MA ES

LOWER PROSPECT CANAL

Draft Plan of Management

VOLUME 2 BACKGROUND INFORMATION

November 1998

Prepared for

National Parks and Wildlife Services,
Metropolitan Regional Parks Unit

Prepared by

Environmental Partnership

Landscape Architects & Urban Planners
2 River Street, Birchgrove NSW 2041
Phone (02) 9555 1033 Fax (02) 9818 5292 Email ep@talent.com.au

TABLE OF CONTENTS

Volume 1 Draft Plan of Management

LOWER CANAL CORRIDOR, PROSPECT

FLORA AND FAUNA ASSESSMENT

PREPARED AS PART OF THE PLAN OF MANAGEMENT FOR THIS AREA

JULY 1998

Report prepared by:
Deryk Engel and John Speight
LesryK Environmental Consultants
PO Box 812 CARINGBAH NSW 2229
Telephone: 018 258129. Fax: (02) 9544 1835

1.0 FLORA AND FAUNA REVIEW
Lesryk Environmental Consultants

TABLE OF CONTENTS

List of Tables

List of Figures

List of Appendices

1.0 INTRODUCTION

This summary of flora and fauna issues associated with the Prospect Lower Canal Corridor has been prepared by LesryK Environmental Consultants for Environmental Partnership Pty Ltd as part of a Plan of Management for the site. The location of the Lower Canal Corridor is shown on Figure 1. The study area encompasses the canal corridor between the Pipehead infrastructure at Guildford and the fenced access to Prospect Reservoir near Hyland Road at Greystanes.

2.0 REVIEW OF BOTANICAL ISSUES

2.1 Surveys Of The Site

A botanical survey of the lower canal area was undertaken in 1993 by David Thomas. A survey and report on the botanical significance of the lower canal area was undertaken by Teresa James of the Sydney Royal Botanic Gardens in 1994. A review of the botanical significance of the site is also included in the National Parks and Wildlife Service's *Western Sydney Urban Bushland Biodiversity Study* (NPWS 1997).

All of these studies describe the existing vegetation on the site and its condition, identify plant species and communities of conservation significance, note the type of vegetation that would have originally occurred on the site, and assess the general conservation significance of the site. The *Urban Bushland Biodiversity Study* also provides a summary of conservation and management recommendations.

The study by Thomas (1993) divided the canal corridor into six sections (referred to as *sites* in the report by Thomas) and included a description of the species occurring within each section, and a comprehensive species list for the whole corridor (Appendix 1). These same six sections are used in this report. They are:

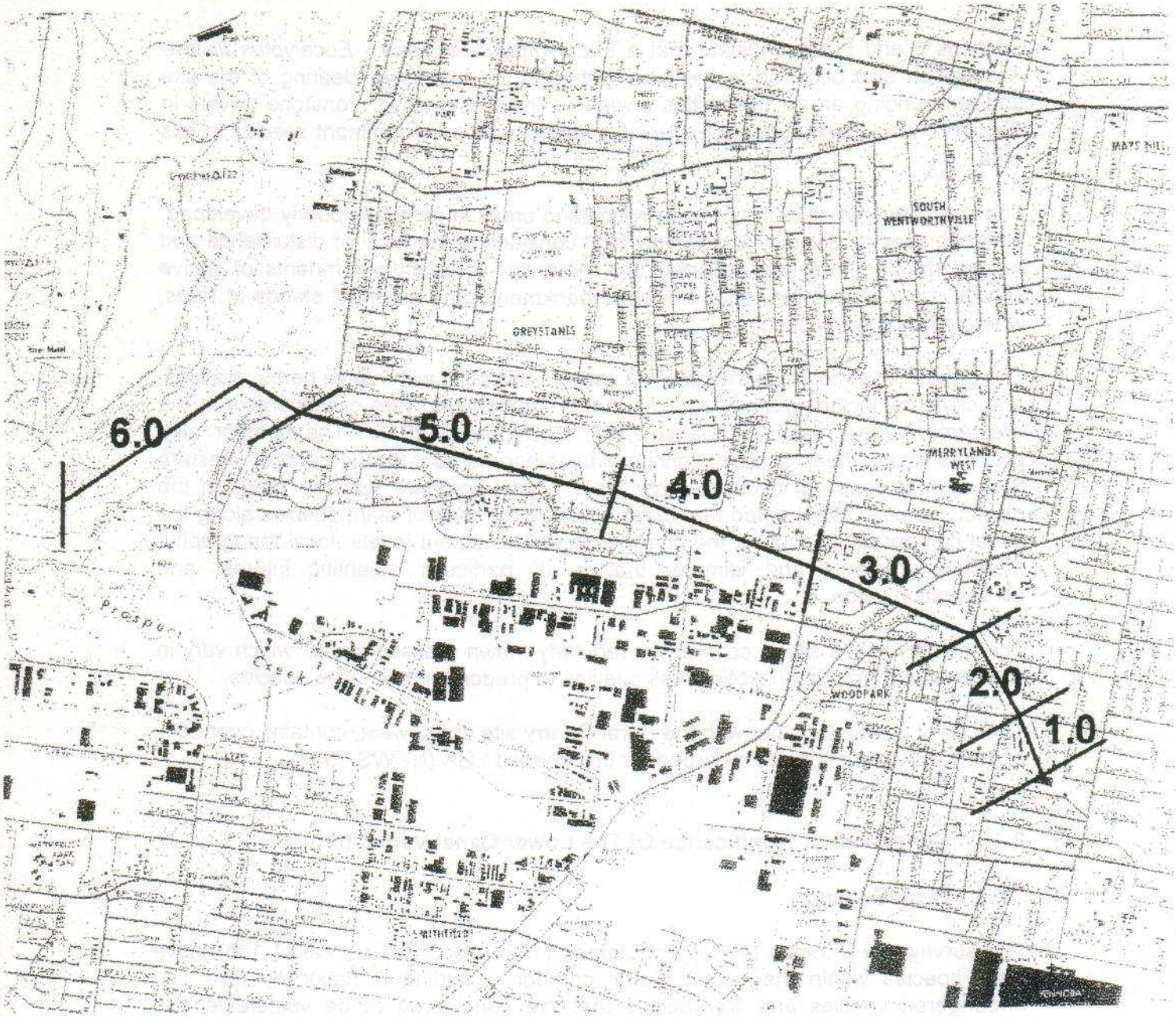
- Section 1. - Pipehead Section.
- Section 2. - Albert Street to Sherwood Road.
- Section 3. - Sherwood Road to Betts Road.
- Section 4. - Betts Road to Bayfield Road.
- Section 5. - Bayfield Road to Gipps Road.
- Section 6. - Gipps Road to Prospect Reservoir.

The location of each section is shown on Figure 2. The western part of Section 6, closest to Prospect Reservoir is outside the study area considered in this management plan. The Lower Canal is entirely within the Holroyd Local Government Area.

2.2 Vegetation

The corridor contains scattered remnants of Grey Box Woodland dominated by Grey Box *Eucalyptus moluccana* and Forest Red Gum *Eucalyptus tereticornis* (map unit 10c of Benson 1992), with occasional trees of Broad-leaved Ironbark *E. fibrosa*, Thin-leaved Stringybark *E. eugenoides* and Rough-barked Apple *Angophora floribunda*. Thomas considers that localised concentrations of *Eucalyptus fibrosa* in

FIGURE 1 : Study Location and Area



- Section 1. - Pipehead Section.
- Section 2. - Albert Street to Sherwood Road.
- Section 3. - Sherwood Road to Betts Road.
- Section 4. - Betts Road to Bayfield Road.
- Section 5. - Bayfield Road to Gipps Road.
- Section 6. - Gipps Road to Prospect Reservoir.

Figure 2 : Canal Sections

Sections 3 and 5 may indicate that a *Eucalyptus moluccana - Eucalyptus fibrosa* Association also occurred in the area, although the extensive clearing of the site and surrounding areas makes this unclear. The existence of ironstone gavels in Section 3 would also suggest *Eucalyptus fibrosa* was a co-dominant species in this area.

The shrub layer in all of the remnant woodland areas is generally poorly developed, although species diversity is relatively high considering the level of disturbance and regular mowing that has occurred until recently. The main remnants of native shrubs occur in protected sites below embankments and amongst stands of trees, where mowing was difficult.

The ground layer contains the greatest species diversity, with native herbs, grasses, and climbers, including many species that are considered rare or vulnerable in the Western Sydney region by Benson and McDougall (1991). The corridor also provides a rare linear, almost continuous bushland corridor through part of Western Sydney that does not occur in other more typical corridors such as roads in the district. James (1994) noted that there is a high turnover of plant species along the canal corridor as a result of the changes in soils, nutrient levels, local topography, moisture gradients and climate, that is of particular scientific interest and conservation value.

The majority of the site is covered by regularly mown grassed areas, which vary in composition from purely exotic grass species to predominantly native species.

The Lower Canal, together with the Boral Quarry site to the west, contains over 50% of the native plant species recorded for the Holroyd LGA (NPWS 1997).

2.3 Conservation Significance Of The Lower Canal Vegetation

2.3.1 Plant Species

The surveys by Thomas (1993) and James (1994) recorded a total of 136 native plant species within the Lower Canal corridor, including 2 nationally rare and endangered species and 33 species that are considered to be vulnerable and inadequately conserved in Western Sydney.

The two plant species of national conservation significance (as listed by Briggs and Leigh 1996) are:

Rice Flower *Pimelea spicata* ROTAP Code 3ECi, Schedule 1 TSC Act (Endangered)
Downy Wattle *Acacia pubescens* ROTAP Code 2VCa, Schedule 2 TSC Act (Vulnerable)

> *Pimelea spicata* only occurs on shale soils and was once widespread on the Cumberland Plain. Clearing for farming and later residential development has reduced its occurrence to only a few small populations, some of which continue to be threatened with destruction by development or weed invasion. The species occurs at one site in Section 6 of the canal corridor with a population of around 200 plants (NPWS 1997). This population is one of the largest in the Sydney region (NPWS 1997).

Acacia pubescens occurs on shale soils and has also has its distribution reduced by farming and residential development. Two populations occur within the Lower Canal corridor; in Sections 2 and 3.

A further three species are regionally rare and vulnerable and of particular conservation significance in Western Sydney (Benson and McDougall 1991). These are:

Native Pennyroyal *Mentha satureioides*,
Wild Sorghum *Sorghum leiocladum*, and
the pea flower *Zornia dyctiocarpa*.

A further 30 species found in the Lower Canal corridor are considered by Benson and McDougall (1991) to be vulnerable and inadequately conserved in western Sydney.

James (1994) states that:

"The high number of vulnerable and inadequately conserved species recorded from the Canal and the occurrence of the rare and endangered *Pimelea spicata*...and *Acacia pubescens*..., highlight the outstanding conservation significance of the area."

Many more species of native plants that have not been recorded in the corridor are likely to regenerate from the existing seed store in the soil if given the opportunity.

2.3.2 Plant Communities

The Grey Box Woodland community is part of the Cumberland Plain woodlands and was previously widely distributed across Western Sydney. Today it occurs as usually small, isolated remnants. These remnants show significant variability over even short distances (NPWS 1997). The Grey Box Woodland community type is listed on Schedule 1 Part 3 Endangered ecological communities of the *Threatened Species Conservation Act 1995* and is protected under that Act.

The Lower Canal corridor has been listed as one of the key core biodiversity areas for Grey Box Woodland in the Western Sydney region by the *Urban Bushland Biodiversity Study* (NPWS 1997). Core biodiversity areas are key sites containing exemplary remnants of plant communities not represented, or very poorly represented in the NPWS estate in Western Sydney, and considered endemic to the region (NPWS 1997). No area of Grey Box Woodland, apart from an insignificant area in Windsor Downs Nature Reserve, is currently conserved.

The botanical conservation significance of the Lower Canal corridor is therefore very high and provides outstanding scientific and educational values. These values can be significantly reduced however through inappropriate bushland management techniques. The use of the corridor for passive recreation purposes is not incompatible with the conservation objectives of the site.

2.4 Wetlands

The two wetlands identified in the Canal Reserve Action Group (CRAG) report, and the supporting letter from the Cumberland Bird Observers Club, located behind Munro Street and at the corner of Gipps Road and Hyland Road are not within the Lower Canal study area. These areas are within the Gipps Road Open Space area under the care and control of Holroyd Council.

These wetlands are reported to have been created by seepage from the canal when it was in use. However, the three drainage gullies that feed natural runoff from Prospect Hill under the canal appear to have a significant input to the wetlands. Further investigations would need to be undertaken to determine the impact of the removal of the water seepage from the canal on these wetlands on vegetation and fauna abundance and diversity.

No proposals for the retention or enhancement of these wetlands is contained in the Plan Of Management for the Gipps Road Open Space area.

The removal of weed species from the drainage lines in the canal corridor and their restoration with locally endemic native species would not effect the existing water flows into the wetlands.

2.5 Heritage Plantings

Historical landscape plantings within the Lower Canal corridor include:

- A row of Sugar Gum *Eucalyptus cladocalyx* (from South Australia) along the southern side of the canal service track in Section 6. These may have been planted soon after the construction of the canal in 1888 and are of heritage value. Within the last 10-20 years, some of the Sugar Gum trees have apparently been replaced by other non-endemic species, including Spotted Gum *Eucalyptus maculata*, Yellow Bloodwood *Corymbia eximia*, and Lemon-scented Gum *E. citriodora*, as they have died (Thomas 1993).

- A row of Washington Palms *Washingtonia sp.* and Canary Island Palms *Phoenix canariensis* and one Kurrajong *Brachychiton populnea* near the screen chamber at Section 1, near the Pipehead buildings and infrastructure.

2.6 Weeds

Weed species occur throughout the corridor, with the highest concentrations occurring along the residential and other boundaries, disturbed soil profiles (earthworks for the canal, aqueduct and bypass pipeline), and along drainage lines.

The major weeds along drainage lines are Blackberry *Rubus fruiticosus*, Small-leaved Privet *Ligustrum sinense*, Large-leaved Privet *Ligustrum lucidum*, Lantana *Lantana camara* and Crofton Weed *Ageratina adenophora*. In drier areas, African Olive and grasses such as *Chloris gayana* and Kikuyu *Pennisetum clandestinum* are most common.

Weeds are also common around the base of most mature trees, where mowing has not been possible. The most common species being African Olive *Olea europaea* subsp. *africana* and Asparagus *Protasparagus officinale*.

The native horticultural specimens that have been recently planted within the corridor, such as the Melaleucas around the stormwater detention basin in Section 5 are also considered to be weeds in the context of the botanical integrity of the corridor and should be removed.

Methods for the management of the common weeds in the Lower Canal Corridor are listed in Appendix 2.

2.7 Creeklines

Only two major creeklines occur within the canal corridor;

- the main channel leading into the wetland behind Munro Road, and
- the creekline near the canal viaduct.

The creekline that leads to the wetland includes a channel and basin upslope of the canal that is well vegetated with large Forest Red Gums *Eucalyptus tereticornis*, and Hickory Wattle *Acacia implexa* forming an upper and mid strata. Other native shrubs, herbs and grasses also occur in this area. Weeds are also prolific in this area as a result of the moist sheltered conditions, including Small-leaved Privet, Large-leaved Privet, African Olive, and Lantana. The lower section of this creekline, downslope of the canal is heavily overgrown by Blackberry, Crofton Weed and other weeds and will require the removal of weeds, the protection of exposed soil against erosion and the planting of some native shrubs to attempt to shade out further weed seedlings.

3.0 KEY NATIVE FLORA MANAGEMENT ISSUES

The key native flora issues associated with the Lower Canal corridor are:

- Protection of the populations of the nationally threatened species *Pimelea spicata* and *Acacia pubescens*.
- Management of the populations of *Pimelea spicata* and *Acacia pubescens* to retain and potentially increase their size.
- Retention of the existing natural changes in plant alliances along the canal corridor.
- Protection of existing regrowth areas, and other areas of high natural regeneration potential. These areas must include the locations of the regionally rare and vulnerable species Native Pennyroyal *Mentha satureioides*, Wild Sorghum *Sorghum leiocladum*, *Brachycome aculeata* and the pea flower *Zornia dyctiocarpa*.
- Provision of interpretative signage.
- Supplementary planting of locally endemic tree species in some areas to link tree canopies or to provide shade in existing open space areas to be used for recreational purposes.

- Compatibility between biological conservation objectives for the Gipps Road Open Space Plan Of Management.
- Weed eradication and control.
- Retention of the historical non-endemic native tree plantings, including the Sugar Gums.
- Replacement of historical Sugar Gum tree plantings in Section 6 with the same species as they die.
- Retention and enhancement of historical precincts through mixed native plantings/ regeneration and exotic plantings.
- Gradual removal of weed species and thickets along watercourses so that native bird habitat is gradually replaced by native species rather than habitat being immediately removed and the wildlife displaced.

4.0 OPPORTUNITIES AND CONSTRAINTS

4.1 Opportunities

- Consolidation and enhancement of the existing botanical conservation values of the site.
- Provision of recreational opportunities in a woodland setting typical of the natural vegetation that originally occurred throughout the area.
- Integration of the urban recreational potentials and other uses (including a short length of a proposed public transport corridor) with the conservation values of the site.

4.2 Constraints

- Pedestrian and park user safety.
- Bushfire threat.
- Populations of rare plants.
- Need to allow regeneration of native bushland by fencing off areas.
- Need to maintain the integrity of the existing natural species distribution and associations for scientific and educational purposes.

5.0 NATIVE FLORA MANAGEMENT PLAN

Strategy Overview

The strategy for the rehabilitation and management of the native vegetation cover and the floristic diversity in the Lower Canal corridor is the use of "assisted natural regeneration". This involves principally fencing off of areas and the cessation of mowing in those areas. This method exploits the existing factors which result in natural regeneration. The cessation of mowing in many areas has already resulted in significant regeneration of native species. This method also reduces the costs associated with planting and maintaining plantings.

The regeneration of the native vegetation would aim to create a largely continuous woodland canopy, with a native understorey of variable species mix and height. The woodland corridor is not proposed to occupy the entire width of the canal corridor, but be created as a meandering woodland corridor that criss-crosses the

canal and allows ample space for open recreation areas, including historic precincts (Figure 3). It would also allow for the provision of lightly wooded areas suitable for picnicking under the shade of trees. The tree canopy of the woodland would therefore be linked through the whole corridor, including across the canal. The understorey of the woodland would not be continuous but would be broken by the canal and any pathways, cycleways or maintenance roads.

The infilling of parts of the canal would enable the understorey to be continuous in some sections and would assist in the movements of terrestrial fauna.

The safety of pedestrians and cyclists using the corridor has also been considered in the plan. In this respect the meandering bushland corridor would reduce the length of areas enclosed by bushland and improve the visibility of park users to adjacent residential areas. Although the Grey Box Woodland does not naturally have a dense understorey and the visibility (and hence safety) is high, regrowth areas may be dense for some time.

The cessation of mowing in some areas along the canal has resulted in the strong regrowth of native tree, grass, herb and some shrub species. The regrowth shows a high diversity of species given the long history of frequent mowing. Even in areas that appear to have been mown within the last few weeks, regrowth is well advanced. The principle method for re-establishing the native flora along the canal corridor is therefore to fence off areas and to stop mowing in those areas to allow natural regrowth to occur.

