control in a single pass. Most sites will still benefit from two-years of weed control prior to direct seeding.

Great care should be taken before exposing highly-erodible soils. Weed control should be in strips approximately one metre wide with a grassy strip retained between rows, or in spots one metre in diameter around each planting location.

Weed control and assessment

Weed control is usually the single most important factor in the success or failure of tree plantings. It is just as critical after planting as before and should be continued for at least one full growing season after planting and preferably for 2 years. A weed-free area of 1m diameter should be maintained around each plant for this period.

Weeds should be controlled when they are actively growing, before they set seed and before they begin to compete with your newly established plants. Different weeds will germinate at different times of the year so you will need to monitor your site regularly. Look at your site each month after planting and schedule weed control when you see actively growing weeds. It is much easier to control weeds before they get too big and before they set seed. If you have an annual program of revegetation planned, it pays to keep records of which weeds occur and when they emerge, as well as effective techniques for their control.

The Florabank website can help to identify weeds. It contains an interactive tool which enables you to select your area and look through a list of weed species known to occur in a particular region, with pictures and information about them. The Weeds CRC produced a range of weed management guidelines that may be helpful to tackle specific problem weed species. Another useful publication is 'Stop Bushland Weeds' by Meg Robertson. This publication also contains a table which shows the most effective times of year to control particular weeds.

Non-chemical methods such as hand weeding, mowing or mulching can also be used. For example, or weedy grass species, mowing when the exotic grasses flower, but before the native grasses do, gives the native grasses an advantage. If repeated over successive years, this method has been shown to increase the cover of native grasses and reduce the area of exotic grasses.

PLANTING

Local Provenance

It is generally accepted that for revegetation for conservation purposes, it is best to choose species that occur locally. Such species are well adapted to the environmental conditions of the site, and their pollinators, predators, symbionts and dependent wildlife are present. There are likely to be sources of seed available locally. Local provenance is principally about getting material that is adapted to local conditions, but also arises out of concerns about genetic pollution.

Florabank now recommends that provenance be considered in the following manner when collecting seed for revegetation:

Get the taxonomy right first

- Make sure you are dealing with the same species/subsp/variety or cultivar

Get the physical and genetic quality right

- Collect from 20-100 plants.
- Collect from plants at least 3 plant-heights apart

Only collect from large populations or pool multiple collections from smaller populations

Store seed under best conditions from collection right through to use

Match the site conditions

- Soil (texture and origin)
- Altitude
- Aspect
- Slope position
- Latitude (use bioregions as the boundary)

Then worry about proximity between collection and revegetation sites. Having said that, where possible, all revegetation works are to be conducted in accordance with current best practices. These include:

1) Collection of seed

a) Must be by appropriately qualified and licenced personnel
b) Must be local provenance seed stock (refer Florabank Guideline No.10)
c) Must be collected in a manner that maximises genetic quality of seeds (refer Florabank Guideline No.5)
d) No more than 20% of the fruit or 10% of plant material should be removed from one plant

2) Determining local provenance

a) Environmental conditions at the collection site should match the existing or desired environmental conditions at the proposed planting site
b) Consider the method is pollination and seed dispersal for the species concerned before deciding on local provenance boundaries (Figure 24).
c) While it is best to collect seed as locally as possible, care must be taken to maximise the genetic diversity of available seed stock to avoid problems associated with inbreeding

Collection Range					
Factors	**Narrow**		**Intermediate**		**Regional**
Pollination	self-pollinated	wind-pollinated	insect-pollinated	bird-pollinated	bat-pollinated
Seed dispersal	gravity			wind or water	bats and birds
Longevity	short-lived				long-lived
Extent	small number and small area				large number and large area
Density	low		medium		high
Fragmentation	low		medium		high

Figure 30. Collection ranges for determining local provenance areas (adapted from Florabank Guideline No.10).

3) Storage of seed

a) Seed must be stored appropriately (refer Florabank Guideline No.1)
b) Seed should be tested for viability before storage (refer Florabank Guideline No.8)

4) Propagation of plants

a) Plants should be propagated so that seedlings will be large enough to transplant onto site
b) Care should be taken that unexpected delays in construction do not cause seedlings to become root-bound
c) Propagation should be conducted in accordance with current best practices

5) References for plant propagation information:

- Wrigley, J.W. & Fagg, M. (1993) 'Bottlebrushes, paperbarks & tea trees: and all other
- plants in the Leptospermum alliance'. Angus & Robertson, Sydney. 352 pp.
- Wrigley, J.W. & Fagg, M. (1996) 'Australian native plants: propagation, cultivation &
- use in landscaping'. 4th ed. Reed. 696 pp
- Ralph, M. (1994) 'Germination of local native plant seed: for revegetation, tree
- planting & direct seeding projects'. Murray Ralph, Fitzroy, Vic. 42 pp.
- Ralph, M. (1997) 'Growing Australian native plants from seed'. Murray Ralph, Fitzroy,
- Vic. 156 pp.
- Ralph, M. (1994) 'Seed collection of Australian native plants for revegetation, tree
- planting and direct seeding'. Murray Ralph, Fitzroy, Vic. 121 pp.

Revegetation techniques

There are three techniques that are commonly used for revegetation: tubestock planting, direct seeding and natural or assisted regeneration.

DIRECT SEEDING	TUBESTOCK PLANTING	NATURAL REGENERATION
(+) Lower establishment costs	(+) More reliable	(+)Plants are well-adapted to the site
(+) Natural look and more diversely structured	(+) Uniform	(+)Establishes healthiest plants
(+) Establishes healthier plants	(+) Revegetation is visible to passers by	(-)May have to wait for a long time for results
(-) Long establishment times may lead to more maintenance such as weed control.	(-) Often results in unnatural looking rows	(-)Needs an adjacent or nearby seed source
(-) Ants have been known to take seed	(-) Higher establishment costs	(+)Lowest establishment costs
(-) Uses lots of seed	(+) Uses small quantities of seed	(-) Long establishment times may lead to more maintenance such as weed control.

Natural Regeneration

Natural regeneration is the term used to describe the growth of plants from seed naturally distributed to the site. Natural regeneration relies on existing seed sources, such as soil or canopy stored seed, or seed transported to the site by water, wind or animals in the area to be revegetated. This method of re-establishing vegetation is especially worthwhile for individuals and groups with limited resources. Natural regeneration is a good first choice, because native plants that grow from this method are likely to be well adapted to the site. If there is a good source of seed, natural regeneration can result in high species diversity, representing the original range of plant species.

Although the process of regeneration itself is 'passive', natural regeneration still usually requires facilitation and management. The areas to be revegetated are usually fenced to exclude stock and allowed to regenerate naturally. Some form of pre-treatment, such as a burn or herbicide treatment, may be applied to the site. If the regeneration fails or is poor, direct seeding or planting seedlings can be considered. As with other methods, implementation of a long-term weed management strategy is important.

Direct Seeding

Direct seeding involves sowing seed directly into prepared ground. Direct seeding generally is more efficient in terms of time, cost and labour, compared to tubestock planting. It also allows for a more diverse seed mix, leading to greater plant diversity. The main limitation with direct seeding is usually the availability of seed. Establishment of plants from direct seeding can be patchy and can take several years, especially for hard-seeded species, but the plants that do establish are often robust and have developed a good root system. There are two main methods of direct seeding:

Hand Sowing: this method is useful for small areas or in inaccessible country. Handfuls of seed mixed with a bulking agent are thrown onto the prepared seed bed. Another method of hand-seeding uses cut stems of a plant with ripe fruit present, laid across a prepared site.

Mechanical direct seeding: this method involves the use of specialised direct seeding equipment, which is calibrated for different seed sizes and planting depths. Large areas can be seeded quickly using this method - up to 50 hectares in one day using one direct seeder.

As with other revegetation methods, ground preparation and weed control is critical. Because germinating seeds must compete with weed seeds that may be in the soil, a weed control program ideally should begin two years before direct seeding. The top layer of soil can also be scalped to remove weed seeds. Control of seed and shoot predators such as ants and red-legged earth mites is also important.

Tubestock Planting

'Tubestock' is the term for seedlings that have been raised in small nursery tubes, for transport to the planting site. Propagation of seedlings can be by seed, by cuttings, or through division. Seedlings can be planted by hand or with a mechanical seedling planter at the prepared site. As with direct seeding, site preparation is essential and will involve weed control and fencing.

Even though tubestock planting is more expensive and requires more labour than direct seeding and natural regeneration, it is a widely used method of revegetation. Results are reliable and immediate, and plant placement is controllable. Because of the labour-intensive nature of tubestock planting (both in propagation and planting), fewer species tend to be planted than with direct seeding.

General planting notes

Plants

Large healthy root systems, with no evidence of root curl, restriction or damage. Plants should be vigorous, well established, and free from disease and pests, of good form consistent with the species or variety. Before planting, plants should be hardened off, not soft or forced, and suitable for planting in the natural climatic conditions prevailing at the site.

General considerations

Replace damaged or failed plants with plants of the same type and size. Supply plants in weed-free containers of the required size. Label at least one plant of each species or variety in a batch with a durable, readable tag.

Deliver plant material to the site on a day to day basis, and plant immediately after delivery. Give notice of proposed changes to plant locations and spacing, for example, to avoid service lines, or to cover the area uniformly. Do not plant in unsuitable weather conditions such as extreme heat, cold, wind or rain. In other than sandy soils, suspend excavation when the soil is wet, or during frost periods.

Placement

Wherever possible, different species should be placed adjacent to each other. Trees and shrubs are to be planted to maximise the diversity of the upper canopy as much as possible.

Remove the plant from the container with minimum disturbance to the root ball, ensure that the root ball is moist and place it in its final position, in the centre of the hole and plumb, and with the top soil level of the plant root ball level with the finished surface of the surrounding soil.

Fertilising and water crystals

Slow release fertiliser pellets should be placed into the plant hole immediately before planting. Install water crystals with the fertiliser according to the manufacturer's recommendations. Best results are obtained if water crystals are soaked in water first.

Backfilling

Backfill holes after planting using topsoil. Lightly tamp down and water to eliminate air pockets. Ensure that topsoil is not placed over the rootball so that the plant stem remains the same height in the ground as it was in the container.

MANAGING THE SPREAD OF PHYTOPHTHORA

Phytophthora cinnamomi

Phytophthora cinnamomi is not visible to the naked eye. Under a microscope, its main body, the mycelium, looks like white hair-like threads. Sporangia (spore sacs) are produced on the mycelium in moist and aerobic conditions and at temperatures of 22-28ºC. In each sporangium 30-40 zoospores are formed and released. Zoospores are motile by way of two flagella, which enables Phytopthora to infect new and healthy root tips. Zoospores survive up to four days. When conditions for growth become less favourable, generally when the soil dries out, mycelium may form another type of spore, known as a chlamydospore. This resting spore has a thick cell wall and is able to survive in the soil or host tissue for many years, waiting for growth conditions to become suitable again. The mycelium can also survive on plant debris on or in the soil.

The most critical interaction in disease development is the simultaneous presence of Phytopthora zoospores and susceptible host plants. A range of factors determines the severity of the disease and its rate of spread. These include temperature, rainfall, soil type and characteristics, and microbial soil populations. Phytopthora is generally found in areas where:

- average annual rainfall is greater than 500 mm (20 inches)
- soils are acid to neutral with low amounts of nutrients and organic matter
- have few micro-organisms
- have poor drainage

Hot bushfires may destroy Phytopthora to a depth of 15 cm below the soil surface. However, the fire also lowers surface soil organic matter and microbial populations, making it more favourable for its growth.

Symptoms of disease

The roots and stems of plants affected by Phytophthora decay with root-rot and then disintegrate, destroying their ability to extract water and nutrients. An infected plant is then subject to water stress which is also known as 'internal drought'. The first visual symptoms of infection are generally shown as yellowing of the foliage (chlorosis) followed by dieback of the entire plant. Depending on local site and environmental conditions, this can occur in a matter of weeks for small shrubs or even several years for large shrubs or trees.

Symptoms vary between different plant species. Xanthorrhoea species for example, die rapidly and may collapse. Acacia species may die quickly but symptoms can be masked by other dieback causes such as general drought conditions. Leaves of Banksia species and Eucalyptus species show slower signs of dieback on their branch tips but may temporarily re-shoot. The Fabaceae, Acacia, Leptospermum and some Epacridaceae become yellow and die back in warm moist periods during spring and autumn. They may recover and form new growth during dry periods in summer or cold periods in midwinter. The cycle continues with dieback occurring again in spring and autumn.

Dieback may also be caused by factors other than Phytophthora. These may include chemicals, old age, fire, mechanical damage, insects, and environmental factors including drought, waterlogging, salt, frost and hail.

How the disease is spread

The single most important cause in the spread of Phytophthora appears to be through the transport of infested gravel, soil and plant material, which adheres to vehicles and heavy machinery. Such machinery is usually used in logging, firefighting, road construction and maintenance of roads and powerlines. A vehicle not cleaned after working in an infested area could easily spread the disease to another site many kilometres away. Phytopthora can also be spread in the following ways:

- through transport of soil and plant material adhering to bicycles, footwear, tools and camping equipment
- through water (as drain off, irrigation or moving ground water). Phytopthora will spread quickly downhill in surface and sub-surface water flows. If found along a watercourse, then surface water will most likely carry Phytopthora downstream into the catchment
- by transfer of infested gravel, soil, water or any other raw material
- from plant to plant through natural sub-surface root contact. The spread uphill and on flat ground is slower (approximately 1 metre per year) as it is confined to root contact from plant to plant
- by transferring infested plants to other sites
- by animals, particularly those with cloven hooves

Prevention of spread: Maintenance of vehicles and machinery

To prevent the spread of Phytopthora vehicles and machinery should be kept hygienically clean of soils which may be infected. A visual inspection should confirm that vehicles and machinery are free of clods of soil, slurry (water and soil mixture) and plant material. The cleaning procedure consists of two steps:

1. Dry brushing

- Remove all soil and plant material with a hard brush or tool. Pay particular attention to wheels, mudflaps and undercarriage.