6.0 REGENERATION AND REVEGETATION CONSIDERATIONS

6.1 Fire

The use of fire as a tool in natural regeneration of the native bushland should be considered in consultation with Sydney Water, the National Parks and Wildlife Service, and the local bushfire brigade and/or NSW Fire Brigades.

With the revegetation of the corridor, the danger of bushfires will increase and hazard reduction burns are likely to become necessary at some stage. The use of fire would serve the dual purpose of reducing fuel levels and assisting the natural revegetation of the corridor.

Native sclerophyll forests and woodlands are adapted to fire as part of their natural cycle and many species need either fire or very dry conditions to split woody cones or capsules and release their seeds. Fire also clears the ground of leaf litter, providing open areas for seedling growth (bare soil favours small seeds such as eucalypts), stimulates seed germination and provides an influx of nutrients to the soil (Buchanan 1989). Fire is also effective in controlling many common weed species by killing the mature plants and the seed store in the ground. In the absence of fire the native bushland will survive but will become increasingly dominated by a smaller range of native species (Benson and Howell 1990). Moist sites such as the creeklines in the canal corridor, are particularly susceptible to the dominance of weeds such as Privet, Lantana and native species such as *Pittosporum undulatum* (Benson and Howell 1990). This effect is already evident in the two main creeklines in the canal corridor; in Section 6 on the northern side of the canal, and in Section 5. In other areas species that are able to resprout, such as

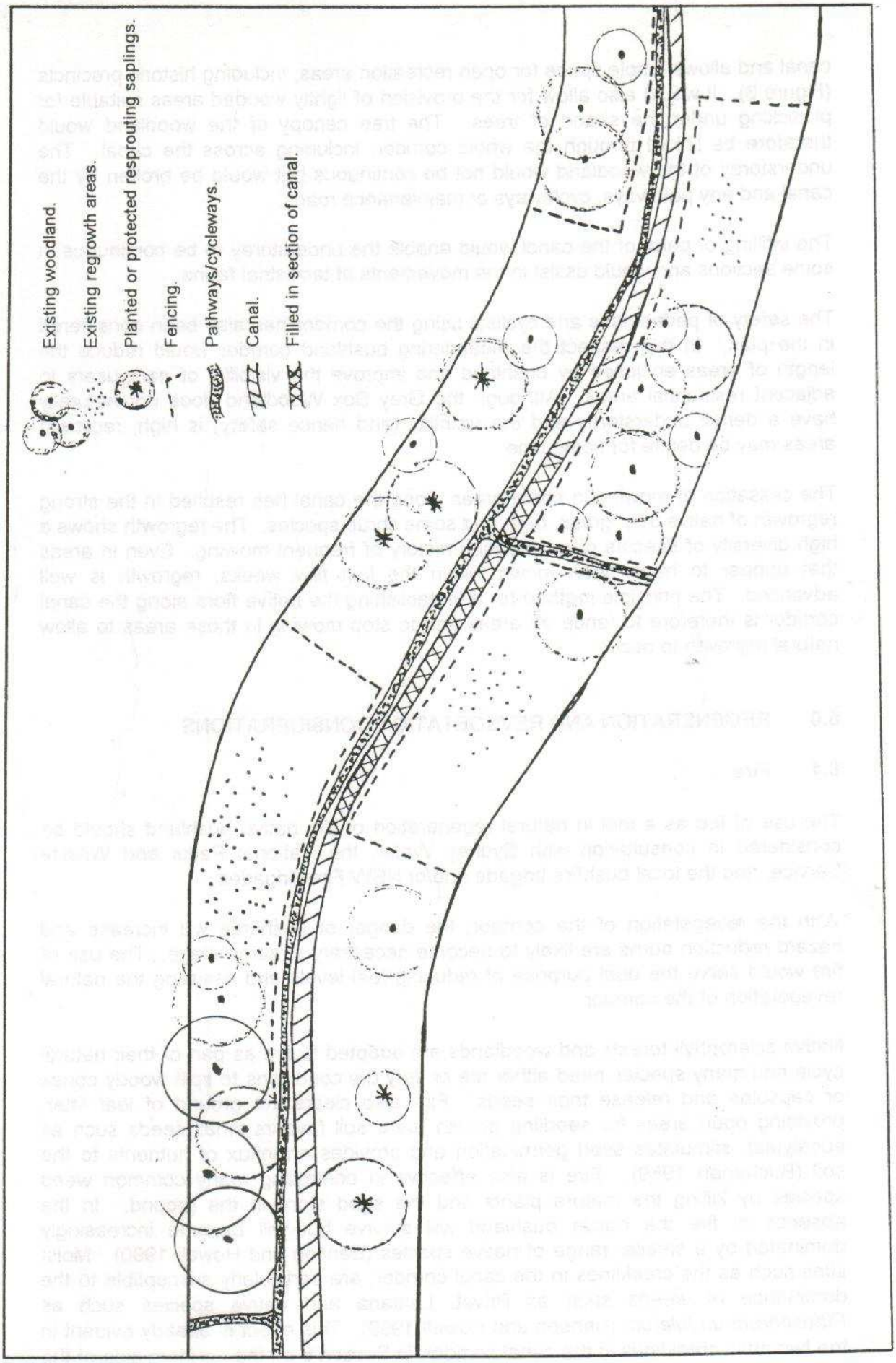


Figure 3 : Recommended Rehabilitation Layout

Bladey Grass and Bracken Fern will be favoured over plants needing to reseed (Benson and Howell 1990).

Any proposed controlled burning of the bushland remnants within the corridor should be undertaken according to the ecological needs of the vegetation. In this respect the following considerations are necessary: frequency, season intensity and location. In the situation of the Lower Canal, it will not be possible to undertake high intensity fires due to proximity of residential areas, nevertheless some changes in intensity should be possible.

Frequency: Burning should not occur every year. If burns occur at too regular an interval some species may be disadvantaged and reduced or even wiped out in the long term. Different species require different periods between fires to enable them to set seed.

Season: Burning should not occur at the same time of year, rather it should be undertaken say in spring during one year and early autumn the next time it is burnt. Burning in late autumn or winter may result in conditions that are too cold for successful germination and also leave bare erodible soil for several months (Buchanan 1989).

Location: Regenerating areas should not be burnt all in the same year. The areas to be burnt should be assessed for their level of regrowth and the available fuel. This approach would also reduce the amount of smoke created during any one time and maintain local air quality to acceptable levels.

In addition, the timing of a fire should consider the native fauna likely to occur in the area. Burning in winter, when most hazard reduction burning occurs, coincides with a lowered activity level for many animals, when they are least able to escape the flames. Some animals such as bats, reptiles and frogs enter torpor and are particularly vulnerable during winter.

6.2 *Pimelea spicata*

Studies of two populations of the rare plant *Pimelea spicata* have shown that it responds well to burning, with vigorous regrowth, prolific fruiting and numerous seedlings occurring at known sites (Nash and Matthes 1993). The use of fire to suppress weeds at the *Pimelea spicata* site should be investigated further with the National Parks and Wildlife Service and the Sydney Royal Botanic Gardens.

The site in the canal corridor is affected by Fennel and African Olive, both of which are reduced by fire.

A site-specific burn could be undertaken at an early stage of the *Pimelea spicata* site management, before other areas are considered for burning.

A Plan of Management specific to the population of *Pimelea spicata* at this site should be prepared in co-operation with the NSW National Parks and Wildlife Service before any burning or other management practices other than fencing is undertaken.

Potential Strategy

In the case of the canal corridor, a preferred strategy may be to allow natural regeneration to occur in fenced most areas for up to five years before it is burnt, while the creeklines and the *Pimelea spicata* site could be burnt as soon as possible to help remove weeds and stimulate native seeds to germinate. Very little fuel is currently available and the bushfire threat is very low. The timing of burning should be dictated by the level of regrowth, the time of year and the amount of fuel available.

6.3 Planting Of Trees In Recreational Areas

If open areas are required to be planted with trees to provide some shade it is recommended that only locally endemic tree species such as *Eucalyptus moluccana*, *E. tereticornis* and *E. fibrosa* are used. These should be propagated from seed collected in the Lower Canal corridor to maintain the genetic integrity of the area. Alternatively, already established saplings that are currently resprouting after mowing could be surrounded by a protective fence to prevent further mowing, and left to grow.

6.4 Weed Management

The management of weeds within the Lower Canal corridor should take several forms according to:

- the habitat,
- the level of native species diversity,
- whether rare native species occur, and
- level and type of weed infestation.

In all cases however, at least one weed management officer or supervisor competent in identifying between weeds and native species should be present at all times of weed removal.

Damp or wet areas such as along drainage lines are usually much more densely invaded by weed species, due to higher moisture and nutrient levels, than drier areas. In some areas, weed species may comprise almost the entire vegetation cover. The seeds of native plant species may still be present in the soil however and topsoils should be retained and protected from erosion. Weed seeds will also germinate however, and further weeding would be necessary after the initial removal of mature weed plants.

In areas such as the drainage line in Section 6, near Prospect Reservoir where the growth of woody weeds is dense, initial weed removal could be more "heavy handed" than in areas of predominantly native regrowth. The cutting out and poisoning of the stumps of woody weeds, or the use of fire to kill them should be investigated at a more detailed Weed Management Plan stage. Any method used should be undertaken so that the habitat of common native fauna such as wrens is not totally removed unless other habitat is available nearby.

The drier mid to upper slopes of the canal corridor are less densely invaded by weeds and more time consuming and careful methods must be employed.

Some methods for the removal of weeds occurring in the corridor are provided in Appendix 2.

6.5 Fencing

Fencing should be aesthetically compatible with a natural bushland recreational park and need only be of a structure that delineates the regeneration sites and dissuades people from entering the areas. The fencing must also allow any terrestrial fauna to freely move through it. Steel star picket fencing with occasional rough cut timber posts and strand wire would be suitable.

6.6 Interpretative Signage

Signs that provide information on the reasons for fencing off regrowth areas should be erected. Details of the populations of the rare plants *Pimelea spicata* and *Acacia pubescens* should not be provided on signs. A good example of a suitable sign is located at a fenced regrowth area at the entrance to the Scout Hall off Gipps Road.

Interpretative signage providing information on the type of vegetation occurring in the corridor and its once widespread distribution, the history of its clearance, its conservation value, and identifying the main species present would help to provide an appreciation of the botanical and ecological values of the corridor.

6.7 Adjacent Open Space

The only area of zoned open space near the Lower Canal corridor is the Gipps Road Open Space area. The Plan Of Management for this area (Holroyd Council 1997) shows areas of locally endemic native woodland plantings along the boundaries with the canal corridor. The proposed regeneration of native woodland along the canal corridor in this area is consistent with this plan.

6.8 Educational Resource

The Lower Canal Corridor provides excellent opportunities for both general environmental education purposes and more specifically the ecology of the Western Sydney region. Four schools are located adjacent to the corridor; Merryland High School, Holroyd High School, Sherwood Grange Public School and Dahlia Street Public School, and others are within a close proximity to the corridor.

There is the potential for these schools and other groups such local bushcare groups and Scouts to become involved in the regeneration and maintenance of the corridor.

Long-term studies of the natural regrowth of Grey Box Woodland or the effects of different fire regimes may also be undertaken in the corridor.

ISSUE	STRATEGY	METHODS	TIME FRAME
Protect populations of *Pimelea spicata* and *Acacia pubescens*.	• Fence the populations.	Use star picket and strand wire fencing.	Immediate.
Protect areas of existing regrowth and areas to be allowed to naturally regrow.	• Fence off those areas. • Investigate the use of fire for regenerating native species.	Use star picket and strand wire fencing.	Immediate.
Suppress weeds in and around the sites of *Pimelea spicata* and Acacia *pubescens*, and assist in increasing their population size.	• Liaise with the National Parks and Wildlife Service Threatened Species Unit as to the best methods for suppressing weeds in and around the sites of *Pimelea spicata* and *Acacia pubescens*, and increasing the population size. • Potentially use fire at the *Pimelea spicata* site, followed by direct application poisoning of woody weeds such as African Olive.		
Provide interpretative signage.	• Install signs at regrowth sites (not threatened species sites) providing information on of the reason for fencing off those areas. • Install signs regarding vegetation type, conservation significance etc.		After fencing is completed.
Ensure any imported fill is clean and weed free.	• Use freshly ripped or excavated material.	Obtain material from Boral Quarry.	

ISSUE	STRATEGY	METHODS	TIME FRAME
Ensure any imported topsoil is clean, weed free and of the same type as naturally occurring in the corridor.	• Use freshly stripped topsoil from local sites where natural bushland is to be removed. • Use clean, weed free topsoil from other development sites in the local area.	Locate development sites where suitable material can be obtained.	
Remove weed species from the site.	• Gradually remove weeds from the site, starting with areas of low weed infestation. • Gradually replace weed tree species along drainage lines with native species by cutting out a few weed trees and replacing native species in their place if necessary. • Investigate the potential use of fire to reduce weeds, particularly in moister sites such as drainage lines.	• Cutting and poisoning of weed trees and shrubs. • Fire. • Bradley method.	Immediate. Long-term.
Supplementary tree planting.	• Undertake supplementary tree planting in picnic areas if required, 'connecting areas' between woodland and around the main pedestrian and cycleway.	• Planting of trees propagated from seed obtained from trees in the canal corridor. • Protect resprouting tree saplings from mowing by staking or fencing.	Immediate and Medium-term.

ISSUE	STRATEGY	METHODS	TIME FRAME
Remove recently planted non-endemic native species.	• Remove native plants that are not endemic to the site. • Maintain the scientific and conservation value of the corridor.	Physical removal of the plantings.	Immediate.
Participation of local groups.	• Encourage the participation of CRAG, local bushcare, community groups and schools in the weed removal and supplementary tree planting scheme.	Direct approaches to community groups and schools.	Immediate to long-term.

7.0 FAUNA ASSESSMENT

In order to assist in the production of the Masterplan and Plan of Management, the diversity of fauna species that utilise and or rely on the habitats present within the Lower Canal area was determined. By identifying the range of species present within, and adjacent to the study area, and those likely to occur, rehabilitation strategies and management proposals could be developed. These strategies are designed to ensure that the present diversity of native species is maintained, by providing a range of resources which are important to the life cycle requirements of those species identified. These life cycle requirements include feeding, roosting, sheltering and breeding areas. By providing these resources, it is expected that the fauna value of the Lower Canal area would be maintained, and that opportunities for an increase in the diversity of native species provided.

7.1 Method Statement

To determine the range of native species known, or likely to occur within the study area, a field survey and literature search was undertaken. Field surveys were undertaken on the 17 February and 4 March 1998 and included a survey of both the habitats present within, and adjacent to, the Canal corridor. The adjacent areas were assessed to determine if there were any opportunities to link these sites with the habitats present within the Canal corridor.

Techniques employed for this investigation included:

- habitat assessment,
- direct observation,
- bird watching,
- identification of amphibian calls,
- identification of indirect faunal evidence (such as scratching, scats and tracks), and
- litter and ground debris searches for amphibians and reptiles.

It is noted that no nocturnal work was undertaken. Given the habitats present within the Canal corridor it is expected that, if this was carried out, that microchiropteran (small insectivorous bats) bats and owls would be detected and the diversity of frog species would be increase.

When surveying the Canal corridor, each vegetation stand present within and adjacent to the survey area was walked and fauna species observed or indicated identified. This method enabled all fauna habitats present within and adjacent to the study area to be assessed and surveyed. During the survey sessions, several ten minute listening periods were undertaken at around 250 metre intervals, thereby enabling species not visible to be detected by their distinctive calls.

Other species previously recorded in the region, but which were not observed during the present study, were identified through reference to the National Parks and Wildlife Service Atlas of NSW Wildlife (NPWS 1998), the National Parks and Wildlife Services Western Sydney Urban Bushland Biodiversity Survey Report (NPWS 1997), the Gipps Road Open Space Plan of Management (EDAW 1997), a report prepared for several proposed drying beds within a portion of Prospect Reservoir (Thomas and Engel 1997) and reports prepared for the Lower Canal area

itself (CRAG 1996, Thomas 1993). Discussions were also held with representative of Sydney Water to determine the effectiveness of a habitat recreation programme within a section of the Canal itself. This section is currently covered and it was thought that it may provide summer roosting habitat for the Common Bent-wing Bat (*Miniopterus schreibersii*). This bat is threatened with extinction and is therefore listed under Schedule 2 of the *Threatened Species Conservation Act 1995*. Those species identified during the literature review process are presented in Appendix 3.

Conventions used

Identifications were made according to nomenclature in :

- Cogger (1992)- reptiles and frogs
- Simpson and Day (1996)- birds
- Strahan (1995)- mammals
- Triggs (1996)- identification of scats, tracks and markings.

The conservation significance of native species is determined with reference to the *Threatened Species Conservation Act 1995*, Holroyd Councils State of the Environment and the National Parks and Wildlife Services Western Sydney Urban Bushland Biodiversity Survey Report (NPWS 1997). These references were utilised to determine the State, regional and local conservation significance of native species recorded or expected.

7.2 Results

7.2.1 Habitat Types Available For Native Species

Within the boundaries of the Lower Canal area a number of habitats types occur. These include:

- Open woodlands;
- Grasslands; and
- Aquatic Environments.

Adjacent to these, commercial forests, grasslands and disturbed areas are present.

Each of these habitats is described below, along with value to native species. A photographic record of certain sections of the Canal area is provided for reference.

Open Woodland

Patches of open woodland are present within the Canal corridor, with the more developed stands occurring to the west of Bayfield Road. Based on the structure of the habitats present, the open woodland can be divided into two, the areas to the west of Gipps Road and the areas to the east. Trees to the west of Gipps Road are around 25 metres in height, support numerous small (0-100 mm in diameter) to medium (100-250 mm) sized hollows and are of medium density. The understorey is a medium to high density layer of native and exotic shrubs, 3 metres in height. The ground cover consists of saplings, exotic grasses and forbs. Leaf litter and ground debris is common.