2. Disinfection

- Disinfect vehicles (wheels, mudflaps and undercarriage in particular) and machinery with water containing a disinfectant until any remaining soil and mud is saturated.
- Allow disinfectant to penetrate for 10 minutes.
- Avoid recontaminating vehicles and machinery! The following disinfectants can be used:

A fungicide, such as Phytoclean®. Dilute 1 part in 50 parts water. Sodium hypochlorite (pool chlorine). Dilute 1 part in 1500 parts water.

Points to remember:

- Clean down on a hard, well-drained surface (such as an unsealed road) in high risk areas.
- Do not wash down with water only, as this will create a more suitable environment for infestation. Always use a disinfectant!
- Phytoclean® is preferred above sodium hypochlorite as it is a more effective disinfectant, as well as being biodegradable and noncorrosive.
- The use of a pressurised spray unit is preferred, as this will minimise the amount of water used.
- Do not drive through wash-down effluent.
- Do not allow mud and wash-down effluent to drain into bushland and surface waters such as rivers, creeks, reservoirs and dams.

Cleaning Footwear and Hand Tools

The fundamental hygiene principle to minimise the spread of Phytopthora is to keep footwear and hand tools hygienically clean and therefore free of Phytopthora. A hygiene kit should contain:

- hard brush
- bottle of disinfectant, such as methylated spirit (undiluted) or household bleach (dilute 1 part in 4 parts water)
- spray bottle

The cleaning procedure consists of two steps:

1. Dry brushing

Remove all soil and plant material from footwear and tools with the hard brush.

2. Disinfection

- Disinfect the entire sole of your footwear and tools using the spray bottle containing the disinfectant
- Allow the sole of the boot to dry for at least one minute
- Step forward to avoid recontamination of footwear
- Disinfect the hard brush!

Points to remember:

- Clean down on a hard, well-drained surface (such as an unsealed road) in high risk areas.
- Do not wash down with water only, as this will create a more suitable environment for infestation. Always use a disinfectant!
- Hand tools can also be disinfected by soaking for a few minutes in the bleach solution, then rinsing with distilled water and wiping dry with a clean paper towel. Clean down on a hard, well-drained surface.

Safety, Health and Welfare

Wear Personal Protective Equipment when handling or using disinfectants, wear, including gloves and safety goggles. All disinfectants are toxic to water organisms and extreme care must be taken in the use and disposal of undiluted, diluted and exhausted solutions.

Remember to:

- re-use containers where possible. Undiluted disinfectants and used containers must be disposed of in an approved refuse disposal site. Triple rinse and crush used containers before dispersal.
- dilute exhausted and diluted solutions an extra five times and spread over the ground a minimum of 50 metres away from surface waters. They may also be inactivated in a pit by addition of organic matter, such as sawdust, absorbing clay or paper.

CONTROL PROGRAMS FOR CARP

Carp are considered a pest species because it degrades the water quality of the ponds and limits the opportunity for native fish populations to become established. It is a prolific breeder and reduces the survival chances for native fish. Carp feed from the bottom of the pond, sucking in substrate (or material at the bottom of the pond) and water in search for aquatic organisms. This decreases water quality by increasing turbidity, consequently preventing light penetration into the water. Less light penetration affects plant growth, which is a valuable food source for native fish, and contributes to erosion of the banks of the ponds.

Although there is wide agreement that carp numbers should be reduced, control efforts are being hampered by a lack of information. Nonetheless, there are several options for reducing carp, and each has its benefits, disadvantages and costs.

Effective control of carp will require the application of a combination of techniques which include:

- **Environmental Rehabilitation** - This includes taking actions that will increase the numbers of native fish, such as creating fishways, and revegetating river banks, re-snagging rivers and looking at ways to release warmer water from dams. These are viewed as a necessary part of river management, but their direct effects on carp are unknown.
- **Physical Removal** - Catching large number of carp is already under way on a small scale and more licences are being issued. To be effective, at least 98% of carp must be removed, which may be very expensive, or impossible to achieve. Methods include netting and electrofishing.
- **Reduce Carp Reproduction** - This strategy involves reducing the numbers of carp eggs that have been laid in shallow habitats such as billabongs and wetlands where most spawning activity occurs. This technique involves lowering the level of water by 45-60 cm to expose and dry out the carp eggs. The technique is being researched and could work well in wetland and billabong habitats.
- **Chemical Poisoning**: - While this is possibly an effective method, poisoning is very expensive and may only work in small or closed bodies of water. In addition, chemical poisoning would not be acceptable for the general environment, and would only be able to be used in habitats such as irrigation channels where the water quality is poor and the environment is no good.

- **Biological Techniques** - These include pathogens (usually viruses), immuno-contraception (interfering with reproduction) and interfering with the genetic make-up of the carp. None of these techniques are currently being used, but they are currently the subject of research and management studies.

Of the above control measures, the most suitable one for Upper Duck River Wetlands and Riparian Corridor is physical removal. The Centennial Park and Moore Park Trust (Trust) has an ongoing Carp eradication program aimed at eliminating carp from the Parklands' pond system, and to encourage native fish stocks to develop. This program has resulted in the removal of over 10 tonnes of carp from the pond system since 1998 – the largest fish weighing a record 24 kilograms.

Several activities under this program include:

- Electro-fishing program: a licensed procedure that stuns the fish which are then netted and removed from the ponds. The fish that are removed from the ponds are processed to make an organic liquid fertiliser.
- Line fishing: a dedicated volunteer-led program to selectively remove carp from the ponds using traditional fishing methods. Following removal from the ponds, the fish are then euthanased and used as bait for commercial fishing.
- Australian bass release: a system of gradually introducing Australian bass (Macquaria novemaculeata) - a native fish species - into the pond ecosystem to reduce carp numbers. 15,000 Australian Bass have been released into the Parklands ponds since 2005.

Key conditions of the Centennial Parklands' carp management program:

- Only the use of manufactured and purpose made barbless hooks is permitted. Barbless hooks are used to prevent any unnecessary suffering to Carp and will readily fall out if on the rare occasion a non-target species is hooked. Volunteers are supplied with approved hooks. No stainless steel hooks permitted.
- Fishing is only allowed in the designated area and at no time trampling of vegetation is allowed. One rod per person and rod is always to be held – no rod is to be left unattended nor is a rod holder permitted.
- Induction of all participants is provided as a prerequisite to participation. This induction prioritises the importance of protecting any non carp species from any action which might result in injury.
- A Fishing Coordinator has been recruited from the Australian National Sports Fishing Association a recognised leading industry body, to supervise all fishing activity undertaken in the Parklands to ensure effective quality control of the program.
- All volunteers are required to meet OHS requirements and are fully inducted on these requirements prior to participation.

EXAMPLES OF LITTER CONTROL DEVICES

Trash rack

End of pipe control device

Trash trap

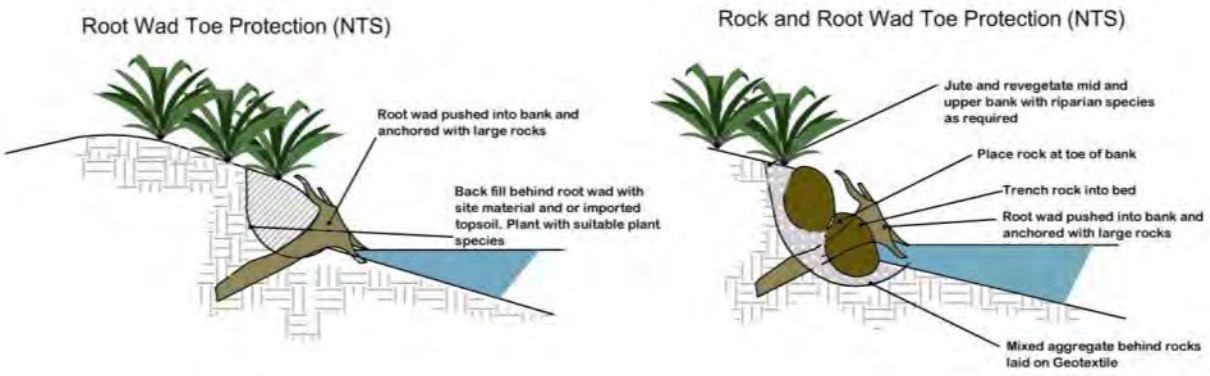
Floating trash trap

http://www.bandalong.com.au/products-and-services/bandalong-litter-trap/

http://wsud.melbournewater.com.au/content/treatment_measures/litter_traps/litter_trap_types.asp#floatingdebris

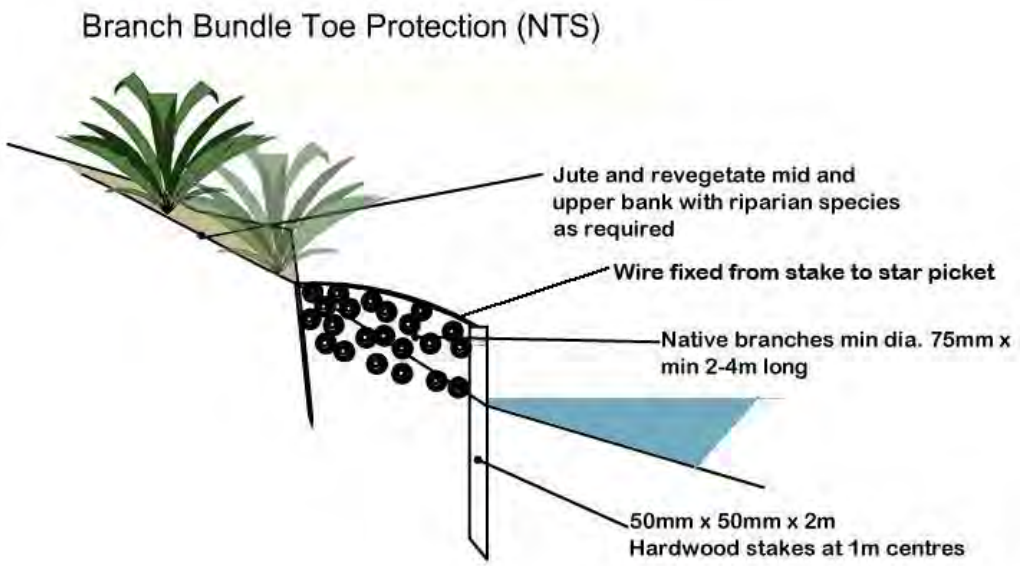
EXAMPLES OF EROSION CONTROL WORKS

Toe protection using root wads



(from Sutherland Shire Waterways Assessment and Rehabilitation Prioritisation, Applied Ecology 2012)

Branch bundle toe protection



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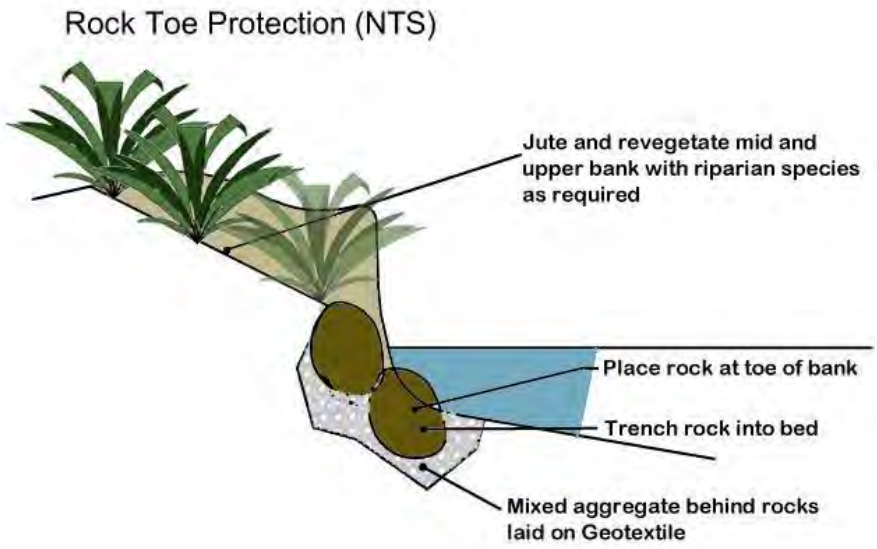
Rock toe protection