The woodland to the east of Gipps Road supports trees which are smaller. These trees are around 20 metres in height, again of medium density but support either small or no hollows. The understorey in these areas is either cleared or consists of a

PHOTOGRAPHIC RECORD OF STUDY AREA

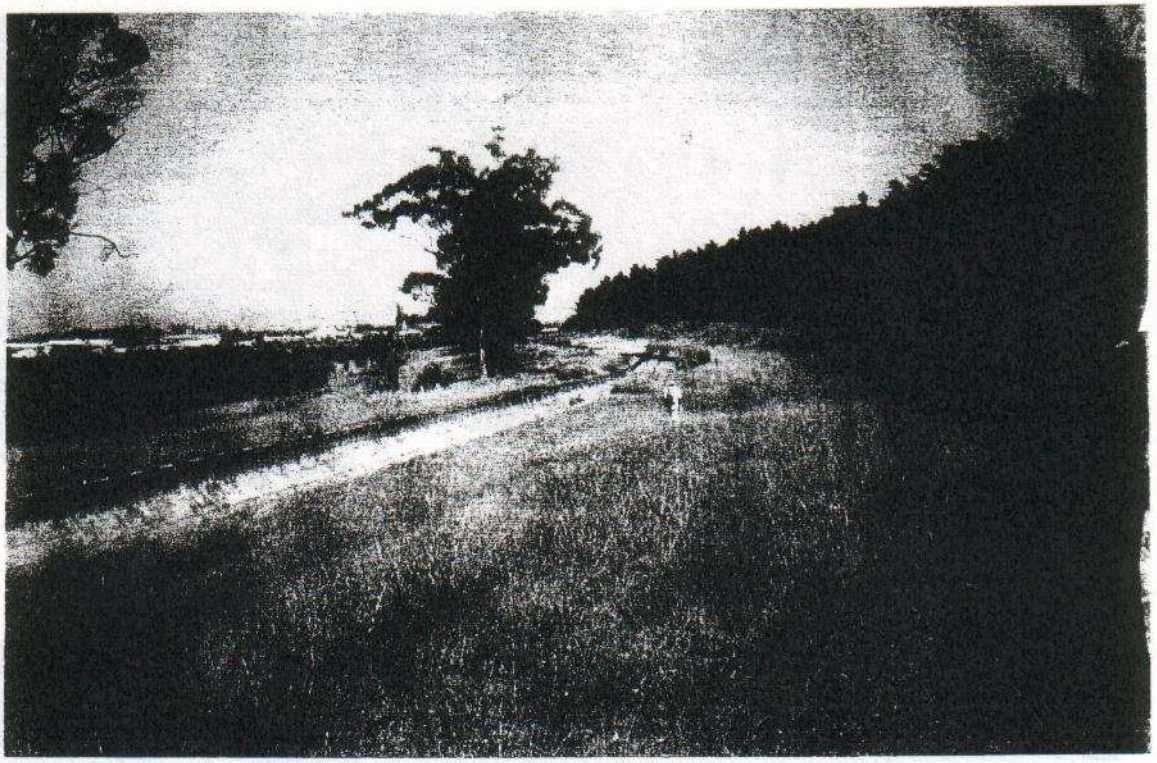


Plate 1 : Looking south west, along canal within Section 6.0.

Plate 2 : Looking south, along drainage line within Section 6.0.

PHOTOGRAPHIC RECORD OF STUDY AREA

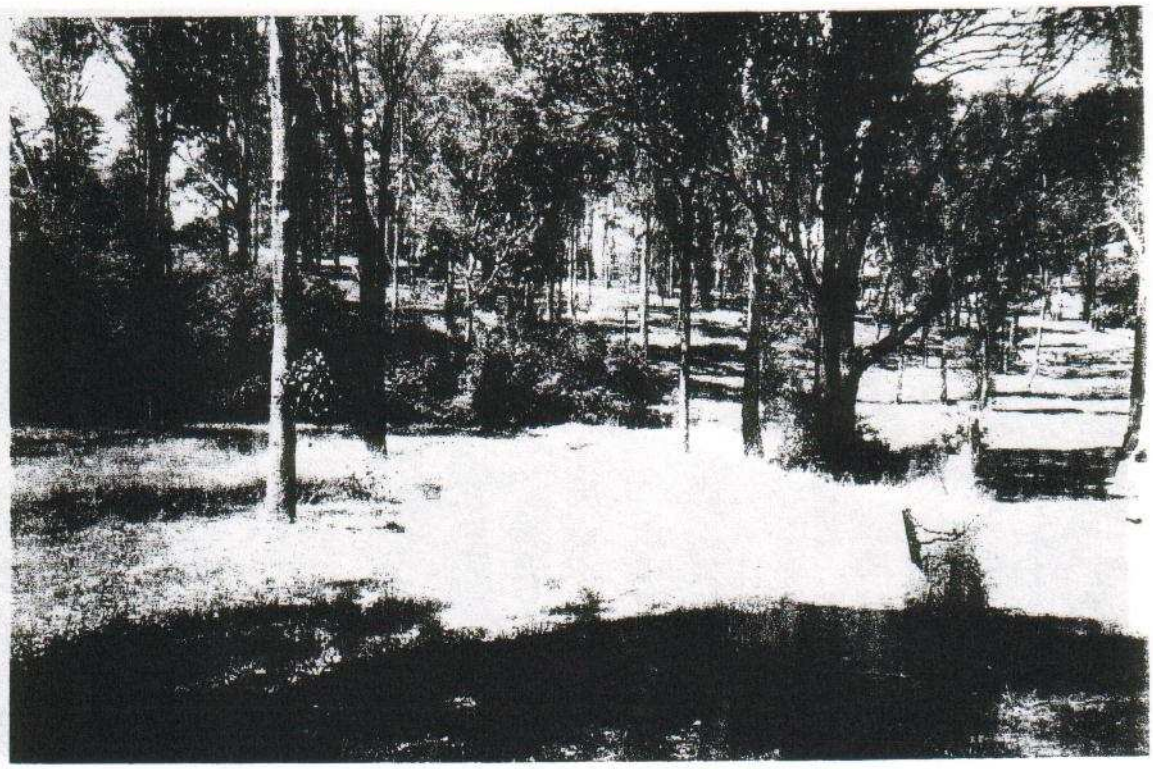


Plate 3: Looking east, along Macquarie Road, within Section 5.0.

sparse density layer of exotic and native shrubs. These shrubs are approximately 1.5 metres in height. The ground cover consists of exotic and native grasses, weeds and forbs. This is a medium to sparse density layer. Leaf litter and ground debris are not as common, presumably due to maintenance of the area.

This habitat type is expected to provide foraging, sheltering, nesting and breeding resources for a variety of birds, reptiles and mammals. In relation to the mammals, these including a number of the microchiropterans.

Grasslands

The grasslands occur throughout the Canal corridor and include areas of both native and exotic species. Where not maintained, the grassland layer is of medium to high density. Within the non-maintained sections of this habitat type isolated trees and shrubs, forbs and weeds are present. Within this community, trees vary in height and can be up to 25 metres. Saplings and exotic shrubs/weeds can be to 1 metre.

The grasslands provide sheltering resources for a range of reptiles, foraging resources for a variety of the birds and microchiropterans and nesting materials. Though consisting predominantly of exotic plant species, this habitat type is considered to provide an important array of resources necessary for the life cycle requirements of a number of native fauna species. Management of the Canal area for native fauna species should therefore include the retention of "unkept" grassland areas.

Where not maintained, adjacent grasslands areas support a similar habitat structure. In these areas the density of the grassland and weed layers are greater.

Aquatic Environments

Excluding the Canal itself, which at the time of report preparation was either dry or held a small amount of water, the only other water bodies are several small drainage lines. These drainage lines were either dry, or carried a small amount of water. Emergent aquatic vegetation is present at some locations along these drainage lines, though the main vegetation is exotic grasses and weeds. Riparian vegetation consists of casuarina and eucalypt saplings, 20 metres in height. The understorey is a medium to high density layer of exotic and native shrubs, 2 metres in height. The middle and ground cover layers are a high density of weeds, exotic shrubs and grasses and forbs. The tree cover along the length of the drainage lines is not continuous, and occurs mainly as isolated pockets.

Those water bodies observed did not appear to support any populations of exotic fish (*Gambusia* spp.). The lack of occurrence of this fish species suggests that habitat value of these drainage lines is relatively high and would be suitable for a number of frog and aquatic invertebrate species.

It is not known if the drainage lines are fed by runoff from the surrounding areas, or water seeping out of the Canal itself but considering the topography of the area, and the drainage works constructed upslope of the Canal to divert water below this structure, it is likely that the flow which feeds these drainage lines is from natural runoff.

Commercial Forests
This habitat type occurs don the slopes of the Prospect quarry and is dominated by commercial pine species. These trees are approximately 15 metres in height and of medium to sparse density. The understorey is essentially cleared and the ground cover appears to be regularly maintained.

As with the open woodland community, this habitat type would provide nesting and foraging resources for a number of native species, including birds, reptiles and microchiropterans. Several of the bird species, mainly the parrots and cockatoos, are also likely to use the pine cones as an occasional food sources.

Disturbed Areas
The disturbed areas include residential properties, school grounds, streetscape plantings and industrial areas. Within these areas a range of horticultural and landscape plantings, streetscape areas and maintained lawns are present. Given the limited amount of extensive woodland in the region, these areas are expected to be utilised during foraging periods by a range of birds and microchiropterans, and these animals, along with a number of reptiles and frogs may also roost, shelter and breed in gardens and roof cavities.

7.2.2 Value Of Habitat Types For Native Species

Due to the limited amount of natural foraging, roosting and breeding habitat in the Holroyd area, the more developed stands of fauna habitats present within the Lower Canal corridor are considered to be of local and regional conservation significance. These more developed stands are those which occur to the west of Bayfield Road. The association of the woodland communities, the adjacent grasslands and aquatic environments is considered to provide resources which are important to the life cycle needs of those birds, mammals, reptiles and frogs known or expected to occur. These resources include roosting, breeding and nesting sites, foraging areas and the provision of nesting materials. To maintain the current level of native biodiversity, observed or known to occur in the study area, it is recommended that this mix of habitat types be maintained. Given the existing "patchy" nature of the fauna habitats present, the location of passive recreation facilities or other compatible land uses is considered possible.

7.3 Field Survey Results

During the present study, 1 native mammals, 32 native birds, 3 reptiles and 2 frogs were recorded (Appendix 3). In regards to the detection of those species observed during the current survey; the Common Brushtail Possum (*Trichosurus vulpecula*) was indicated through the observation of distinctive scratchings on several of the smooth barked trees; all birds and reptiles were observed; the Common Eastern Froglet (*Crinia signifera*) was heard calling from several of the drainage lines and the Brown-striped Frog (*Limnodynastes peronii*) was hand captured. Of the animals recorded during the current survey, one, the Yellow-rumped Thornbill (*Acanthiza chrysorrhoa*), is of regional conservation significance. This species has been identified as being of regional significance because its population numbers have declined due to habitat removal, fragmentation and loss (NPWS 1997). This bird species inhabits open forests, woodlands and grasslands and favours "edge country", that is where woodlands and grasslands meet (Frith 1977). The Yellow-

rumped Thornbill feeds on insects, spiders and seeds and nests in the outer foliage of a tree or large shrub (Frith 1977, Simpson and Day 1996). Feeding occurs in trees, shrubs or on the ground (Frith 1977).

Previous studies undertaken either within the Lower Canal area or in adjacent areas have identified an additional 1 native mammal, 105 native birds, 7 reptiles and 3 frogs (Appendix 3). Of these animals known for the region, 3 are listed under the Schedules to the *Threatened Species Conservation Act 1995* and 23 are considered to be of regional conservation significance as indicated in the National Parks 1997 report (Table 1).

Through reference to the National Parks and Wildlife Service's database, one invertebrate of conservation significance, the Large Land Snail (*Meridolum corneovirens*), was identified as having been found in the vicinity of the Lower Canal. This species is listed as Endangered under Schedule 1 of the *Threatened Species Conservation Act 1995*. *Meridolum corneovirens* is a small snail, approximately 22 millimetres in height, elliptical in shape and found in remnant pockets of bushland on the Cumberland Plain (Australian Museum pers.comm.). Unlike introduced snails, this snail has no patterning whatsoever and is pale to slightly yellow. The species is never seen above ground and is usually found buried in the loose soil under logs, bark, clumps of grass and sometimes stones (NSW Scientific Committee Final Determination, Australian Museum pers. comm.). This species is threatened through reductions in habitat and current development pressures (NSW Scientific Committee Final Determination).

Table 1 : Species of Conservation Significance Recorded Within Either the Study Area or Surrounding Region

Large Land Snail	*Meridolum corneovirens*	Schedule 1 *TSC ACT 1995*
Regent Honeyeater	*Xanthomyza phrygia*	Schedule 1 *TSC ACT 1995*
Swift Parrot	*Lathamus discolor*	Schedule 2 *TSC ACT 1995*
Powerful Owl	*Ninox strenua*	Schedule 2 *TSC ACT 1995*
Stubble Quail	*Coturnix pectoralis*	Regionally Significant
Brown Quail	*Coturnix ypsilophora*	Regionally Significant
Great Crested Grebe	*Podiceps cristatus*	Regionally Significant
Great Egret	*Ardea alba*	Regionally Significant
Nankeen Night Heron	*Nycticorax caledonicus*	Regionally Significant
Grey Goshawk	*Accipiter novaehollandiae*	Regionally Significant
Peregrine Falcon	*Falco peregrinus*	Regionally Significant
Peaceful Dove	*Geopelia striata*	Regionally Significant
Fork-tailed Swift	*Apus pacificus*	Regionally Significant
Azure Kingfisher	*Alcedo azurea*	Regionally Significant
Striated Pardalote	*Pardalotus striatus*	Regionally Significant
Buff-rumped Thornbill	*Acanthiza reguloides*	Regionally Significant
Yellow-rumped Thornbill	*Acanthiza chrysorrhoa*	Regionally Significant

Fuscous Honeyeater	*Lichenostomus fuscus*	Regionally Significant
Jacky Winter	*Microeca fascinans*	Regionally Significant
Crested Shrike-tit	*Falcunculus frontatus*	Regionally Significant
Restless Flycatcher	*Myiagra inquieta*	Regionally Significant
Rufous Songlark	*Cincloramphus mathewsi*	Regionally Significant
Zebra Finch	*Taeniopygia guttata*	Regionally Significant
Plum-headed Finch	*Neochmia modesta*	Regionally Significant
Chestnut-breasted Mannikin	*Lonchura castaneothorax*	Regionally Significant
Lace Monitor *	*Varanus varius*	Regionally Significant
Common Scaly-foot	*Pygopus lepidopodus*	Regionally Significant
Red-naped Snake	*Furina diadema*	Regionally Significant

* - this species is considered by the author to be extinct in the study region. The last documented record for this animal was in December 1992 (NPWS 1998) and it is expected that such a large and visible reptile would be regularly observed if it was still in the area.

7.4 Other Threatened Species Potentially Occurring In The Region

The Lower Canal area occurs within the known home ranges of a number of microchiropterans (Parnaby 1992, Strahan 1995). Of these animals a number are of conservation concern as identified under Schedule 2 of the *Threatened Species Conservation Act 1995*. If present, those threatened microchiropterans likely to occur would either shelter or roost in the small to medium sized tree hollows, or under loose bark, and most would forage along the woodland edges, over the grasslands, along the drainage lines and/or through/over the woodland canopy. Without more detailed night work the exact species of microchiropteran present within the Canal corridor cannot be determined, but it can be assumed that they would constitute one or more of the threatened woodland dependant, or woodland utilising species (Table 2).

Table 2 : Threatened Microchiropterans Potentially Occurring Within The Boundaries Of The Lower Canal Corridor

Large-eared Pied Bat	*Chalinolobus dwyeri*
Eastern False Pipistrelle	*Falsistrellus tasmaniensis*
Common Bentwing-bat	*Miniopterus schreibersii*
Eastern Freetail Bat	*Mormopterus norfolkensis*
Large Footed Myotis	*Myotis adversus*
Yellow-bellied Sheathtail-bat	*Saccolaimus flaviventris*
Greater Broad-nosed Bat	*Scoteanax rueppellii*

Table 3 : Management Recommendations to Enhance and Protect Threatened, Regionally Significant and Protected Native Fauna

ISSUE	STRATEGY	METHOD	TIME FRAME
Large Land Snail	• Preserve and enhance habitat • Retain Cumberland Woodland • Provide sheltering sites	• Enhance and connect stands of Cumberland Woodland. • Cease mowing under woodland areas. • Cease mowing of regrowth areas. • Retain fallen logs and other natural debris. • Provide sheltering sites (logs, branches, rocks) in stands of woodland. • Retain grassland, woodland edges.	• Endeavour to link patches of woodland over next 5 years. • immediately. • immediately. • immediately. • over next year. • immediately.
Threatened birds	• Provide a relatively continuous canopy through or over which bird can fly. • Ensure that connection to Prospect Reservoir is maintained.	• Link stands of woodland as identified in Flora report.	• Endeavour to link patches of woodland over next 5 years.
Provide roosting and foraging habitat for microchiropterans	• Provide roosting hollows • Provide a relatively continuous canopy through or over which bats can fly. • Maintain the grassland, woodland edge.	• Planting of eucalypts • Erection of nesting boxes • Monitoring of nesting boxes to ensure introduced species does not occur • Restrict moving of grassland, woodland edge.	• immediate and up to 5 years. • immediate and ongoing. • immediate and ongoing. • immediate.
Retain roosting , nesting and breeding habitat for regionally significant birds and reptiles	• Provide stands of native shrubs. • Provide eucalypts. • Maintain some areas of dense grasslands for foraging and nesting needs.	• Establish dense stands of acacias and similar plants at selected locations within study area. • Plant eucalypts and supplement existing stands. • Maintain some areas of existing grassland	• Endeavour to provide natural shrublands over next 5 years. • Endeavour to link patches of woodland over next 5 years.

	• Retain trees with hollows. • Retain dead trees.	areas. • Cease maintaining some of the existing areas of mown grassland. • Maintain existing stands of exotic shrubs till native species have established. • Retain existing natural debris.	• immediately and ongoing • immediate • at least 3 years or till acacias etc form dense stand • immediately and ongoing
Retain foraging habitat for regionally significant birds and reptiles	• Provide shrubs which attract insects. • Provide nectar and pollen producing plants. • Provide woodland areas. • Provide dense stands of plants for small birds to shelter in.	• Plant locally occurring native shrub species including eucalypts and acacias. • Maintain existing privet stands till acacia shrublands are established. • Maintain corridor value of Canal area through supplementary plantings which link woodland patches.	• Endeavour to provide additional woodlands and shrublands over next 5 years. • at least 3 years or till stands of native shrubs become established. • Endeavour to link patches of woodland over next 5 years.

7.5 Fauna Management Recommendations

The following table identifies the management recommendations presented to ensure that the existing fauna assemblages are maintained. The management recommendations presented have been designed to :

a) protected and enhance the habitat value of the area for threatened species; and
b) protected and enhance the habitat value of the area for regionally significant species.

In presenting the following recommendations, efforts have been made to ensure that they are compatible with the "original" fauna habitats present, and the resources these provided to native species, and that they aim to enhance the fauna habitat value for species which would rely on the area for their life cycle needs. For example, the Powerful Owl, though recorded from the Canal area, is unlikely to be a resident species. This species is more likely to have been recorded in the area during one of its foraging movements, and therefor recommendations are presented which assist its movement and foraging patterns, as opposed to its breeding and/or roosting needs.

It has been assumed that measures proposed for the provision of habitat for regionally significant and threatened species would also benefit the protected, though common-to-abundant resident fauna populations.

8.0 SUMMARY OF BUSHLAND MANAGEMENT, OBJECTIVES AND TIME FRAME

8.1 Objectives

To enhance and conserve an endangered ecological community, and its associated flora and fauna assemblages, while providing scope for the passive recreational use of the Lower Canal area. Enhancement measures to include cessation of mowing, enhancement and rehabilitation of regenerating woodlands, connectivity of woodland areas, preservation and expansion of fauna habitats.

In providing management recommendations for the Lower Canal area, measures which preserve this key core biodiversity area and its associated threatened species are presented.

8.2 Detailed Actions

8.2.1 Flora

The Lower Canal area is considered to have high botanical conservation value. the following recommendations are expected to protect and enhance this value, ensuring that a significant regional and state resource is maintained and protected.