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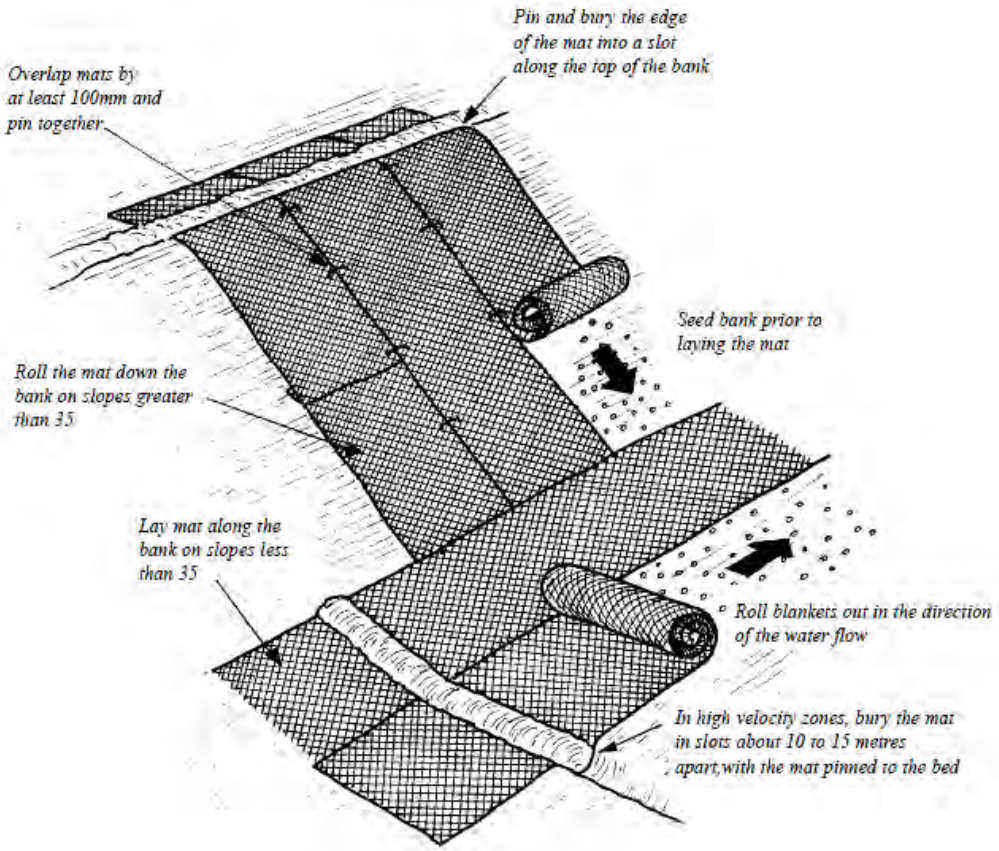
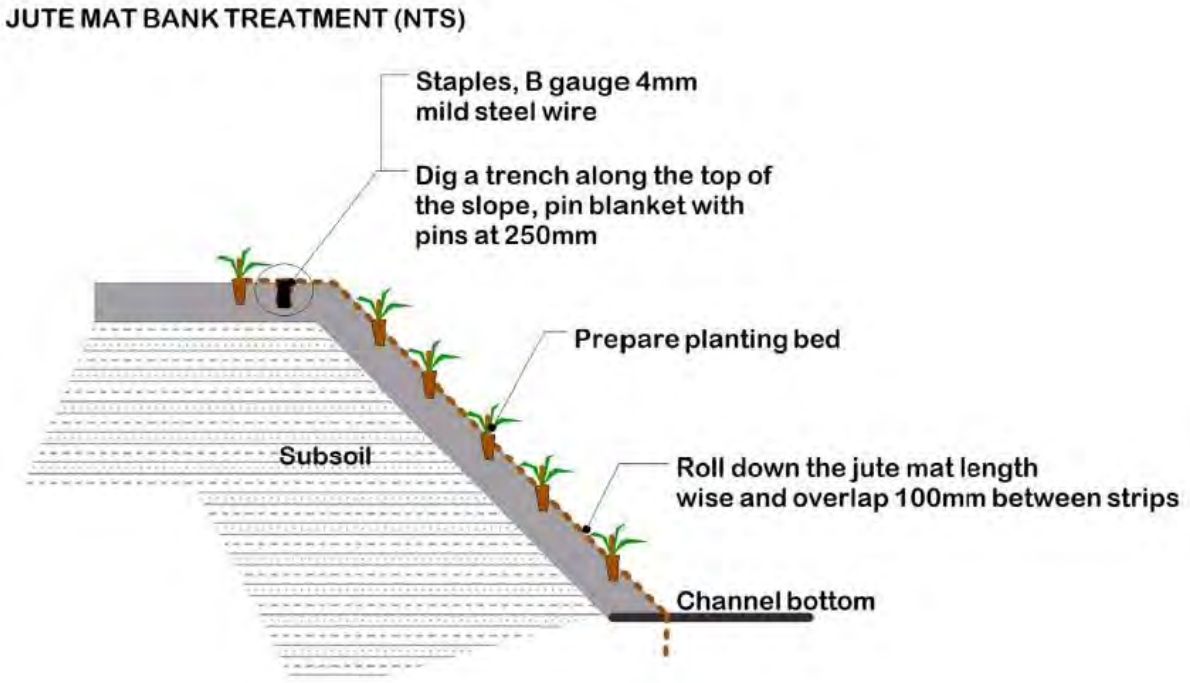
Jute matting bank stabilisation treatment