- Liaise with the National Parks and Wildlife Service Threatened Species Unit regarding the protection of the populations of *Pimelea spicata* and *Acacia pubescens*. It is the responsibility of the NPWS to prepare a species recovery

plan for these populations and their on-going management should be a co-operative effort between Council, Sydney Water and the NPWS.

- Cease mowing activities in the areas that are to be left to naturally regenerate.
- Identify areas that are to be set aside for conservation purposes and are to be left to naturally regenerate. These must include all of the northern side of the canal, existing areas of regeneration on the southern side, and the areas containing the species *Pimelea spicata*, *Acacia pubescens*, *Zornia dyctiocarpa*, *Sorghum leiocladum*, *Brachycome aculeata*, *Mentha satureioides* and *Eucalyptus fibrosa*.
- Areas set aside for conservation purposes must also preserve the existing change in plant species alliances along the corridor.
- When the Recovery Plans are available, implement protection measures for the populations of *Pimelea spicata* and *Acacia pubescens*.
- Establish buffer zones between regeneration areas and maintained areas.
- Retain the existing historical plantings of Sugar Gum, Spotted Gum, Lemon-scented Gum and Yellow Bloodwood along the upper section of the Canal (Section 6), and the Washington Palms, Canary Island Palms and Kurrajong.
- Prepare a specific weed management program for the site to incorporate progressive weed eradication that does not result in a significant loss of existing fauna habitat and soil erosion.
- The boundaries between conservation areas and passive recreation areas on the southern side of the canal should be fenced to prevent uncontrolled access.
- Non-endemic native species recently planted in certain parts of the corridor and which do not form part of the historical plantings should be removed.
- Ensure sediment contaminated runoff from the development or fill stockpiles during the construction does not enter bushland regenerating areas.
- Provide interpretive signage that explains the importance of the vegetation in the corridor.
- Develop a fire management strategy that addresses the requirements of both the safety of park user and adjacent residential areas, and the ecological requirements of the vegetation in the corridor.

8.2.2 Fauna

To enhance the value of the Lower Canal for native fauna species, the following actions are recommended. Based on the field assessment, and consultation of current literature, the following recommendations are expected to encourage native species and ensure that any threatened animals present in the canal area are protected.

- Enhance and connect stands of Cumberland Woodland.
- Cease mowing under woodland areas.
- Cease mowing of regrowth areas.
- Retain fallen logs and other natural debris.
- Provide sheltering sites (logs, branches, rocks) in stands of woodland.
- Retain grassland, woodland edges.
- Planting of eucalypts.
- Erection of nesting boxes.
- Monitoring of nesting boxes to ensure establishment by introduced species does not occur.
- Establish dense stands of acacias and similar plants at selected locations within study area.
- Maintain some areas of existing grassland areas.
- Maintain existing stands of exotic shrubs till native species have established.
- Retain existing natural debris.

8.3. Priorities for actions / implementation

Action	Time Frame
1.0 Liaise with National Parks and Wildlife Service	Immediately
2.0 Cease mowing in areas of high conservation value	Immediately
3.0 Identify conservation areas, areas to be set aside	Immediately
4.0 Establishment of buffer zones	Immediately
5.0 Retention of historical plantings	Immediately
6.0 Retention of ground debris in areas of high conservation value	Immediately
7.0 Ensure sediment controls are in place	Immediate and ongoing
8.0 Erection of nesting boxes	Immediate, over next year, ongoing
9.0 Monitoring of nesting boxes	Immediate, over next year, ongoing
10.0 Fencing of conservation areas	0 – 1 years
11.0 Implementation of NPWS recovery plans	As available : 0 – 5 years
12.0 Preparation of weed management plan, including removal of non-endemics as locally occurring natives establish.	0 – 5 years
13.0 Provision of interpretive signage	0 – 5 years
14.0 Development of fire management plan	0 – 5 years
15.0 Enhancement of grasslands, woodlands and shrublands	0 – 10 years
16.0 Connection of woodland stands	0 – 10 years
17.0 Connecting woodland areas with other sites in region	0 – 20 years

9.0 REFERENCES

Benson, D. (1992) The natural vegetation of the Penrith 1:100 000 sheet *Cunninghamia* 2 (4) 503-662.

Benson, D. and Howell, J. (1990) *Taken for Granted: The Bushland of Sydney and its Suburbs*. Royal Botanic Gardens, Sydney.

Benson, D. and McDougall, L. (1991) *Rare Bushland Plants of Western Sydney*. Royal Botanical Gardens Sydney.

Briggs, J. and Leigh, J. (1996) *Rare or Threatened Australian Plants*. CSIRO Canberra.

Buchanan, R. A. (1989) *Bush Regeneration Recovering Australian Landscapes*. TAFE Student Learning Publications.

Cogger, H. (1992) *Reptiles and Amphibians of Australia*. Reed Books, Chatswood.

CRAG: Canal Reserve Action Group (1996) *Prospect Lower Canal Lineal Park Development And Management Proposal*.

EDAW (1997) *Gipps Road Open Space Plan of Management*. EDAW.

Frith, H.J. (1977) (Ed) *Complete book of Australian Birds*. Readers Digest, Surry Hills.

McDonald, R.C., Isbell, R.F., Speight, J.G., Walker, J. and Hopkins, M.S. (1990) *Australian Soil and Land Survey Field Handbook*. Inkata Press, Melbourne.

McLoughlin, L. (1998) The impact of planting for restoration of remnant bushland on its scientific and educational values: implications for conservation planning. In *Pacific Conservation Biology*. Vol. 3: 27-38.

Mills, K. (1988) (Ed) *Illawarra Conservation. The Investigation and Protection of the Natural and Human Environment in the Illawarra Region of New South Wales*. Report prepared for the South Coast Conservation Society, the National Parks Association of New South Wales (Illawarra Branch) and the Illawarra Environmental Heritage Committee by Kevin Mills and Associates, Woonona.

Nash, S. and Matthes, M. (1993) *Conservation Research And Species Recovery Plan:* Pimelea spicata. Australian Nature Conservation Agency Endangered Species Program Project No. 308.

National Parks and Wildlife Service NSW (1997) *Western Sydney Urban Bushland Biodiversity Study*. National Parks and Wildlife Service, Hurstville.

National Parks and Wildlife Service NSW (1998) *Atlas of NSW Wildlife – flora*. National Parks and Wildlife Service.

National Parks and Wildlife Service NSW (1998) *Atlas of NSW Wildlife – fauna*. National Parks and Wildlife Service.

Parsons, W. and Cuthbertson, E. (1992) *Noxious Weeds of Australia*. Inkata, Melbourne.

Parnaby, H. (1992) *An Interim Guide to Identification of Insectivorous Bats of South-eastern Australia*. Technical Reports of the Australian Museum No 8.

Simpson, K. and Day, N. (1996) *Field Guide to the Birds of Australia*. Viking O'Neil Victoria.

Soil Conservation Commission of NSW (1993) *Soils: Their Properties and Management*. Sydney University Press in association with Oxford University Press, Australia

Strahan, R. (1995) (Ed) *The Mammals of Australia*. Reed Books, Chatswood.

Thomas, D. (1993) *Lower Canal Vegetation Survey (Prospect Reservoir - Pipehead Guildford)*. Unpublished report to Sydney Water Board.

Thomas, D. and Engel, D. (1997) *Flora and Fauna Survey of Area for Temporary Storage of Prospect Reservoir Water Filtration Plant Residue Material*. Report prepared for the Sydney Water Corporation by David Thomas and Associates, Deniston.

Triggs, B. (1996) *Tracks, Scats and Other Traces: A Field Guide to Australian Mammals*. Oxford University Press, Melbourne.

Acknowledgements

Many thanks to Teresa James, Herbarium Royal Botanical Gardens, for her assistance in the provision of information in regards to plant species present in the Lower Canal Corridor.

APPENDIX 1 : PLANT SPECIES LIST

Key to Status Code

C Conserved
V Vulnerable in Western Sydney (NPWS 1997)
REG Regionally significant species in Western Sydney (NPWS 1997)
3EC Nationally Endangered (Briggs and Leigh 1996)
2VC Nationally Vulnerable (Briggs and Leigh 1996)
* Denoted introduced species

Sites (as per Thomas 1993)
1. Pipehead Section, Guildford
2. Albert Street – Sherwood Road Section
3. Sherwood Road – Betts Road
4. Betts Road – Bayfields Road
5. Bayfields Road – Gipps Road
6. Gipps Road – Prospect Reservoir

Family	Species	Status	Site					
			1	2	3	4	5	6
Acanthaceae	Brunoniella australis	C			+		+	+
Alismataceae	Alisma plantago-aquatica	V						+
Amaranthaceae	Alternanthera denticulata	C						+
Anacardiaceae	*Schinus molle		+		+			
Apiaceae	Centella asiatica	C	+					
	*Foeniculum vulgare							+
Aracaceae	*Phoenix canariensis		+	+				
	* ?Washintonia sp.		+					
Asclepiadaceae	*Araujia hortorum		+	+	+	+	+	+
	Leichhardtia leptophylla	V			+			
Asteraceae	*Ageratina adenophora		+		+			+
	*Bidens pilosa		+	+	+	+	+	+
	Brachyscome aculeata	REG						+
	Calotis lappulacea	V		+	+			
	Chrysocephalum apiculatum	V		+				+
	*Conyza albida		+	+	+	+	+	+
	*Gnaphalium americanum		+		+		+	
	*Hypochoeris radicata		+	+	+	+	+	+
	Senecio hispidulus	V		+	+			
	*S. madagascariensis		+	+	+	+	+	+
	S. quadridentatus	V		+				
	Solenogyne bellioides	V						+
	*Tragopogon porrifolius							+
	Vittadinia muelleri	V			+			
	V. pustulata	REG	+	+		+	+	+
	V. sulcata	REG					+	

Bignoniaceae	*Jacaranda mimosifolia								+
	Pandorea pandorana	V				+			
Campanulaceae	Wahlenbergia stricta	V		+			+	+	
	W. gracilis	C						+	+
Caprifoliaceae	*Lonicera japonica						+		
Caryophyllaceae	*Petrorhagia nanteuilii							+	
	*Silene gallica				+				
Casuarinaceae	Allocasuarina torulosa	C						+	
	Casuarina glauca	C						+	
Celastraceae	Maytenus silvestris	C		+					
Chenopodiaceae	Einadia hastata	C		+	+		+		
	E. nutans ssp. linifolia	V					+		
	E. polygonoides	V							+
	E. trigonos	V				+			+
Commelinaceae	Commelina cyanea	C					+		
	*Tradescantia albiflora							+	
Convolvulaceae	Convolvulus erubescens	V					+	+	+
	Dichondra repens	C		+		+	+	+	+
Cyperaceae	Carex appressa	C							+
	C. longebrachiata	V				+			+
	Cyperus sp.			+		+			
	Fimbristylis dichotoma	C						+	+
	Gahnia ?aspera	C				+			
	*Isolepis prolifer					+			+
	I. cernua	V			+	+			
	Schoenoplectus validus	V							+
	Eleocharis acuta	V						+	
Dilleniaceae	Hibbertia diffusa	C					+		
Epacridaceae	Astroloma humifusum	C						+	+
Euphorbiaceae	Breynia oblongifolia	C			+		+	+	
	Chamaesyce dallachyana	V						+	
	Phyllanthus gasstroemii					+			
	P. virgatus	V			+			+	
Fabaceae (Caesalpinioideae)	*Caesalpinea decapetala							+	+
(Faboideae)	Daviesia ulicifolia	C							+
	D. varians	C		+				+	
	Dillwynia sieberi	C			+				
	*Gleditsia sp.								+
	Glycine clandestina	C		+	+	+	+	+	+
	G. tabacina	C				+			
	Hardenbergia violacea	C			+	+		+	+
	Indigofera australis	C			+	+			+
	Kennedia rubicunda	C			+	+			
	Lespedeza juncea ssp. sericea	REG							+
	Pultenaea microphylla	REG					+	+	
	*Trifolium sp.			+					+

	*Vicia sativa							+	+
	Zornia dictyocarpa	V			+				
(Mimosoideae)	Acacia falcata	C		+	+				+
	A. implexa	V						+	+
	A. parramattensis	C	+	+	+			+	+
	A. pubescens	SVCa		+	+				
Gentianaceae	*Centaurium tenuiflorum		+	+	+	+	+	+	
Geraniaceae	Geranium solanderi var. solanderi	V		+	+			+	+
Goodeniaceae	Goodenia hederacea	C			+			+	+
	Scaevola albida	V			+			+	+
Haloragaceae	Gonocarpus teucrioides	C							+
	Haloragis heterophylla	V		+					
Hypericaceae	Hypericum gramineum	C			+	+		+	+
Hypoxidaceae	Hypoxis hygrometrica	C		+					
Iridaceae	*Freesia hybrid								+
	*Romulea rosea var. australis								+
Juncaceae	*J. bufonius							+	
	J. continuus	C							+
	J. planifolius	C			+				
	J. prismatocarpus	V						+	
	J. usitatus	C							+
	J. sp.			+					
Lamiaceae	Ajuga australis	V						+	
	Mentha satureioides	V							+
	*Stachys arvensis								+
Lauraceae	*Cinnamomum camphora						+		+
Liliaceae	Arthropodium milleflorum	C							
	*Asparagus officinalis								+
	Caesia sp.	C			+				
	Dianella longifolia	C			+				+
	D. revoluta	C		+	+			+	
	Laxmannia gracilis	C		+					
	*Myrsiphyllum asparagoides								+
	*Protasparagus aethiopicus								+
	*P. officinale		+	+	+	+		+	+
	*P. sprengeri							+	
	Tricoryne elatior	C			+				
Linaceae	Linum marginale	V			+			+	+
	*L. trigynum		+	+	+	+		+	+
Lobeliaceae	Pratia purpurascens	C						+	
Lomandraceae	Lomandra filiformis	C		+					+
	L. longifolia	C			+				
	L. multiflora	C					+	+	
Loranthaceae	Amyena miquelii	V	+						
Lythraceae	Lythrum hyssopifolia	V							+

Meliaceae	*Melia azedarach							+	
Myoporaceae	Myoporum debile	C		+	+				
Myrsinaceae	Rapanea variabilis	C	+						
Myrtaceae	Angophora floribunda	C	+					+	+
	A. floribunda X A. subvelutina							+	
	*Eucalyptus citriodora		+	+					+
	*E. cladocalyx		+						+
	E. eugenioides	C				+		+	
	*E. eximia								+
	E. fibrosa	C	+		+			+	
	*E. bicostata		+						
	E. maculata	V	+	+				+	+
	E. moluccana	C	+	+	+	+		+	+
	E. sideroxylon	C				+			
	E. tereticornis	C			+	+		+	+
	Melaleuca styphelioides	C	+	+	+				
	Syncarpia glomulifera	C	+						
Ochnaceae	*Ochna serrulata				+			+	
Oleaceae	*Ligustrum lucidum		+	+	+			+	+
	*L. sinense		+					+	+
	Notelaea longifolia	C							+
	*Olea africana		+	+	+	+		+	+
Onagraceae	Epilobium billardierianum ssp. cinereum	V							+
Orchidaceae	Dipodium punctatum							+	
Oxalidaceae	Oxalis sp.		+					+	
Orchidaceae	Dipodium punctatum	V						+	
Pittosporaceae	Bursaria spinosa	C		+	+			+	+
	Pittosporum revolutum	C	+						+
	P. undulatum	C	+	+	+				+
Plantaginaceae	Plantago gaudichaudii	V			+	+		+	+
	*P. lanceolata		+	+	+	+		+	+
Poaceae	Agrostis avenacea var. avenacea	C			+	+		+	
	Aristida ramosa	C			+	+		+	+
	A. vagans	C				+		+	+
	*Avena fatua				+				
	Bothriochloa macra	V	+	+	+	+		+	+
	*Briza major					+			
	*B. subaristata				+	+		+	+
	*Bromus diandrus								+
	*B. catharticus								+
	Capillipedium spicigerum	V							+
	*Chloris gayana					+		+	+
	Chloris truncata	V		+	+			+	+
	C. ventricosa	V							+
	Cymbopogon refractus	V		+	+	+		+	+
	*Cynodon dactylon								+
	Danthonia linkii	V							+
	D. setacea	V		+	+				+

	D. tenuior	C					+	+
	Dichanthium sericeum	V						+
	Dichelachne micrantha	C			+	+	+	+
	Dichelachne parva	V						+
	*Ehrharta erecta							+
	Elymus scaber var. scaber	V						+
	Eragrostis brownii	C						+
	E. leptostachya	C						+
	*E. curvula			+	+		+	+
	Eragrostis ?parviflora	V						+
	Eriochloa pseudoacrotricha	V			+	+		+
	Imperata cylindrica	C					+	+
	Microlaena stipoides	C			+	+		+
	*Melinis repens							+
	Panicum decompositum	REC						+
	Panicum simile	C						+
	Paspalidium distans	C						+
	*Paspalum dilatatum			+	+	+	+	+
	*Pennisetum clandestinum			+	+	+		+
	Poa labillardieri	V				+		+
	*Setaria sp.	C				+		
	Sorghum leiocladum	V					+	+
	*Sporobolus indicus var. capensis							+
	S. creber	V						+
	S. elongatus	V						+
	Themeda australis	C			+	+	+	+
Polygalaceae	Polygala japonica	V						+
Polygonaceae	Persicaria decipiens	C						+
	Persicaria lapathifolia	C				+		
	Rumex brownii	V			+			+
Ranunculaceae	Clematis glycinoides	C				+		
	Ranunculus lappaceus	V						+
	*R. repens					+		
Rosaceae	*Rosa rubiginosa							+
	*Rubus fruticosus					+	+	+
	R. parvifolius	C				+		+
Rubiaceae	Asperula conferta	C					+	+
	Opercularia ?varia	C			+		+	
	O. diphylla	C					+	
Salicaceae	*Salix babylonica							+
Santalaceae	Exocarpos cupressiformis	C				+		+
Sapindaceae	Dodonaea triquetra	C				+		
Sinopteridaceae	Cheilanthes sieberi	C						+
	Cheilanthes distans	C						+
Scrophulariaceae	*Kickxia elatine							+
	*Misopates orontium							+
	Veronica plebeia	C						+
Solanaceae	*Cestrum parqui							+
	*Solanum mauritianum							+
Stackhousiaceae	Stackhousia viminea	C			+	+		+

Thymelaeaceae	**Pimelea spicata**	3EC						+
Typhaceae	Typha orientalis	C			+			+
Verbenaceae	Clerodendrum tomentosum	C						+
	*Lantana camara				+		+	+
	*Verbena bonariensis		+	+	+	+	+	+
Vitaceae	Cayratia clematidea	V						

Crofton Weed

Crofton Weed *Ageratina adenophora* occurs as a primary succession species and tends to produce large numbers of effectively dispersed seeds which have a long viability. It colonises margins of forest communities, gullies and areas of disturbance. Seedlings can successfully germinate with minimum light and are capable of colonising large, bare areas. When the upright stems touch the ground, layered plantlets are formed. Large infestations should be sprayed with recommended concentrations of Roundup Dry* in spring and summer or as Parsons and Cuthbertson (1992) suggest, should be controlled by slashing before flowering and replaced by native shrub and herb species. The treated stands will require follow up sprays as the seed store will not be affected by the initial spraying.

Planting should supplement removal in order to reduce germination of seed stores.

Lantana

Lantana provides habitat for small passerine birds. When Lantana canes contact the ground, layered plantlets are formed. Lantana stands should be removed gradually, at a pace commensurate with natural regeneration to maintain habitat for native fauna species. Small stands should be dealt with individually, each crown (base) requires removal and subsequent removal of any layered stems should not be over-looked. Large stands should be sprayed in springtime with a recommended concentration of Roundup Dry* or should be controlled by slashing, then frilling stems and applying a recommended concentration of Roundup Dry*, with a non-drip applicator to fresh wounds.

Kikuyu

Kikuyu is a rhizomatous and stoloniferous aggressive perennial weed. It occurs commonly on all sites, forming dense mats in disturbed areas. A recommended concentration of Roundup Dry* should be used in springtime and areas requiring treatment should be slashed prior to spraying to encourage active uptake of the concentration. Follow up treatment will be necessary especially where cover is dense.

Other Weed Species

The annual and biennial herbaceous species that occur within the study area include Cobbler's Pegs *Bidens pilosa*, Tall Fleabane *Conzya albida*, Prickly Lettuce *Lactuca serriola*, Fireweed *Senecio madagascariensis*, Shepard's Purse *Capsella bursa-pastoris*, Petty Spurge *Euphorbia peplus*, White Clover *Trifolium repens*, Pigeon Grass *Setaria pumila, Sporobolus capensis*, and Stinking Roger *Tagetes minuta*. They are early colonisers of disturbed areas, requiring high light levels and ample moisture to produce abundant seed. Seed viability over time is likely to be greatly reduced. These species should be sprayed with a recommended concentration of Roundup Dry* in spring and summertime.

The perennial herbs recorded in the study include Cat's Ear *Hypochaeris radicata*, White Clover *Trifolium repens*, Paddy's Lucerne *Sida rhombifolia, Oxalis corniculatum, Plantago* spp., Curled Dock *Rumex crispus, Ranunculus repens, Verbena* spp., *Tradescantia* spp., Umbrella Sedge *Cyperus eragrostis*, Kikuyu *Pennisetum clandestinum*, and Buffalo Grass *Stenotaphrum secundatum*.

Treatment requires manual removal of small areas of infestation and slashing of larger areas. Both require subsequent applications of Roundup Dry* directly onto exposed stems in a recommended concentration.

The perennial climbers and scramblers recorded in the survey include Mothvine *Araujia hortorum,* Japanese Honeysuckle *Lonicera japonica,* Bridal Creeper *Myrsiphyllum asparagoides* and Blackberry *Rubus fruticosus* species aggregate. Treatment requires manual removal of small areas of infestation and slashing of larger areas. Both require subsequent applications of Roundup Dry* painted directly onto exposed stems in a recommended concentration. Bridle Creeper *Myrsiphyllum asparagoides* is a rhizomatous trailer. Treatment requires the removal of each soil borne propagule (ie. each rhizome).

Woody Species

The woody perennial species that occurred within the survey area include Privet *Ligustrum* spp., African Olive *Olea europaea* ssp. *africana* and Pine *Pinus radiata.* Plantings should be removed at a slow rate once native plant species have become established. The exposed stems of woody perennials should be treated with a recommended concentration of Roundup Dry* and remaining stumps should be ground and removed.

CHEMICAL CONTROL

Although standard Glyphosate formulations are relatively safe environmentally, recent research indicates that their residues are harmful to frogs.

Roundup Dry* is a new product that has been prepared for normal weed treatment. It contains a lower percentage of phosphorous and surfactant and has been shown to be more compatible in natural areas. The recommended concentration ratio of Roundup Dry* and water is as follows:

GROWTH FORM	SOLUTION REQUIRED
Annual weed species	3 -5gr/lt
Perennial weed species	5gr/lt
Tough (woody) perennial weed species	< 7gr/lt

An alternative Glyphosate formulation - Roundup Biactive* has been specifically prepared for use near (not in) waterways. It contains reduced levels of phosphorous and surfactant and has been found to be compatible with native flora and fauna species. Recommended concentration ratios are advised.

Where chemical control has been recommended as a treatment, substitute Roundup Dry* for Roundup Biactive* when within 30m of water ways, channels, dams, drains or other water bodies to effectively reduce spray drift.

An assessment of Roundup Dry* and Roundup Biactive* and its compatibility with native flora and fauna species has been prepared by the National Registration Authority.

Table 4 : The control and removal of exotic species

Class and Family	Botanical Name	Propagules	Removal Technique
Asclepiadaceae	*Araujia hortorum*	Seed	Large areas: spray. Small areas: remove all parts and follow up spray if necessary
Asteraceae	*Ageratina adenophora*	Seed	Large areas: spray. Small areas: remove all parts and follow up spray if necessary
	Ageratina riparia	Seed	Large areas: spray. Small areas: remove all parts and follow up spray if necessary
	Bidens pilosa	Seed	Large areas: spray. Small areas: remove all parts and follow up spray if necessary
	Cirsium vulgare	Seed	Large areas: spray. Small areas: remove all parts and follow up spray if necessary
	Conyza albida	Seed	Large areas: spray. Small areas: remove all parts and follow up spray if necessary
	Delairea odorata	Seed	Large areas: spray. Small areas: remove all parts and follow up spray if necessary
	Hypochaeris radicata	Seed	Large areas: spray. Small areas: remove all parts and follow up spray if necessary
	Lactuca serriola	Seed -	Large areas: spray. Small areas: remove all parts and follow up spray if necessary
	Senecio madagascariensis	Seed	Large areas: spray. Small areas: remove all parts and follow up spray if necessary
	Senecio tamoides	Seed and adventitious roots	Large areas: spray. Small areas: remove all parts and follow up spray if necessary
	Tagetes minuta	Seed	Hand removal of all parts
Caprifoliaceae	*Lonicera japonica*	Seed and adventitious growth	Large areas: spray. Small areas: remove all parts and follow up spray if necessary
Convolvulaceae	*Ipomoea indica*	Seed and adventitious growth	Large areas: spray. Small areas: remove all parts and follow up spray if necessary
Euphorbiaceae	*Euphorbia peplus*	Annual herb	Hand removal of all parts
Fabaceae: Caesalpinioides	*Caesalpinia decapetala*	Seed	Cut and paint in growth season only
	Senna floribunda	Seed	Hand remove
	Senna pendula var. *glabrata*	Seed	Hand remove
Fabaceae: Faboideae	*Cytisus scoparius ssp. scoparius*	Seed	Hand remove
	Erythrina x sykesii	Seed and coppice	Hand remove; cut and paint in growth season only
	Trifolium repens	Seed and stolons	Remove all above ground parts (all parts if possible) and follow up spray in growing season

Class and Family	Botanical Name	Propagules	Removal Technique
Fabaceae: Mimosaceae	*Paraserianthes lophantha*	Seed	Hand remove; cut and paint in growth season only
Lauraceae	*Cinnamomum camphora*	Seed	Hand remove; cut and paint in growth season only
Malvaceae	*Sida rhombifolia*	Seed	Remove all above ground parts (all parts if possible) and follow up spray in growing season
Oleaceae	*Ligustrum lucidum*	Seed and suckering	Hand remove; cut and paint in growth season only
	Ligustrum sinense	Seed and suckering	Hand remove; cut and paint in growth season only
	Olea europaea ssp. *africana*	Seed	Hand remove; cut and paint in growth season only
Phytolaccaceae	*Phytolacca octandra*	Seed	Large areas: spray. Small areas: remove all parts and follow up spray if necessary
Plantaginaceae	*Plantago lanceolata*	Seed	Remove all above ground parts (all parts if possible) and follow up spray in growing season
Polygonaceae	*Rumex sagittatus*	Seed and tubers	Large areas: spray. Small areas: remove all parts and follow up spray if necessary
	Rumex crispus	Seed	Large areas: spray. Small areas: remove all parts and follow up spray if necessary
	Ranunculus repens	Seed	Large areas: spray. Small areas: remove all parts and follow up spray if necessary
Rosaceae	*Cotoneaster pannosus*	Seed	Remove all above ground parts ;cut and paint in growth season only
	Rubus fruticosus species aggregate	Seed and stolons	Remove all above ground parts ; cut and paint in growth season only
Rubiaceae	*Coprosma repens*	Seed	Remove all above ground parts ; cut and paint in growth season only
	Cardiospermum grandiflorum	Seed	Large areas: spray. Small areas: remove all parts and follow up spray if necessary
Solanaceae	*Solanum mauritianum*	Seed	Remove all above ground parts
	Solanum nigrum	Seed	Remove all above ground parts (all parts if possible) and follow up spray in growing season
Verbenaceae	*Lantana camara*	Seed	Large areas: spray. Small areas: remove all parts and follow up spray if necessary
	Verbena bonariensis	Seed	Large areas: spray. Small areas: remove all parts and follow up spray if necessary
	Verbena rigida	Seed	Large areas: spray. Small areas: remove all parts and follow up spray if necessary
Apiaceae	*Hydrocotyle bonariensis*	Stolons	Remove all above ground parts (all parts if possible) and follow up spray in growing season

Class and Family	Botanical Name	Propagules	Removal Technique
Asparagaceae	*Protasparagus aethiopicus*	Seed	Remove all above ground parts (all parts if possible) and follow up spray in growing season
	Myrsiphyllum asparagoides	Seed	Remove all above ground parts (all parts if possible) and follow up spray in growing season
Cannaceae	*Tradescantia albiflora*	Stolons	Remove all above ground parts (all parts if possible) and follow up spray in growing season
	Tradescantia zebrina	Stolons	Remove all above ground parts (all parts if possible) and follow up spray in growing season
Cyperaceae	*Cyperus eragrostis*	Seed	Remove all above ground parts (all parts if possible) and follow up spray in growing season
Liliaceae	*Lilium formosanum*	Bulbils, Seed and bulbs	Remove all above ground parts (all parts if possible) and follow up spray in growing season
Poaceae	*Avena fatua*	Seed	Large areas: spray. Small areas: remove all parts and follow up spray if necessary
	Chloris gayana	Seed	Large areas: spray. Small areas: remove all parts and follow up spray if necessary
	Paspalum dilatatum	Above ground rhizomes and Seed	Large areas: spray. Small areas: remove all parts and follow up spray if necessary
	Pennisetum clandestinum	Rhizomes, stolons	Large areas: spray. Small areas: remove all parts and follow up spray if necessary
	Setaria pumila	Seed	Large areas: spray. Small areas: remove all parts and follow up spray if necessary
	Sporobolus capensis	Seed	Large areas: spray. Small areas: remove all parts and follow up spray if necessary
	Stenotaphrum secundatum	Stolons and Seed	Large areas: spray. Small areas: remove all parts and follow up spray if necessary

APPENDIX 3 : FAUNA OBSERVED OR KNOWN TO OCCUR WITHIN EITHER THE STUDY SITE AND/OR SURROUNDING REGION

Source

1 = Species Recorded During The Present Survey
2 = NPWS (1998) – search radius six kilometres centered on study area
3 = Thomas and Engel (1997)
4 = CRAG (1996)
5 = Thomas (1993)
6 = Species indicated in the NPWS (1997) report as occurring in the Holroyd Local Government Area
7 = EBC Consultants (1986)

Key

= Indicated species of conservation significance as listed under the *Threatened Species Conservation Act 1995*
♦ = Identifies regionally significant species (NPWS 1997).
♦? = Identifies species which are considered to be of regional significance (NPWS 1997), but their conservation status is still to be determined.
* = Indicates introduced species.
a = Identity of species not confirmed at time of study.

COMMON NAME	SCIENTIFIC NAME	1	2	3	4	5	6	7
Invertebrates								
# Large Land Snail	*Meridolum corneovirens*		x					
Mammals								
Common Brushtail Possum	*Trichosurus vulpecula*	x	x					
Grey-headed Flying Fox	*Pteropus poliocephalus*		x					
* Rabbit	*Oryctolagus cuniculus*	x	x	x			x	
* Brown Hare	*Lepus capensis*		x	x			x	
* Fox	*Vulpes vulpes*	x	x				x	
* Feral Cat	*Felis catus*		x				x	
* Dog	*Canis familiaris*		x				x	
Birds								
♦Stubble Quail	*Coturnix pectoralis*				x		x	
♦Brown Quail	*Coturnix ypsilophora*			x	x		x	
Australian Pelican	*Pelecanus conspicillatus*				x		x	
Darter	*Anhinga melanogaster*				x		x	
Little Pied Cormorant	*Phalacrocorax melanoleucos*				x		x	
Great Cormorant	*Phalacrocorax carbo*				x		x	
Little Black Cormorant	*Phalacrocorax sulcirostris*				x		x	x
♦Great Crested Grebe	*Podiceps cristatus*		x					
Hoary-headed Grebe	*Poliocephalus poliocephalus*				x		x	
Australasian Grebe	*Tachybaptus*				x		x	

	novaehollandiae							
Black Swan	*Cygnus atratus*				x		x	
Pacific Black Duck	*Anas superciliosa*		x		x	x	x	x
Grey Teal	*Anas gracilis*				x		x	
Hardhead (White-eyed Duck)	*Aythya australis*		x					
Australian Wood Duck	*Chenonetta jubata*				x		x	
Dusky Moorhen	*Gallinula tenebrosa*		x		x		x	x
Purple Swamphen	*Porphyrio porphyrio*		x		x		x	
Eurasian Coot	*Fulica atra*						x	
White-necked Heron	*Ardea pacifica*				x			x
White-faced Heron	*Egretta novaehollandiae*	x			x		x	x
Cattle Egret	*Ardea ibis*				x		x	x
•Great Egret	*Ardea alba*				x		x	x
Little Egret	*Egretta garzetta*				x		x	x
Intermediate Egret	*Ardea intermedia*				x		x	x
Striated Heron	*Butorides striatus*		x					
•Nankeen Night Heron	*Nycticorax caledonicus*				x			
Australian White Ibis	*Threskiornis molucca*		x		x		x	
Straw-necked Ibis	*Threskiornis spinicollis*				x		x	x
Royal Spoonbill	*Platalea regia*				x		x	
Yellow-billed Spoonbill	*Platalea flavipes*				x		x	x
Common Sandpiper	*Actitis hypoleucos*		x					
Latham's (Japanese) Snipe	*Gallinago hardwickii*				x		x	
Masked Lapwing	*Vanellus miles*	x	x	x	x		x	x
Silver Gull	*Larus novaehollandiae*				x		x	
Black-shouldered Kite	*Elanus axillaris*		x		x		x	x
Wedge-tailed Eagle	*Aquila audax*		x					
Brown Goshawk	*Accipiter fasciatus*				x		x	x
•Grey Goshawk	*Accipiter novaehollandiae*		x		x		x	
Swamp Harrier	*Circus approximans*				x		x	
•Peregrine Falcon	*Falco peregrinus*				x		x	
Australian Hobby	*Falco longipennis*				x		x	
Brown Falcon	*Falco berigora*	x						x
Nankeen Kestrel	*Falco cenchroides*				x	a	x	x
* Rock Dove	*Columba livia*	x	x	x	x		x	x
* Spotted Turtle-Dove	*Streptopelia chinensis*	x	x	x	x	x	x	x
•Peaceful Dove	*Geopelia striata*				x		x	
Crested Pigeon	*Ocyphaps lophotes*	x		x	x	x	x	
Yellow-tailed Black-Cockatoo	*Calyptorhynchus funereus*				x		x	
Galah	*Eolophus roseicapilla*	x	x		x	x	x	x
Long-billed Corella	*Cacatua tenuirostris*	x						
Sulphur-crested Cockatoo	*Cacatua galerita*	x	x		x	x	x	
Rainbow Lorikeet	*Trichoglossus haematodus*	x	x		x		x	
Scaly-breasted Lorikeet	*Trichoglossus chlorolepidotus*				x		x	
# Swift Parrot	*Lathamus discolor*		x				x	
Crimson Rosella	*Platycercus elegans*				x		x	

Eastern Rosella	*Platycercus eximius*	x	x		x	x	x	
* Peachface Lovebirds	*Agopornis roseicollis*	x						
Red-rumped Parrot	*Psephotus haematonotus*		x		x		x	
Pallid Cuckoo	*Cuculus pallidus*				x		x	
Fan-tailed Cuckoo	*Cuculusflabelliformis*		x		x		x	x
Horsfield's Bronze-Cuckoo	*Chrysococcyx basalis*				x		x	x
Shining Bronze-Cuckoo	*Chrysococcyx lucidus*		x		x		x	x
Common Koel	*Eudynamys scolopacea*				x		x	
# Powerful Owl	*Ninox strenua*				x		x	
Southern Boobook	*Ninox novaeseelandiae*		x		x		x	
Barn Owl	*Tyto alba*				x		x	x
Tawny Frogmouth	*Podargus strigoides*				x		x	
•Fork-tailed Swift	*Apus pacificus*				x			
•Azure Kingfisher	*Alcedo azurea*				x		x	
Laughing Kookaburra	*Dacelo novaeguineae*	x	x	x	x		x	x
Sacred Kingfisher	*Todiramphus sancta*				x		x	
Rainbow Bee-eater	*Merops ornatus*				x		x	
Dollarbird	*Eurystomus orientalis*	x			x		x	
White-throated Treecreeper	*Cormobates leucophaeus*	x			x		x	
Varied Sitella	*Daphnoenositta chrysoptera*							x
Superb Fairy-wren	*Malurus cyaneus*	x	x	x	x	x	x	x
Varigated Fairy-wren	*Malurus lamberti*				x		x	
Spotted Pardalote	*Pardalotus punctatus*	x	x	x	x		x	x
•Striated Pardalote	*Pardalotus striatus*		x		x		x	
White-browed Scrubwren	*Sericornis frontalis*		x		x		x	x
Weebill	*Smicrornis brevirostris*				x		x	x
Brown Gerygone	*Gerygone mouki*		x		x		x	
Brown Thornbill	*Acanthiza pusilla*	x			x		x	x
Yellow Thornbill	*Acanthiza nana*		x		x		x	x
Striated Thornbill	*Acanthiza lineata*				x		x	
•Buff-rumped Thornbill	*Acanthiza reguloides*				x		x	
•Yellow-rumped Thornbill	*Acanthiza chrysorrhoa*	x		x	x		x	x
Red Wattlebird	*Anthochaera carunculata*				x	x	x	
Brush Wattlebird	*Anthochaera chrysoptera*	x		x	x		x	
Noisy Friarbird	*Philemon corniculatus*		x		x		x	
# Regent Honeyeater	*Xanthomyza phrygia*		x					
Noisy Miner	*Manorina melanocephala*	x	x	x	x	x	x	
Lewins Honeyeater	*Meliphaga lewinii*				x		x	
Yellow-faced Honeyeater	*Lichenostomus chrysops*	x	x		x		x	x
•Fuscous Honeyeater	*Lichenostomus fuscus*				x		x	
White-plumed Honeyeater	*Lichenostomus penicillatus*	x	x	x	x		x	x
White-cheeked Honeyeater	*Phylidonyris nigra*		x		x		x	
New Holland Honeyeater	*Phylidonyris novaehollandiae*	x						
Eastern Spinebill	*Acanthorhynchus tenuirostris*		x		x		x	
Scarlet Honeyeater	*Myzomela sanguinolenta*		x		x		x	
Eastern Whipbird	*Psophodes olivaceus*		x		x	x	x	