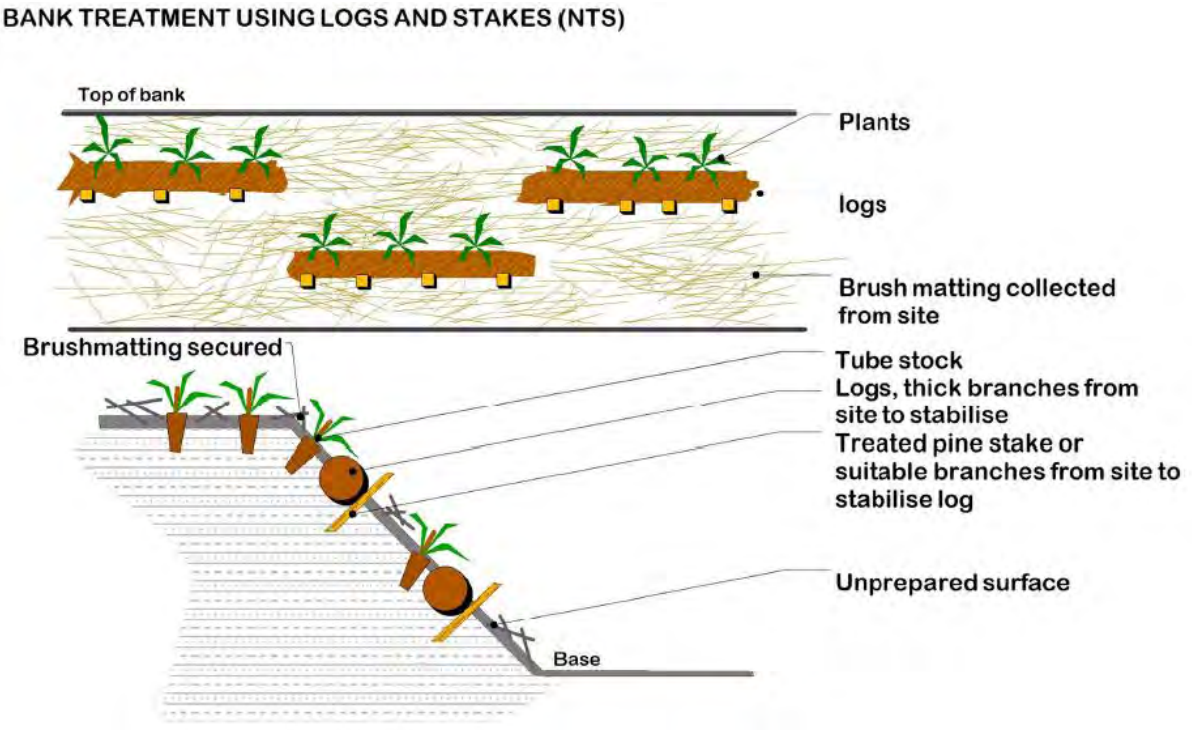


Jute matting bank stabilisation with planting



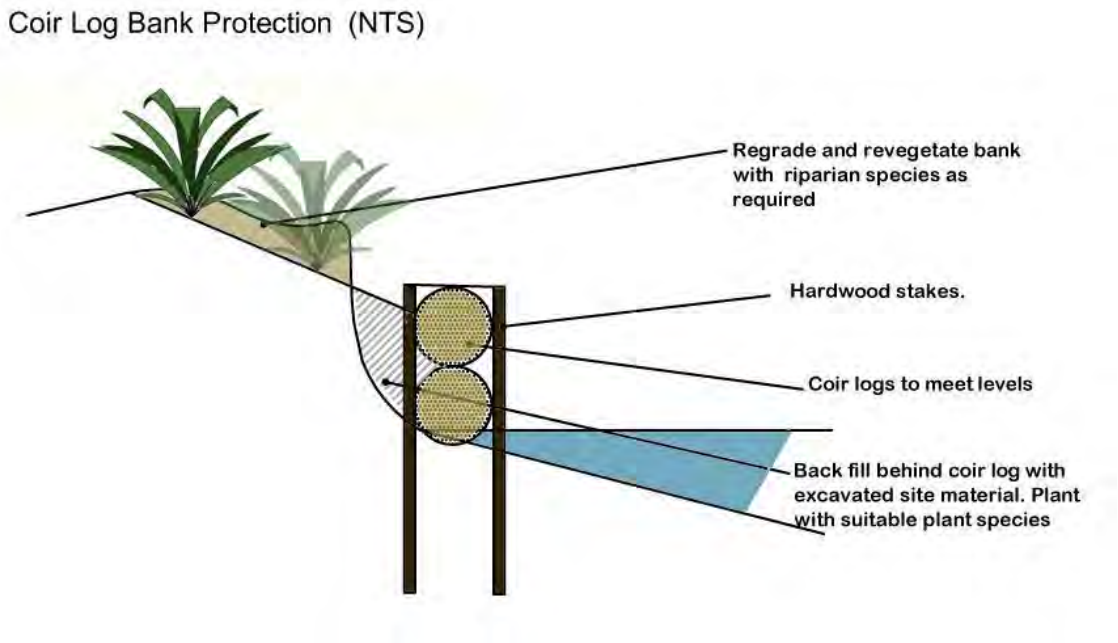
(from Sutherland Shire Waterways Assessment and Rehabilitation Prioritisation, Applied Ecology 2012)

Bank stabilisation using brush matting with logs and stakes



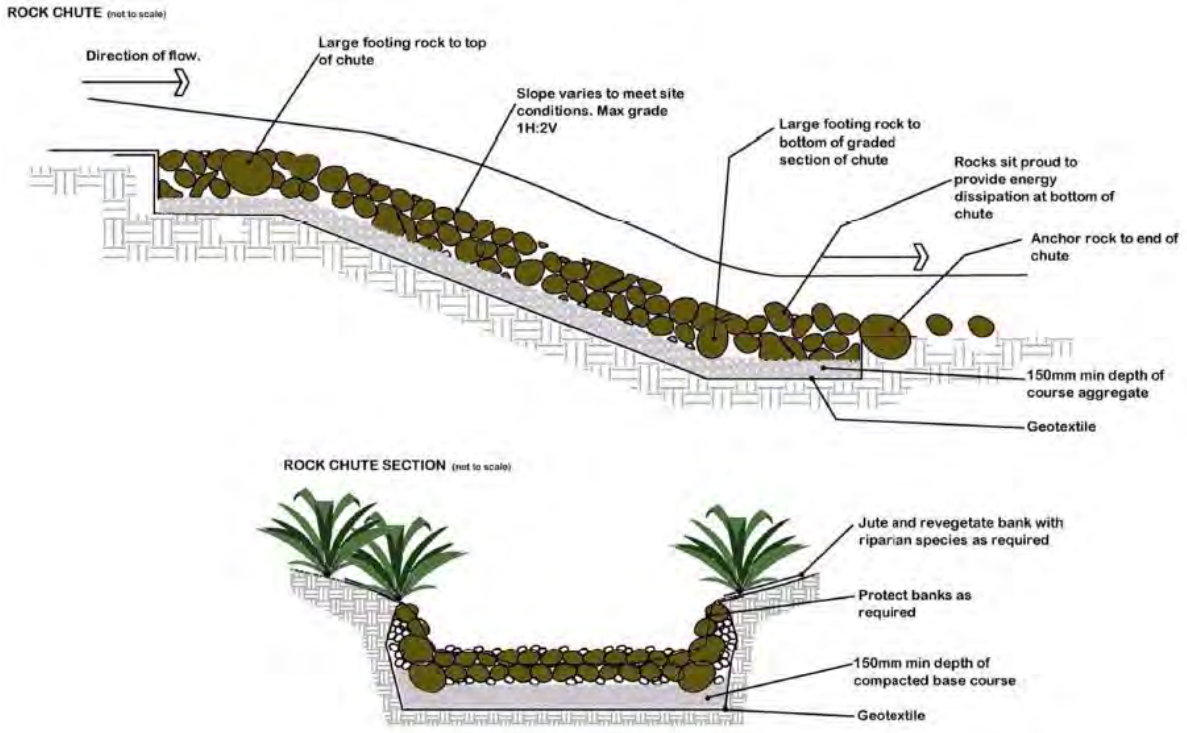
(from Sutherland Shire Waterways Assessment and Rehabilitation Prioritisation, Applied Ecology 2012)