Rose Robin	*Petroica rosea*				x		x	
Eastern Yellow Robin	*Eopsaltria australis*		x		x		x	x
•Jacky Winter	*Microeca fascinans*				x		x	x
Rufous Fantail	*Rhipidura rufifrons*		x					
Grey Fantail	*Rhipidura fuliginosa*		x		x		x	x
Willie Wagtail	*Rhipidura leucophrys*	x	x	x	x	x	x	x
•Crested Shrike-tit	*Falcunculus frontatus*			x	x		x	
Grey Shrike-thrush	*Colluricincla harmonica*			x	x		x	x
Golden Whistler	*Pachycephala pectoralis*				x		x	
Rufous Whistler	*Pachycephala rufiventris*				x		x	
Leaden Flycatcher	*Myiagra rubecula*		x					
•Restless Flycatcher	*Myiagra inquieta*				x		x	
Magpie-lark	*Grallina cyanoleuca*	x	x	x	x	x	x	x
Spangled Drongo	*Dicrurus bracteatus*		x		x		x	
Olive-backed Oriole	*Oriolus sagittatus*				x		x	
Spotted Bowerbird	*Chlamydera maculata*		x					
Black-faced Cuckoo-shrike	*Coracina novaehollandiae*	x	x	x	x	x	x	x
Cicadabird	*Coracina tenuirostris*				x		x	
White-brested Woodswallow	*Artamus leucorhynchus*		x					
Dusky Woodswallow	*Artamus cyanopterus*			x	x		x	
Grey Butcherbird	*Cracticus torquatus*	x	x	x	x	x	x	
Australian Magpie	*Gymnorhina tibicen*	x	x	x	x	x	x	x
Pied Currawong	*Strepera graculina*	x	x		x	x	x	x
Australian Raven	*Corvus coronoides*	x	x	x	x	x	x	x
White-backed Swallow	*Cheramoeca leucosternus*		x					
Welcome Swallow	*Hirundo neoxena*	x	x	x	x		x	x
Tree Martin	*Hirundo nigricans*				x		x	
Fairy Martin	*Hirundo ariel*				x		x	
Richard's Pipit	*Anthus novaeseelandiae*		x		x		x	x
•Rufous Songlark	*Cincloramphus mathewsi*				x		x	
Clamorous Reed-warbler	*Acrocephalus stentoreus*		x		x		x	
Golden-headed Cisticola	*Cisticola exilis*				x		x	x
Little Grassbird	*Megalurus gramineus*				x		x	x
* House Sparrow	*Passer domesticus*	x	x	x	x		x	x
* European Greenfinch	*Carduelis chloris*		x		x		x	
* European Goldfinch	*Carduelis carduelis*	x	x		x		x	
Double-barred Finch	*Taeniopygia bichenovii*	x	x				x	
•Zebra Finch	*Taeniopygia guttata*				x		x	
•Plum-headed Finch	*Neochmia modesta*							
Red-browed Finch	*Neochmia temporalis*	x	x	x	x		x	x
* Nutmeg Mannikin	*Lonchura punctulata*	x	x		x		x	
•Chestnut-breasted Mannikin	*Lonchura castaneothorax*			x	x	x	x	
Mistletoebird	*Dicaeum hirundinaceum*		x		x	x	x	x
Silvereye	*Zosterops lateralis*	x	x		x		x	x
* Red-whiskered Bulbul	*Pycnonotus jocosus*	x	x		x		x	x
* Common Blackbird	*Turdus merula*		x		x		x	x
* Common Myna	*Acridotheres tristis*	x	x	x	x	x	x	x

* Common Starling	*Sturnus vulgaris*	x	x	x	x		x	x
Reptiles								
Wood Gecko	*Diplodactylus vittatus*		x					
•? Common Scaly-foot	*Pygopus lepidopodus*		x					
•Lace Monitor	*Varanus varius*		x					
Striped Skink	*Ctenotus robustus*		x					
Eastern Water Skink	*Eulamprus quoyii*	x	x	x				
Grass Skink	*Lampropholis delicata*	x	x	x				
Garden Skink	*Lampropholis guichenoti*	x						
Eastern Blue-tongued	*Tiliqua scincoides*		x			x		
•? Red-naped Snake	*Furina diadema*		x				x	
Bandy Bandy	*Vermicella annulata*		x				x	
Amphibians								
Common Eastern Froglet	*Crinia signifera*	x	x				x	
Brown-striped Frog	*Limnodynastes peroni*	x					x	
Spotted Grass Frog	*Limnodynastes tasmaniensis*						x	
Eastern Dwarf Tree Frog	*Litoria fallax*						x	
Peron's Tree Frog	*Litoria peronii*						x	

2.0 ENGINEERING REVIEW
Ove Arup & Partners

Lower Prospect Canal Masterplan and Plan of Management

Engineering Review

Prepared for
Environmental Partnership

by
Ove Arup & Partners

July 1998

10482

REPORT ISSUE AUTHORISATION

PROJECT: Lower Prospect Canal Masterplan and Plan of Management - Engineering Review

Project No: 10482

Rev	Date	Purpose of Issue/Nature of Revision	Prepared by	Issue Authorised by
1	8/7/98	First Issue	TNG / MAE	

This report takes into account the particular instructions and requirements of our Client. It is not intended for and should not be relied upon by any third party and no responsibility is undertaken to any third party.

Ove Arup & Partners
477 Kent Street
Sydney NSW 2000
PO Box Q116
QVB Post Office
Sydney NSW 1230
Australia
Telephone (02) 9320 9320
Facsimile (02) 9320 9321

Arup Partner Pty Ltd
ACN 002 536 647

Ove Arup Consult Pty Ltd
ACN 002 536 503

Ove Arup Pty Ltd
ACN 000 966 165

CONTENTS

1. INTRODUCTION

Ove Arup and Partners were commissioned by Environmental Partnership to undertake an Engineering Review for the Lower Prospect Canal Plan of Management. This Engineering Review deals with the structural and hydraulic/hydrological issues associated with the canal in its existing condition and upgrading requirements for the future use of the canal.

2. STRUCTURAL ASSESSMENT

2.1 Canal

2.1.1 Existing Condition

The canal has undergone severe degradation which can be expected to continue. Problems include:

- significant levels of spalling is evident along the full length of the canal;
- many concrete panels have failed and are now out of position, having slipped below other panels. Panels have also bowed and cracked;
- reinforcement bars and external ties between adjacent panels, have undergone severe corrosion and would appear to be liable to failure in the future.

The panels have undergone severe abrasion by the flowing water. This has resulted in an exposed aggregate face to the concrete panels, and reduced cover to the steel reinforcement.

Some areas of the canal have an in-situ concrete lining that has severe horizontal cracking. Differential movement has occurred along the sides of the cracks creating an unstable environment.

2.1.2 Recommendations

The current canal lining is unstable in many locations and if left in its current state is likely to eventually collapse. It is recommended that the canal not be used for public access until remedial measures take place. Possible remedial measures depend on the future use of the canal. If the canal is to be opened to public access for example as a bike track, it is recommended that the existing lining be removed and replaced or that the canal be filled in.

2.2 Aqueduct and Adjacent Structures

2.2.1 Existing Condition

Cracking is evident in each arch of the viaduct. The cracking begins at the first internal joint in the sandstone block headstock adjacent to each side. The cracks extend for a distance of between 300 mm and 2.5 m into the arch structure. Cracks are not restricted to mortar joints but also extend through bricks. Significant efflorescence is evident at the cracks. This is probably the result of water leaking through the joints and reacting with the cement mortar. This cracking does not impair the arching action of the viaduct but would impair the transverse stiffness of the aqueduct structure. The cracking would indicate that the aqueduct may not be water tight. Transverse steel tie rods between the aqueduct walls show signs of corrosion. These ties inhibit access within the Aqueduct.

2.2.2 Recommendations

To ensure the long term stability of the aqueduct remedial measures would be required regardless of usage These remedial measures would include:

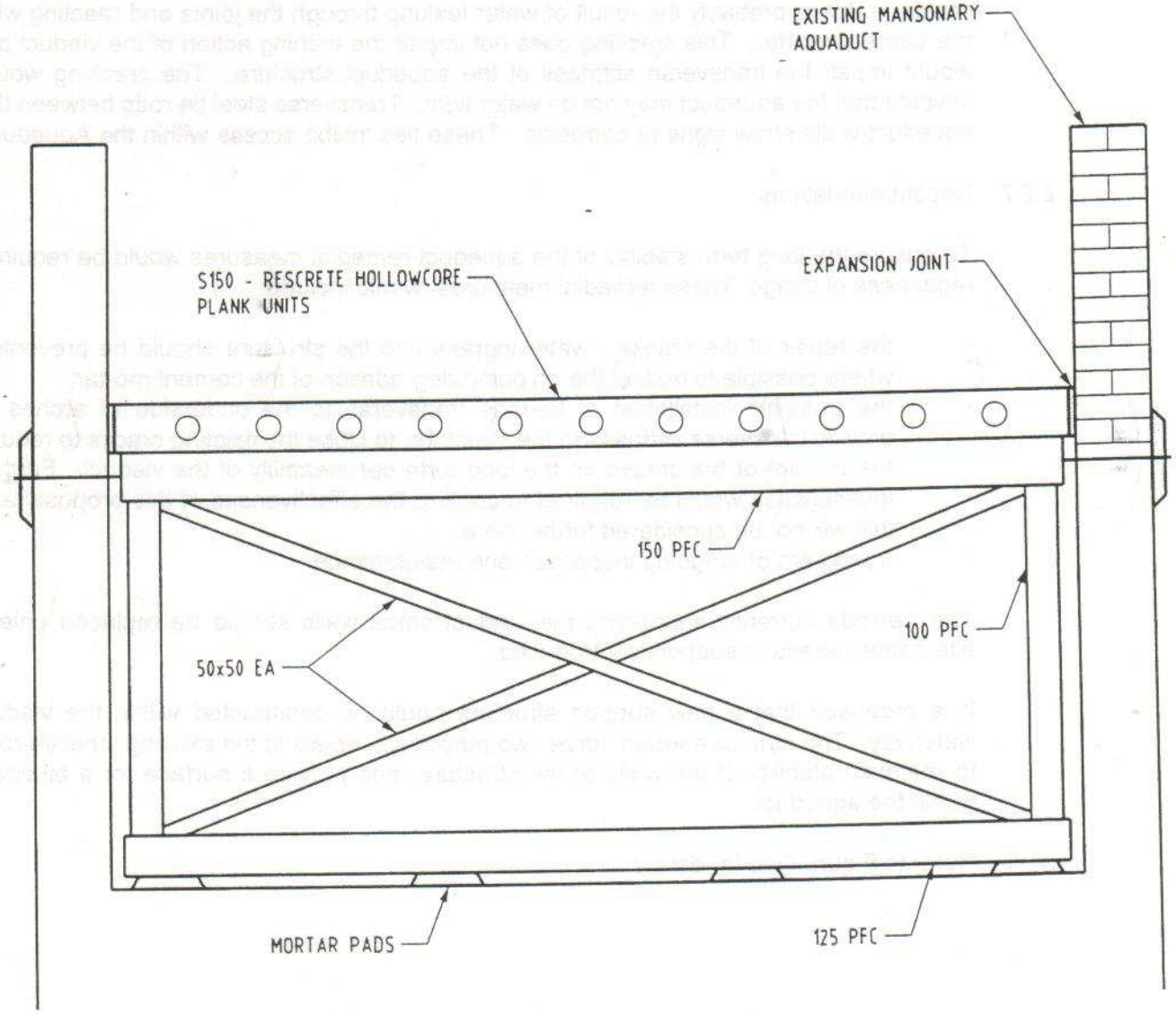
- the repair of the cracks - water ingress into the structure should be prevented where possible to restrict the on going degradation of the cement mortar;
- the possible installation of tie-rods transverse to the underside of arches to provide transverse stiffness to the structure, to close the existing cracks to reduce the impact of the cracks on the long term serviceability of the viaduct. Further investigation would be required to confirm the effectiveness of this proposal and this will not be considered further here;
- a program of on-going inspection and maintenance.

The tie-rods currently supporting the viaduct canal walls should be replaced unless alternative means of support is introduced.

It is proposed that a new support structure could be constructed within the viaduct waterway. The structure would serve two purposes; replacing the existing steel tie-rods to maintain stability of the walls of the structure, and provide a surface for a bikepath within the aqueduct.

Refer to Figure One for details.

PROSPECT CANAL AQUADUCT
BIKEPATH STRUCTURE



- STEEL SUPPORT FRAME AT APPROXIMATELY 4m CENTRES

FIGURE 1

g:\civgen\com\10482c\sk001.dgn

2.3 Sedimentation Channel

2.3.1 Existing Condition

The sedimentation channel exhibits a significant amount of corrosion to all exposed steel and large cracking to the concrete structure.

Footbridges span the channel both across and along the length of the structure. The footbridge along the length of the channel is supported at regular intervals by beams spanning the width of the channel.

This footbridge comprises a continuous slab over many spans. Cracking has occurred in the slab over the top of the majority of the beams as a result of negative (hogging) bending. The reinforcement in this section is unknown. The support beams appear to be UB steel sections encased in concrete. Significant cracking has occurred to many of these beams including:

- longitudinal cracking on the top face at the centre;
- sagging moment bending causing cracking to the underside of the beams which has resulted in the concrete spalling from the surface and exposing the bottom flanges of the UB sections. The bottom flanges appear to be highly corroded;
- diagonal shear cracks evident near the supports of many beams.

2.3.2 Recommendations

The structure would appear unsafe and would require modifications and repairs if the area is to be opened to the public.

a) **Option 1**

Demolish the Sedimentation Channel in total. This would allow for full public access to all parts of the Sedimentation Channel, allowing the Channel to be used for a wide variety of purposes. The structure could be replaced with an identical structure designed for long term stability and durability.

b) **Option 2**

A short section of the sedimentation channel could be demolished and re-built for use by the public. The remainder of the channel could be filled and opened to public access or fenced to restrict public access.

c) **Option 3**

The footbridge and its supports only could be demolished and a new footbridge provided that could serve two purposes. First, it would provide access to the sedimentation channel for the public. Secondly, it could be used as a horizontal strut that would provide lateral stability to the channel, in a similar way to the existing supports. It is important to note that the existing support beams have deteriorated significantly and are considered unsafe for public use.

d) **Option 4**

Maintain the structure in its current state. If the existing structure is to be maintained it is recommended that public access to the structure be restricted. The structure could be used for viewing by the public, with restricted access such that continued degradation does not impose a risk to the safety of the public.

2.4 Road Underpass for Bikepath

The original sandstone block canal lining will be used for the lining of the road underpass structures. The condition of this lining is uncertain and has not been inspected as it is hidden beneath the existing precast concrete plates. When the concrete plates have been removed the sandstone blocks should be inspected to determine their suitability for use as a retaining system to support the underpass walls. Refer to Figure Two for a cross-section of the underpass treatment.

PROSPECT CANAL

PROPOSED CANAL CROSS SECTION AT ROAD UNDERPASSES

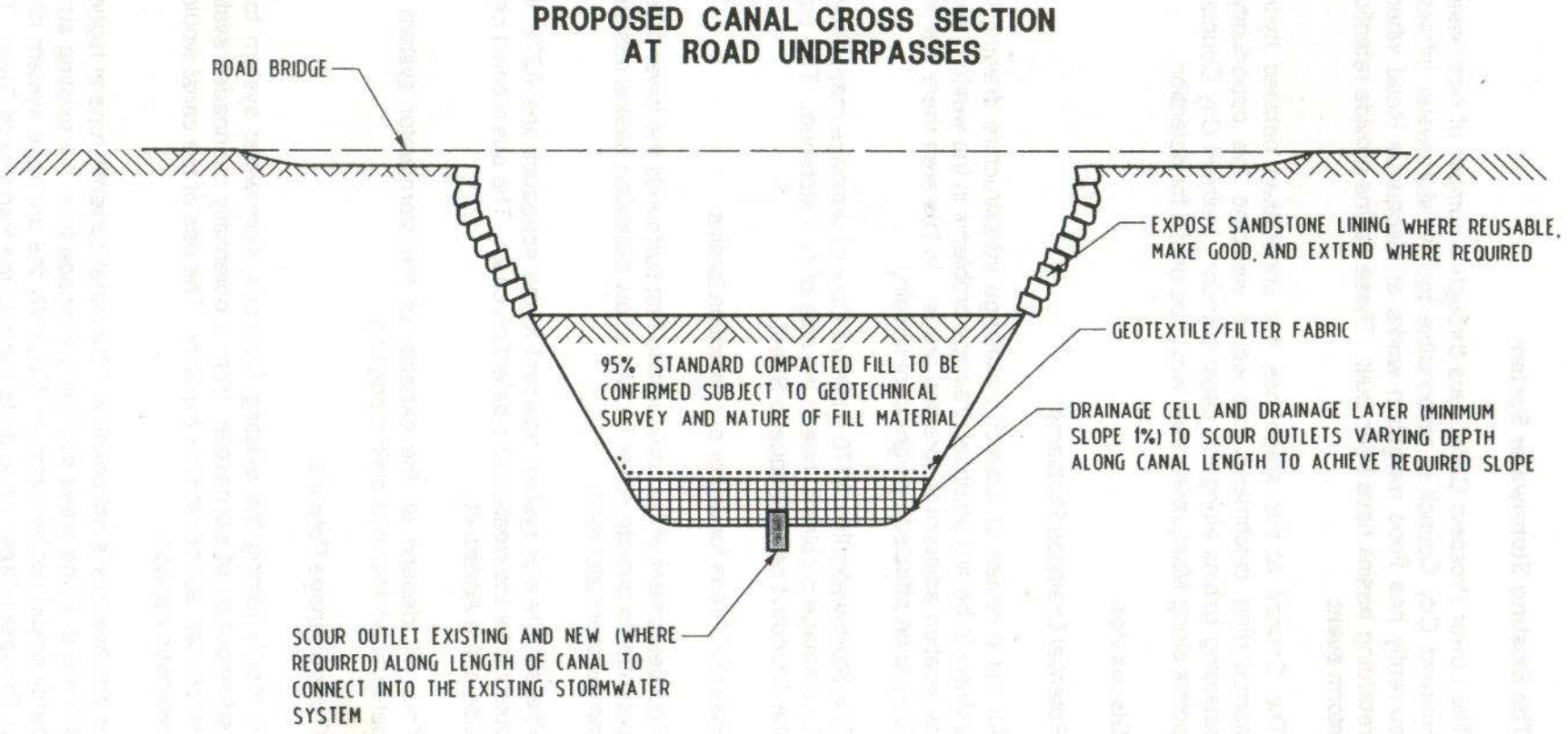


FIGURE 2

\civgen\com\10482c\sk001.dgn

3. HYDRAULIC/HYDROLOGIC ASSESSMENT

3.1 The Existing Stormwater System

The Lower Prospect Canal runs through a number of stormwater catchments in which Holroyd City Council is responsible for the stormwater infrastructure. The Council currently has flood mitigation works at Macquarie Road where a series of 3 linked retarding basins have been built. These basins provide retention for up to the 1 in 100 storm event.

The Council at this stage has not undertaken detailed hydraulic modelling of the surrounding catchments but would welcome the opportunity to provide additional retarding basins along the canal corridor. Holroyd City Council indicated that any low points along Macquarie street would be useful for detention.

3.2 Discussion

3.2.1 Potential Drainage Problems

An initial review of Council's drainage infrastructure drawing indicated that there are unlikely to be any potential drainage problems in the western section of the canal due to its location adjacent to forested areas. In this area there are few residential properties likely to be affected by significant flooding.

The Stormwater line A270 (Holroyd Council drainage map) shows the greatest potential for drainage problems, due to the size of its catchment. This pipe is located adjacent to the Aqueduct near Macquarie Street.

3.2.2 Potential Areas for wet or dry detention basins

Redevelopment of the corridor land that surrounds the lower prospect canal provides the potential to provide areas for wet or dry detention basins assisting drainage in the local stormwater catchment

The stormwater system adjacent to the aqueduct, line A270, would have the greatest potential for the creation of a detention basin. The basin could be located on the northern side of the Aqueduct.

This will depend on the capacity of the stormwater system in the catchment area determined after hydraulic modelling.

3.2.3 Trunk drainage Potential

In theory joining the existing Council's stormwater system to the canal would allow redistribution of stormwater from a potentially overloaded system to other catchments which had additional pipe capacity. The use of the canal would also provide additional detention capacity.

In practice this is not practical. The canal currently runs at higher levels than the natural surface in some areas so joining drainage from the existing stormwater system into the canal would not be possible. Currently the drainage system drains from north to south to Prospect Creek or south to north to the Parramatta River. The canal runs from east to west from Prospect Reservoir to facilities at Guildford.

3.2.4 Potential Sources of Natural Flow

Intermittent sources of water will be unsuitable if the canal were to be established as a natural water course unless a series of ponds could be constructed that would contain permanent water. Dry ponds tend collect litter and are seen as "untidy" in the public eye.

If the canal was to be supplied by stormwater from the urban catchment litter would be a potential problem. The stormwater would require pretreatment prior to entry into the natural water course.

If a permanent water feature were to be created, a dam type system could be required. Top up water would be supplied from screened flows from urban runoff or via a dedicated line from Prospect Reservoir. Outflow from the system would be to the existing council stormwater system.

It would be preferable to obtain water from Prospect Reservoir for a water feature. If this was the method to be used it would be preferable to locate the feature at the western end of the corridor to reduce the length of pipe required for providing water and hence reduce costs.

If permanent stands of water are to be created it would be necessary to recirculate the water by pumping to prevent stagnation. This would result in high capital cost and high operating and maintenance costs. It would also be necessary to undertake maintenance works on the canal to prevent leaking of the structure.

3.3 Recommendations

3.3.1 General

The availability of land surrounding the Lower Prospect Canal provides an opportunity to improve water quality and the capacity of the existing stormwater system.

Water quality and system capacity in the area can be improved through the creation of water quality control / retardation ponds. Two potential areas have been identified in the Masterplan. These are located at the Boothtown Aqueduct adjacent to Macquarie Street and Munro Creek west of Gipps Road.

As well as addressing stormwater drainage in adjacent catchments areas it is important to address the issue of draining stormwater which falls within the canal structure and within the canal reserve. The existing canal drainage system will require analysis and appropriate upgrading will be required. If the canal is to be used as a cycleway, the base of the canal would need to incorporate drainage cells with increased grades to existing and new outlets. These outlets would be connected to the existing stormwater system. Refer to Figure 3 for details.

It will be necessary to investigate the existing condition of the scour outlets to determine the need for maintenance and to determine the capacity of the outlets. A 1% minimum drainage grade to outlet points in the base of the canal structure would be the desirable minimum.

PROSPECT CANAL

PROPOSED CANAL CROSS SECTION

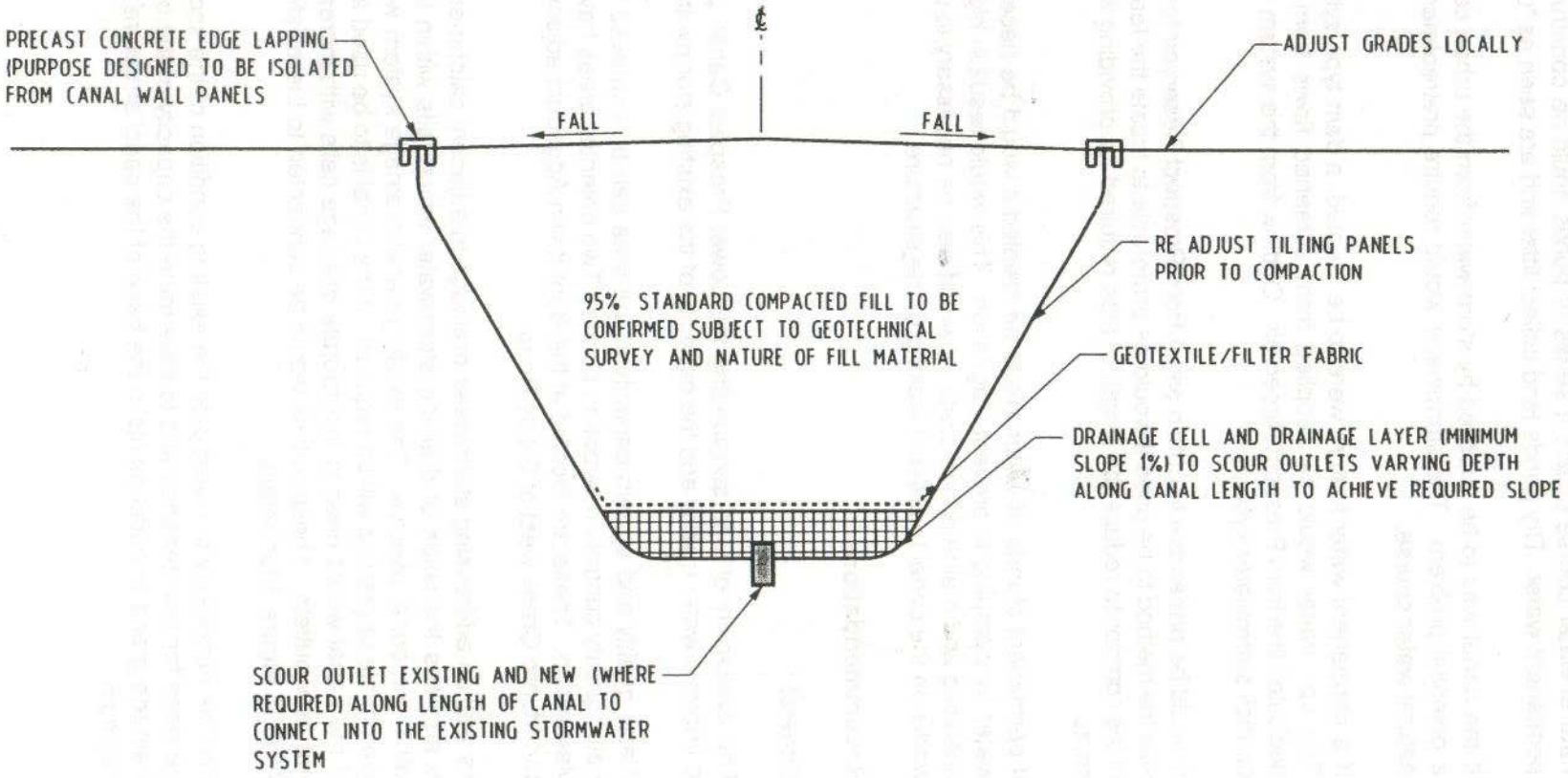


FIGURE 3

The drainage cell may be used independently or in conjunction with the regrading of the canal base with concrete. The latter option is not recommended as the canal structure will be altered. The drainage cell should be covered with a geotextile /filter fabric to prevent the drainage cell becoming clogged.

Where the canal is built in cut, subsoil drainage should be installed along the up hill side of the canal. This subsoil drainage could flow directly into the canal or cross under the canal into the existing council stormwater system. This will depend on the extent of filling within the canal. Where the canal is to be completely filled there will be no special requirements.

It is assumed that the canal was originally designed to take earth and water pressures in the filled and unfilled states. If the canal is to be retained in any form a detailed structural analysis will be required to confirm the capacity of the canal to support loads over a reasonable service life.

4. DETAILED ACTIONS AND PRIORITIES

a) *Planning*

Action	Priority
Undertake hydraulic analysis of the surrounding drainage catchments. Analyse the capacity of the existing system and recommend upgrading requirements. Analysis may require the physical inspection of pipes and other structures.	High, immediate.
Design water quality control / retardation ponds. Identify possible locations for the ponds and optimise system configuration.	High, as part of design phase.
Assess the impacts of water quality / retardation ponds on the surrounding hydrology and surrounding community, eg safety.	High, as part of design phase.
Investigate existing drainage of the canal structure. Investigate the condition of the existing outlets and identify the upgrading requirements or the need for augmentation with additional outlet points to meet the drainage requirements of the canal and future use as a cycleway.	High, immediate.
Design canal drainage in conjunction with the design of the cycleway. Determine use of drainage cell independent to, or in conjunction with the regrading of the canal base with concrete. The canal base will require a minimum grade of 1 % to provide sufficient fall to canal outlets.	Medium, as part of design phase.
Analyse structural capacity of canal in proposed configurations and of other structures such as the Aqueduct, inverted syphon control structures, footbridges and other structures to be retained after reconstruction.	Medium, as part of design phase

b) ***Implementation***

Action	Priority
Prepare basin design and documentation and commission installation. Incorporate requirements for planting within basins.	Medium, as part of design and construction phases.
Prepare subsoil drainage design and documentation and commission installation of subsoil drainage along the top of the canal where the canal is in cut.	Low, as part of design and construction phases.

c) ***Ongoing Management and Maintenance***

Action	Priority
Establish maintenance requirements for water quality pond/ retardation basin.	High, as part of the design phase.
Initiate program for mowing of banks and harvesting of macrophytes, weed removal, removal of accumulated sediment by dredging or after draining of basins and litter removal.	Medium, ongoing after construction.
Monitor and inspect system every six months and after large storm events.	Medium, ongoing after construction.
Maintain access track for maintenance vehicles.	Medium, ongoing from now.
Any wetland ponds will require a major retro fit or decommissioning when the wetlands reach their design life.	Low, periodic after commissioning.
Unblocking outlet structures on the drainage infrastructure.	High, immediate.
Inspect the trunk drainage system to determine condition of grates, pits, pipes and control structures. Repair and replace as required.	Low, ongoing from now.
Inspect structures annually and incorporate maintenance program.	Medium, ongoing

5. CANAL FILLING

5.1 General

Prior to filling the canal it will be necessary to undertake a detailed geotechnical investigation on the surrounding soil in cut and especially in embankment fill. This will affect the stability of the canal structure.

The canal panels should be readjusted to an even surface.

Geotechnical analysis of the fill material will be necessary to obtain required compaction levels. Standard Compaction of 95% is required to use the canal structure as a cycle way. Compaction would be to Australian Standard 3798 requirements.

5.2 Implications of Clay as a Fill Material

Clay fill will be difficult to compact and the material is likely to be unstable. If the clay material is placed in the upper section of the canal it will reduce infiltration of water into the canal. However, it would be difficult to drain water from the clay fill.

5.3 Recommendations

It is recommended that free draining granular fill be used within the canal unless the canal lining is completely demolished.

3.0 ASSESSMENT OF ABORIGINAL SITES
National Parks & Wildlife Service

16/04/98

Jenny Burge
Environmental Partnership
2 River Street
Birchgrove, N.S.W. 2041

Our ref: ASR 4437

RECEIVED
23 APR 1998
ENVIRONMENTAL PARTNERSHIP P/L
A.C.N. 003 876 953

NSW NATIONAL PARKS AND WILDLIFE SERVICE

Dear Jenny,

RE: Aboriginal Site Search, Lower Prospect Canal Corridoor

I refer to your enquiry, dated 16/03/98, in relation to known Aboriginal sites at the above location. A search of the NSW Aboriginal Sites Register has revealed no recorded sites in that area.

The following qualifications apply to Aboriginal Sites Register Database:

- The database only records "known" sites. Unknown sites may occur in areas which have not been subject to systematic survey.

- Location details are recorded as Australian Map Grid (AGM) references. Past experience indicates that the accuracy of theses references depends on the skills of the recorder. Sites listed on the database have been recorded by people with a range of skill levels (archaeologists, members of the public, students, Aboriginal Land Council representative and surveyors). Therefore, when a search of the Register identifies site(s) in or near the area of interest it is recommended that the location of the site(s) be accurately confirmed on the ground.

- Sites are known to occur elsewhere in the area and there is a possibility that unrecorded sites could exist in those locations..

Given these limitations, and the fact that all Aboriginal sites are protected under NSW legislation, you are advised that a survey for Aboriginal sites may be required should any development be proposed which would affect this area. For further advice and information please contact the NPWS Zone Cultural Heritage Officer, Phil Hunt, Sydney Zone (02) 9585 6677

Yours Faithfully,

Paul Houston
Aboriginal Sites Registrar
Cultural Heritage Services Division

43 Bridge Street
PO Box 1967
Hurstville NSW
2220 Australia
Tel: (02) 9585 6444
Fax: (02) 9585 6555
www.npws.nsw.gov.au

4.0 REVIEW OF MASTERPLAN PROPOSALS
NSW Heritage Office

NSW Heritage Office

Contact: M North
Telephone: 02-9849 9568
northm@heritage.nsw.gov.au
File: H98/00074/1
Your Ref:

Mr Adam Hunter
Environmental Partnership
2 River St
Birchgrove NSW 2041

RE: Lower Prospect Canal Draft Plan of Management Comments

Dear Adam,

My apologies for the delay of these comments. Unfortunately I have not been in the office much recently.

By and large the Draft PoM is fine in heritage terms. There are a few small additions/changes I would make:

- pg. 83, under "Relics provisions of the NSW Heritage Act"

The first paragraph should make reference to the Archaeological Assessment in Higgenbotham's study, which lists a few identified archaeological sites.

- pg. 103, top of page, final dot point of S5.1.1

I would change the wording of the final sentence from "removal of fill to carry out future archaeological investigations" to "future historical investigations", as I think if anyone did want to re-excavate a section of the canal in the future an archaeological assessment and excavation permit would be unnecessary.

- pg. 104, under 4. Heritage Conservation

Reword sentence beginning" With regard to the canal structure itself..." to say that "sections of the canal should remain unfilled, to provide examples of the channel's ...construction."

- pg. 119 Figure 6.3

Add a row to the table for the following heritage grant programs: Heritage 2001, Heritage Assistance Program, Federation Fund Program. Contact our Grants Co-ordinator, Mr Dennis McManus, on 9849 9576 for specific details about the programs.

- pg. 126 Figure 6.4

Add a row to the table for "Protect archaeological heritage in the Lower Canal corridor". Performance criteria: Implementation of recommendations of Higgenbotham's archaeological assessment; Monitoring technique: Assess impacts of works in canal region on archaeological sites; Evaluation: Archaeological sites are protected and excavated only if necessary.

Reword this as you like.

Once again, my apologies for the delay.

Regards,

10.7.98

MacLaren North

5.0 HERITAGE MANAGEMENT STRATEGIES FOR MANAGEMENT STRATEGY FRAMEWORK

Edward Higginbotham & Associates

HERITAGE MANAGEMENT STRATEGIES FOR MANAGEMENT STRATEGY FRAMEWORK.

LOWER CANAL, BETWEEN PROSPECT RESERVOIR AND PIPEHEAD, N.S.W.

Edward Higginbotham
MA (Cambridge), PhD (Sydney), MAACAI.
EDWARD HIGGINBOTHAM & ASSOCIATES PTY LTD
140 Smith Street
SUMMER HILL, NSW 2130.
PO Box 97
HABERFIELD, NSW 2045.
(02) 9716-5154.
Fax. (02) 9716-8547.

For
Environmental Partnership Pty Ltd

July 1998

CONTENTS.

ACKNOWLEDGMENTS.

The author would like to thank

Client: Mr. Adam Hunter, Environmental Partnership Pty Ltd

1. INTRODUCTION.

1.1. Background.

This report was commissioned by Environmental Partnership Pty Ltd on 9 February 1998.

1.2. Brief.

The purpose of this report is as follows:

1. Briefing of design team on heritage issues (not included in report).
2. Review and comment on draft planning schemes (not included in report).
3. Preparation of heritage management strategies based on preferred masterplan (subject report).

1.3. Location of site.

The Lower Canal is part of the Upper Nepean Scheme. It runs from Prospect Reservoir to Pipehead.

The Upper Canal commences at the Pheasant's Nest Weir on the Nepean River, and proceeds by tunnel to the Cataract River at Broughton's Pass. A weir across the Cataract River diverts the flow of the tunnel and the river into the Cataract Tunnel.

From Broughton's Pass, the Upper Canal delivers water by gravity through open canal and tunnel to Prospect Reservoir, with subsidiary offtakes along the route for Ingleburn Dam, and Liverpool Dam and the Campbelltown and Camden areas. Prospect Reservoir also receives water from the Warragamba Dam by major pipelines.

The main outlets from Prospect Reservoir are the Lower Canal, the 72" and the 84" Pipelines, all to Pipehead.[1] In addition there are the Prospect Elevated Pumping Station to Prospect Hill and Prospect Elevated Reservoirs, for the supply of the Blacktown area, and the Thornleigh Electric Pumping Station to Thornleigh

[1] Grid reference: PROSPECT. 9030-2-N. 1:25,000. 56H. LH. 121527.

Reservoir, for the supply of the Upper North Shore. Both of the latter are on the north eastern shore of Prospect Reservoir.

1.4. Study methodology and limitations.

This report has been designed to integrate with the main report. It does not therefore follow the standard format of a conservation plan or archaeological assessment report.[2]

The report has used the Heritage Study of the Upper Canal, Prospect Reservoir & Lower Canal (Upper Nepean Scheme) as principal source material.[3]

1.5. Author identification.

This report was prepared by Edward Higginbotham.

2 Heritage Office and Department of Urban Affairs and Planning. 1996. *NSW Heritage Manual.*

3 Edward Higginbotham. 1992. Heritage Study of the Upper Canal, Prospect Reservoir & Lower Canal (Upper Nepean Scheme). Water Board.

2. MANAGEMENT STRATEGY FRAMEWORK

2.1. Cultural Heritage.

The cultural significance of the Lower Canal and the Upper Nepean Scheme in general demands that the water supply system should be conserved and managed with a high level of care. A number of policies are therefore formulated to ensure this outcome.

Policy 1. The Upper Nepean Scheme should be conserved as a whole.
The cultural significance of the Upper Nepean Scheme demands that it should be conserved as a whole. While this does not mean that the whole system should be kept in operating condition, it does require that:

1. The whole course of the system should be conserved.
2. All significant elements should be conserved, in accordance with the recommendations of the Heritage Study of the Upper Canal, Prospect Reservoir & Lower Canal (Upper Nepean Scheme).[4]
3. The corridor of the Lower Canal should be retained as a single element, with connections to Prospect Reservoir and Pipehead.
4. The upper rim or structure of the Lower Canal should remain visible or be denoted by some form of linear boundary for its complete length.