Coir log bank protection



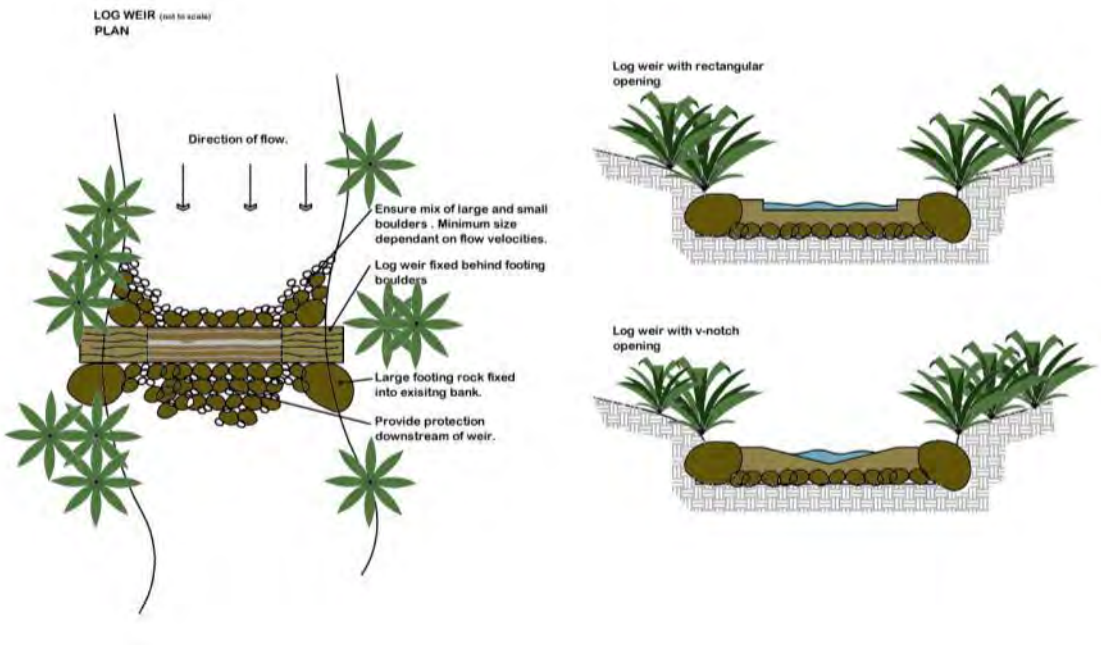
(from Sutherland Shire Waterways Assessment and Rehabilitation Prioritisation, Applied Ecology 2012)

Rock chutes for channel bed stabilisation



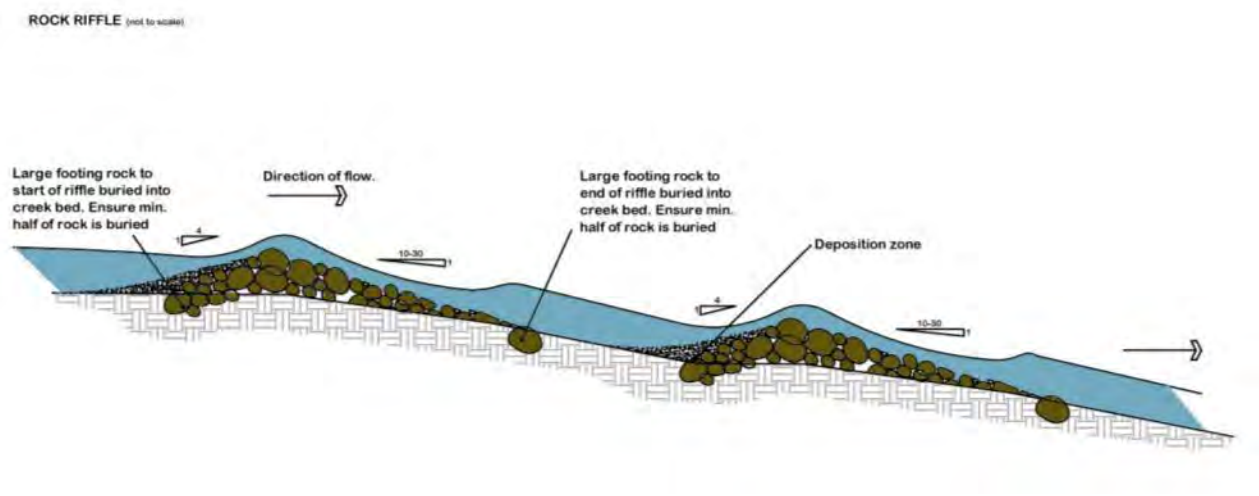
(from Sutherland Shire Waterways Assessment and Rehabilitation Prioritisation, Applied Ecology 2012)

Log weirs for channel bed stabilisation



(from Sutherland Shire Waterways Assessment and Rehabilitation Prioritisation, Applied Ecology 2012)

Rock riffles for channel bed stabilisation



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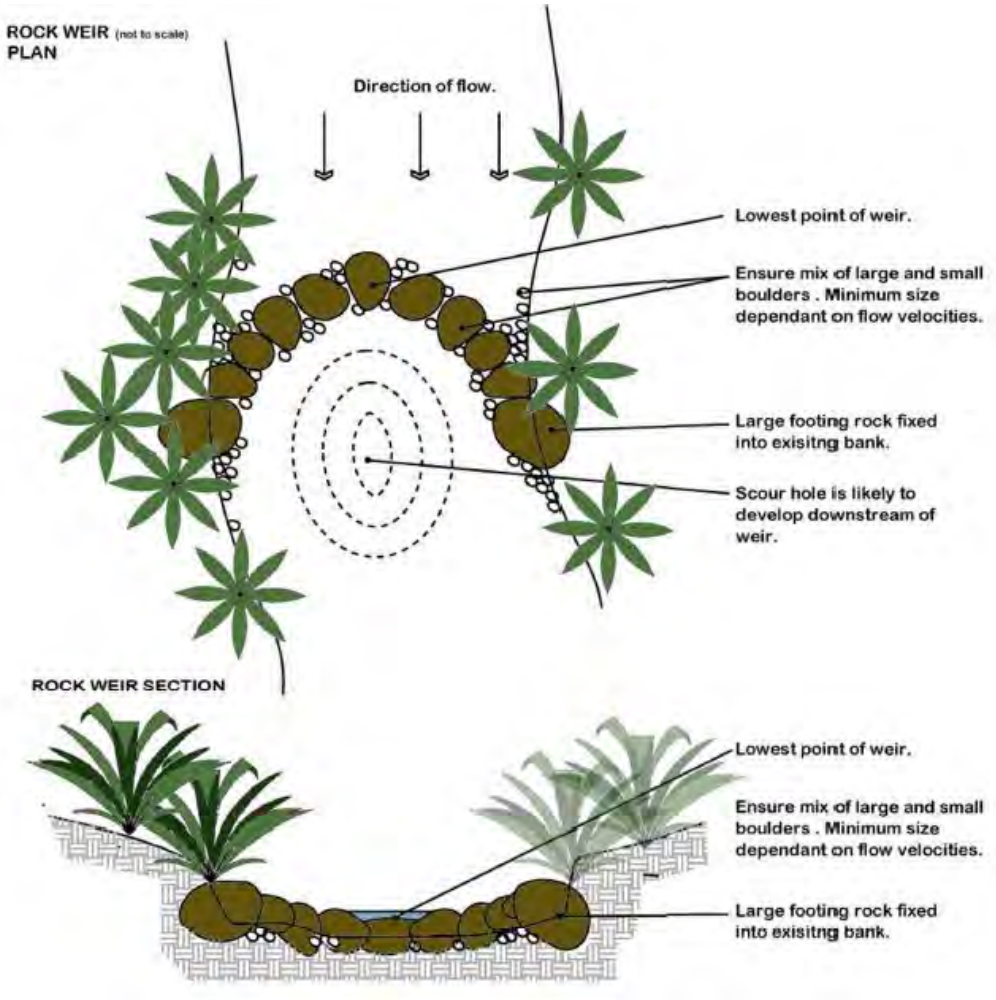
Rock weirs for channel bed stabilisation