The deteriorating condition of the Monier plates and their attachment to the sides of the canal should not inhibit the conservation of the Lower Canal. The infill of the canal channel should stabilise this problem. Advice should be sought on whether this measure would actually slow down the rate of deterioration.

Policy 2. The Upper Nepean Scheme should be conserved in a manner which retains its significance without bias or distortion.
Measures which might distort the cultural significance of the place should be avoided. For example, substantial revegetation of the canal corridor with native plantings would distort the significance of the place.

In the conservation and management of a place, it is important to keep the significance of the site as a whole in proper focus. Any action which affects an item or element of the Lower Canal needs to be assessed for its impact on the whole, in terms of:

[4] Edward Higginbotham. 1992. Heritage Study of the Upper Canal, Prospect Reservoir & Lower Canal (Upper Nepean Scheme). Water Board.

1. Minimising the changes to the place as a whole.[5]
2. Avoiding distortion of the evidence.[6]
3. Giving equal consideration to all aspects of cultural significance, without unwarranted emphasis on one aspect over others, or one period over others.[7]
4. The conservation of an appropriate setting for the place.[8]

The backfilling of the canal structure would by itself distort the cultural significance of the place, unless it is accompanied by a well designed interpretation and display strategy, including:

1. A selected number of areas where the profile of the canal structure is visible.
2. Sections of canal with running water to indicate its original function.

An important opportunity exists for the interpretation and display of the Lower Canal at the top end of the canal or Receiving Basin. The Upper and Lower Valve Houses, together with the short section of open canal at the Receiving Basin could be interpreted and displayed to great advantage by the use of running water in the Receiving Basin and along a short section of canal. The water could be recycled by pump, in order not to waste potable water from the Reservoir.

Policy 3. The future use of the Lower Canal should not take priority over the cultural significance of the water supply system.

Future uses should complement the conservation objectives and should enhance the significance of the place. Any use which requires substantial changes to the structures of the Lower Canal should be avoided.

Policy 4. Measures used to conserve or develop the Lower Canal should be reversible, so that the system may be reinstated in future, if required.

The current level of deterioration of the fabric of the Lower Canal should be addressed in any proposal for future use. Any proposed use should also have a beneficial effect on the stability and maintenance of the structure.

Policy 5. A high priority should be given to the interpretation and display of the Upper Nepean Scheme.

---

5 ICOMOS. 1979, revised 1981, 1988. The Burra Charter. Article 3.
6 ICOMOS. 1979, revised 1981, 1988. The Burra Charter. Article 3.
7 ICOMOS. 1979, revised 1981, 1988. The Burra Charter. Article 6.
8 ICOMOS. 1979, revised 1981, 1988. The Burra Charter. Article 8.

Apart from the conservation and management of a place, there is also an obligation to interpret and display a significant site, in such a way as to explain the importance of the place to the general public, without bias, distortion or undue emphasis on one item over another, or one period over another. The explanation and interpretation of the place must clearly indicate why the place has been conserved and its heritage values. It should enable a wider appreciation and a greater understanding of the place.

This obligation to interpret and display may be considered in terms of the ability of the place to 'demonstrate a way of life, taste, custom, process or function of particular interest.'[9] This factor was given greater emphasis by J. S. Kerr in the assessment of cultural significance in the second edition of his book, entitled *The Conservation Plan.*[10] This may be described as its educational or 'public significance'.[11] One of the principle means of imparting the educational or public significance of a place is through interpretation and display.[12]

Policy 6. Integration of Lower Canal with neighbouring heritage items.
The Lower Canal should be linked and connected not only to the remainder of the Upper Nepean Scheme, but also to neighbouring heritage items, for example, the Hyland Road Dairy Farm Complex.[13]

Policy 7. Repository for archaeological relics and other heritage items.
The conservation of the Lower Canal requires the retention of all significant fabric, except where heritage items fall into distinctive groups or types. Examples from these groups or types should be conserved, the remainder should preferably be conserved, but if removed, the significant fabric should be retained with a view to future reinstatement.

---

9 J. S. Kerr, *The Conservation Plan. A guide to the preparation of conservation plans for places of European cultural significance*, first edition, National Trust of Australia (N.S.W. Branch), Sydney, 1982, p. 4.
10 J. S. Kerr, *The Conservation Plan. A guide to the preparation of conservation plans for places of European cultural significance*, second edition, National Trust of Australia (N.S.W. Branch), Sydney, 1985.
11 M. Pearson, 'Assessing the significance of historical archaeological resources', in S. Sullivan, & S. Bowdler, *Site survey and significance assessment in Australian archaeology*, Dept. of Prehistory, Research School of Pacific Studies, ANU, Canberra, 1984, p. 32.
12 J. S. Kerr, *The Conservation Plan. A guide to the preparation of conservation plans for places of European cultural significance*, fourth edition, National Trust of Australia (N.S.W. Branch), Sydney, 1996. pages 38-39.
13 Edward Higginbotham. 1993. Plan of management for the Hyland Road Farm Group, Hyland Road, Greystanes, N.S.W., Holroyd City Council.

Provision should be made in a suitable repository for the safekeeping of fabric removed from the Lower Canal during conservation, maintenance and reuse.

3. RECOMMENDATIONS.

In accordance with the Heritage Study of the Upper Canal, Prospect Reservoir & Lower Canal (Upper Nepean Scheme), the following recommendations are appropriate for the conservation and management of the Lower Canal:[14]

3.1. Archival Recording.

In accordance with the ICOMOS Burra Charter, Articles 23 and 28, the Lower Canal should be recorded to archival standard prior to disturbance of the place.

Guidelines for archival recording were prepared by the NSW Department of Planning in 1994.[15]

3.2. Excavation permits.

1. Prior to the commencement of works on the site, an excavation permit, under the Heritage Act of NSW, should be obtained (See the Relics Provisions of the NSW Heritage Act).

The excavation permit may be obtained by a qualified archaeologist on behalf of the client. A permit may take 3-4 weeks to obtain from the Heritage Council of NSW.

2. Sufficient time and resources should be made available for the proper excavation and recording of archaeological features, discovered during the archaeological investigation.

3. The standard conditions of the excavation permit require the work to be completed to a high standard. The investigation should include:

1. A detailed record of all features and structures discovered, using plans, photographs and written records.
2. A catalogue of all the artifacts and other relics recovered, including accurate provenance, description and interpretation.

---

[14] Edward Higginbotham. 1992. Heritage Study of the Upper Canal, Prospect Reservoir & Lower Canal (Upper Nepean Scheme). Water Board.

[15] Department of Planning and Heritage Council of New South Wales, 1994. *NSW Heritage. How to prepare archival records of heritage items*. Sydney.

3. The stabilisation, cleaning and packaging of all the artifacts, and the placement of the collection in a permanent repository.
4. The backfilling of the excavation, where appropriate.
5. The preparation of a final report, including a description and interpretation of the excavation, detailed historical research, the contribution to research themes, and excavation method.

4. Any archaeological investigation should be carried out in accordance with the NSW Heritage Manual and specifically the *Archaeological Assessment Guidelines.*[16]

3.3. Conservation and management.

The Heritage Study of the Upper Canal, Prospect Reservoir & Lower Canal (Upper Nepean Scheme), makes the following recommendations for the conservation and management of the Lower Canal:[17]

1. The following inventory items should be permanently conserved.

Inventory number	Item type	Type number
10	Covered Way	
20	Canal	12
28	Aqueduct	5
29	Inverted Syphon	
38	Canal	11
48	Sedimentation Channel	

All sections of the canal should be conserved. This may partly be achieved by infilling of the structure, although it will be necessary to retain some open sections. Advice should be obtained from a qualified conservation practitioner on the method and materials used in backfilling (See Policies 1 and 2).

[16] Heritage Office & Department of Urban Affairs and Planning, NSW. 1996. *Archaeological Assessments*. Sydney.
[17] Edward Higginbotham. 1992. Heritage Study of the Upper Canal, Prospect Reservoir & Lower Canal (Upper Nepean Scheme). Water Board.

2. It is preferable that all the following items should be conserved. If this is not possible then the impact of removing an item should be assessed and only removed if the majority of other examples in the group can be conserved.

Item Type	Type Number	Inventory Number	Notes
Canal Overbridge	14	5	
Canal Overbridge	14	42	
Canal Overbridge	18	13	Lower Canal only.
Canal Overbridge	18	15	Lower Canal only.
Canal Overbridge	18	51	Lower Canal only.
Cottage Site	22		
Culvert	4	16	Lower Canal Type 4 differs slightly from elsewhere in type of stone used.
Culvert	4	18	as above.
Culvert	4	26	as above.
Culvert	4	33	as above.
Culvert	4	35	as above.
Culvert	4	41	as above.
Culvert	6	17	
Culvert	6	19	
Culvert	6	27	
Culvert	6	32	
Culvert	6	45	
Culvert	8	19	
Culvert	8	27	
Culvert	9	1	Lower Canal only.
Culvert	9	6	Lower Canal only.
Culvert	9	12	Lower Canal only.
Culvert	9	14	Lower Canal only.
Culvert	9	39	Lower Canal only.
Culvert	9	44	Lower Canal only.
Flume	3	3	
Flume	13	4	
Flume	16	8	Lower Canal only.

Flume	16	36	Lower Canal only.
Flume	16	43	Lower Canal only.
Flume	17	9	Lower Canal only.
Flume	17	11	Lower Canal only.
Scour Valve	2	18	Lower Canal only.
Scour Valve	2	31	Lower Canal only.
Scour Valve	2	34	Lower Canal only.
Scour Valve	2	40	Lower Canal only.
Scour Valve	2	49	Lower Canal only.

The minimum conservation requirement of one example in each group, as proposed by the Heritage Study, is no longer considered to be appropriate and should be replaced by the wording of this recommendation.

3. Conservation plans should be prepared for the following items to determine appropriate conservation and management measures..

Item Type	**Type Number**	**Inventory Number**	**Notes**
Aqueduct	5	28	Greystanes (Boothtown) Aqueduct
Canal	11	38	Lower Canal (Monier Plates)
Canal	12	20	Concrete canal near Gipps St
Canal Overbridge	14	5	
Canal Overbridge	14	42	
Canal Overbridge	18	13	
Canal Overbridge	18	15	
Canal Overbridge	18	51	
Covered Way		10	
Culvert	4	16	
Culvert	4	18	
Culvert	4	26	
Culvert	4	33	
Culvert	4	35	

Culvert	4	41	
Culvert	6	17	
Culvert	6	19	
Culvert	6	27	
Culvert	6	32	
Culvert	6	45	
Flume	3	3	
Flume	13	4	
Flume	17	9	
Flume	17	11	
Inverted Syphon		29	Greystanes (Boothtown) Inverted Syphon
Sedimentation Channel		48	Sedimentation Channel and By-pass

3.4. Interpretation and display.

1. An Interpretation and Display Strategy or Plan should be prepared for the Lower Canal. It should seek to explain the importance of the place to the general public, without bias, distortion or undue emphasis on one item over another, or one period over another. The explanation and interpretation of the place must clearly indicate why the place has been conserved and its heritage values. It should enable a wider appreciation and a greater understanding of the place.

The Interpretation and Display Strategy or Plan should seek to place the Lower Canal in its historical context of the Upper Nepean Scheme, and should also seek to integrate the place with neighbouring and associated heritage items.

APPENDIX 1. THE RELICS PROVISIONS OF THE NSW *HERITAGE ACT.*

The *Heritage Act* contains various legal measures to protect historical archaeological resources.

Where historical research has revealed the location of historic settlement, experience has shown that the discovery of relics is highly likely once the soil is disturbed. When relics are revealed the Heritage Council must be notified. This may involve delay until appropriate arrangements can be made to record the archaeological remains. As a result, developers and others are normally advised that excavation permits must be obtained prior to undertaking works, which involve excavation or the disturbance of historic sites. In this way most delays can be avoided.

The NSW *Heritage Act* defines a 'relic' as:

> *any deposit, object or material evidence -*
> *(a). which relates to the settlement of the area that comprises New South Wales, not being aboriginal settlement; and*
> *(b) which is 50 or more years old*

Section 139 of the *Heritage Act* provides that:

> *A person shall not disturb or excavate any land for the purpose of discovering, exposing or moving a relic, not being a relic subject to a conservation instrument, except in accordance with an excavation permit.*

If a site is the subject of an order under section 130, an Interim Conservation Order, or a Permanent Conservation Order, approval for an excavation is required under section 60 of the *Heritage Act*..

If a site is not the subject of an order under the *Heritage Act*, an excavation permit is required, in accordance with section 140.

Section 146 of the *Heritage Act* requires that the accidental discovery of relics should be reported to the Heritage Council of NSW.

When an item of heritage significance comes under the ownership or control of a public authority, the authority is required to record it in a Heritage and Conservation

Register, under section 170 of the *Heritage Act*. The purpose of the provision is to alert the authority whenever works are proposed, which might affect the item.

APPENDIX 2. THE ICOMOS BURRA CHARTER.

Preamble

Having regard to the International Charter for the Conservation and Restoration of Monuments and Sites (Venice 1966), and the Resolutions of 5th General Assembly of the International Council on Monuments and Sites (ICOMOS) (Moscow 1978), the following Charter was adopted by Australia ICOMOS on 19th August 1979 at Burra Burra. Revisions were adopted on 23rd February 1981 and on 23 April 1988.

Definitions

Article 1. For the purpose of this Charter:

1.1 *Place* means site, area, building or other work, group of buildings or other works together with associated contents and surroundings.

1.2 *Cultural significance* means aesthetic, historic, scientific or social value for past, present or future generations.

1.3 *Fabric* means all the physical material of the *place*.

1.4 *Conservation* means all the processes of looking after a *place* so as to retain its *cultural significance*. It includes *maintenance* and may according to circumstance include *preservation, restoration, reconstruction* and *adaptation* and will be commonly a combination of more than one of these.

1.5 *Maintenance* means the continuous protective care of the *fabric*, contents and setting of a *place*, and is to be distinguished from repair. Repair involves *restoration* or *reconstruction* and it should be treated accordingly.

1.6 Preservation means maintaining the *fabric* of a *place* in its existing state and retarding deterioration.

1.7 *Restoration* means returning the EXISTING *fabric* of a *place* to a known earlier state by removing accretions or by reassembling existing components without the introduction of new material.

1.8 *Reconstruction* means returning a *place* as nearly as possible to a known earlier state and is distinguished by the introduction of materials (new or old) into the *fabric*. This is not to be confused with either re-creation or conjectural reconstruction which are outside the scope of this Charter.

1.9 *Adaptation* means modifying a *place* to suit proposed compatible uses.

1.10 *Compatible use* means a use which involves no change to the culturally significant fabric, changes which are substantially reversible, or changes which require a minimal impact.

Conservation Principles

Article 2. The aim of *conservation* is to retain the *cultural significance* of a *place* and must include provision for its security, its *maintenance* and its future.

Article 3. *Conservation* is based on a respect for the existing *fabric* and should involve the least possible physical intervention. It should not distort the evidence provided by the *fabric*.

Article 4. *Conservation* should make use of all the disciplines which can contribute to the study and safe-guarding of a *place*. Techniques employed should be traditional but in some circumstances they may be modern ones for which a firm scientific basis exists and which have been supported by a body of experience.

Article 5. *Conservation* of a *place* should take into consideration all aspects of its *cultural significance* without unwarranted emphasis on any one aspect at the expense of others.

Article 6. The conservation policy appropriate to a *place* must first be determined by an understanding of its *cultural significance*.

Article 7. The conservation policy will determine which uses are compatible.

Article 8. *Conservation* requires the maintenance of an appropriate visual setting: eg., form, scale, colour, texture and materials. No new construction, demolition or modification which would adversely affect the setting should be allowed. Environmental intrusions which adversely affect appreciation or enjoyment of the *place* should be excluded.

Article 9. A building or work should remain in its historical location. The moving of all or part of a building or work is unacceptable unless this is the sole means of ensuring its survival.

Article 10. The removal of contents which form part of the *cultural significance* of the *place* is unacceptable unless it is the sole means of ensuring their security and *preservation*. Such contents must be returned should changed circumstances make this practicable.

Conservation Processes

Preservation

Article 11. *Preservation* is appropriate where the existing state of the *fabric* itself constitutes evidence of specific *cultural significance*, or where insufficient evidence is available to allow other conservation processes to be carried out.

Article 12. *Preservation* is limited to the protection, *maintenance* and, where necessary, the stabilisation of the existing *fabric* but without the distortion of its *cultural significance*.

Restoration

Article 13. *Restoration* is appropriate only if there is sufficient evidence of an earlier state of the *fabric* and only if returning the fabric to that state reveals the *cultural significance* of the *place*.

Article 14. *Restoration* should reveal anew culturally significant aspects of the *place*. It is based on respect for all the physical, documentary and other evidence and stops at the point where conjecture begins.

Article 15. *Restoration* is limited to the reassembling of displaced components or removal of accretions in accordance with Article 16.

Article 16. The contributions of all periods to the *place* must be respected. If a *place* includes the *fabric* of different periods, revealing the *fabric* of one period at the expense of another can only be justified when what is removed is of slight *cultural significance* and the *fabric* which is to be revealed is of much greater *cultural significance*.

Reconstruction

Article 17. *Reconstruction* is appropriate only where a *place* is incomplete through damage or alteration and where it is necessary for its survival, or where it reveals the *cultural significance* of the *place* as a whole.

Article 18. *Reconstruction* is limited to the completion of a depleted entity and should not constitute the majority of the *fabric* of a *place*.

Article 19. *Reconstruction* is limited to the reproduction of *fabric*, the form of which is known from physical and/or documentary evidence. It should be identifiable on close inspection as being new work.

Adaptation

Article 20. *Adaptation* is acceptable where the *conservation* of the *place* cannot otherwise be achieved, and where the *adaptation* does not substantially detract from its cultural significance.

Article 21. *Adaptation* must be limited to that which is essential to a use for the *place* determined in accordance with Articles 6 and 9.

Article 22. *Fabric* of *cultural significance* unavoidably removed in the process of *adaptation* must be kept safely to enable its future reinstatement.

Conservation Practice

Article 23. Work on a *place* must be preceded by professionally prepared studies of the physical, documentary and other evidence, and the existing *fabric* recorded before any intervention in the *place*.

Article 24. Study of a *place* by any intervention in the *fabric* or by archaeological excavation should be undertaken where necessary to provide data essential for decisions on the *conservation* of the *place* and/or to secure evidence about to be lost or made inaccessible through necessary *conservation* or other unavoidable action. Investigation of a *place* for any other reason which requires physical disturbance and which adds substantially to a scientific body of knowledge may be permitted, provided that it is consistent with the conservation policy for the *place*.

Article 25. A written statement of conservation policy must be professionally prepared setting out the *cultural significance* and proposed *conservation* procedure together with justification and supporting evidence, including photographs, drawings and all appropriate samples.

Article 26. The organisation and individuals responsible for policy decisions must be named and specific responsibility taken for each such decision.

Article 27. Appropriate professional direction and supervision must be maintained at all stages of the work and a log kept of new evidence and additional decisions recorded as in Article 25 above.

Article 28. The records required by Articles 23, 25, 26 and 27 should be placed in a permanent archive and made publicly available.

Article 29. The items referred to in Articles 10 and 22 should be professionally catalogued and protected.

Words in italics are defined in Article 1.