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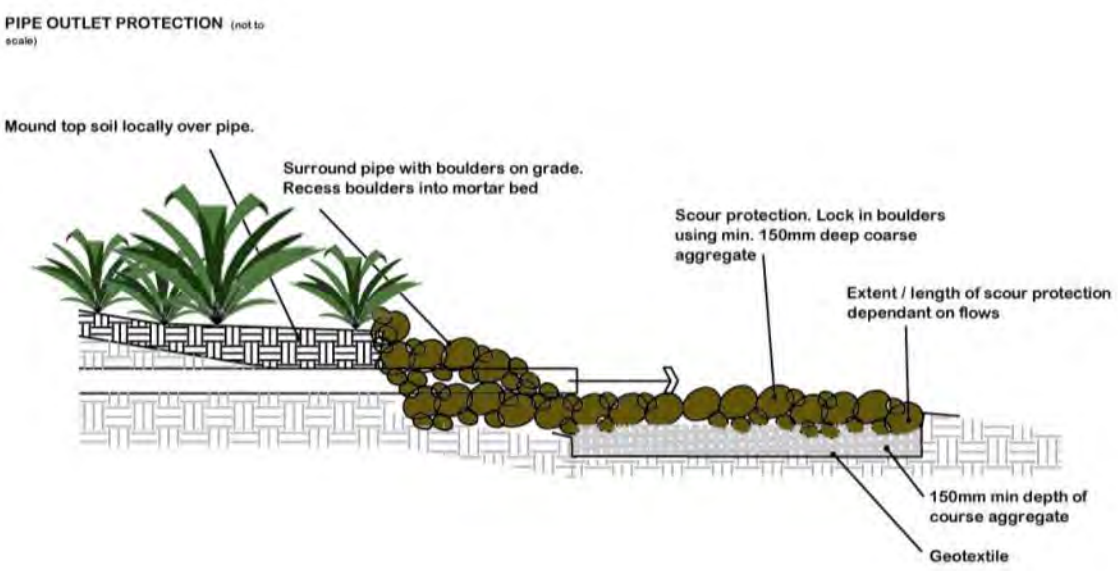
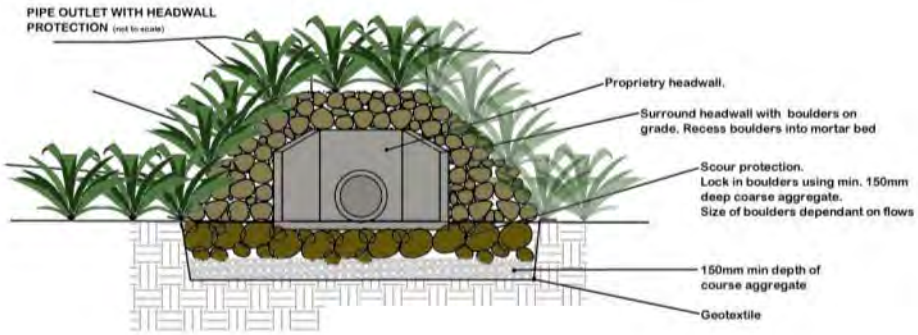
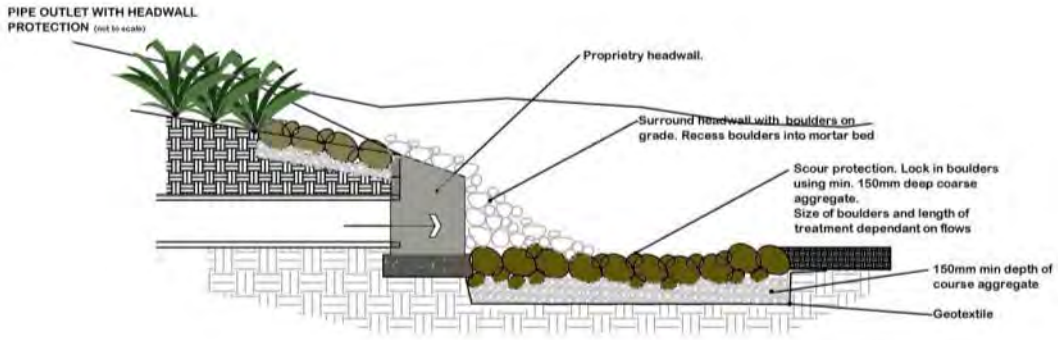
Pipe outlet protection



(from Sutherland Shire Waterways Assessment and Rehabilitation Prioritisation, Applied Ecology 2012)

Headwall and outlet protection





(from Sutherland Shire Waterways Assessment and Rehabilitation Prioritisation, Applied Ecology 2012)

DESIGN GUIDELINES FOR STREET FURNITURE

Elements of street furniture need to be co-ordinated with each other and with their surroundings. Designers should check the master plan, design guidelines and other planning documents relevant to the site for any requirements for street furniture styles, colours and finishes. Street and park furniture needs to:

- exhibit high resistance to vandalism
- be durable against weathering and deterioration
- be suitable for use by people with a wide range of needs including children, the aged and people with disabilities
- have a low whole-of-life cost.

Paint finishes should be selected on the basis of superior resistance to fading, vandal resistance and appropriateness for the surface they are coating. Graffiti coatings should be considered for surfaces likely to be affected by graffiti. Within these requirements, park furniture should be selected to enhance the unique design character of the space.

Park furniture positioning and selection should respond to the demands of the public and the physical location. The number of furniture items is a direct response to the requirements of the particular space. Park furniture should be positioned to focus on an activity or a view and take advantage of seasonal change, especially winter sun and summer shade. Where possible designers should site furniture in ways that provide shelter from the rain and other local weather patterns such as winter winds.

Seating is a major component in spaces that are created primarily for relaxing or resting. Seating in these spaces should be designed for longer duration sitting. Aggregations or multiples of seating may be required in central locations where they can be placed to encourage conversation or to generate a sense of place. This form of seating is normally inwardly facing, should be visible but not intrusive and sited in a manner that does not obstruct a view, activity or desire lines. Seats in secluded areas should be sited near or directly under street lighting. Avoid locating seats in grass where maintenance of the grass around and beneath the seat will be difficult. Also avoid placing seats around trees where they collect leaf litter and require increased maintenance.

Seats with an all metal framework, durable finish, armrests, slats perpendicular to the length of the seat are preferred. Seating surfaces should have ample space between slats; this type of surface tends to dry more quickly after rain. Seats should be designed to avoid entrapment hazards (see Australian Standard AS 1924.2 for head entrapment and Design Standard 15 Playgrounds and Playground Equipment for finger entrapment). Armrests and slats perpendicular to the length of the seat help to reduce vandalism; especially the danger and damage caused by in-line skaters and skateboard riders.